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Edition 3
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Documentation History

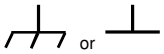
All Editions and Updates of this manual and their creation date are listed below. The first Edition of the manual is Edition 1. The Edition number increments by 1 whenever the manual is revised. Updates, which are issued between Editions, contain replacement pages to correct or add additional information to the current Edition of the manual. Whenever a new Edition is created, it will contain all of the Update information for the previous Edition. Each new Edition or Update also includes a revised copy of this documentation history page.

Edition 1 . . . . . January, 1992
Update 1 . . . . . August, 1992
Edition 2 . . . . . March, 1993
Edition 3 . . . . . April, 1995

Safety Symbols

Instruction manual symbol affixed to product. Indicates that the user must refer to the manual for specific WARNING or CAUTION information to avoid personal injury or damage to the product.

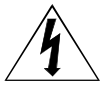
Indicates the field wiring terminal that must be connected to earth ground before operating the equipment—protects against electrical shock in case of fault.



Frame or chassis ground terminal—typically connects to the equipment's metal frame.

Alternating current (AC).

Direct current (DC).



Indicates hazardous voltages.

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Calls attention to a procedure, practice, or condition that could cause bodily injury or death.

CAUTION

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according to ISO/IEC Guide 22 and EN 45014

Manufacturer's Name: Hewlett-Packard Company
Loveland Manufacturing Center

Manufacturer's Address: 815 14th Street S.W.
Loveland, Colorado 80537

declares, that the product:

Product Name: Arbitrary Function Generator

Model Number: E1340A

Product Options: All

conforms to the following Product Specifications:

Safety: IEC 1010-1 (1990) Incl. Amend 1 (1992)/EN61010-1 (1993)
CSA C22.2 #1010.1 (1992)
UL 1244

EMC: CISPR 11:1990/EN55011 (1991): Group1 Class A
IEC 801-2:1991/EN50082-1 (1992): 4kVCD, 8kVAD
IEC 801-3:1984/EN50082-1 (1992): 3 V/m
IEC 801-4:1988/EN50082-1 (1992): 1kV Power Line
.5kV Signal Lines

Supplementary Information: The product herewith complies with the requirements of the Low Voltage Directive 73/23/EEC and the EMC Directive 89/336/EEC and carries the CE-marking accordingly.

Tested in a typical configuration in an HP B-Size VXI mainframe.

April, 1995 **Jim White, QA Manager**

European contact: Your local Hewlett-Packard Sales and Service Office or Hewlett-Packard GmbH, Department HQ-TRE, Herrenberger Straße 130, D-71034 Böblingen, Germany (FAX +49-7031-14-3143).

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Chapter 1
Getting Started with the HP E1340A

Chapter Contents

This chapter shows you how to configure, install, and begin using the HP E1340A Arbitrary Function Generator (AFG). The main sections of this chapter include:

Preparation for Use

This section shows how to prepare the AFG for use. Included are instructions to install the AFG, to download the AFG Device Driver, and to address the AFG.

Installing the AFG

The AFG can be installed in any mainframe slot, except slot 0. For installation instructions in a B-Size VXIbus System, refer to the *B-size Installation and Getting Started Guide*. For installation instructions in C-Size VXIbus Systems, refer to the *C-size Installation and Getting Started Guide*.

Downloading the AFG Device Driver

The HP E1340A AFG driver allows the AFG to operate in an HP E1300/E1301 Mainframe or HP E1405/E1406 Command Module using the Standard Commands for Programmable Instruments (i.e., SCPI) instrument command language. The driver is supplied on the AFG's example program disks (see "Instrument and Programming Languages" on page 19 for more information on the disks).

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The procedure for downloading the driver is contained in the HP Installation Note *Downloading Device Drivers*. The *E1300/E1301 Mainframe Manual*, *HP E1405 Command Module Manual*, and *E1406 Command Module Manual* also contain the installation procedure.

Mainframe/Command Module Requirements

To download a driver, the ROM version number of the HP E1300/E1301 Mainframe or HP E1405 Command Module must be A.06.00 or above. To determine the version number, send the IEEE 488.2 common command *IDN?. A typical returned value (for the HP E1300A Mainframe) is:

```
HEWLETT-PACKARD,E1300A,0,A.06.01
```

where "A.06.01" is the version number.

Recommended Systems to Download the Drivers

The AFG instrument driver can be downloaded with the following systems.

HP BASIC with an External HP-IB Controller

This system downloads the driver over the Hewlett-Packard Interface Bus (HP-IB*) with an HP BASIC controller, like the HP Series 200/300 computer. Be sure to connect the computer to the Mainframe's / Command Module's HP-IB port. The program to download the driver is named "VXIDLD_GET", and is in GET/SAVE format. The program is located on the HP IBASIC example program disk (HP part number E1340-10035). This disk is formatted in the LIF format.

HP IBASIC in an HP E1300/E1301 Mainframe or HP E1405/E1406 Command Module

This system downloads the drivers using the HP IBASIC (i.e., HP Instrument BASIC) program language. The language comes with options to the HP E1300/E1301 Mainframe and the HP E1405/E1406 Command Modules. IBASIC reads disks formatted in either the LIF or MS-DOS® format and can use either example program disk (dependent on your disk drive). To download the driver from the LIF disk or the DOS disk, use "AUTOST".

Externally Connected MS-DOS® Computer

This system downloads the driver using an MS-DOS computer over the RS-232 serial interface. Connect the computer to the Mainframe's / Command Module's RS-232 port. The program to download the driver is named "VXIDLD.EXE" and is located on the DOS example program disk (HP part number E1340-10036). This disk is formatted for MS-DOS.

* HP-IB is Hewlett-Packard's implementation of IEEE Std 488.1-1978

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AFG Logical Address

The AFG is shipped from the factory with a logical address setting of 80, as shown in Figure 1-1.

The E1340A AFG logical address is used:

- to place the AFG in the servant area of a commander (e.g. HP E1405/E1406 Command Module).
- to address the AFG (see "Addressing the AFG" later in this chapter).

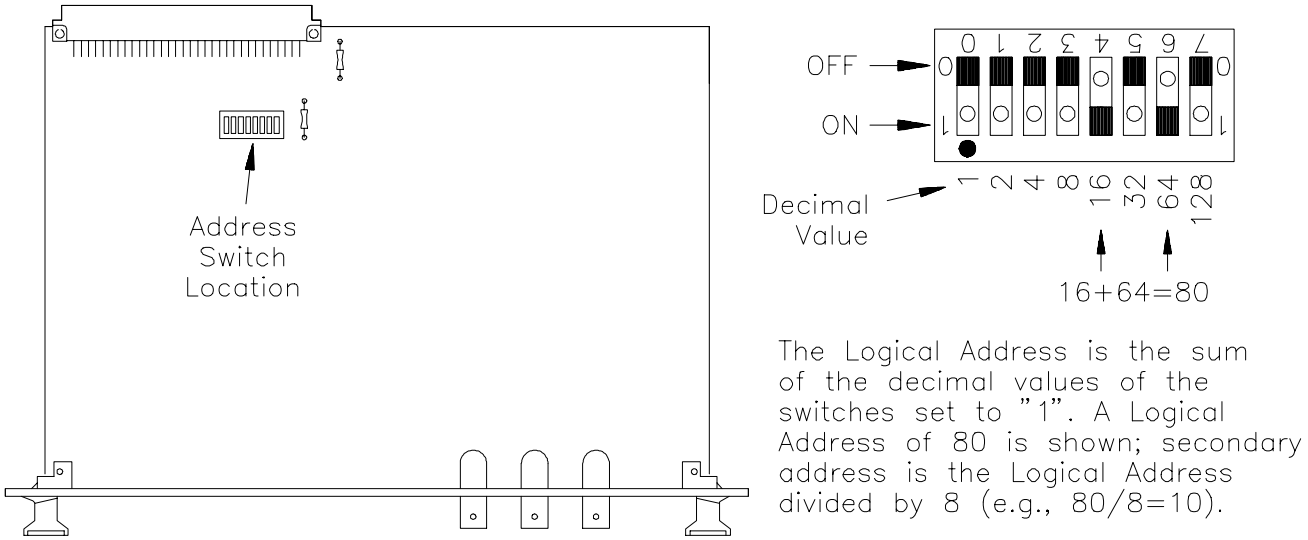

Figure 1-1. Setting the Logical Address

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Assigning the AFG to a Commander

In VXIbus systems, each device must be in the servant area of a commander. Note the following when assigning the E1340A AFG:

- In a B-size system, the system instrument is the commander. Any AFG logical address (1 - 255) places the AFG in the commander servant area. The AFG logical address should remain at 80, or if necessary, set to some other multiple of 8 (see "Addressing the AFG").
- The E1340A AFG is a register-based device. If the AFG's driver is downloaded in the HP E1405/E1406 Command Module, then the AFG must be in the servant area of the Command Module to program with SCPI commands.

Addressing the AFG

The following information explains how the AFG is addressed using different computer (controller) configurations.

IBASIC

To program the AFG in a B-size or C-size system using IBASIC, the AFG must have a unique address. The address is a combination of the IBASIC interface select code, the Mainframe's/Command Module's primary HP-IB address, and the AFG's secondary HP-IB address. An address in this form in an HP IBASIC statement appears as:

```
OUTPUT 80910;"SOUR:ROSC:SOUR INT"
```

Interface Select Code (8): The IBASIC interface select code is 8. This select code is used to access all devices installed in B-size and C-size systems under IBASIC control.

Primary HP-IB Address (09): This is the address of the HP-IB port on the Mainframe or Command Module. Valid addresses are 0 to 30. The mainframe/command module has a factory set address of 9.

Secondary HP-IB Address (10): This address is derived from the logical address of the device (AFG) by dividing the logical address by 8. For the E1340A AFG factory set logical address of 80, the secondary address is 10.

External Controller and PC

When programming the AFG from an external computer such as a HP Series 300 or PC, the addressing convention used is the same as IBASIC except for the interface select code. An example is shown below:

```
OUTPUT 70910;"SOUR:ROSC:SOUR INT"
```

Interface Select Code (7): Determined by the address of the HP-IB interface card in the computer. In most Hewlett-Packard computers, this card has a factory set address of 7, including the HP 82335 HP-IB Interface Card (this card was used with an HP Vectra personal computer to create the C and QuickBASIC example programs).

The **Primary HP-IB Address** and **Secondary HP-IB Address** are the same as described previously for IBASIC programming.

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Instrument and Programming Languages

The purpose of this manual is to teach you how to use the E1340A AFG. To do this, the manual uses block diagrams, flowcharts, and example programs. The programs shown in the manual are SCPI programs written in HP IBASIC. These programs, and QuickBASIC and C language versions of the programs are on the following disks which ship with the manual:

- HP E1340A Instrument Driver and HP IBASIC Example Programs - 3.5" 720 kbyte disk (E1340-10035)
- HP E1340A Instrument Driver and QuickBASIC and C Language Example programs - 3.5" 1.44 Mbyte disk (E1340-10036)

SCPI Programming

SCPI (Standard Commands for Programmable Instruments) is an ASCII-based instrument command language designed for test and measurement instruments. The HP E1300/E1301 Mainframe or HP E1405/E1406 Command Module with the AFG driver installed interprets the ASCII command strings and sets the AFG accordingly. The Mainframe/Command Module does this by writing to the AFG registers.

SCPI Command Structure

The AFG SCPI command set is found in Chapter 7. SCPI commands are based on a hierarchical structure, also known as a tree system. In this system, associated commands are grouped together under a common node or root, thus, forming subtrees or subsystems. An example is the AFG's 'ARM' subsystem shown below.

```
ARM
    [:STARt|SEQuence[1]]
        [:LAYer[1]]
            :COUNt <number>
        :LAYer2
            :COUNt <number>
            :SLOPe <edge>
            :SOURce <source>
```

ARM is the root keyword of the command, :STARt|SEQuence1 is the second level keyword, :LAYer1 and :LAYer2 are third level keywords, and so on. A colon (:) always separates a command keyword from a lower level keyword as shown below:

```
ARM:LAY2:SOUR EXT
```


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A semicolon (;) is used to separate two commands within the same subsystem, and can also save typing. For example, sending this command message:

```
ARM:LAY2:SOUR EXT;SLOP POS;COUN 10
```

Is the same as sending these three commands:

```
ARM:LAY2:SOUR EXT
ARM:LAY2:SLOP POS
ARM:LAY2:COUN 10
```

Manual Format

The typical format of commands listed in the command reference and throughout this manual is:

```
[SOURce:]FREQuency:MODE <mode>
```

Command headers enclosed in brackets are optional. UPPER CASE letters in the header are required, lower case letters can be omitted. **To aid in learning the AFG command set, all headers are included in the example programs; however, the headers are abbreviated**. In an example program, the previous statement with a *mode* parameter of FIX would appear as:

```
SOUR:FREQ:MODE FIX
```

Command Coupling

Many of the AFG SCPI commands are value coupled. This means that the value set by one command may affect the valid limits for the values of other commands. This can result in "Settings Conflict" errors when the program executes. To prevent these errors, the AFG commands must be executed in a "Coupling Group".

The AFG uses one coupling group. Commands not in the coupling group must precede or follow commands in the coupling group. Executing uncoupled commands in the coupling group breaks the coupling and can cause a "Settings Conflict" error.

The coupling group and associated commands can be found in Appendix B, Table B-2.

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How to Execute Coupled Commands

Command coupling determines the AFG programming sequence. Coupled commands must be contiguous and executed in the same program statement. This is done by placing the commands in the same program line, or by suppressing the end-of-line terminator until the last (coupled) command has been sent (HP IBASIC programs only).

To send multiple commands in a single line or in a single statement, the commands are linked with a semicolon (;) and a colon (:). This is illustrated in the following lines:

```
SOUR:ROSC:SOUR  INT;:SOUR:FUNC:SHAP  SIN
```

or

```
SOUR:ROSC:SOUR  INT;
:SOUR:FUNC:SHAP  SIN
```

Both techniques are used in the programs found throughout this manual.

Note that the semicolon (;) **and** colon (:) link commands within different subsystems. Only a semicolon (;) is required to link commands within the same subsystem (see "SCPI Command Structure" earlier in this chapter).

Note See "HP IBASIC Language Programs" later in this chapter for information on suppressing the end-of-line terminator.

---

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HP IBASIC Language Programs

The following information identifies the system on which the HP IBASIC programs were written and shows how the programs are structured.

System Configuration

Except where noted, the example programs in HP IBASIC were developed (and tested) on the following system:

Mainframe: HP E1301A Mainframe (IBASIC Option)

HP E1340A Logical Address: 80

Instrument Language: SCPI

Program Structure

The structure of an example program in HP IBASIC is shown below:

```
1    !RE-SAVE"ARB_GEN"
2    !This program generates a 4096 point, 0 to 5V ramp waveform.
3    !The data is transferred to the AFG as voltages.
4    !
10   !Assign I/O path between IBASIC and the E1340A.
20   ASSIGN @Afg TO 80910
30   COM @Afg,Waveform(1:4096)
40   !
50   !Set up error checking
60   ON INTR 8 CALL Errmsg
70   ENABLE INTR 8;2
80   OUTPUT @Afg;"*CLS"
90   OUTPUT @Afg;"*SRE 32"
100  OUTPUT @Afg;"*ESE 60"
110  !
120  !Call the subprogram which resets the AFG.
130  CALL Rst
140  !Set AFG parameters
150  OUTPUT @Afg;"SOUR:ROSC:SOUR INT;";      !reference oscillator
160  OUTPUT @Afg;":SOUR:FREQ:FIX 1E3;";      !frequency
170  OUTPUT @Afg;":SOUR:FUNC:SHAP USER;";    !function
180  OUTPUT @Afg;":SOUR:VOLT:LEV:IMM:AMPL 5.1V"!scale
                                              amplitude
190  !
200  !Call subprogram which defines waveform segment.
210  CALL Ramp_wave
220  !
230  !Select output sequence and initiate waveform
240  OUTPUT @Afg;"SOUR:FUNC:USER A"
250  OUTPUT @Afg;"INIT:IMM"                  !wait-for-arm state
```

Continued on next page

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```
260   !
270   WAIT .1                              !allow interrupt to be serviced
280   OFF INTR 8
290   END
300   !
310   SUB Ramp_wave
320 Ramp_wave:  !Subprogram which defines a ramp waveform
330         COM @Afg,Waveform(*)
340         FOR I=1 TO 4096
350             Waveform(I)=I*.00122
360         NEXT I
370         !
380         OUTPUT @Afg;"SOUR:LIST:SEGM:SEL A"!Select segment name
390         OUTPUT @Afg;"  SOUR:LIST:SEGM:VOLT";Waveform(*)!load
                                                        waveform points
400   SUBEND
410   !
420   SUB Rst
430 Rst:  !Subprogram which resets the E1340.
440         COM @Afg,Waveform(*)
450         OUTPUT @Afg;"*RST;*OPC?"  !reset the AFG
460         ENTER @Afg;Complete
470   SUBEND
480   !
490   SUB Errmsg
500 Errmsg:  !Subprogram which displays E1340 programming errors
510         COM @Afg,Waveform(*)
520         DIM Message$[256]
530         !Read AFG status byte register and clear service request bit
540         B=SPOLL(@Afg)
550         !End of statement if error occurs among coupled commands
560         OUTPUT @Afg;""
570         OUTPUT @Afg;"ABORT"          !abort output waveform
580         REPEAT
590         OUTPUT @Afg;"SYST:ERR?"    !read AFG error queue
600         ENTER @Afg;Code,Message$
610         PRINT Code,Message$

620         UNTIL Code=0
630         STOP
640   SUBEND
```


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Turning Off (Suppressing) the End-Of-Line Terminator

As mentioned, coupled commands must be contiguous and executed in the same program statement. By suppressing the end-of-line (EOL) terminator (Line Feed) on a command line, coupled commands can be sent on separate lines, yet as a single program statement.

In HP IBASIC programs, the EOL terminator is suppressed by placing a semicolon (;) following the quotation mark (") which closes the command string. In the program above, the commands in lines 150 - 180 are in the coupling group. The semicolons following the command strings in lines 150 through 170 suppress the EOL terminator; therefore lines 150 - 180 are sent as a single statement.

Getting Programs

The HP IBASIC programs are stored on the disk as ASCII files. The program name is shown in the program title and in line 1 of the program (e.g., 1 !RE-SAVE"ARB_GEN"). To get a program, type:

GET "*file name*" (e.g., GET "ARB_GEN")

Declaring IBASIC Variables in COM (common) Memory

When writing or modifying IBASIC programs, array variables can be declared in COM (common) memory. Variables not in COM memory reside in the IBASIC stack. The 'stack' is a 32 kByte (default) segment of memory which contains components such as pointers and local variables for subprograms and declarations. When too many variables (or too large an array) are in the stack, Error 2 - Memory Overflow will occur. If a memory overflow occurs, the stack size can be changed with the command PROGram:MALLocate <*nbytes*> (see the *Instrument BASIC User's Manual* for more information).

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C Language Programs

All of the C Language example programs in this manual are written for the HP 82335 HP-IB Interface Card using the HP-IB Command Library for C. Unless otherwise noted, the library functions used in the programs are compatible with the ANSI C standard.

The following identifies the system on which the programs are written, shows how to compile the programs, and gives a typical example program.

System Configuration

The C programs were developed on the following system:

Controller: HP Vectra 386/25 personal computer (386 processor operated at 25 MHz)

HP-IB Interface Card: HP 82335 HP-IB Interface with Command Library

Mainframe: HP 75000 Series B/C

Slot0/Resource Manager: HP E1301A Mainframe/E1405/E1406 Command Module

HP E1340A Logical Address: 80

Instrument Language: SCPI

C Compiler Used

Unless otherwise noted, all C Language programs were compiled (and tested) using the following compilers:

- Microsoft® C Version 5.10
- Microsoft® QuickC© Version 2.0
- Borland Turbo C© Version 2.0
- Borland Turbo C++© Version 1.0

Running a Program

To run a program, first compile and link the program to make an executable file. To compile a program:

- Link the appropriate HP-IB C library (located on the HP-IB Command Library disk that came with the HP-IB Interface Card). Use the following libraries:
  - Microsoft® C and QuickC©: clhpib.lib
  - Turbo C© and C++©: tchhpib.lib
- If NOT compiling in the Large/Huge memory model, include the "cfunc.h" header file in the program (located on the HP-IB Command Library disk that came with the HP-IB Interface Card).

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- Be sure the necessary paths have been added to the AUTOEXEC.BAT file for the compilers to find the library and header files (see the appropriate C Language manual to set the proper paths).

To compile the programs from the DOS command line using the Large memory model, execute the following:

- Microsoft® C:

  cl /AL <*path**program name*> *path**clhpib.lib*

- Microsoft® QuickC©:

  qcl /AL <*path**program name*> *path**clhpib.lib*

- Turbo C© and Turbo C++©:

  tcc -ml <*path**program name*> *path**tchhpib.lib*

Change the "/AL" and "-ml" parameters to the appropriate types when compiling in the smaller memory models (see the appropriate C Language manual for the parameter type).

C Program Example

Following is an example program written in C using the HP 82335 HP-IB Interface Card. The program:

- sends commands to the AFG to generate an arbitrary waveform
- receives data from the AFG
- shows how to send coupled commands
- performs error checking of the AFG

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```
/* ARB_GEN.C - This program generates a 4096 points ramp. The data to */
/*                    generate the ramp is transferred to the AFG as voltages */

/* Include the following header files */
#include  <stdio.h>
#include  <string.h>
#include  <malloc.h>      /* Use “alloc.h” for Turbo C(c) or C++(c) */
#include  <cfunc.h>       /* This file is from the HP-IB Command Library Disk */

#define  ISC 7L           /* Assigns the HP-IB select code */
#define  ADDR 70910L  /* Assign an I/O path between the computer and the AFG */

/* Functions */
void  gen_seg(void);
void  cmd_exe(char *commands[], int    length);
void  run_query(void);
void  rst_clr(void);
void  send_data(char *commands, float *Wave_seg, int    num_size);
void  check_error(char *func_tion);

/*****************************************************************************/
void  main(void)          /* Run the program */
{
rst_clr();                /* Reset the AFG */
gen_seg();                /* Generate segment list and output sequence */
run_query();              /* Query waveform segment memory */
}
/*****************************************************************************/
void  gen_seg(void)
{
char static *set_commands[] =/* Use “set_commands” to setup the AFG */
{
“SOUR:ROSC:SOUR INT;”              /* Select the Ref. Oscillator */
“:SOUR:FREQ:FIX 1e3;”              /* Set waveform frequency */
“:SOUR:FUNC:SHAP USER;”            /* Command to select the user function */
“:SOUR:VOLT:LEV:IMM:AMPL 5.1V”,    /* Set the amplitude */

“SOUR:LIST:SEGM:SEL a”             /* Select the segment name */
},
```

Continued on next page

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```
*seg_commands =              /* Use “seg_commands” to store segments */

“SOUR:LIST:SEGM:VOLT ”,      /* Command to send volts data */

*out_commands[] =       /* Use the “out_commands” array to generate output */
{
“SOUR:FUNC:USER a”,          /* Select the user name */
“INIT:IMM”                   /* Start waveform generation */
};

float     *Wave_seg;
int       loop,
     seg_size = 4096;        /* Set the segment size to 4096 points */

     /* Allocate sufficient memory for storing the segments into computer memory */
Wave_seg = (float*) malloc (seg_size * sizeof (float));

     /* Setup the AFG */
cmd_exe(set_commands, sizeof(set_commands) / sizeof(char*));

     /* Call routine to check for AFG errors */
check_error(“gen_seg (set_commands)”);

     /* Calculate the segments */
for (loop = 0; loop < seg_size; loop ++)
     Wave_seg[loop] = (loop * .00122);

     /* Call function to execute the final command with segment data */
send_data(seg_commands, Wave_seg, seg_size);

     /* Call routine to check for AFG errors */
check_error(“gen_seg (seg_commands)”);

     /* Setup the AFG for output */
cmd_exe(out_commands, sizeof(out_commands) / sizeof(char*));

     /* Call routine to check for AFG errors */
check_error(“gen_seg (out_commands)”);
```

Continued on next page

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```
    /* Free the allocated memory */
free (Wave_seg);
}
/*****************************************************************************/
void   cmd_exe(char *commands[], int   length)
{
int       loop;

    /* Execute each command group using a loop */
for (loop = 0; loop < length; loop++)
    IOOUTPUTS(ADDR, commands[loop], strlen(commands[loop]));
}

/*****************************************************************************/
void   send_data(char *commands, float *Wave_seg, int   num_size)
{
char static state[2] = {13, 10};

    /* First disable EOI and EOL to send continuous data to the AFG; send last
command */
IOEOI (ISC, 0);IOEOL (ISC, " ", 0);
IOOUTPUTS (ADDR, commands, strlen(commands));

    /* Re-enable EOL and EOI for normal HP-IB operation; then send the data */
IOEOI (ISC, 1);IOEOL (ISC, state, 2);
IOOUTPUTA (ADDR, Wave_seg, num_size);
}
/*****************************************************************************/
void   run_query(void)
{
char     name[6];
int       length = 5;

    /* Query segment memory */
IOOUTPUTS(ADDR, "SOUR:LIST:SEGM:SEL?", 19);
IOENTERS(ADDR, name, &length);

printf("\nWaveform Segment currently selected: %s", name);
}
```

Continued on next page

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```
/*****************************************************************************/
void    rst_clr(void)
{
float into;

     /* Executes the commands that resets the AFG and clears its error register */
IOOUTPUTS(ADDR, "*RST;*OPC?", 10);
IOENTER(ADDR, &into);
IOOUTPUTS(ADDR, "*CLS;*OPC?", 10);
IOENTER(ADDR, &into);
}
/*****************************************************************************/
void    check_error(char *func_tion)
{
char      into[161];
int       length = 160;

IOOUTPUTS(ADDR, "SYST:ERR?", 9);  /* Query error register */
IOENTERS(ADDR, into, &length);          /* Enter error message */

if (atoi(into) != 0)                          /* Determine if error is present */
                                              /* If errors present, print and exit */
{
     while (atoi(into) != 0)
     {
          printf("Error %s in function %s\n\n", into, func_tion);
          IOOUTPUTS(ADDR, "SYST:ERR?", 9);
          IOENTERS(ADDR, into, &length);
     }

     exit(1);
}
}
```


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QuickBASIC Language Programs

All of the QuickBASIC Language example programs in this manual are written for the HP 82335 HP-IB Interface Card using the HP-IB Command Library for BASIC.

The following identifies the system on which the programs are written, shows how to compile the programs, and gives a typical example program.

System Configuration

The QuickBASIC programs were developed on the following system:

Controller: HP Vectra 386/25 personal computer (386 processor operated at 25 MHz)

HP-IB Interface Card: HP 82335 HP-IB Interface with Command Library

Mainframe: HP 75000 Series B/C

Slot0/Resource Manager: HP E1301A Mainframe/E1405/E1406 Command Module

HP E1340A Logical Address: 80

Instrument Language: SCPI

Running a Program

To run a program, first compile and link the program to make an executable file. You can either compile and link the program in the QuickBASIC environment, or compile and link separately on the command line as follows.

Using the QuickBASIC Environment

To compile and link a program, select the QuickBASIC environment as follows:

qb <*path**program name*> /l *path**qbhpib*

This loads both the program and HP-IB library into the QuickBASIC environment. Note that this only selects the QuickBASIC version 4.0 and above environment. For other versions of QuickBASIC, refer to the "HP 82335 Using the HP-IB Interface and Command Library" manual.

Using the Command Line

To compile and link using the command line is a two step method as follows:

First, compile the program by executing:

bc <*path* *program name*>

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This generates an object listing that has the same name as the program name with an OBJ extension. This object file must be linked to the HP-IB library.

Second, link the HP-IB library:

link <*path* *program name*>

After prompted for a run file, press the Enter key. The executable file with an EXE extension is then generated.

QuickBASIC Program Example

The following is an example program written in QuickBASIC using the HP 82335 HP-IB Interface Card. The program:

- sends commands to the AFG to generate an arbitrary waveform
- receives data from the AFG
- shows how to send coupled commands
- performs error checking of the AFG

```
' ARB_GEN.BAS - This program generates a 4096 points ramp. The data to
'                generate the ramp is transferred to the AFG as voltages

DECLARE SUB GenSeg ()
DECLARE SUB CmdExe (Commands$(), Length%)
DECLARE SUB SendData (Commands$, WaveSeg!(), NumSize%)
DECLARE SUB RstClr ()
DECLARE SUB CheckError (FuncType$)
DECLARE SUB RunQuery ()

COMMON SHARED ADDR&, ISC&

REM $INCLUDE: 'QBSETUP'

ISC& = 7  'Assigns the HP-IB select code
ADDR& = 70910   'Assign an I/O path between the computer and the AFG

CALL RstClr  ' Reset the AFG
CALL GenSeg  ' Generate segment list and output sequence
CALL RunQuery  ' Query segment name

END

SUB CheckError (FuncType$)

Max.Length% = 160: Actual.Length% = 0
```

Continued on next page

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```
Info$ = SPACE$(Max.Length%)

CALL IOOUTPUTS(ADDR&, "SYST:ERR?", 9)  ' Query error register
CALL IOENTERS(ADDR&, Info$, Max.Length%, Actual.Length%)
Info$ = LEFT$(Info$, Actual.Length%)

IF VAL(Info$) <> 0 THEN
CLS
WHILE VAL(Info$) <> 0
    PRINT   : PRINT   Info$; "  in function: "; FuncType$
    Actual.Length% = 0

    CALL IOOUTPUTS(ADDR&, "SYST:ERR?", 9)
    CALL IOENTERS(ADDR&, Info$, Max.Length%, Actual.Length%)
    Info$ = LEFT$(Info$, Actual.Length%)
WEND
END
END IF

END SUB

SUB CmdExe (Commands$(), Length%)

FOR I = 1 TO Length%
CALL IOOUTPUTS(ADDR&, Commands$(I), LEN(Commands$(I)))
NEXT I

END SUB

SUB GenSeg

DIM SetCommands$(1 TO 2)
DIM OutCommands$(1 TO 2)
DIM WaveSeg!(1 TO 4096)

SetCommands$(1) = "SOUR:ROSC:SOUR INT;"  ' Select the Ref. Oscillator
SetCommands$(1) = SetCommands$(1) + ":SOUR:FREQ:FIX 1e3;" ' Set
                                    waveform frequency
SetCommands$(1) = SetCommands$(1) + ":SOUR:FUNC:SHAP USER;"
                                    ' Select user function
```

Continued on next page

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```
SetCommands$(1) = SetCommands$(1) + ":SOUR:VOLT:LEV:IMM:AMPL 5.1V"
                                                    ' Set the amplitude

SetCommands$(2) = "SOUR:LIST:SEGM:SEL a"  ' Select the segment name

SegCommands$ = "SOUR:LIST:SEGM:VOLT "  ' Command to send volts data

OutCommands$(1) = "SOUR:FUNC:USER a"  ' Select the user name

OutCommands$(2) = "INIT:IMM"  ' Start waveform generation

' Setup the AFG
CALL CmdExe(SetCommands$(), 2)

' Call function to check for AFG errors
CALL CheckError("GenSeg (SetCommands)")

' Calculate the segments; store in memory
FOR I = 1 TO 4096
WaveSeg!(I) = I * .00122
NEXT I

' Call function to execute the final command with segment data
CALL SendData(SegCommands$, WaveSeg!(), 4096)

' Call function to check for AFG errors
CALL CheckError("GenSeg (SegCommands)")

'Setup the AFG for output
CALL CmdExe(OutCommands$(), 2)

' Call function to check for AFG errors
CALL CheckError("GenSeg (OutCommands)")

END SUB

SUB RstClr

CALL IOOUTPUTS(ADDR&, "*RST;*OPC?", 10)
CALL IOENTER(ADDR&, Into!)
```

Continued on next page

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```
CALL IOOUTPUTS(ADDR&, "*CLS;*OPC?", 10)
CALL IOENTER(ADDR&, Into!)

END SUB

SUB RunQuery

Max.Length% = 20: Actual.Length = 0
Info$ = SPACE$(Max.Length%)

' Query segment name
CALL IOOUTPUTS(ADDR&, "SOUR:LIST:SEGM:SEL?", 19)
CALL IOENTERS(ADDR&, Info$, Max.Length%, Actual.Length%)
Info$ = LEFT$(Info$, Actual.Length%)

PRINT   : PRINT   "Segment Name: "; Info$

END SUB

SUB SendData (Commands$, WaveSeg!(), NumSize%)

Endline$ = CHR$(13) + CHR$(10)

' First disable EOI and EOL to send continuous data to the AFG; send last command
CALL IOEOI(ISC&, 0)
CALL IOEOL(ISC&, " ", 0)
CALL IOOUTPUTS(ADDR&, Commands$, LEN(Commands$))

' Re-enable EOL and EOI for normal HP-IB operation; then send the data
CALL IOEOI(ISC&, 1)
CALL IOEOL(ISC&, Endline$, LEN(Endline$))
CALL IOOUTPUTA(ADDR&, SEG WaveSeg!(1), NumSize%)

END SUB
```


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Introductory Programs

The introductory programs in this section include:

- AFG Self-Test
- Resetting the AFG and clearing its status registers
- Querying the AFG power-on/reset settings
- Checking for Errors
- Generating a sine wave

AFG Self-Test

The AFG self-test is executed with the command:

*TST?

Table 1-1. HP E1340A Self-Test Codes.

Self-Test Code	Description
0	Test passed
1	Test failed. An error message describes the failure.

The self-test checks communication between the E1340A and the E1300/01 mainframe or Command Module. Upon completion of the test, one of the self-test codes listed in Table 1-1 is returned.

HP IBASIC (SLFTST)

```
1     !RE-SAVE “SLFTST”
10    !Send the self-test command, enter and display the result.
20    DIM Message$[256]
30    OUTPUT 80910;"*TST?"
40    ENTER 80910;Rslt
50    IF Rslt <>0 THEN
60       REPEAT
70          OUTPUT 80910;"SYST:ERR?"
80          ENTER 80910;Code,Message$
90          PRINT Code,Message$
100   UNTIL Code=0
110   END IF
120   PRINT Rslt
130   END
```


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C and QuickBASIC Programs

The C and QuickBASIC versions of SLFTST are on the C language example programs disk (HP P/N E1340-10036).

Resetting and Clearing the AFG

The commands used to reset and clear the AFG are:

```
*RST
*CLS
```

Resetting the AFG sets it to its power-on configuration and clearing the AFG clears its status registers. Status register programming is covered in Chapter 8.

HP IBASIC (RSTCLS)

```
1       !RE-SAVE"RSTCLS"
10      !Assign an I/O path between IBASIC and the AFG.
20      ASSIGN @Afg TO 80910
30      COM @Afg
40      !Call the subprogram
50      CALL Rst_cls
60      END
70      !
80      SUB Rst_cls
90  Rst_cls:   !subprogram which resets and clears the AFG.
100         COM @Afg
110         OUTPUT @Afg;"*RST;*CLS;*OPC?" !reset and clear the AFG
120         ENTER @Afg;Complete
130     SUBEND
```

C and QuickBASIC Programs

The C and QuickBASIC versions of RSTCLS are on the C language example programs disk (HP P/N E1340-10036).

Querying the Power-On/Reset Configuration

After resetting the AFG or cycling power, the AFG parameters are set to their power-on values. These values are listed in Appendix B, Table B-5.

The command which queries each AFG parameter setting is:

```
*LRN?
```


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```
1       !RE-SAVE "LRN"
10      !Assign an I/O path between IBASIC and the AFG.
20      ASSIGN @Afg TO 80910
30      !Call the subprogram
40      CALL Lrn_conf(@Afg)
50      END
60      !
70      SUB Lrn_conf(@Afg)
80   Lrn_conf:  !subprogram which queries the AFG reset configuration
90         DIM Lrn$[1000],Temp$[40]
100        OUTPUT @Afg;"*LRN?"
110        ENTER @AFG;Lrn$
120        Temp$=""
130        FOR I=1 TO LEN(Lrn$)
140           IF Lrn$[I,I]=";" THEN
150              PRINT Temp$    !print Temp$ when ; is received
160              Temp$=""
170           ELSE
180              Temp$=Temp$&Lrn$[I,I]  !build Temp$ from *LRN data
190           END IF
200        NEXT I
210        SUBEND
```

C and QuickBASIC Programs

The C and QuickBASIC versions of LRN are on the C language example programs disk (HP P/N E1340-10036).

Checking for Errors

The following HP IBASIC program shows the lines and subprogram added to the HP IBASIC programs to check for errors. Line 140 clears the AFG standard event status register. Lines 150 and 160 unmask the appropriate bits in the AFGs status byte register and standard event status register.

When an error occurs, the subprogram "Errmsg" reads the AFG error queue and displays the code and message. Note that line 310 is used to force an "end of statement" condition should a syntax error occur in a group of commands. Otherwise, the ABORT command in line 320 could be considered as part of the group and be ignored by the AFG SCPI interpreter.

Note An alternative HP IBASIC error checking program is in the *C-Size VXIbus Systems Installation and Getting Started Guide*. Error checking routines for C language and QuickBASIC programs are found in programs ARB_GEN.C and ARB_GEN.BAS, listed previously in this chapter.

---

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HP IBASIC (ERRORCHK)

```
1       !RE-SAVE"ERRORCHK"
2       !This program represents the method used to check for programming
3       !errors in HP IBASIC programs.
10      !Assign I/O path between IBASIC and the E1340A.
20      ASSIGN @Afg TO 80910
30      COM @Afg
40      !Define branch to be taken when an E1340A error occurs.
50      !Enable IBASIC interface to generate interrupt when error occurs.
60      ON INTR 8 CALL Errmsg
70      ENABLE INTR 8;2
80      !Clear all bits in the standard event status register, unmask the
90      !standard event status group summary bit in the E1340A status byte
100     !register (decimal weight 32), unmask the query error, device
110     !dependent error, execution error, and command error bits
120     !(decimal sum 60) in the E1340A standard event status register.
130     OUTPUT @Afg;"*CLS"
140     OUTPUT @Afg;"*SRE 32"
150     OUTPUT @Afg;"*ESE 60"
160     !
170     !Subprogram calls would be here
180     !
190     WAIT .1  !allow error branch to occur before turning intr off
200     OFF INTR 8
210     END
220     !
230     SUB Errmsg
240   Errmsg:  !Subprogram which displays E1340 programming errors
250       COM @Afg
260       DIM Message$[256]
270       !Read AFG status byte register and clear service request bit
280       B=SPOLL(@Afg)
290       !End of statement if error occurs among coupled commands
300       OUTPUT @Afg;""
310       OUTPUT @Afg;"ABORT"  !abort output waveform
320       REPEAT
330         OUTPUT @Afg;"SYST:ERR?"  !read AFG error queue
340         ENTER @Afg;Code,Message$
350         PRINT Code,Message$
360       UNTIL Code=0
370       STOP
380     SUBEND
```


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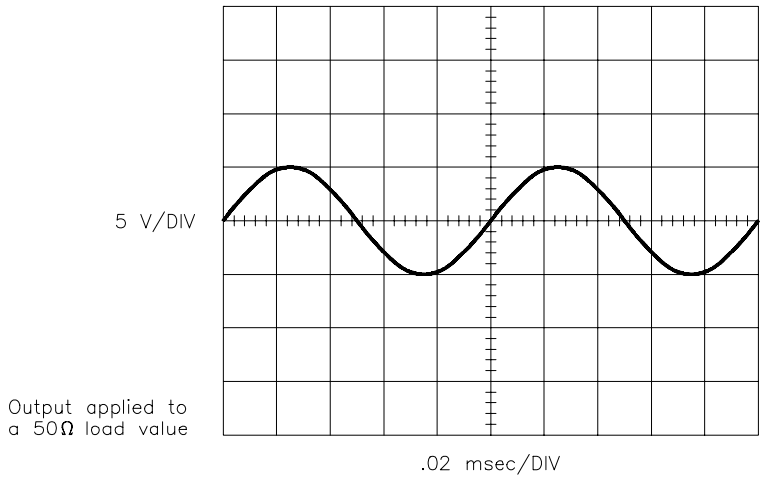
Generating a Sine Wave

To output a sine wave, only an amplitude needs to be specified and the AFG placed in the wait-for-trigger state (INIT). Using the minimum amount of AFG commands, this programs generates a 10 kHz, 10 Vp-p sine wave.



HP IBASIC (RSTSINE)

```
1     !RE-SAVE"RSTSINE"
2     !This program outputs a sine wave based on a specified amplitude
3     !and the reset settings of the AFG.
4     !
10    !Assign an I/O path between IBASIC and the AFG.
20    ASSIGN @Afg TO 80910
30    COM @Afg
40    !
50    !Reset the AFG
60    CALL Rst
70    OUTPUT @AFG;"SOUR:VOLT:LEV:IMM:AMPL 5"   !set amplitude
80    OUTPUT @Afg;"INIT:IMM"  !output sine wave using reset conditions
90    END
100   !
110   SUB Rst
120 Rst:  !subprogram which resets the AFG.
130       COM @Afg
140       OUTPUT @Afg;"*RST;*OPC?"          !reset the AFG
150       ENTER @Afg;Complete
160   SUBEND
```

C and QuickBASIC Programs

The C and QuickBASIC versions of RSTSINE are on the C language example programs disk (HP P/N E1340-10036).

HP E1340A Example Programs

For easy reference, names and descriptions of the example programs in this manual are summarized in Appendix B, Table B-1.

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Chapter 2
Generating Standard Waveforms with the HP E1340A

Chapter Contents

This chapter shows how to generate standard waveforms (SINusoid, SQUare, TRIangle, and RAMPS) using the HP E1340A 12-Bit Arbitrary Function Generator (hereafter called the "AFG").

The following sections show how to generate standard waveforms, how to setup the AFG for different output loads, how to select the output amplitude units (i.e., V, Vpeak, etc.), and how to set the waveform amplitude and offset. The sections are as follows:

Standard Waveforms Flowchart

The flowchart on page 42 shows the sequence used to generate standard waveforms. The reset (power-on) values of each command are also noted on the f owchart. The programs in this chapter begin with a reset (the IEEE 488.2 *RST command) which places the AFG into its power-on state. Thus, the programs do not execute all of the commands on the flowchart.

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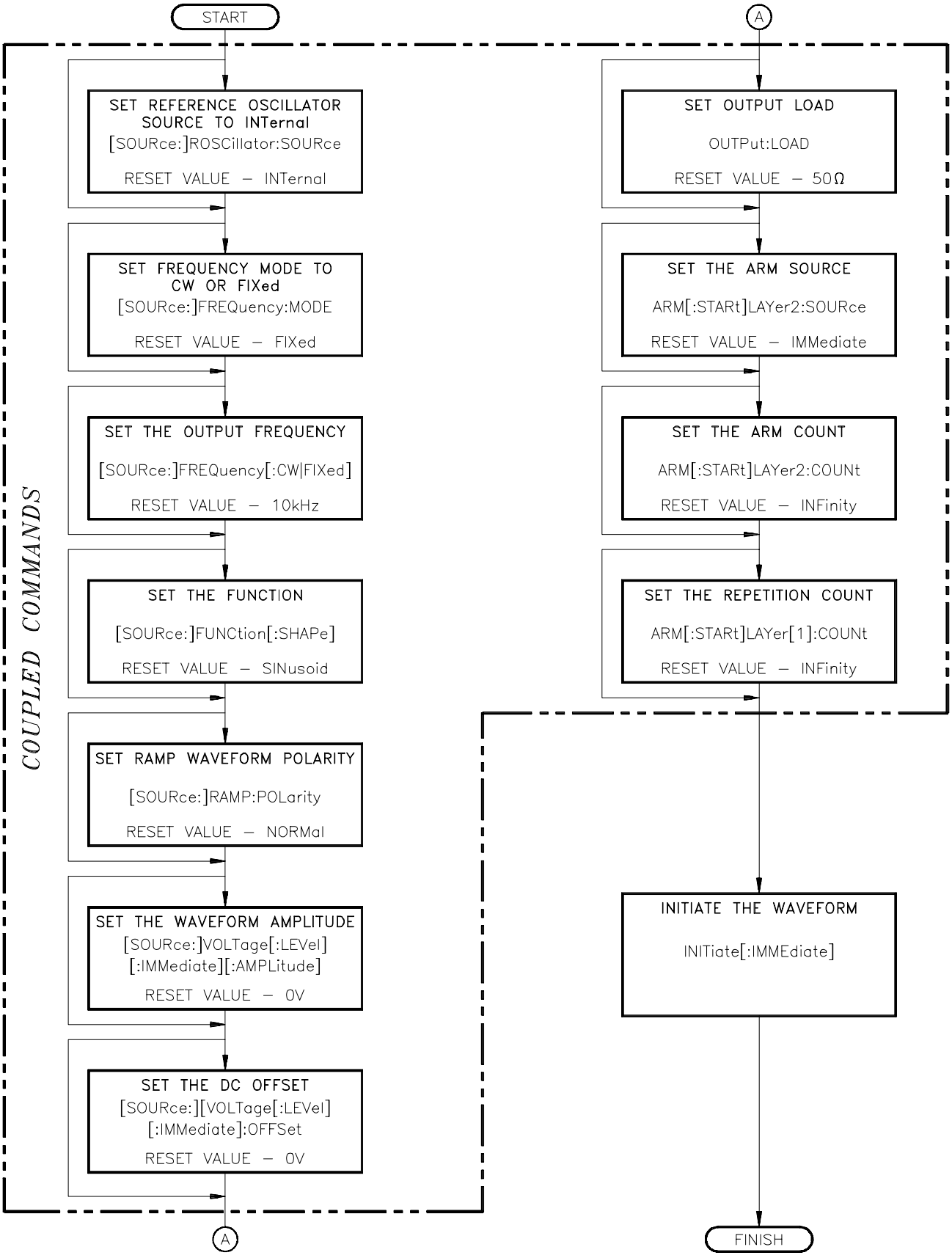

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Generating DC Voltages

This program outputs a +5 V DC voltage. The commands are:

1. Reset the AFG - *RST

   The *RST command aborts any waveform output and selects the sinusoid function.

2. Select the Function -
   [SOURce:]FUNCtion[:SHAPe] DC

   This command selects the DC function.

3. Set the Amplitude -
   [SOURce:]VOLTage[:LEVel][:IMMediate][:AMPLitude] <*amplitude*>

   This command specifies the amplitude. Refer to the section called "Selecting the Amplitude Levels and Output Units" on page 50 for more information.

HP IBASIC Program Example (DCVOLTS)

```
1       !RE-SAVE"DCVOLTS"
2       !This program outputs 5V dc.
3       !
10      !Assign I/O path between IBASIC and the E1340A.
20      ASSIGN @Afg TO 80910
30      COM @Afg
40      !
50      !Set up error checking
60      ON INTR 8 CALL Errmsg
70      ENABLE INTR 8;2
80      OUTPUT @Afg;"*CLS"
90      OUTPUT @Afg;"*SRE 32"
100     OUTPUT @Afg;"*ESE 60"
110     !
120     !Call the subprogram which resets the AFG.
130     CALL Rst
140     !
150     !Set AFG parameters
160     OUTPUT @Afg;"SOUR:FUNC:SHAP DC" !function
170     OUTPUT @Afg;"SOUR:VOLT:LEV:IMM:AMPL 5V" !amplitude
180     !
190     WAIT .1                          !allow interrupt to be serviced
```

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```
200   OFF INTR 8
210   END
220   !
230   SUB Rst
  •
  •
300   SUB Errmsg
  •
  •
```

C and QuickBASIC Program Versions

The C example program, DCVOLTS.C, is in directory "CPROG" and the QuickBASIC example program, DCVOLTS.BAS, is in directory "QBPROG" on the C and QuickBASIC example disk (part number E1340-10036).

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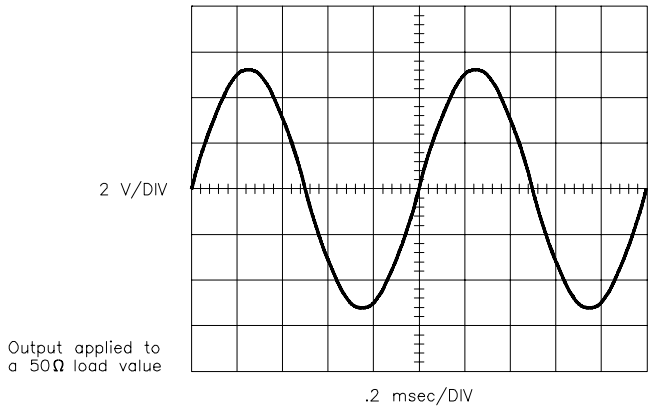
Generating Sine, Triangle, and Square Waves



This program outputs a Sine Wave at 1 kHz and 5 V output level. The commands are:

1. Reset the AFG - *RST

   The *RST command aborts any waveform output and selects the sinusoid function.

2. Set the Waveform Frequency -
   [SOURce:]FREQuency[:FIXed] <*frequency*>

   This command specifies the waveform frequency. Refer to Appendix B for the frequency limits.

3. Select the Function -
   [SOURce:]FUNCtion[:SHAPe] SINusoid

   This command selects the SINusoid function. (Although *RST automatically selects this function, it is selected here for good programming practice.) For the Triangle and Square Wave functions, use the TRIangle and SQUare parameters, respectively, instead of SINusoid.

4. Set the Amplitude -
   [SOURce:]VOLTage[:LEVel][:IMMediate][:AMPLitude] <*amplitude*>

   This command specifies the amplitude. Refer to the section called "Selecting the Amplitude Levels and Output Units" on page 50 for more information.

5. Initiate the Waveform -
   INITiate[:IMMediate]

   This command generates an immediate output with the arm source set to IMMediate. Refer to Chapter 5 for triggering information.

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HP IBASIC Program Example (SINEWAVE)

```
1     !RE-SAVE“SINEWAVE”
2     !This program generates a 5V, 1 kHz sine wave.
3     !
10    !Assign I/O path between IBASIC and the E1340A.
20    ASSIGN @Afg TO 80910
30    COM @Afg
40    !
50    !Set up error checking
60    ON INTR 8 CALL Errmsg
70    ENABLE INTR 8;2
80    OUTPUT @Afg;“*CLS”
90    OUTPUT @Afg;“*SRE 32”
100   OUTPUT @Afg;“*ESE 60”
110   !
120   !Call the subprogram which resets the AFG.
130   CALL Rst
140   !
150   !Set AFG parameters
160   OUTPUT @Afg;“SOUR:FREQ:FIX 1E3;”;!frequency
170   OUTPUT @Afg;“:SOUR:FUNC:SHAP SIN;”;!function
180   OUTPUT @Afg;“:SOUR:VOLT:LEV:IMM:AMPL 5V”!amplitude
190   OUTPUT @Afg;“INIT:IMM”          !wait-for-arm state
200   !
210   WAIT .1                         !allow interrupt to be serviced
220   OFF INTR 8
230   END
240   !
250   SUB Rst
  •
  •
320   SUB Errmsg
  •
  •
```

C and QuickBASIC Program Versions

The C example program, SINEWAVE.C, is in directory “CPROG” and the QuickBASIC example program, SINEWAVE.BAS, is in directory “QBPROG” on the C and QuickBASIC example disk (part number E1340-10036).

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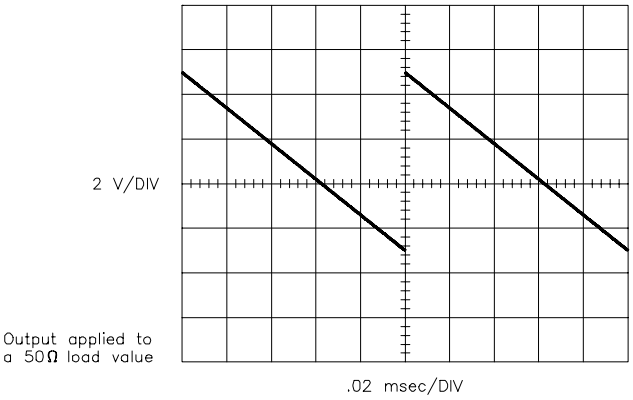
Generating Ramp Waves



This program outputs a negative going Ramp at 10 kHz, 4 V output level, and +1 V offset. The commands are:

1. Reset the AFG - *RST

   The *RST command aborts any waveform output, selects the sinusoid function, selects the 42.9 MHz reference oscillator source, 10 kHz frequency, arm start immediate, 0 V offset, and 0 V output.

2. Set the Frequency -
   [SOURce:]FREQuency[:FIXed] <*frequency*>

   This command specifies the frequency. Refer to Appendix B for the frequency limits.

3. Select the Function -
   [SOURce:]FUNCtion[:SHAPe] RAMP

   This command selects the RAMP function.

4. Select the Ramp Polarity -
   [SOURce:]RAMP:POLarity INVerted

   This command selects the polarity of the RAMP wave. Use NORMal for the initial voltage to go positive; use INVerted for the initial voltage to go negative.

5. Set the Amplitude -
   [SOURce:]VOLTage[:LEVel][:IMMediate][:AMPLitude] <*amplitude*>

   This command specifies the amplitude. Refer to the section called "Selecting the Amplitude Levels and Output Units" on page 50 for more information.

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6. Set the Offset -
   [SOURce:]VOLTage[:LEVel][:IMMediate]:OFFSet <*offset*>

   This command specifies the offset. Refer to the section called "Selecting the Amplitude Levels and Output Units" on page 50 for more information.

7. Initiate the Waveform -
   INITiate[:IMMediate]

   This command generates an immediate output with the arm source set to IMMediate. Refer to Chapter 5 for triggering information.

HP IBASIC Program Example (RAMPWAVE)

```
1     !RE-SAVE"RAMPWAVE"
2     !This program generates a 4V, 10 kHz negative-going ramp wave.
3     !
10    !Assign I/O path between IBASIC and the E1340A.
20    ASSIGN @Afg TO 80910
30    COM @Afg
40    !
50    !Set up error checking
60    ON INTR 8 CALL Errmsg
70    ENABLE INTR 8;2
80    OUTPUT @Afg;"*CLS"
90    OUTPUT @Afg;"*SRE 32"
100   OUTPUT @Afg;"*ESE 60"
110   !
120   !Call the subprogram which resets the AFG.
130   CALL Rst
140   !
150   !Set AFG parameters
160   OUTPUT @Afg;"SOUR:ROSC:SOUR INT;";!reference oscillator
170   OUTPUT @Afg;":SOUR:FREQ:FIX 10E3;";!frequency
180   OUTPUT @Afg;":SOUR:FUNC:SHAP RAMP;";!function
190   OUTPUT @Afg;":SOUR:RAMP:POL INV;";!ramp polarity
200   OUTPUT @Afg;":SOUR:VOLT:LEV:IMM:AMPL 4V;";!amplitude
210   OUTPUT @Afg;":SOUR:VOLT:LEV:IMM:OFFS 1V"!offset
220   OUTPUT @Afg;"INIT:IMM"          !wait-for-arm state
230   !
240   WAIT .1                         !allow interrupt to be serviced
250   OFF INTR 8
260   END
270   !
280   SUB Rst
```

Continued on next page

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```
•
•
350   SUB Errmsg
•
•
```

C and QuickBASIC Program Versions

The C example program, RAMPWAVE.C, is in directory "CPROG" and the QuickBASIC example program, RAMPWAVE.BAS, is in directory "QBPROG" on the C and QuickBASIC example disk (part number E1340-10036).

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Selecting the Amplitude Levels and Output Units

This program shows how to set the output amplitude using the VPP (volts peak-to-peak) output unit. The commands are:

1. Reset the AFG - *RST

   The *RST command aborts any waveform output, selects the sinusoid function, selects the 42.9 MHz reference oscillator source, arm start immediate, 0 V offset, and 0 V output.

2. Select the Output Units -
   [SOURce:]VOLTage[:LEVel][:IMMediate][:AMPLitude]:UNIT:VOLTage <*units*>

   This command selects the following output units:
   V - Volts
   VPK - Volts peak
   VPP - Volts peak-to-peak
   VRMS - Volts rms
   W - Watts
   DBM|DBMW - dB referenced to 1 milliwatt

   These units are assumed only if no other units are specified in the [SOURce:]VOLTage[:LEVel][:IMMediate][:AMPLitude] <*amplitude*> command. The output units are only valid for amplitude and not offsets (volts is required for offsets).

3. Set the Amplitude and the Offset -
   [SOURce:]VOLTage[:LEVel][:IMMediate][:AMPLitude] <*amplitude*>

   [SOURce:]VOLTage[:LEVel][:IMMediate]:OFFSet <*offset*>

   These commands specify the amplitude and offset. Refer to Appendix B for the amplitude limits. The maximum value of the combined amplitude and offset voltages must remain within the 7 V limit.

4. Initiate the Waveform -
   INITiate[:IMMediate]

   This command generates an immediate output with the arm source set to IMMediate. Refer to Chapter 5 for triggering information.

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HP IBASIC Program Example (OUTPUNIT)

```
1     !RE-SAVE“OUTPUNIT”
2     !This program sets the AFG’s output units to volts peak-to-peak.
3     !
10    !Assign I/O path between IBASIC and the E1340A.
20    ASSIGN @Afg TO 80910
30    COM @Afg
40    !
50    !Set up error checking
60    ON INTR 8 CALL Errmsg
70    ENABLE INTR 8;2
80    OUTPUT @Afg;“*CLS”
90    OUTPUT @Afg;“*SRE 32”
100   OUTPUT @Afg;“*ESE 60”
110   !
120   !Call the subprogram which resets the AFG.
130   CALL Rst
140   !
150   !Set AFG parameters
160   OUTPUT @Afg;“SOUR:VOLT:LEV:IMM:AMPL:UNIT:VOLT VPP”
                                        !output units
      •
      •
200   OUTPUT @Afg;“SOUR:VOLT:LEV:IMM:AMPL 8;”;!amplitude
210   OUTPUT @Afg;“:SOUR:VOLT:LEV:IMM:OFFS 1”!offset
220   OUTPUT @Afg;“INIT:IMM”  !wait-for-arm state
230   !
240   WAIT .1                           !allow interrupt to be serviced
250   OFF INTR 8
260   END
270   !
280   SUB Rst
      •
      •
350   SUB Errmsg
      •
      •
```

C and QuickBASIC Program Versions

The C example program, OUTPUNIT.C, is in directory “CPROG” and the QuickBASIC example program, OUTPUNIT.BAS, is in directory “QBPROG” on the C and QuickBASIC example disk (part number E1340-10036).

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Program Comments

The following comments give additional details on the program examples in this chapter.

Reference Oscillator Sources

- The SINusoid, SQUare, TRIangle, and RAMP functions can use any of the Reference Oscillator Sources. The sources, selected by [SOURce:]ROSCillator:SOURce, are:

  INTernal - 42.94967296 MHz (power-on value)
  EXTernal - User provided value (the front panel "Aux In" BNC)

- If using the EXTernal reference oscillator source, enter the source frequency to the AFG using [SOURce:]ROSCillator:FREQuency:EXTernal <*frequency*>.

Output Load Comments

- For correct output amplitude values, the load applied to the AFG "Signal Output" terminals must be the same value as the selected AFG output impedance value.

- To output to an open circuit, execute OUTPut:LOAD INFinity or 9.9E+37. The HP E1340A then outputs the correct amplitude and offset for an open circuit. The amplitude and offset range are doubled while resolution worsens by a factor of 2.

Output Units Comments

- The selected unit type can be overridden by sending a unit suffix with the amplitude command. For example, if the selected unit is VPP, sending:

  ```
  [SOURce:]VOLTage[:LEVel][:IMMediate][:AMPLitude] 5V
  ```

  changes the unit type to volts (i.e., V) for that command. However, the default unit type remains in effect for subsequent amplitude commands that are sent without the unit suffix.

- The V (volts) suffix and VPK (volts peak) suffix generate the same amplitude values for all time varying waveforms like SINusoid, SQUare, TRIangle, and RAMPS.

- The default unit type only applies for amplitudes and not for offsets. The unit for offsets must always be specified in "V" for volts. For example, executing:

  ```
  [SOURce:]VOLTage:OFFSet .1VPP
  ```

  causes an error. To prevent the error, execute either:

  ```
  [SOURce:]VOLTage:OFFSet 0.1
  ```

  or

  ```
  [SOURce]:VOLTage:OFFSet 0.1V
  ```


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- The W, DBM, and DBMW unit types references the amplitude levels to the 50 Ω output load value. Thus, the W, DBM, and DBMW values are meaningless and not available when selecting an open circuit load.

Using MINimum and MAXimum Parameters

You can execute many commands (like [SOURce:]FREQuency[:CW|:FIXed]) using the MINimum or MAXimum parameters instead of a number value. However, MIN and MAX are internally converted immediately to numeric values when received using the values of other commands in effect at that time. The values of other commands affecting the MIN and MAX computation are subsequently changed, but the already computed MIN and MAX values do **not** change.

Thus, if a group of coupled commands are sent where the MINimum and MAXimum parameters conflict with the current AFG setting, the AFG generates an error. This happens even though the commands that follow may set the AFG to a state that does not conflict with the MINimum and MAXimum parameters.

For best results, use values in the commands and do not use the MINimum and MAXimum parameters.

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Chapter 3
Generating Arbitrary Waveforms with the HP E1340A

Chapter Contents

This chapter shows how to generate arbitrary waveforms using the HP E1340A 12-Bit Arbitrary Function Generator (called the "AFG").

The following sections show how to generate arbitrary waveforms. Also included are example programs that generate various arbitrary waveforms. The sections are as follows:

Arbitrary Waveforms Flowchart

The flowchart on page 58 shows the commands and the command execution order to generate standard waveforms. The reset (power-on) values of each command are also noted on the flowchart. Note that the IEEE 488.2 *RST command places the AFG into its power-on state. Thus, it may be unnecessary to execute all of the commands on the flowchart.

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How the AFG Generates Arbitrary Waveforms

Refer to Figure 3-1. An arbitrary waveform consists of two parts, a waveform segment (or all points on a waveform) and a segment sequence. The segments contain the actual voltage points of the waveform. The segment sequence determines which waveform segments are to be output.

The AFG has four waveform segments available: A, B, C, and D. The size of each waveform segment is 4096 points. Thus, to store data into a waveform segment, the number of data items (or waveform points) must be 4096.

To output a waveform, set the user function to output one or more of the waveform segments. To output a waveform with a single waveform segment, use one of the A through D waveform segments. To output waveforms with multiple waveform segments, use a combination of AB or ABCD waveform segments. The AB combination outputs the 8192 point waveform defined by the A and B waveform segments. Thus, the A segment is output first and then the B segment. The ABCD combination outputs the 16384 point waveform defined by the A , B, C, and D waveform segments. Thus, the A segment is output first and the D segment is output last.

Similarly, the AB combination outputs a waveform with 8192 points and the ABCD combination outputs a waveform with 16384 points.

The segment values can be either sent as voltage values
(use [SOURce:]LIST[:SEGMent]:VOLT <*voltage_list*>) or DAC
(digital-to-analog converter) codes
(use [SOURce:]LIST[:SEGMent]:VOLT:DAC <*voltage_list*>).
If sent as voltage values, the AFG converts them to DAC codes before storing them in memory.

To output a waveform, the AFG sets the DAC to the voltage value of the selected waveform segment. The waveform frequency determines the waveform repetition rate.

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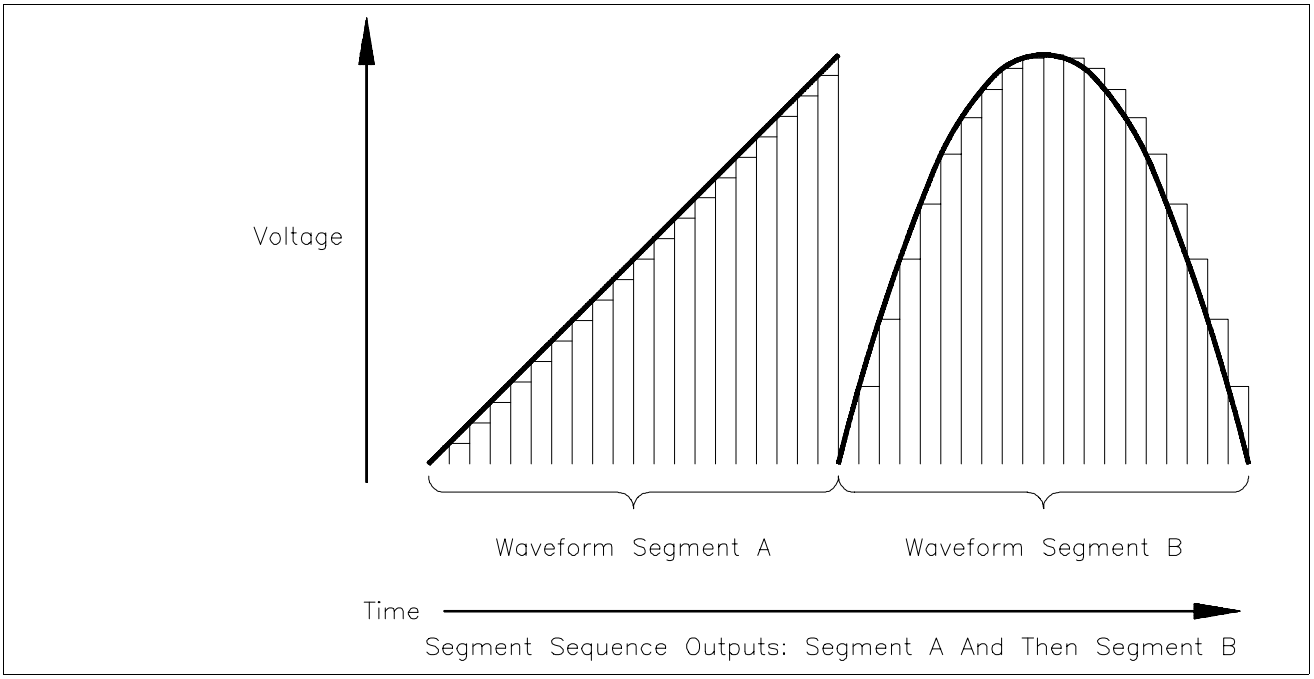

Figure 3-1. Generating Arbitrary Waveforms

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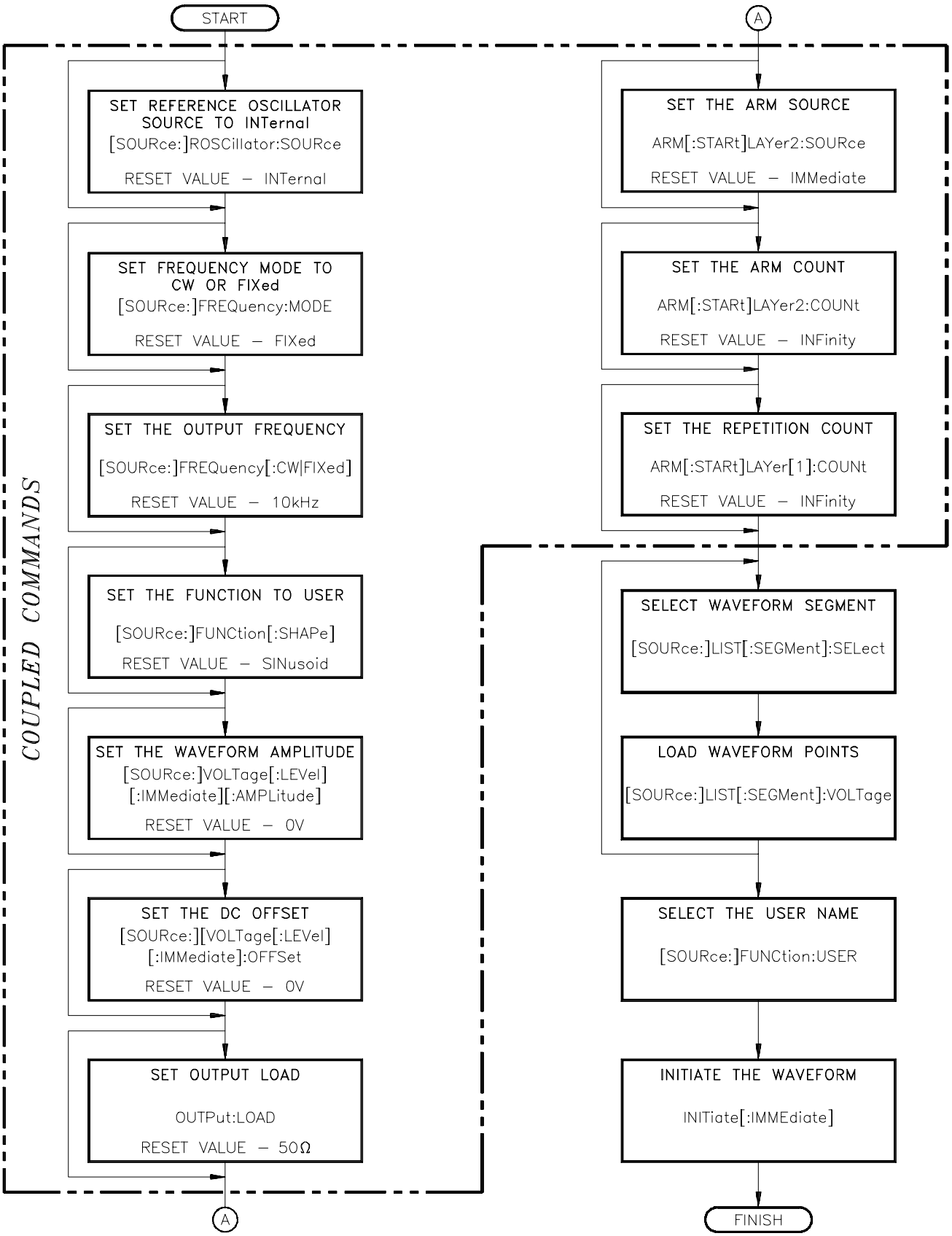

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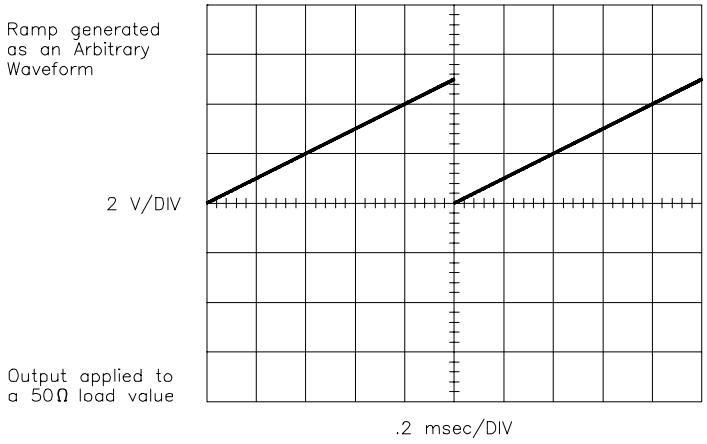
Generating a Simple Arbitrary Waveform



This program shows how to generate an arbitrary waveform with a single waveform segment. The example generates a 4096 point ramp. The AFG stores the waveform segment into segment memory as voltage data points. The commands are:

1. Reset the AFG - *RST

   The *RST command aborts any waveform output and sets the AFG to a defined state.

2. Select the Reference Oscillator -
   [SOURce:]ROSCillator:SOURce <*source*>

   This command selects the Reference Oscillator Source (see "Program Comments" later in this chapter).

3. Set the Waveform Frequency -
   [SOURce:]FREQuency[:CW|FIXed] <*frequency*>

   This command sets the repetition rate of the waveform. See Appendix B for the frequency limits.

4. Select the Arbitrary Waveform Function -
   [SOURce:]FUNCtion[:SHAPe] USER

   This command selects the arbitrary waveform function.

5. Set the Maximum Output Amplitude -
   [SOURce:]VOLTage[:LEVel][:IMMediate][:AMPLitude] <*amplitude*>

   This command specifies the maximum output amplitude. The amplitude must be equal or greater than the maximum voltage value of the waveform segment. Refer to Appendix B for the amplitude limits.

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6. Select the Waveform Segment -
   [SOURce:]LIST[:SEGMent]:SELect <*name*>

   Use either A, B, C, or D in <*name*> for the waveform segment.

7. Store the Waveform Segment as Voltages -
   [SOURce:]LIST[:SEGMent]:VOLTage <*voltage_list*>

   This command stores the points of the waveform segment into the AFG's segment memory. These points are sent to the AFG as volts which are the output voltage points that constitutes the waveform segment.

8. Select the User Name -
   [SOURce:]FUNCtion:USER <*name*>

   This command selects the waveform segment to be output. Make the *name* in this command the same name as the waveform segment to be output.

9. Initiate the Waveform -
   INITiate[:IMMediate]

   This command generates an immediate output with the arm source set to IMMediate. Refer to Chapter 5 for triggering information.

10. Query the Waveform Segment (Optional) -
    [SOURce:]LIST[:SEGment]:SELect?

    This command returns the currently selected waveform segment.

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HP IBASIC Program Example (ARB_GEN)

```
1     !RE-SAVE“ARB_GEN”
2     !This program generates a 4096 point, 0 to 5V ramp waveform.
3     !The data is transferred to the AFG as voltages.
4     !
10    !Assign I/O path between IBASIC and the E1340A.
20    ASSIGN @Afg TO 80910
30    COM @Afg,Waveform(1:4096)
40    !
50    !Set up error checking
60    ON INTR 8 CALL Errmsg
70    ENABLE INTR 8;2
80    OUTPUT @Afg;“*CLS”
90    OUTPUT @Afg;“*SRE 32”
100   OUTPUT @Afg;“*ESE 60”
110   !
120   !Call the subprogram which resets the AFG.
130   CALL Rst
140   !Set AFG parameters
150   OUTPUT @Afg;“SOUR:ROSC:SOUR INT;”;!reference oscillator
160   OUTPUT @Afg;“:SOUR:FREQ:FIX 1E3;”;!frequency
170   OUTPUT @Afg;“:SOUR:FUNC:SHAP USER;”;!function
180   OUTPUT @Afg;“:SOUR:VOLT:LEV:IMM:AMPL 5.1V”!scale
                                                amplitude
190   !
200   !Call subprogram which defines waveform segment.
210   CALL Ramp_wave
220   !
230   !Select output sequence and initiate waveform
240   OUTPUT @Afg;“SOUR:FUNC:USER A”
250   OUTPUT @Afg;“INIT:IMM”          !wait-for-arm state
260   !
270   WAIT .1                         !allow interrupt to be serviced
280   OFF INTR 8
290   END
300   !
310   SUB Ramp_wave
320 Ramp_wave: !Subprogram which defines a ramp waveform
330       COM @Afg,Waveform(*)
340       FOR I=1 TO 4096
350           Waveform(I)=I*.00122
360       NEXT I
370   !
380       OUTPUT @Afg;“SOUR:LIST:SEGM:SEL A”!Select segment name
```

Continued on next page

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```
390        OUTPUT @Afg;"  SOUR:LIST:SEGM:VOLT";Waveform(*)!load
                                                    waveform points
400    SUBEND
410    !
420    SUB Rst
  •
  •
490    SUB Errmsg
  •
  •
```

C and QuickBASIC Program Versions

The C example program, ARB_GEN.C, is in directory "CPROG" and the QuickBASIC example program, ARB_GEN.BAS, is in directory "QBPROG" on the C and QuickBASIC example disk (part number E1340-10036).

Transferring Data in C

To transfer data to the AFG requires that the data sent with the [SOURce:]LIST[:SEGMent]:VOLTage command must be contiguous. To do this, send no carriage return (CR) and line feed (LF) before transferring all the data. The send_data function does this as follows (refer to the C function below):

1. Disable EOI and EOL using IOEOI (ISC, 0) and IOEOL (ISC, " ", 0), respectively. ISC contains the HP-IB select code, and the 0 and " " (NULL) values disables the carriage return (CR) and line feed (LF) to allow the AFG to receive a command string without a terminator.

2. Next, sent to the AFG the SCPI [SOURce:]LIST[:SEGment]:VOLTage command string using IOOUTPUTS (ADDR, commands, strlen(commands)). ADDR contains the AFG HP-IB address, commands contains the SCPI command string, and strlen(commands) contains the string length of commands. This enables the AFG to receive voltage data. Since CR or LF is disabled, the AFG holds execution until all the data is sent.

3. Enable EOI and EOL using IOEOI (ISC, 1) and IOEOL (ISC, state, 2), respectively. The variable state contains the decimal codes for CR and LF. Although EOL and EOI are enabled, no CR and LF is sent until all voltage data transfer is completed (next step).

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4. The voltage data values are sent next using the array Wave_seg in IOOUTPUTA (ADDR, Wave_seg, num_size). The values in Wave_seg are in a floating point format. IOOUTPUTS automatically separates each value in the arrays by a comma (,).

5. After all the data is sent, the data transfer terminates with a CR and LF. This lets the AFG know that it can receive a new command.

```
void   send_data(char *commands, float *Wave_seg, int   num_size)
{
   char static state[2] = {13, 10};

        /* First disable EOI and EOL; then send the last command */
   IOEOI (ISC, 0);IOEOL (ISC, " ", 0);
   IOOUTPUTS (ADDR, commands, strlen(commands));

        /* Re-enable EOL and EOI for normal HP-IB operation; then
             send the last data */
   IOEOI (ISC, 1);IOEOL (ISC, state, 2);
   IOOUTPUTA (ADDR, Wave_seg, num_size);
}
```

Transferring Data in QuickBASIC

To transfer data to the AFG requires that the data sent with the [SOURce:]LIST[:SEGMent]:VOLTage command must be contiguous. To do this, send no carriage return (CR) and line feed (LF) before transferring all the data. The SendData routine in the QuickBASIC program do this as follows (refer to the QuickBASIC routine below):

1. Disable EOI and EOL using IOEOI (ISC&, 0) and IOEOL (ISC&, " ", 0), respectively. ISC& contains the HP-IB select code, the 0 and " " (NULL) values disables the carriage return (CR) and line feed (LF) to allow the AFG to receive a command string without a terminator.

2. Next, sent to the AFG the SCPI [SOURce:]LIST[:SEGment]:VOLTage command string using IOOUTPUTS(ADDR&, Commands$, LEN(Commands$). ADDR& contains the AFG HP-IB address, Commands$ contains the SCPI command string, and LEN(Commands$) contains the string length of Commands$. This enables the AFG to receive voltage data. Since CR or LF is disabled, the AFG holds execution until all the data is sent.

3. Enable EOI and EOL using IOEOI(ISC&, 1) and IOEOL(ISC&, Endline$, LEN(Endline$)), respectively. The variable Endline$ contains the decimal codes for CR and LF. Although EOL and EOI are enabled, no CR and LF is sent until all voltage data transfer is completed (next step).

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4. The voltage data values are sent next using the array WaveSeg!() in IOOUTPUTA(ADDR&, SEG WaveSeg!(1), NumSize%). The values in WaveSeg! are in a floating point format. IOOUTPUTS automatically separates each value in the arrays by a comma (,).

5. After all the data is sent, the data transfer terminates with a CR and LF. This lets the AFG know that it can receive a new command.

```
SUB SendData (Commands$, WaveSeg!(), NumSize%)

Endline$ = CHR$(13) + CHR$(10)

   ' First disable EOI and EOL; then send the last command
CALL IOEOI(ISC&, 0)
CALL IOEOL(ISC&, " ", 0)
CALL IOOUTPUTS(ADDR&, Commands$, LEN(Commands$))

   ' Re-enable EOL and EOI for normal HP-IB operation; then send the data
CALL IOEOI(ISC&, 1)
CALL IOEOL(ISC&, Endline$, LEN(Endline$))
CALL IOOUTPUTA(ADDR&, SEG WaveSeg!(1), NumSize%)

END SUB
```


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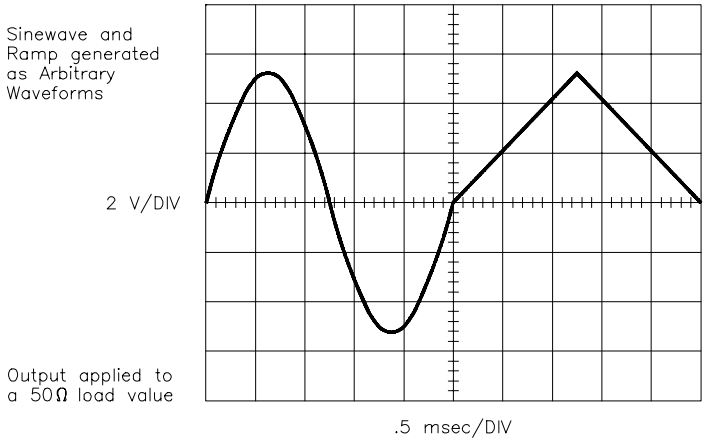
Executing Several Waveform Segments



This program shows how to generate an arbitrary waveform that combines two different waveform segments. One waveform segment generates a 1 kHz, 5 V sine wave. The other one generates a 1 kHz, 5 Vpeak triangle.
The commands are:

1. Reset the AFG - *RST

   The *RST command aborts waveform output and sets the AFG to a defined state.

2. Set the Waveform Frequency -
   [SOURce:]FREQuency[:CW|FIXed] <*frequency*>

   This command sets the repetition rate of the waveform. See Appendix B for the frequency limits.

3. Select the Arbitrary Waveform Function -
   [SOURce:]FUNCtion[:SHAPe] USER

   This command selects the arbitrary waveform function. Couple the command to the previous frequency command.

4. Set the Maximum Output Amplitude -
   [SOURce:]VOLTage[:LEVel][:IMMediate][:AMPLitude] <*amplitude*>

   This command specifies the maximum output amplitude. The amplitude must be equal or greater than the maximum voltage value of the waveform segment. Refer to Appendix B for the amplitude limits

5. Select the First Waveform Segment -
   [SOURce:]LIST[:SEGMent]:SELect A
   Use A to select the first waveform segment.

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6. Store the First Waveform Segment as Voltages -
   [SOURce:]LIST[:SEGMent]:VOLTage <*voltage_list*>

   This command stores the points of the "A" waveform segment into the AFG's segment memory. These points are sent to the AFG as volts which are the output voltage points that constitutes the waveform segment.

7. Select the Second Waveform Segment -
   [SOURce:]LIST[:SEGMent]:SELect B

   Use B to select the second waveform segment.

8. Store the Second Waveform Segment as Voltages -
   [SOURce:]LIST[:SEGMent]:VOLTage <*voltage_list*>

   This command stores the points of the B waveform segment into the AFG's segment memory. These points are sent to the AFG as volts which are the output voltage points that constitutes the waveform segment.

9. Select the User Name -
   [SOURce:]FUNCtion:USER AB

   This command selects the waveform segments to be output (i.e., AB).

10. Initiate the Waveform - INITiate[:IMMediate]

    This command generates an immediate output with the arm source set to IMMediate. Refer to Chapter 5 for triggering information.

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HP IBASIC Program Example (MULSEG)

```
1     !RE-SAVE“MULSEG”
2     !This program generates an arbitrary waveform comprised of two
3     !waveform segments. One segment is a sine wave and the other
4     !segment is a triangle wave.
5     !
10    !Assign I/O path between IBASIC and the E1340A.
20    ASSIGN @Afg TO 80910
30    COM @Afg,Waveform1(1:4096),Waveform2(1:4096)
40    !
50    !Set up error checking
60    ON INTR 8 CALL Errmsg
70    ENABLE INTR 8;2
80    OUTPUT @Afg;“*CLS”
90    OUTPUT @Afg;“*SRE 32”
100   OUTPUT @Afg;“*ESE 60”
110   !
120   !Call the subprogram which resets the AFG.
130   CALL Rst
140   !
150   !Set AFG parameters
160   OUTPUT @Afg;“SOUR:FREQ:FIX 10E3;”;!frequency
170   OUTPUT @Afg;“:SOUR:FUNC:SHAP USER;”; !function
180   OUTPUT @Afg;“:SOUR:VOLT:LEV:IMM:AMPL 5.1V” !scale
                                                  amplitude
190   !
200   !Call subprogram which defines waveform segments A and B.
210   CALL Sine_tri_wave
220   !
230   !Select output sequence and initiate waveform
240   OUTPUT @Afg;“SOUR:FUNC:USER AB”
250   OUTPUT @Afg;“INIT:IMM”          !wait-for-arm state
260   !
270   WAIT .1                         !allow interrupt to be serviced
280   OFF INTR 8
290   END
300   !
310   SUB Sine_tri_wave
320 Sine_tri_wave:  !Subprogram which defines waveforms
330       COM @Afg,Waveform1(*),Waveform2(*)
340       FOR I=1 TO 4096
350           Waveform1(I)=5*(SIN(2*PI*(I/4096)))
360       NEXT I
370       !
```

Continued on next page

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```
380         OUTPUT @Afg;“SOUR:LIST:SEGM:SEL A”
                                        !select segment name
390         OUTPUT @Afg;“  SOUR:LIST:SEGM:VOLT”;Waveform1(*)
                                        !load waveform points
400         !

420             Waveform2(I)=I*.0024414
430         NEXT I
440         FOR I=2048 TO 4096
450             Waveform2(I)=(4096-I)*.0024414
460         NEXT I
470         !
480         OUTPUT @Afg;“SOUR:LIST:SEGM:SEL B”  !select segment name
490         OUTPUT @Afg;“  SOUR:LIST:SEGM:VOLT”;Waveform2(*)
                                        !load waveform points
500     SUBEND
510     !
520     SUB Rst
    •
    •
590     SUB Errmsg
    •
    •
```

C and QuickBASIC Program Versions

The C example program, MULSEG.C, is in directory “CPROG” and the QuickBASIC example program, MULSEG.BAS, is in directory “QBPROG” on the C and QuickBASIC example disk (part number E1340-10036).

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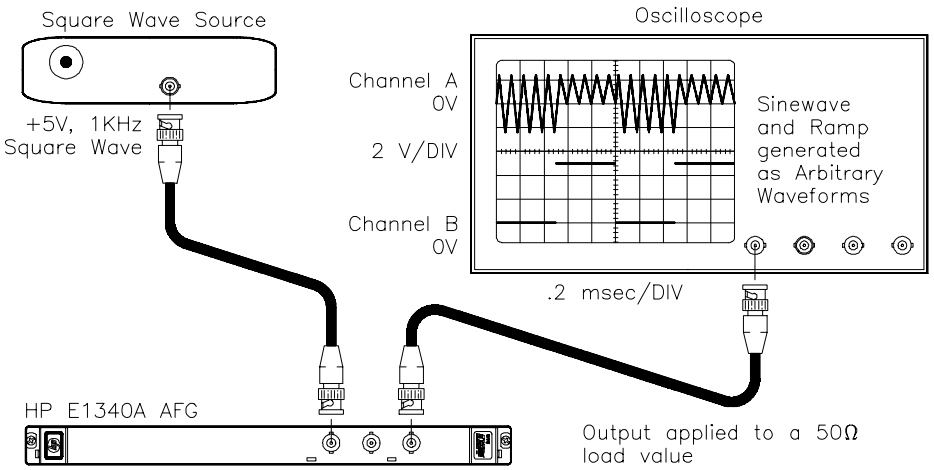
Arbitrary Waveform Hopping



This program performs waveform hopping of waveform segments A and B. Use a very stable 1 kHz, 0 to 5 V square wave applied to the AFG's "Aux In" connector to switch between the waveform segments. The positive level of the square wave outputs waveform segment A to generate a 5 cycle sine wave. The zero level of the square wave outputs waveform segment B to generate a 5 cycle triangle wave. (You may need to adjust the 1 kHz square wave to output a stable arbitrary waveform.) There will be about a 20 msec delay between a transition on the "Aux In" connector and the output switching.

1. Reset the AFG - *RST

   The *RST command aborts waveform output and sets the AFG to a defined state.

2. Setup the AFG for an Arbitrary Waveform Output -
   [SOURce:]FREQuency[:CW|FIXed] <*frequency*>
   [SOURce:]FUNCtion[:SHAPe] USER
   [SOURce:]VOLTage[:LEVel][:IMMediate][:AMPLitude] <*amplitude*>

   These commands setup the AFG to output arbitrary waveforms.

3. Select the First Waveform Segment -
   [SOURce:]LIST[:SEGMent]:SELect A

   Use A to select the first waveform segment.

4. Store the First Waveform Segment as Voltages -
   [SOURce:]LIST[:SEGMent]:VOLTage <*voltage_list*>

   This command stores the points of the "A" waveform segment into the AFG's segment memory. These points are sent to the AFG as volts which are the output voltage points that constitutes the waveform segment.

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5. Select the Second Waveform Segment -
   [SOURce:]LIST[:SEGMent]:SELect B

   Use B to select the second waveform segment.

6. Store the Second Waveform Segment as Voltages -
   [SOURce:]LIST[:SEGMent]:VOLTage <*voltage_list*>

   This command stores the points of the "B" waveform segment into the AFG's segment memory. These points are sent to the AFG as volts which are the output voltage points that constitutes the waveform segment.

7. Select the User Name -
   [SOURce:]FUNCtion:USER HOP_AB

   This command setup the AFG to hop between waveform segments A and B.

8. Initiate the Waveform - INITiate[:IMMediate]

   This command generates an immediate output with the arm source set to IMMediate. Refer to Chapter 5 for triggering information.

HP IBASIC Program Example (ARB_HOP)

```
1     !RE-SAVE"ARB_HOP"
2     !This program hops (selects) between two waveform segments based
3     !on the level of a 1 kHz, 0 to 5V square wave applied to the AFG's
4     !"Aux In" connector. A low level selects segment A (sine wave), a
5     !high level selects segment B (triangle wave).
6     !
10    !Assign I/O path between IBASIC and the E1340A.
20    ASSIGN @Afg TO 80910
30    COM @Afg,Waveform1(1:4096),Waveform2(1:4096)
40    !
50    !Set up error checking
60    ON INTR 8 CALL Errmsg
70    ENABLE INTR 8;2
80    OUTPUT @Afg;"*CLS"
90    OUTPUT @Afg;"*SRE 32"
100   OUTPUT @Afg;"*ESE 60"
110   !
120   !Call the subprogram which resets the AFG.
130   CALL Rst
140   !Set AFG parameters
150   OUTPUT @Afg;"SOUR:FREQ:FIX 10E3;";!frequency
160   OUTPUT @Afg;":SOUR:FUNC:SHAP USER;"; !function
```

Continued on next page

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```
170   OUTPUT @Afg;":SOUR:VOLT:LEV:IMM:AMPL 5.1V" !scale
                                          amplitude
180   !
190   !Call subprogram which defines waveform segments A and B.
200   CALL Sine_tri_wave
210   !
220   !Select output sequence and initiate waveform
230   OUTPUT @Afg;"SOUR:FUNC:USER HOP_AB"
240   OUTPUT @Afg;"INIT:IMM"          !wait-for-arm state
250   !
260   WAIT .1                         !allow interrupt to be serviced
270   OFF INTR 8
280   END
290   !
300   SUB Sine_tri_wave
310 Sine_tri_wave:                    !Subprogram which defines
                                      waveforms
320       COM @Afg,Waveform1(*),Waveform2(*)
350       FOR I=1 TO 4096
360           Waveform1(I)=5*(SIN(2*PI*(I/4096)))
370       NEXT I
380       !
390       OUTPUT @Afg;"SOUR:LIST:SEGM:SEL A"!Select segment name
400       OUTPUT @Afg;"  SOUR:LIST:SEGM:VOLT";Waveform1(*)
                                      !load waveform points
410       !
420       FOR I=1 TO 2047
430           Waveform2(I)=I*.0024414
440       NEXT I
450       FOR I=2048 TO 4096
460           Waveform2(I)=(4096-I)*.0024414
470       NEXT I
480       !
490       OUTPUT @Afg;"SOUR:LIST:SEGM:SEL B"!Select segment name
500       OUTPUT @Afg;"  SOUR:LIST:SEGM:VOLT";Waveform2(*)
                                      !load waveform points
510   SUBEND
520   !
530   SUB Rst
  •
  •
600   SUB Errmsg
  •
  •
```


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C and QuickBASIC Program Versions

The C example program, ARB_HOP.C, is in directory "CPROG" and the QuickBASIC example program, ARB_HOP.BAS, is in directory "QBPROG" on the C and QuickBASIC example disk (part number E1340-10036).

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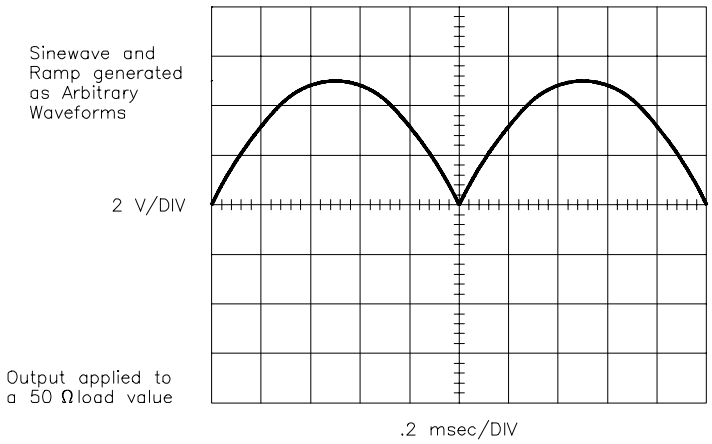
Generating Built-In Arbitrary Waveforms



The AFG has 16 built-in arbitrary waveforms available for use. All of these waveforms have 4096 points and are stored in an EPROM (see "Program Comments" for the waveform listing). To execute the waveforms, download the data points into waveform segment A, B, C, or D. The following program downloads and generates the 16th waveform.

1. Reset the AFG - *RST

   The *RST command aborts waveform output and sets the AFG to a defined state.

2. Setup the AFG for an Arbitrary Waveform Output -
   [SOURce:]FREQuency[:CW|FIXed] <*frequency*>
   [SOURce:]FUNCtion[:SHAPe] USER
   [SOURce:]VOLTage[:LEVel][:IMMediate][:AMPLitude] <*amplitude*>

   These commands setup the AFG to output an arbitrary waveform.

3. Download the Waveform Data from the EEProm into Memory -
   [SOURce:]ARBitrary:DOWNload <*source*>, <*dest*>, <*length*>

   This command downloads the segment data from the EPROM where <*source*> selects the waveform block in the EPROM, <*dest*> is the waveform segment name (i.e., A, B, C, or D), and <*length*> is the waveform segment length (i.e., 4096).

4. Select the User Name -
   [SOURce:]FUNCtion:USER <*name*>

   This command selects the waveform segment to be output. Make the *name* in this command the same name as the waveform segment to be output.

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5. Initiate the Waveform -
   INITiate[:IMMediate]

   This command generates an immediate output with the arm source set to IMMediate. Refer to Chapter 5 for triggering information.

HP IBASIC Program Example (ROM_DOWN)

```
1     !RE-SAVE“ROM_DOWN”
2     !This program downloads a 4096 point waveform to waveform segment
3     !memory from block 16 (EEPR16) of the AFG’s waveform EEPROM.
4     !
10    !Assign I/O path between IBASIC and the E1340A.
20    ASSIGN @Afg TO 80910
30    COM @Afg
40    !
50    !Set up error checking
60    ON INTR 8 CALL Errmsg
70    ENABLE INTR 8;2
80    OUTPUT @Afg;“*CLS”
90    OUTPUT @Afg;“*SRE 32”
100   OUTPUT @Afg;“*ESE 60”
110   !
120   !Call the subprogram which resets the AFG.
130   CALL Rst
140   !
150   !Set AFG parameters
160   OUTPUT @Afg;“SOUR:FREQ:FIX 1E3;”;!frequency
170   OUTPUT @Afg;“:SOUR:FUNC:SHAP USER;”;!function
180   OUTPUT @Afg;“:SOUR:VOLT:LEV:IMM:AMPL 5V”!amplitude
190   OUTPUT @Afg;“SOUR:ARB:DOWN EEPR16,A,4096”!download
                                                waveform
200   OUTPUT @Afg;“SOUR:FUNC:USER A”  !select sequence
210   OUTPUT @Afg;“INIT:IMM”          !wait-for-arm state
220   !
230   WAIT .1                         !allow interrupt to be serviced
240   OFF INTR 8
250   END
260   !
270   SUB Rst
      •
      •
340   SUB Errmsg
      •
      •
```


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C and QuickBASIC Program Versions

The C example program, ROM_DOWN.C, is in directory "CPROG" and the QuickBASIC example program, ROM_DOWN.BAS, is in directory "QBPROG" on the C and QuickBASIC example disk (part number E1340-10036).

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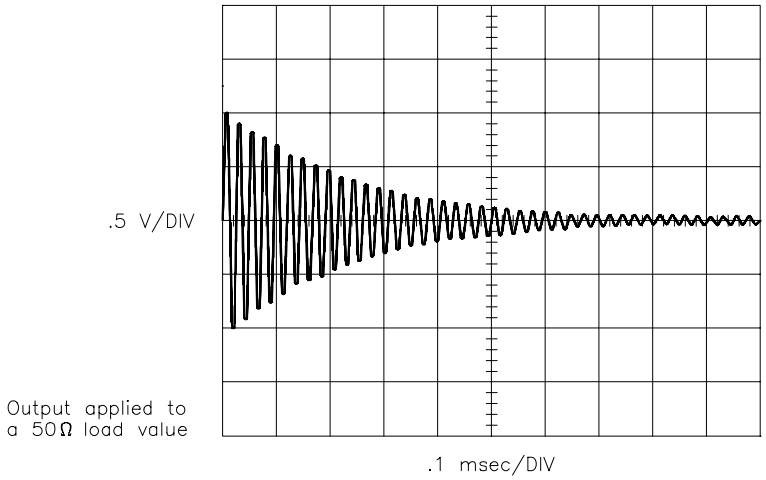
Sample Programs

The following programs generate various arbitrary waveforms. All programs output waveforms at a 1 kHz waveform frequency and 5 V amplitude.

Due to the similarity of all the programs, only the first program is completely presented here. Only the differences are shown by the other programs.

Generating a Damped Sine Wave

This program generates a Damped Sine Wave using 4096 segments or points.



HP IBASIC Program Example (SIN_D)

```
1     !RE-SAVE“SIN_D”
2     !This program generates a damped sine wave.
3     !
10    !Assign I/O path between IBASIC and the E1340A.
20    ASSIGN @Afg TO 80910
30    COM @Afg,Waveform(1:4096)
40    !
50    !Set up error checking
60    ON INTR 8 CALL Errmsg
70    ENABLE INTR 8;2
80    OUTPUT @Afg;“*CLS”
90    OUTPUT @Afg;“*SRE 32”
100   OUTPUT @Afg;“*ESE 60”
110   !
```

Continued on next page

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```
120   !Call the subprogram which resets the AFG.
130   CALL Rst
140   !
150   !Set AFG parameters
160   OUTPUT @Afg;"SOUR:FREQ:FIX 1E3;";!frequency
170   OUTPUT @Afg;":SOUR:FUNC:SHAP USER;";!function
180   OUTPUT @Afg;":SOUR:VOLT:LEV:IMM:AMPL 1.1V" !scale
                                                  amplitude
190   !
200   !Call subprogram which defines waveform segment.
210   CALL Damped_sine
220   !
230   !Select output sequence and initiate waveform
240   OUTPUT @Afg;"SOUR:FUNC:USER A"
250   OUTPUT @Afg;"INIT:IMM"          !wait-for-arm state
260   !
270   WAIT .1                         !allow interrupt to be serviced
280   OFF INTR 8
290   END
300   !
310   SUB Damped_sine
320 Damped_sine:  !Subprogram which defines a damped sine wave
330       COM @Afg,Waveform(*)
340       A=4/4096
350       W=(2*PI)/50
360       FOR T=1 TO 4096
370             Waveform(T)=EXP(-A*T)*SIN(W*T)
380       NEXT T
390       !
400       OUTPUT @Afg;"SOUR:LIST:SEGM:SEL A"!select segment name
410       OUTPUT @Afg;"SOUR:LIST:SEGM:VOLT";Waveform(*)!load
                                                  waveform points
420   SUBEND
430   !
440   SUB Rst
  •
  •
510   SUB Errmsg
  •
  •
```

C and QuickBASIC Program Versions

The C example program, SIN_D.C, is in directory "CPROG" and the QuickBASIC example program, SIN_D.BAS, is in directory "QBPROG" on the C and QuickBASIC example disk (part number E1340-10036).

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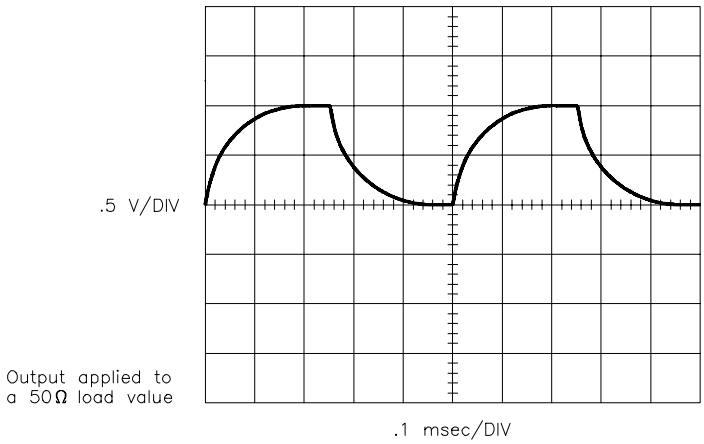
Generating an Exponential Charge/Discharge Waveform

This program generates an Exponential Charge/Discharge Waveform with 4096 segments or points.



HP IBASIC Program Example (CHARGE)

This program is similar to the "SIN_D" BASIC program on page 76, with the following differences:

```
1       !RE-SAVE"CHARGE"
2       !This program generates an exponential charge/discharge waveform.
   •
   •
210     CALL Charge
   •
   •
310     SUB Charge
320   Charge:!Subprogram which defines an exponential charge/discharge
330            !waveform.
340         COM @Afg,Waveform(*)
350         Rc=400
360         FOR T=1 TO 4096
370              IF T>=0 AND T<2047 THEN
380               Waveform(T)=1*(1-EXP(-T/Rc))
390              END IF
400              IF T>=2047 THEN
410              Waveform(T)=1*(1-EXP(-2048/Rc))-1*(1-EXP(-(T-2047)/Rc))
420              END IF
430         NEXT T
440         !
450         OUTPUT @Afg;"SOUR:LIST:SEGM:SEL A"!select segment name
460         OUTPUT @Afg;"  SOUR:LIST:SEGM:VOLT";Waveform(*)!load
                                                    waveform points
470     SUBEND
```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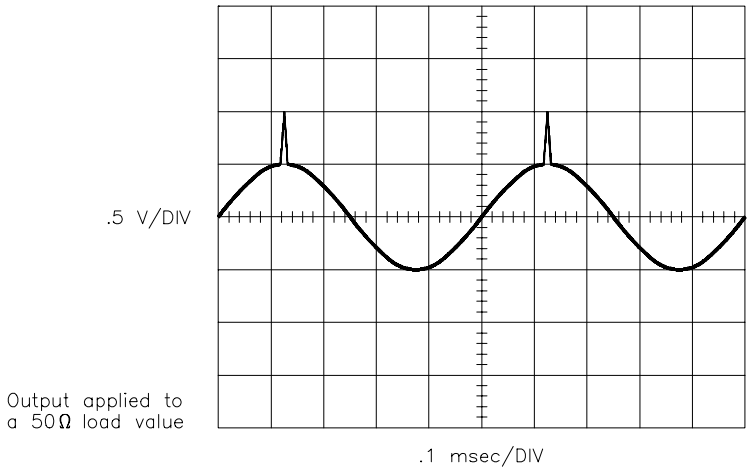
C and QuickBASIC Program Versions

The C example program, CHARGE.C, is in directory "CPROG" and the QuickBASIC example program, CHARGE.BAS, is in directory "QBPROG" on the C and QuickBASIC example disk (part number E1340-10036).

Generating a Sine Wave with Spikes

This program generates a Sine Wave with Spikes using 4096 segments or points.



HP IBASIC Program Example (SPIKES)

This program is similar to the "SIN_D" BASIC program on page 76, with the following differences:

```
1     !RE-SAVE"SPIKES"
2     !This program generates a sine wave with a spike.
  •
  •
150   !Set AFG parameters
160   OUTPUT @Afg;"SOUR:FREQ:FIX 1E3;";!frequency
170   OUTPUT @Afg;":SOUR:FUNC:SHAP USER;"; !function
180   OUTPUT @Afg;":SOUR:VOLT:LEV:IMM:AMPL 1.5V"   !scale amplitude
190   !
200   !Call subprogram which defines waveform segment.
210   CALL Sine_spike
  •
  •
310   SUB Sine_spike
320 Sine_spike:  !Subprogram which defines a sine wave with a spike
330       COM @Afg,Waveform(*)
340       FOR I=1 TO 4096
350           Waveform(I)=.5*SIN(2*PI*(I/4096))
360       NEXT I
370       Width=50
```

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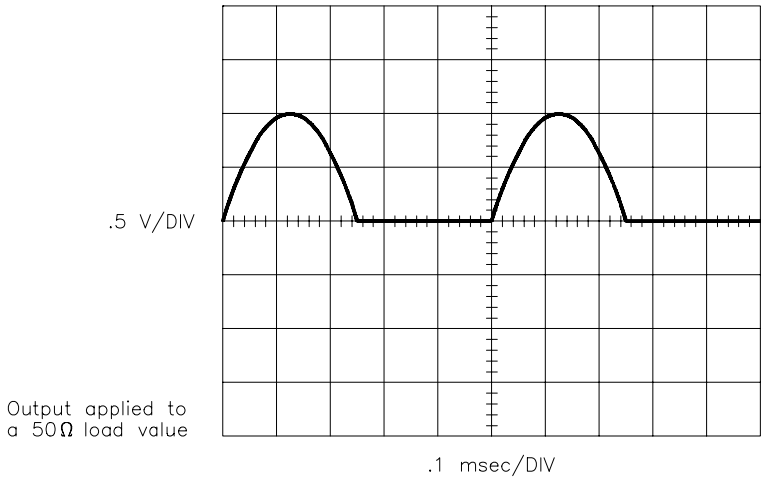
```
380       FOR J=1 TO Width/2
390           Waveform(J+1024)=Waveform(J+1024)+J*.04
400       NEXT J
410       FOR J=1 TO Width/2
420           Waveform(J+1024+Width/2)=Waveform(J+1024+Width/2)
              +1-(J*.04)
430       NEXT J
440       !
450       OUTPUT @Afg;"SOUR:LIST:SEGM:SEL A"!select segment name
460       OUTPUT @Afg;"  SOUR:LIST:SEGM:VOLT";Waveform(*)!load
                                                  waveform points
470   SUBEND
```

C and QuickBASIC Program Versions

The C example program, SPIKES.C, is in directory "CPROG" and the QuickBASIC example program, SPIKES.BAS, is in directory "QBPROG" on the C and QuickBASIC example disk (part number E1340-10034).

Generating a Half-Rectified Sine Wave

This program generates a Half-Rectified Sine Wave using 4096 segments or points.



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HP IBASIC Program Example (SIN_R)

This program is similar to the "SIN_D" BASIC program on page 76, with the following differences:

```
1       !RE-SAVE"SIN_R"
2       !This program generates a 1/2 wave rectified sine wave.
   •
   •
210     CALL Rec_sine
   •
   •
310     SUB Rec_sine
320  Rec_sine:      !Subprogram which defines a rectified sine wave
330          COM @Afg,Waveform(*)
340          FOR I=1 TO 4096
350               Waveform(I)=SIN(2*PI*(I/4096))
360          NEXT I
370          FOR I=2049 TO 4096
380               Waveform(I)=0
390          NEXT I
400          !
410          OUTPUT @Afg;"SOUR:LIST:SEGM:SEL A"!select segment name
420          OUTPUT @Afg;"SOUR:LIST:SEGM:VOLT";Waveform(*)!load
                                                        waveform points
430     SUBEND
```

C and QuickBASIC Program Versions

The C example program, SIN_R.C, is in directory "CPROG" and the QuickBASIC example program, SIN_R.BAS, is in directory "QBPROG" on the C and QuickBASIC example disk (part number E1340-10036).

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Program Comments

The following comments give additional details on the program examples in this chapter.

Amplitude Effects on Voltage List

If the segment data is sent as voltage values, the AFG changes the data into digital-to-analog converter (DAC) codes. This requires that the voltage value of the segment data MUST NOT exceed the AFG's current amplitude level (set by [SOURce:]VOLTage[:LEVel][:IMMediate][:AMPLitude]). If it does, the AFG generates an error.

Reference Oscillator Sources

- The SINusoid, SQUare, TRIangle, and RAMP functions can use any of the Reference Oscillator Sources. The sources, selected by [SOURce:]ROSCillator:SOURce, are:

  INTernal - 42.94967296 MHz (power-on value)
  EXTernal - User provided value (the front panel "Aux In" BNC)

- If using the EXTernal reference oscillator source, enter the source frequency to the AFG using [SOURce:]ROSCillator:FREQuency:EXTernal <*frequency*>.

Waveforms in the EPRom

The following are the waveforms located in the EPRom:

EEPRom1	Sine Wave
EEPRom2	Triangle Wave
EEPRom3	Sin(x)/x for 8.25 radians
EEPRom4	Haversine
EEPRom5	Square Wave
EEPRom6	First ten terms of a Square Wave
EEPRom7	First four terms of a Square Wave
EEPRom8	Falling Ramp
EEPRom9	First 20 terms of a Falling Ramp
EEPRom10	Rising Ramp
EEPRom11	First 20 terms of a Rising Ramp
EEPRom12	White Noise
EEPRom13	Modulated White Noise
EEPRom14	A 3rd, 4th, 5th Harmonic Chord
EEPRom15	8 cycles of a linear rising Sine Wave
EEPRom16	Positive half-cycle Sine Wave

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Chapter 4
HP E1340A Sweeping and Frequency-Shift Keying

Chapter Contents

This chapter covers the sweeping and frequency-shift keying (FSK) features of the HP E1340A Arbitrary Function Generator (AFG). The chapter is organized as follows:

The Command Reference

Detailed information on the commands introduced in this chapter can be found in Chapter 7 under "Command Reference". The commands in this chapter are shown in their entirety (optional headers included) to help you locate them in the reference.

Programming Flowchart

The flowchart on page 84 shows the commands and the command execution order to generate standard waveforms. The reset (power-on) values of each command are also noted on the flowchart. Note that the IEEE 488.2 *RST command places the AFG into its power-on state. Thus, it may be unnecessa y to execute all of the commands on the flowchart.

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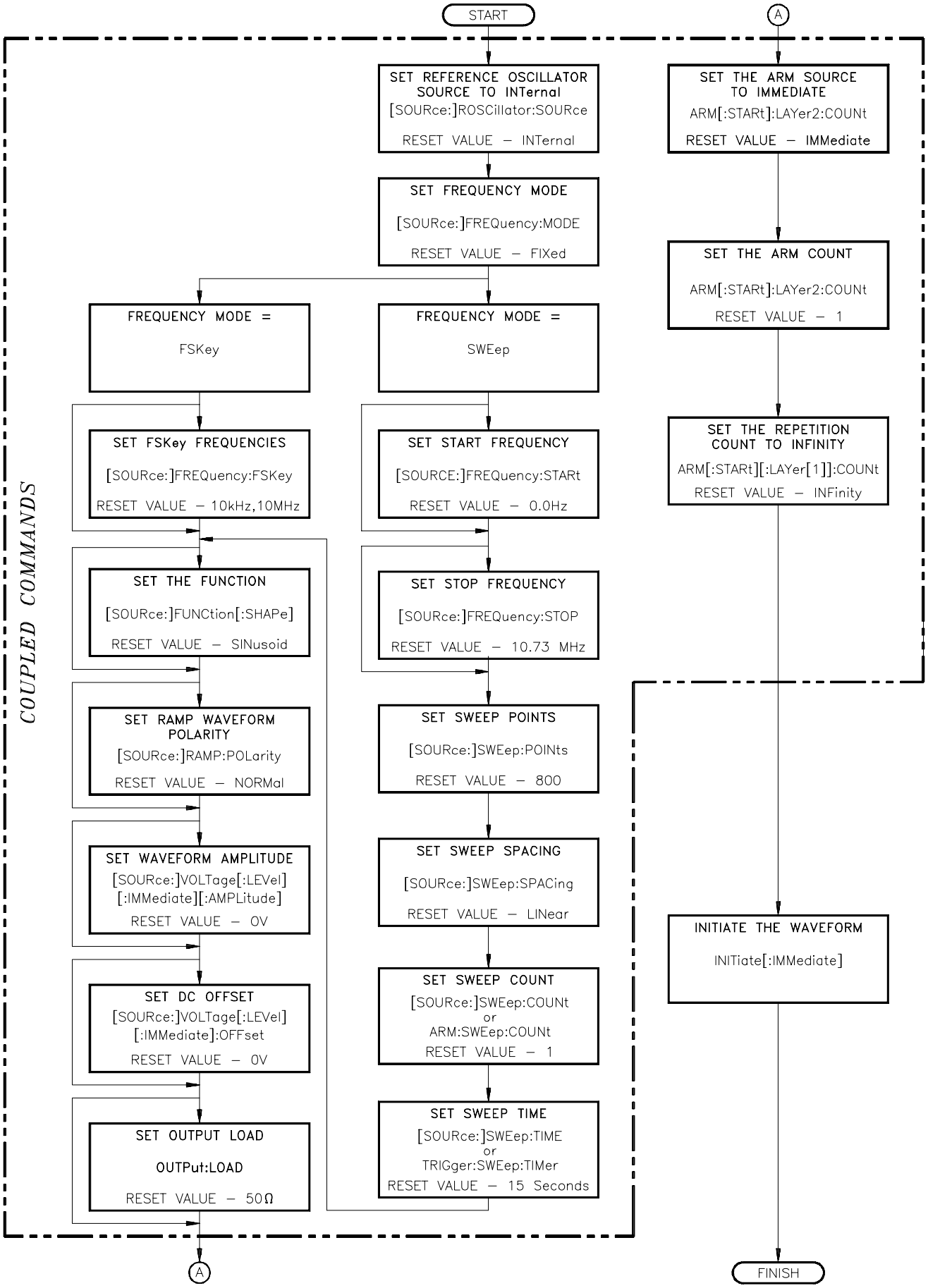

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Sweeping

The AFG offers linear frequency sweeping of standard waveforms (i.e. sine, square, triangle, ramp) and arbitrary waveforms from 0.0 Hz to 15 MHz for sine waves, and 0.0 Hz to 1 MHz for square, triangle, and ramp waves.

The command subsystems covered in this section include:

- [SOURce:]ROSCillator
- [SOURce:]FREQuency
- [SOURce:]SWEep

Sweeping Considerations

The AFG only allows for continuous repetitive sweeping. The INITiate [:IMMediate] command starts the sweeping at a fixed rate determined by the number of points in the sweep and the sweep time. For more information on sweeping, see Chapter 7 under the [SOURce:]SWEep subsystem.

Sweeping Using Start and Stop Frequencies

The following program specifies a start frequency and a stop frequency and continuously sweeps between 0 and 1 MHz. The program also queries the start frequency, stop frequency, center frequency, and frequency span to show the relationship between them.

Using the flowchart as a guide, the steps of this program are:

1. Select the Reference Oscillator -
   [SOURce:]ROSCillator:SOURce <*source*>
2. Select the Frequency Sweep Mode -
   [SOURce:]FREQuency:MODE SWEep
3. Set the Start Frequency -
   [SOURce:]FREQuency:STARt <*start_freq*>
4. Set the Stop Frequency -
   [SOURce:]FREQuency:STOP <*stop_freq*>
5. Select the Output Function -
   [SOURce:]FUNCtion[:SHAPe] <*shape*>
6. Set the Signal Amplitude -
   [SOURce:]VOLTage[:LEVel][:IMMediate][:AMPLitude] <*amplitude*>
7. Place the AFG in the Wait-for-arm State -
   INITiate[:IMMediate]

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HP IBASIC (SMPLSWP1)

```
1     !RE-SAVE“SMPLSWP1”
2     !This program sweeps a sine wave from 0 Hz to 1 MHz by specifying
3     !start and stop frequencies.
4     !
10    !Assign I/O path between IBASIC and the E1340A.
20    ASSIGN @Afg TO 80910
30    COM @Afg
40    !
50    !Set up error checking
60    ON INTR 8 CALL Errmsg
70    ENABLE INTR 8;2
80    OUTPUT @Afg;“*CLS”
90    OUTPUT @Afg;“*SRE 32”
100   OUTPUT @Afg;“*ESE 60”
110   !
120   !Call the subprogram which resets the AFG.
130   CALL Rst
140   !
150   !Set AFG parameters
160   OUTPUT @Afg;“SOUR:ROSC:SOUR INT;”;!reference oscillator
170   OUTPUT @Afg;“:SOUR:FREQ:MODE SWE;”;!frequency mode
180   OUTPUT @Afg;“:SOUR:FREQ:STAR 0;”;!start frequency
190   OUTPUT @Afg;“:SOUR:FREQ:STOP 1E6;”;!stop frequency
200   OUTPUT @Afg;“:SOUR:FUNC:SHAP SIN;”; !function
210   OUTPUT @Afg;“:SOUR:VOLT:LEV:IMM:AMPL 5V” !amplitude
220   OUTPUT @Afg;“INIT:IMM”            !wait-for-arm state
230   !
240   !Call subprogram which queries sweep parameters
250   CALL Query
260   !
270   WAIT .1                           !allow interrupt to be serviced
280   OFF INTR 8
290   END
300   !
310   SUB Query
320 Query:  !Subprogram which queries sweep parameters
330         COM @Afg
340         OUTPUT @Afg;“SOUR:FREQ:STAR?”
350         ENTER @Afg;Sweep1$
360         OUTPUT @Afg;“SOUR:FREQ:STOP?”
370         ENTER @Afg;Sweep2$
380         OUTPUT @Afg;“SOUR:FREQ:CENT?”
390         ENTER @Afg;Sweep3$
```

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```
400         OUTPUT @Afg;“SOUR:FREQ:SPAN?”
410         ENTER @Afg;Sweep4$
420         PRINT “START = ”;Sweep1$,“STOP = ”;Sweep2$
430         PRINT
440         PRINT “CENTER = ”;Sweep3$,“SPAN = ”;Sweep4$
450     SUBEND
460     !
470     SUB Rst
    •
    •
540     SUB Errmsg
    •
    •
```

The start, stop, center, and span values returned are:

```
START = +0.000000000E+000          STOP = +1.000000000E+006
CENTER = +5.000000000E+005         SPAN = +1.000000000E+006
```

C and QuickBASIC Programs

The C program SMPLSWP1.C is in directory “CPROG”, and the QuickBASIC program SMPLSWP1.BAS is in directory “QBPROG” on the example program disk HP P/N E1340-10036.

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Sweeping Using Start and Span Frequencies

The following program specifies a start frequency and a frequency span to continuously sweep from 1 kHz to 21 kHz. The program also queries the start frequency, stop frequency, center frequency, and frequency span to show the relationship between them. Using the flowchart as a guide, the steps of this program are:

1. Select the Frequency Sweep Mode -
   [SOURce:]FREQuency:MODE SWEep
2. Set the Start Frequency -
   [SOURce:]FREQuency:STARt <*start_freq*>
3. Set the Frequency Span -
   [SOURce:]FREQuency:SPAN <*freq_span*>
4. Set the Output Function -
   [SOURce:]FUNCtion[:SHAPe] <*shape*>
5. Set the Signal Amplitude -
   [SOURce:]VOLTage[:LEVel][:IMMediate][:AMPLitude] <*amplitude*>
6. Place the AFG in the Wait-for-arm State -
   INITiate[:IMMediate]

HP IBASIC (SMPLSWP2)

```
1     !RE-SAVE“SMPLSWP2”
2     !This program sweeps a sine wave from 1 kHz to 21 kHz by
3     !specifying a start frequency and a frequency span.
4     !
10    !Assign I/O path between IBASIC and the E1340A.
20    ASSIGN @Afg TO 80910
30    COM @Afg
40    !
50    !Set up error checking
60    ON INTR 8 CALL Errmsg
70    ENABLE INTR 8;2
80    OUTPUT @Afg;“*CLS”
90    OUTPUT @Afg;“*SRE 32”
100   OUTPUT @Afg;“*ESE 60”
110   !
120   !Call the subprogram which resets the AFG.
130   CALL Rst
140   !
150   !Set AFG parameters
160   OUTPUT @Afg;“SOUR:FREQ:MODE SWE;”;!frequency mode
170   OUTPUT @Afg;“:SOUR:FREQ:STAR 1E3;”;!start frequency
180   OUTPUT @Afg;“:SOUR:FREQ:SPAN 20E3;”;!frequency span
190   OUTPUT @Afg;“:SOUR:FUNC:SHAP SIN;”; !function
```

Continued on next page

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```
200   OUTPUT @Afg;":SOUR:VOLT:LEV:IMM:AMPL 5V" !amplitude
210   OUTPUT @Afg;"INIT:IMM"          !wait-for-arm state
220   !
230   !Call subprogram which queries sweep parameters
240   CALL Query
250   !
260   WAIT .1                         !allow interrupt to be serviced
270   OFF INTR 8
280   END
290   !
300   SUB Query
310 Query:  !Subprogram which queries sweep parameters
320         COM @Afg
330         OUTPUT @Afg;"SOUR:FREQ:STAR?"
340         ENTER @Afg;Sweep1$
350         OUTPUT @Afg;"SOUR:FREQ:STOP?"
360         ENTER @Afg;Sweep2$
370         OUTPUT @Afg;"SOUR:FREQ:CENT?"
380         ENTER @Afg;Sweep3$
390         OUTPUT @Afg;"SOUR:FREQ:SPAN?"
400         ENTER @Afg;Sweep4$
410         PRINT "START = ";Sweep1$,"STOP = ";Sweep2$
420         PRINT
430         PRINT "CENTER = ";Sweep3$,"SPAN = ";Sweep4$
440   SUBEND
450   !
460   SUB Rst
   •
   •
530   SUB Errmsg
   •
   •
```

The start, stop, center, and span values returned are:

```
START = +1.000000000E+003          STOP = +2.100000000E+004
CENTER = +1.100000000E+004         SPAN = +2.000000000E+004
```

C and QuickBASIC Programs

The C program SMPLSWP2.C is in directory "CPROG", and the QuickBASIC program SMPLSWP2.BAS is in directory "QBPROG" on the example program disk HP P/N E1340-10036.

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Sweep Points Vs. Sweep Time

To demonstrate the relationship between the number of points (frequencies) in a frequency sweep and the time of the sweep, the following program uses 100 frequency points to continuously sweep from 5 kHz to 15 kHz in 0.5 seconds. (See "Program Comments" to determine the sweep time.)

Using the flowchart as a guide, the steps of this program are:

1. Select the Frequency Sweep Mode -
   [SOURce:]FREQuency:MODE SWEep
2. Set the Start Frequency -
   [SOURce:]FREQuency:STARt <*start_freq*>
3. Set the Stop Frequency -
   [SOURce:]FREQuency:STOP <*stop_freq*>
4. Set the Number of Points (frequencies) in the Frequency Sweep -
   [SOURce:]SWEep:POINts <*number*>
5. Set the Sweep Repetition Time -
   [SOURce:]SWEep:TIME <*number*>
6. Set the Output Function -
   [SOURce:]FUNCtion[:SHAPe] <*shape*>
7. Set the Signal Amplitude -
   [SOURce:]VOLTage[:LEVel][:IMMediate][:AMPLitude] <*amplitude*>
8. Place the AFG in the Wait-for-arm State -
   INITiate[:IMMediate]

HP IBASIC (SWP_PVST)

```
1     !RE-SAVE"SWP_PVST"
2     !This program sweeps a sine wave from 5 kHz to 15 kHz
3     !in 0.5 seconds to demonstrate how to set the sweep time.
4     !
10    !Assign I/O path between IBASIC and the E1340A.
20    ASSIGN @Afg TO 80910
30    COM @Afg
40    !
50    !Set up error checking
60    ON INTR 8 CALL Errmsg
70    ENABLE INTR 8;2
80    OUTPUT @Afg;"*CLS"
90    OUTPUT @Afg;"*SRE 32"
100   OUTPUT @Afg;"*ESE 60"
110   !
120   !Call the subprogram which resets the AFG.
130   CALL Rst
```

Continued on next page

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```
140   !
150   !Set AFG parameters
160   OUTPUT @Afg;“SOUR:FREQ:MODE SWE;”;!frequency mode
170   OUTPUT @Afg;“:SOUR:FREQ:STAR 5E3;”;!start frequency
180   OUTPUT @Afg;“:SOUR:FREQ:STOP 15E3;”;!stop frequency
190   OUTPUT @Afg;“:SOUR:SWE:POIN 100;”;  !sweep points
200   OUTPUT @Afg;“:SOUR:SWE:TIME .495;”;  !sweep time
210   OUTPUT @Afg;“:SOUR:FUNC:SHAP SIN;”; !function
220   OUTPUT @Afg;“:SOUR:VOLT:LEV:IMM:AMPL 5V” !amplitude
230   OUTPUT @Afg;“INIT:IMM”          !wait-for-arm state
240   !
250   WAIT .1                         !allow interrupt to be serviced
260   OFF INTR 8
270   END
280   !
290   SUB Rst
  •
  •
360   SUB Errmsg
  •
  •
```

C and QuickBASIC Programs

The C program SWP_PVST.C is in directory “CPROG”, and the QuickBASIC program SWP_PVST.BAS is in directory “QBPROG” on the example program disk HP P/N E1340-10036.

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Frequency-Shift Keying

Frequency-shift keying (FSK) changes the frequency of the output waveform or sample rate based on the signal level of the frequency-shift keying control source. FSK frequencies can range from 0.0 Hz to 20 MHz. The frequency-shift keying control source is applied to the front panel "Aux In" BNC Connector.

The command subsystems associated with frequency-shift keying include:

- [SOURce:]ROSCillator
- [SOURce:]FREQuency
  - FSK mode and related commands

Program Example

The following program shows the basic steps involved in setting up and using the frequency-shift keying function of the AFG. A 5V, 1 kHz square wave control signal is applied to the AFG's front panel "FSK" port. Output frequencies of 20 kHz and 10 kHz occur as the level of the 1 kHz signal changes.

Using the flowchart as a guide, the steps of this program are:

1. Select the Reference Oscillator -
   [SOURce:]ROSCillator:SOURce <*source*>
2. Select the Frequency-shift Keying Mode -
   [SOURce:]FREQuency:MODE FSK
3. Select the FSK Frequencies -
   [SOURce:]FREQuency:FSKey <*frequency1*>,<*frequency2*>
4. Set the Output Function -
   [SOURce:]FUNCtion[:SHAPe] <*shape*>
5. Set the Signal Amplitude -
   [SOURce:]VOLTage[:LEVel][:IMMediate][:AMPLitude] <*amplitude*>
6. Place the AFG in the Wait-for-arm State -
   INITiate[:IMMediate]

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HP IBASIC (FSK1)

```
1     !RE-SAVE“FSK1”
2     !This program sets up frequency-shift keying using the AFG’s "Aux In"
3     !port as the control source. A high signal on the port selects the
4     !first frequency. A low signal on the port selects the second frequency.
5     !
10    !Assign I/O path between IBASIC and the E1340A.
20    ASSIGN @Afg TO 80910
30    COM @Afg
40    !
50    !Set up error checking
60    ON INTR 8 CALL Errmsg
70    ENABLE INTR 8;2
80    OUTPUT @Afg;“*CLS”
90    OUTPUT @Afg;“*SRE 32”
100   OUTPUT @Afg;“*ESE 60”
110   !
120   !Call the subprogram which resets the AFG.
130   CALL Rst
140   !
150   !Set AFG parameters
160   OUTPUT @Afg;“SOUR:ROSC:SOUR INT;”;!reference oscillator
170   OUTPUT @Afg;“:SOUR:FREQ:MODE FSK;”;!frequency mode
180   OUTPUT @Afg;“:SOUR:FREQ:FSK 10E3,20E3;”;!FSK frequencies
190   OUTPUT @Afg;“:SOUR:FUNC:SHAP SIN;”;!function
200   OUTPUT @Afg;“:SOUR:VOLT:LEV:IMM:AMPL 5V” !amplitude
210   OUTPUT @Afg;“INIT:IMM”          !wait-for-arm state
220   !
230   WAIT .1                         !allow interrupt to be serviced
240   OFF INTR 8
250   END
260   !
270   SUB Rst
  •
  •
340   SUB Errmsg
  •
  •
```

FSK frequencies are: +1.000000000E+004,+2.000000000E+004

C and QuickBASIC Programs

The C program FSK1.C is in directory “CPROG”, and the QuickBASIC program FSK1.BAS is in directory “QBPROG” on the example program disk HP P/N E1340-10036.

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Program Comments

The following information is associated with sweeping and frequency-shift keying. Included are details on the operation of these functions, and on the various modes, ranges, etc., used in the programs in this chapter.

Reference Oscillator Sources

There are two reference oscillator sources for the AFG which are selected by the [SOURce:]ROSCillator:SOURce command:

EXTernal: The AFG's front panel "Aux In" BNC .
INTernal: The internal 42.94967296 MHz oscillator.

The INTernal reference oscillator gives a frequency resolution of .01 Hz.

INTernal is the default reference oscillator source. Thus, in many programs, the source is not specified.

AFG Frequency Modes

There are three frequency "modes" available in the AFG. The modes selected by the [SOURce:]FREQuency:MODE command are:

CW|FIXed: Single frequency mode.
FSKey: Frequency shift keying mode.
SWEep: Frequency sweep mode.

Frequency Points

The number of frequencies generated (points) in a frequency sweep can be from 2 to 1,073,741,824. The default number is 1001. The number of points is set with the SOURce:SWEep:POINts command and applies to sweeps only.

Specifying a Sweep Time

The sweep time (set by SOURce:SWEep:TIME) is the period from the **generation** of the first frequency in the sweep or list to the **generation** of the last frequency (see below).

The duration (t) of each frequency is:

specified sweep time/(frequency points - 1)

For multiple sweeps or repetitions through the list, the duration of the last frequency (f_n) is also t. To maintain a constant rate between sweeps or repetitions, the duration of f_n must be accounted for as follows:

$\text{Sweep time}_{\text{specified}} = \text{Sweep repetition time}_{\text{desired}} * ((\text{points} - 1)/\text{points})$

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Chapter 5

HP E1340A Arming and Marker Outputs

Chapter Contents

This chapter shows you how to arm and gate the HP E1340A AFG in order to start and advance standard and arbitrary waveforms. This chapter also shows how generate the different marker outputs at the "Aux Out" BNC connector. The sections of this chapter include:

The ARM Configuration

The HP E1340A AFG uses an ARM triggering configuration to output the standard and arbitrary waveforms. When initiated, an arm signal enables the AFG to output the waveforms each time an arm signal is received.

The ARM States

The AFG operates within three states: Idle, Wait-for-arm, and Instrument Action.

When power is applied, or following a reset or an abort, the AFG is in the Idle state. The AFG is set to the Wait-for-arm state with the INITiate[:IMMediate] command.

The AFG starts instrument action when it receives an arm from the specified arm source.

After the instrument action (waveform is output) occurs, the AFG returns to the Wait-for-arm state until the next arm occurs. When the specified arm count has been reached, the AFG returns to the Idle state.

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Initiating Waveforms

After the AFG has been configured to output the desired waveform, the AFG is set to the Wait-for-arm state with the command:

INITiate[:IMMediate]

INITiate is an uncoupled command and is generally the last command executed before a waveform is output:

```
100    SUB Sine_wave
110  Sine_wave:  !Subprogram which outputs a sine wave
120         COM @Afg
130         OUTPUT @Afg;“SOUR:FREQ:FIX 1E3;”;!frequency
140         OUTPUT @Afg;“:SOUR:FUNC:SHAP SIN;”; !function
150         OUTPUT @Afg;“:SOUR:VOLT:LEV:IMM:AMPL 5 V”!amplitude
160         OUTPUT @Afg;“INIT:IMM”       !wait-for-arm state
170    SUBEND
```

If INITiate[:IMMediate] is executed when the AFG is not in the Idle state, error 213, "Init ignored" is generated.

Arming the AFG

In order for the AFG to output a waveform, it must be armed. The information in this section covers the commands and programming sequence used to arm the AFG for fixed frequency waveform generation.

Arming Commands

The commands which arm the AFG allow you to specify the following:

- the arm source
- the slope of an external arm signal
- the number of arms per INITiate[:IMMediate] command
- the number of waveform cycles per arm

The arming commands include:

```
ARM
    [:STARt|SEQuence[1]]
        [:LAYer[1]]
            :COUNt <number>
        :LAYer2
            :COUNt <number>
            :SLOPe <edge>
            :SOURce <source>
```

The arming commands for continuous waveforms are coupled commands.

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Note Detailed information on the commands introduced in this chapter can be found in Chapter 7 - "Command Reference". The commands in this chapter are shown in their entirety (optional headers included) to help you locate them in the reference.

Setting the Arm Source

The following program shows how to select the source which arms the AFG. The program selects the AFG's "Aux In" BNC connector as the arming source. When the AFG receives as arming signal, it outputs a 10 kHz, 1 Vpp square wave.

The steps of this program are:

1. Select the FIXed Frequency Mode -
   [SOURce:]FREQuency:MODE <*mode*>
2. Set the Output Frequency -
   [SOURce:]FREQuency[:CW|:FIXed] <*frequency*>
3. Set the Output Function -
   [SOURce:]FUNCtion[:SHAPe] <*shape*>
4. Set the Signal Amplitude -
   [SOURce:]VOLTage[:LEVel][:IMMediate][:AMPLitude] <*amplitude*>
5. Set the Arm Source -
   ARM[:STARt]:LAYer2:SOURce <*source*>
6. Set the Edge of the External Arm Signal -
   ARM[:STARt]:LAYer2:SLOPe <*edge*>
7. Place the AFG in the Wait-for-arm State -
   INITiate[:IMMediate]

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HP IBASIC (EXT_ARM)

```
1     !RE-SAVE“EXT_ARM”
2     !This program arms the AFG with an external signal applied to the
3     !AFG’s "Aux In" port. When armed, the AFG outputs 100 cycles
4     !of a 10 kHz, 1 Vpp square wave.
5     !
10    !Assign I/O path between IBASIC and the E1340A.
20    ASSIGN @Afg TO 80910
30    COM @Afg
40    !
50    !Set up error checking
60    ON INTR 8 CALL Errmsg
70    ENABLE INTR 8;2
80    OUTPUT @Afg;“*CLS”
90    OUTPUT @Afg;“*SRE 32”
100   OUTPUT @Afg;“*ESE 60”
110   !
120   !Call the subprogram which resets the AFG.
130   CALL Rst
140   !
150   !Set AFG parameters
160   OUTPUT @Afg;“SOUR:FREQ:MODE FIX;”;!frequency mode
170   OUTPUT @Afg;“:SOUR:FREQ:FIX 1E3;”;!frequency
180   OUTPUT @Afg;“:SOUR:FUNC:SHAP SQU;”; !function
190   OUTPUT @Afg;“:SOUR:VOLT:LEV:IMM:AMPL 1VPP;”; !amplitude
200   OUTPUT @Afg;“:ARM:STAR:LAY2:SOUR EXT;”; !arm source
210   OUTPUT @Afg;“:ARM:STAR:LAY2:COUN INF;”; !arm count
220   OUTPUT @Afg;“:ARM:STAR:LAY1:COUN 1E3” !cycle count
230   OUTPUT @Afg;“INIT:IMM”          !wait-for-arm state
240   !
250   WAIT .1                         !allow interrupt to be serviced
260   OFF INTR 8
270   END
280   !
290   SUB Rst
      •
      •
360   SUB Errmsg
      •
      •
```

C and QuickBASIC Programs

The C program EXT_ARM.C is in directory “CPROG”, and the QuickBASIC program EXT_ARM.BAS is in directory “QBPROG” on the example program disk HP P/N E1340-10036.

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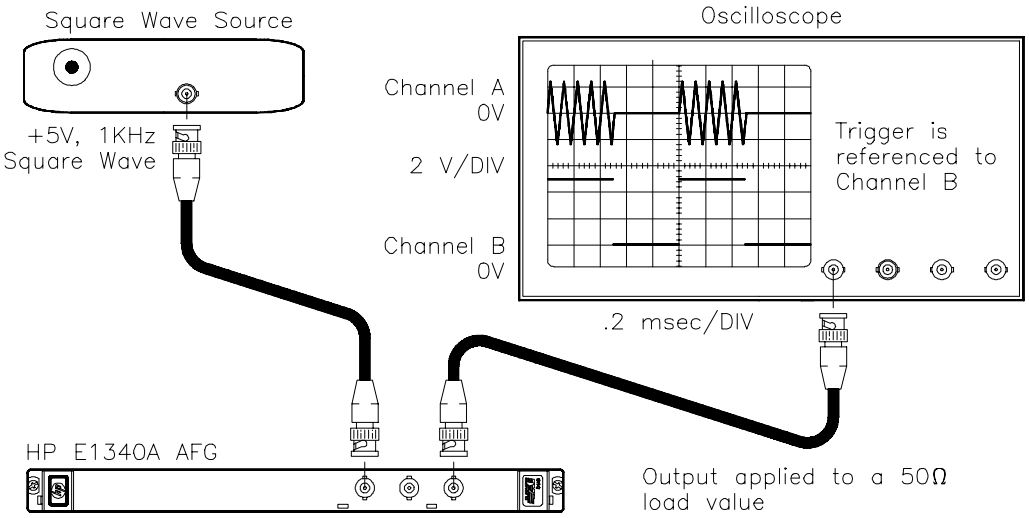
Setting the Arm and Waveform Cycle Count

The following program shows you how to set the number of arms the AFG is to receive before returning to the Idle state, and how to set the number of waveform cycles (repetitions) per arm.



The program sets a five cycle burst that occurs each time the AFG receives an external arm. There will be about a 50 msec delay between a transistion on the "Aux In" connector and the output switching.

The steps of this program are:

1. Set the Output (Burst) Frequency -
   [SOURce:]FREQuency[:CW|:FIXed] <*frequency*>
2. Set the Output Function -
   [SOURce:]FUNCtion[:SHAPe] <*shape*>
3. Set the Signal Amplitude -
   [SOURce:]VOLTage[:LEVel][:IMMediate][:AMPLitude] <*amplitude*>
4. Set the Arm Source -
   ARM[:STARt]:LAYer2:SOURce <*source*>
5. Set the Edge of the External Arm Signal -
   ARM[:STARt]:LAYer2:SLOPe <*edge*>
6. Set the Arm Count -
   ARM[:STARt]:LAYer2:COUNt <*number*>
7. Set the Number of Waveform Cycles (Burst Count) -
   ARM[:STARt][:LAYer[1]]:COUNt <*number*>
8. Place the AFG in the Wait-for-arm State -
   INITiate[:IMMediate]

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```
1     !RE-SAVE“BURST”
2     !This program sets the arm count to infinity and the waveform
3     !repetition count to 5. The arm source is set to external and a
4     !1 kHz square wave is applied to "Aux In" connector. The AFG outputs
5     !a 5 cycle burst on each positive edge of the external arm signal.
6     !
10    !Assign I/O path between IBASIC and the E1340A.
20    ASSIGN @Afg TO 80910
30    COM @Afg
40    !
50    !Set up error checking
60    ON INTR 8 CALL Errmsg
70    ENABLE INTR 8;2
80    OUTPUT @Afg;“*CLS”
90    OUTPUT @Afg;“*SRE 32”
100   OUTPUT @Afg;“*ESE 60”
110   !
120   !Call the subprogram which resets the AFG.
130   CALL Rst
140   !
150   !Set AFG parameters
160   OUTPUT @Afg;“SOUR:FREQ:FIX 10E3;”;!frequency
170   OUTPUT @Afg;“:SOUR:FUNC:SHAP SIN;”; !function
180   OUTPUT @Afg;“:SOUR:VOLT:LEV:IMM:AMPL 2.5VPP;”; !amplitude
190   OUTPUT @Afg;“:ARM:STAR:LAY2:SOUR EXT;”; !arm source
200   OUTPUT @Afg;“:ARM:STAR:LAY2:SLOP POS;”; !arm slope
210   OUTPUT @Afg;“:ARM:STAR:LAY2:COUN INF;”; !arm count
220   OUTPUT @Afg;“:ARM:STAR:LAY1:COUN 5” !cycle count
230   OUTPUT @Afg;“INIT:IMM”          !wait-for-arm state
240   !
250   WAIT .1                         !allow interrupt to be serviced
260   OFF INTR 8
270   END
280   SUB Rst
  •
  •
360   SUB Errmsg
  •
  •
```

C and QuickBASIC Programs

The C program BURST.C is in directory “CPROG”, and the QuickBASIC program BURST.BAS is in directory “QBPROG” on the example program disk HP P/N E1340-10036.

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Gating the Waveforms

Gating a waveform is the process of suspending the output waveform. This is accomplished by gating the reference oscillator on and off. An active gate suspends waveform output at the point when the AFG receives the gate. Set the gate inactive and waveform output resumes.

The following example shows how to use the AFG's "Aux In" BNC to suspend waveform output. A high (TTL level) on the BNC activates the gate.

The steps of program are as follows:

1. Set the Reference Oscillator Source -
   [SOURce:]ROSCillator:SOURce <*source*>
2. Set the Output (Burst) Frequency -
   [SOURce:]FREQuency[:CW|:FIXed] <*frequency*>
3. Set the Output Function -
   [SOURce:]FUNCtion[:SHAPe] <*shape*>
4. Set the Signal Amplitude -
   [SOURce:]VOLTage[:LEVel][:IMMediate][:AMPLitude] <*amplitude*>
5. Set the Gate State On -
   [SOURce:]ROSCillator:GATE:STATe <*state*>
6. Place the AFG in the Wait-for-arm State -
   INITiate[:IMMediate]

HP IBASIC (GATE_SIG)

```
1     !RE-SAVE“GATE_SIG”
2     !This program gates the output of a 10 kHz triangle wave. When
3     ! the gate signal is high, the gate is active and the waveform is
4     !suspended. When the gate signal is low, the gate is inactive and
5     !the waveform resumes.
6     !
10    !Assign I/O path between IBASIC and the E1340A.
20    ASSIGN @Afg TO 80910
30    COM @Afg
40    !
50    !Set up error checking
60    ON INTR 8 CALL Errmsg
70    ENABLE INTR 8;2
80    OUTPUT @Afg;“*CLS”
90    OUTPUT @Afg;“*SRE 32”
```

Continued on next page

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```
100   OUTPUT @Afg;"*ESE 60"
110   !
120   !Call the subprogram which resets the AFG.
130   CALL Rst
140   !
150   !Set AFG parameters
160   OUTPUT @Afg;"SOUR:FREQ:FIX 10E3;";!frequency
170   OUTPUT @Afg;":SOUR:FUNC:SHAP TRI;"; !function
180   OUTPUT @Afg;":SOUR:VOLT:LEV:IMM:AMPL 5V" !amplitude
190   OUTPUT @Afg;"SOUR:ROSC:GATE:STAT ON"!enable gating
200   OUTPUT @Afg;"INIT:IMM"          !wait-for-arm state
210   !
220   WAIT .1                         !allow interrupt to be serviced
230   OFF INTR 8
240   END
250   !
260   SUB Rst
  •
  •
330   SUB Errmsg
  •
  •
```

C and QuickBASIC Programs

The C program GATE_SIG.C is in directory "CPROG", and the QuickBASIC program GATE_SIG.BAS is in directory "QBPROG" on the example program disk HP P/N E1340-10036.

Aborting Waveforms

Aborting a waveform places the AFG in the Idle state. The waveform is halted and the output remains at the last amplitude point when the abort was executed. The command which aborts a waveform is:

ABORt

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Marker Outputs

The following describes the different marker outputs generated at the AFG's front panel "Aux Out" BNC connector.

Marker Commands

The marker commands are:

```
[SOURce:]
    MARKer
        :FEED <source>
        :POLarity <polarity>
```

The marker commands are coupled commands.

Available Marker Sources

There are three marker sources available for output at the AFG's front panel "Aux Out" BNC. The different marker sources are as follows:

OUTPut:ZERO

This source outputs a marker pulse whenever the waveform crosses through zero. Set the output polarity to INVerted using the [SOURce:]MARKer:POLarity command. This outputs a positive marker pulse whenever the waveform crosses zero. Marker output is high when the main output is <0V and low when the main output is >0V. Note that since an analog comparator detects zero-crossing, it may not detect exact crossing. Also, at high frequencies, the comparator's sensitivity declines and it may not detect signal excursions much less than the DAC's full scale range for both negative and positive polarities.

SEGMent

This source outputs a marker pulse at the completion of a segment. For multiple segment waveforms (AB or ABCD), the AFG outputs a marker pulse at the end of each segment 2 or 4 pulses per repetition of the waveforms. Set the output polarity to NORMal using the [SOURce:]MARKer:POLarity command. This outputs a positive marker pulse.

[SOURce:]ROSCillator

The source outputs the internal reference oscillator signal. Set the output polarity to NORMal using the [SOURce:]MARKer:POLarity command. This outputs a TTL compatible oscillator signal.

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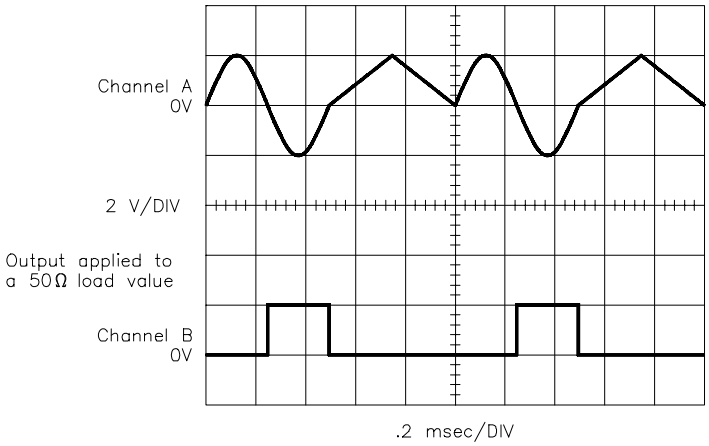
SWEep

This source outputs a marker pulse on the last point of a frequency sweep. Set the output polarity either to NORMal or INVerted using the [SOURce:]MARKer:POLarity command.

Generating Zero Crossing Marker Pulses

This program outputs a marker pulse whenever the waveform crosses through zero. The program generates an arbitrary waveform using two different waveform segments. One waveform segment generates a 1 kHz, 5 V sine wave. The other one generates a 1 kHz, 5 Vpeak triangle.



The commands are:

1. Reset the AFG - *RST

2. Setup the AFG for an Arbitrary Waveform Output -
   [SOURce:]FREQuency[:CW|FIXed] <*frequency*>
   [SOURce:]FUNCtion[:SHAPe] USER
   [SOURce:]VOLTage[:LEVel][:IMMediate][:AMPLitude] <*amplitude*>

3. Select the Marker Source -
   [SOURce:]MARKer:FEED <*source*>

4. Select the Marker Pulse Polarity -
   [SOURce:]MARKer:POLarity <*polarity*>

5. Generate and Store the First Waveform Segment -
   [SOURce:]LIST[:SEGMent]:SELect A
   [SOURce:]LIST[:SEGMent]:VOLTage <*voltage_list*>

6. Generate and Store the Second Waveform Segment -
   [SOURce:]LIST[:SEGMent]:SELect B
   [SOURce:]LIST[:SEGMent]:VOLTage <*voltage_list*>

7. Generate the Output -
   [SOURce:]FUNCtion:USER AB
   INITiate[:IMMediate]

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HP IBASIC (MARK_OUT)

```
1     !RE-SAVE“MARK_OUT”
2     !This program outputs marker pulses with all amplitude points less
3     !than 0V. The output sequence consists of two arbitrary waveforms.
4     !
10    !Assign I/O path between IBASIC and the E1340A.
20    ASSIGN @Afg TO 80910
30    COM @Afg,Waveform1(1:4096),Waveform2(1:4096)
40    !
50    !Set up error checking
60    ON INTR 8 CALL Errmsg
70    ENABLE INTR 8;2
80    OUTPUT @Afg;“*CLS”
90    OUTPUT @Afg;“*SRE 32”
100   OUTPUT @Afg;“*ESE 60”
110   !
120   !Call the subprogram which resets the AFG.
130   CALL Rst
140   !
150   !Set AFG parameters
160   OUTPUT @Afg;“SOUR:FREQ:FIX 10E3;”;!frequency
170   OUTPUT @Afg;“:SOUR:FUNC:SHAP USER;”; !function
180   OUTPUT @Afg;“:SOUR:VOLT:LEV:IMM:AMPL 5.1V” !scale
                                                  amplitude
190   OUTPUT @Afg;“:SOUR:MARK:FEED ““OUTP:ZERO””;”; !marker
                                                  source
200   OUTPUT @Afg;“:SOUR:MARK:POL INV” !marker source polarity
210   !
220   !Call subprogram which defines waveform segments A and B.
230   CALL Sine_tri_wave
240   !
250   !Select output sequence and initiate waveform
260   OUTPUT @Afg;“SOUR:FUNC:USER AB”
270   OUTPUT @Afg;“INIT:IMM”          !wait-for-arm state
280   !
290   WAIT .1                         !allow interrupt to be serviced
300   OFF INTR 8
310   END
320   !
330   SUB Sine_tri_wave
340   Sine_tri_wave: !Subprogram which defines waveforms
350         COM @Afg,Waveform1(*),Waveform2(*)
360         FOR I=1 TO 4096
370               Waveform1(I)=5*(SIN(2*PI*(I/4096)))
380         NEXT I
```

Continued on next page

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```
390         !
400         OUTPUT @Afg;"SOUR:LIST:SEGM:SEL A"!select segment name
410         OUTPUT @Afg;"  SOUR:LIST:SEGM:VOLT";Waveform1(*)
                                                !load waveform points
420         !
430         FOR I=1 TO 2047
440             Waveform2(I)=I*.0024414
450         NEXT I
460         FOR I=2048 TO 4096
470             Waveform2(I)=(4096-I)*.0024414
480         NEXT I
490         !
500         OUTPUT @Afg;"SOUR:LIST:SEGM:SEL B"!select segment name
510         OUTPUT @Afg;"  SOUR:LIST:SEGM:VOLT";Waveform2(*)
                                                !load waveform points
520     SUBEND
530     !
540     SUB Rst
    •
    •
610     SUB Errmsg
    •
    •
```

C and QuickBASIC Programs

The C program MARK_OUT.C is in directory "CPROG", and the QuickBASIC program MARK_OUT.BAS is in directory "QBPROG" on the example program disk HP P/N E1340-10036.

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Program Comments

The following information is associated with arming operation of the AFG.

Reference Oscillator Sources

There are two reference oscillator sources for the AFG which are selected by the [SOURce:]ROSCillator:SOURce command:

EXTernal: The AFG's front panel "Aux In" BNC.

INTernal: The internal 42.94967296 MHz oscillator (default source).

AFG Frequency Modes

There are three frequency "modes" available in the AFG using ([SOURce:]FREQuency). The modes selected by the [SOURce:]FREQuency:MODE command are:

CW|FIXed: Single frequency mode.

FSKey: Frequency shift keying mode.

SWEep: Frequency sweep mode.

CW or **FIXed** is the default mode but is specified in many of the programs to emphasize that the arm source specified by ARM[:STARt]:LAYer2:SOURce <*source*> is for fixed (continuous) frequency waveforms.

AFG Arming Sources

The arming sources set by the ARM[:STARt]:LAYer2:SOURce <*source*> command are:

EXTernal: The HP E1340A's front panel "Start Arm In" BNC connector (TTL levels). Available for repetitive burst output only.

IMMediate: Immediate arming. An arm is internally generated when the start trigger sequence enters the wait-for-arm state.

AFG Arm Count

The arm count specifies the number of arms the AFG is to receive before it returns to the Idle state. The arm count is set with the ARM[:STARt]:LAYer2:COUNt command. The default value is 1.

Waveform Repetition Count

The waveform repetition (cycle) count specifies the number of cycles per arm. The cycle count is specified with the ARM[:STARt][:LAYer[1]]:COUNt <*number*> command. The range for the cycle count is 1 through 65534, or INFinity. The default value is INFinity.

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Enabling the Gate

Before the AFG reference oscillator can be gated, the gate must be enabled. This is done with the [SOURce:]ROSCillator:GATE:STATe command. When the mode is ON, gating is enabled. When OFF, gating is disabled.

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Chapter 6
HP E1340A High Speed Operation

Chapter Contents

This chapter explains how to use the HP E1340A Arbitrary Function Generator at faster speeds and other operations.

Chapter 3 shows how to transfer waveform segments to the AFG as voltage values. This is the slowest method to transfer the lists to the AFG. This chapter shows faster ways to transfer the data to the AFG. The sections are as follows:

Using DAC Data to Generate Waveforms

Transferring waveform segments as Digital-to-Analog Converter (DAC) Codes to the AFG is faster than transferring a voltage list. The following shows how to transfer the lists as DAC codes using 16-bit integers. The DAC codes are transferred to the AFG as a comma (,) separated list. Be sure to set the upper 4 bits of the integers to 0.

Determining DAC Codes

For outputs into matched loads and with the amplitude set to maximum (+5.11750V), the following DAC codes generate the following outputs:

Code **0** outputs -5.12 V or negative full scale voltage
Code **+2048** outputs 0 V
Code **+4095** outputs +5.11750 V or positive full scale voltage

To calculate DAC codes from voltage values, use the formula:

DAC Code = (voltage value / .0025) + 2048

For example, to output -2V:

DAC Code = (-2 / .0025) + 2048 = -800 + 2048 = 1248

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Program Example

This program shows how to store a waveform segment (i.e., points of an arbitrary waveform) into the AFG's segment memory. The program transfers the data to the AFG as a comma (,) separated list. The example generates a 4096 point +5 V to -5 V negative going ramp.

1. Reset the AFG - *RST

2. Setup the AFG for Output -
   [SOURce:]FREQuency[:CW|FIXed] <*frequency*>
   [SOURce:]FUNCtion[:SHAPe] USER
   [SOURce:]VOLTage[:LEVel][:IMMediate][:AMPLitude] <*amplitude*>

3. Select the DAC Data Source -
   [SOURce:]ARBitrary:DAC:SOURce INTernal

   This command selects the source that transfers data to the DAC (see "Program Comments"). Use INTernal to transfer the data using the [SOURce:]FUNCtion USER subsystem. (Reset automatically sets this command; it is given here for good programming practice.)

4. Select the Waveform Segment -
   [SOURce:]LIST[:SEGMent]:SELect <*name*>

   Use either A, B, C, or D in <*name*> for the waveform segment.

5. Store the Waveform Segment as DAC Data -
   [SOURce:]LIST[:SEGMent]:VOLTage:DAC <*voltage_list*>

   This command stores the waveform segment into segment memory using DAC codes consisting of 16-bit integers.

6. Generate the Output -
   [SOURce:]FUNCtion:USER <*name*>
   INITiate[:IMMediate]

HP IBASIC Program Example (UNS_DAT)

```
1     !RE-SAVE"UNS_DAT"
2     !This program downloads AFG data in the form of DAC codes
3     !(unsigned numbers). The data represents a 5V ramp waveform.
4     !
10    !Assign I/O path between IBASIC and the E1340A.
20    ASSIGN @Afg TO 80910
30    COM @Afg,Waveform(1:4096)
40    !
50    !Set up error checking
60    ON INTR 8 CALL Errmsg
70    ENABLE INTR 8;2
```

Continued on next page

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```
80    OUTPUT @Afg;"*CLS"
90    OUTPUT @Afg;"*SRE 32"
100   OUTPUT @Afg;"*ESE 60"
110   !
120   !Call the subprogram which resets the AFG.
130   CALL Rst
140   !
150   !Set AFG parameters
160   OUTPUT @Afg;"SOUR:FREQ:FIX 1E3;";!frequency
170   OUTPUT @Afg;":SOUR:FUNC:SHAP USER;";!function
180   OUTPUT @Afg;":SOUR:VOLT:LEV:IMM:AMPL 5.11750V"!scale
                                                    amplitude
190   !
200   !Call subprogram which defines waveform segment A (ramp wave).
210   CALL Ramp_wave
220   !
230   !Select output sequence and initiate waveform
240   OUTPUT @Afg;"SOUR:FUNC:USER A"
250   OUTPUT @Afg;"INIT:IMM"          !wait-for-arm state
260   !
270   WAIT .1          !allow interrupt to be serviced
280   OFF INTR 8
290   END
300   !
310   SUB Ramp_wave
320 Ramp_wave:  !Subprogram which defines ramp waveform
330       COM @Afg,Waveform(*)
340       FOR I=2048 TO -2047 STEP -1!calculate waveform points as dac
                                                    codes
350           Waveform(2049-I)=((I*.0024426)/.0025)+2048
360       NEXT I
370       !
380       OUTPUT @Afg;"SOUR:ARB:DAC:SOUR INT"!dac data source
                                                    (internal)
390       OUTPUT @Afg;"SOUR:LIST:SEGM:SEL A"!select segment name
400       OUTPUT @Afg;"SOUR:LIST:SEGM:VOLT:DAC ";Waveform(*)
                                                    !load ampl points
410   SUBEND
420   !
430   SUB Rst
  •
  •
500   SUB Errmsg
  •
  •
```


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C and QuickBASIC Program Versions

The C example program, UNS_DAT.C, is in directory "CPROG" and the QuickBASIC example program, UNS_DAT.BAS, is in directory "QBPROG" on the C and QuickBASIC example disk (part number E1340-10036).

This program is very similar to the example programs used in Chapter 3. The only difference is that this program transfers the segment data as DAC codes instead of voltage values.

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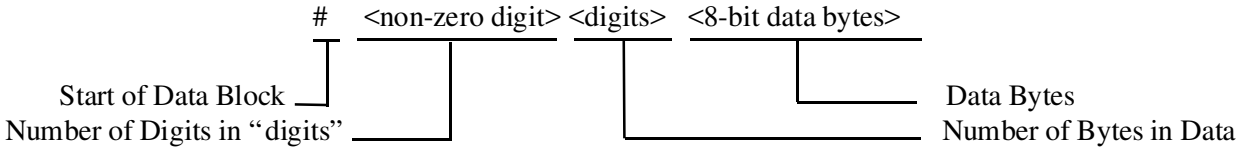
Using Definite Length Blocks to Transfer Data

The AFG can receive DAC codes as Definite Length Arbitrary Block Data consisting of 16-bit integers. This is a much faster method to transfer data than using a comma (,) separated list that was used in "Using DAC Data to Generate Waveforms" on page 109. Be sure to set the upper 4 bits of the integers to 0.

Definite Length Block Data Format

A typical data block using the definite length format consists of:



where:

- "#" shows that the data to be sent is in an arbitrary block format
- "<non-zero digit>" is a single digit number that shows the number of digits contained in <digits>; for example, if the <digits> value equals 100 or 4096, the <non_zero digit> value equals 3 or 4, respectively
- "<digits>" shows the number of data bytes to be sent; for example, if 4096 data bytes are to be sent, <digits> equals 4096 (see "Data Byte Size" below)
- "<8-bit data bytes>" is the data (i.e., DAC codes) sent to the AFG
- A typical example of a data block sending 8192 8-bit data bytes is:

  #48192<data bytes>

Data Byte Size

The DAC codes are transferred to the AFG as 16-bit integer values that meet the coding set by the IEEE 488.2 standard. Since IEEE 488.2 requires an 8-bit code, the 16-bit integer must be sent as 2 8-bit values for each 16-bit integer. Note that the AFG requires that the most significant bit of each 16-bit integer be sent first.

For example, to send a waveform segment consisting of 4096 DAC codes (4096 points), the actual number of "digits" and "8-bit data bytes" equals: 4096 * 2 = 8192.

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Program Example

This program shows how to store a waveform segment (i.e., points of an arbitrary waveform) into the AFG's segment memory. The waveform segment are sent as DAC codes using the Definite Length Block Data transfer method. The example generates a 4096 point 0 to +5 V positive going ramp.

1. Reset the AFG - *RST

2. Setup the AFG for Output -
   [SOURce:]FREQuency[:CW|FIXed] <*frequency*>
   [SOURce:]FUNCtion[:SHAPe] USER
   [SOURce:]VOLTage[:LEVel][:IMMediate][:AMPLitude] <*amplitude*>

3. Select the DAC Data Source -
   [SOURce:]ARBitrary:DAC:SOURce INTernal

   This command selects the source that transfers data to the DAC (see "Program Comments"). Use INTernal to transfer the data using the [SOURce:]LIST[1] subsystem.

4. Select the Waveform Segment -
   [SOURce:]LIST[:SEGMent]:SELect <*name*>

   Use either A, B, C, or D in <*name*> for the waveform segment.

5. Store the Waveform Segment as DAC Data -
   [SOURce:]LIST[:SEGMent]:VOLTage:DAC <*voltage_list*>

   This command stores the waveform segment into segment memory using DAC codes sent as Definite Length Block Data.

6. Generate the Output -
   [SOURce:]FUNCtion:USER <*name*>
   INITiate[:IMMediate]

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HP IBASIC Program Example (DACBLOK)

To transfer Definite Length Block Data to the AFG requires that the data sent with the [SOURce:]LIST[:SEGMent]:VOLTage:DAC command must be contiguous. To do this, send no carriage return (CR) and line feed (LF) before all the data is transferred.

```
1     !RE-SAVE“DACBLOK”
2     !This program downloads AFG amplitude data in the form of DAC codes
3     !(unsigned numbers). The data is sent in a IEEE-488.2 definite length
4     !block in 16-bit integer format. The waveform is a 4096 point ramp wave.
5     !
10    !Assign I/O paths between IBASIC and the E1340A.
20    ASSIGN @Afg TO 80910
30    ASSIGN @Afg1 TO 80910;FORMAT OFF !path for binary data
40    COM @Afg,@Afg1,INTEGER Waveform(1:4096)
50    !
60    !Set up error checking
70    ON INTR 8 CALL Errmsg
80    ENABLE INTR 8;2
90    OUTPUT @Afg;“*CLS”
100   OUTPUT @Afg;“*SRE 32”
110   OUTPUT @Afg;“*ESE 60”
120   !
130   !Call the subprogram which resets the AFG.
140   CALL Rst
150   !
160   !Set AFG parameters
170   OUTPUT @Afg;“SOUR:FREQ:FIX 1E3;”;!frequency
180   OUTPUT @Afg;“:SOUR:FUNC:SHAP USER;”;!function
190   OUTPUT @Afg;“:SOUR:VOLT:LEV:IMM:AMPL 5V” !scale amplitude
200   !
210   !Call subprogram which defines waveform segment A (ramp wave).
220   CALL Ramp_wave
230   !
240   !Select output sequence and initiate waveform
250   OUTPUT @Afg;“SOUR:FUNC:USER A”
260   OUTPUT @Afg;“INIT:IMM”          !wait-for-arm state
270   !
280   WAIT .1                         !allow interrupt to be serviced
290   OFF INTR 8
300   END
310   !
```


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```
320    SUB Ramp_wave
330  Ramp_wave:  !Subprogram which defines ramp waveform
340        COM @Afg,@Afg1,INTEGER Waveform(*)
350        FOR I=1 TO 4096              !calculate waveform points as dac
                                        codes
360            Waveform(I)=((I*.00122)/.0025)+2048
370        NEXT I
380        !
390        OUTPUT @Afg;"SOUR:ARB:DAC:SOUR INT"  !dac data source
                                                   (internal)
400        OUTPUT @Afg;"SOUR:LIST:SEGM:SEL A"!select segment name
410        OUTPUT @Afg USING "#,K";"SOUR:LIST:SEGM:VOLT:DAC #48192"
420        OUTPUT @Afg1;Waveform(*)   !8192 bytes: 4 digits
                                      (2 bytes/ampl point)
430        OUTPUT @Afg                !CR LF
440    SUBEND
450    !
460    SUB Rst
   •
   •
530    SUB Errmsg
   •
   •
```

C and QuickBASIC Program Versions

The C example program, DACBLOK.C, is in directory "CPROG" and the QuickBASIC example program, DACBLOK.BAS, is in directory "QBPROG" on the C and QuickBASIC example disk (part number E1340-10036).

Transferring Data in C

To transfer Definite Length Block Data to the AFG requires that the data sent with the [SOURce:]LIST[:SEGMent]:VOLTage:DAC command must be contiguous. To do this, send no carriage return (CR) and line feed (LF) before transferring all the data. The send_data function does this as follows (refer to the C function below):

1. Disable EOI and EOL using IOEOI (ISC, 0) and IOEOL (ISC, " ", 0), respectively. ISC contains the HP-IB select code, and the 0 and " " (NULL) values disables the carriage return (CR) and line feed (LF) to allow the AFG to receive a command string without a terminator.

2. Next, sent to the AFG the SCPI [SOURce:]LIST[1][:SEGment]:VOLTage:DAC command string using IOOUTPUTS (ADDR, commands, strlen(commands)). ADDR contains the AFG HP-IB address, commands contains the SCPI command string, and strlen(commands) contains the string length of commands. This enables the AFG to receive voltage data. Since CR or LF is disabled, the AFG holds execution until all the data is sent.

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3. Enable EOI and EOL using IOEOI (ISC, 1) and IOEOL (ISC, state, 2), respectively. The variable state contains the decimal codes for CR and LF. Although EOL and EOI are enabled, no CR and LF is sent until all voltage data transfer is completed (next step).

4. The DAC data values are sent next using the array Wave_seg in IOOUTPUTAB (ADDR, Wave_seg, num_bytes). Wave_seg contains the <8-bit data bytes>, num_bytes contains the value for the number of bytes to be transferred, and swap contains the swap value (see "Swapping the Data Bytes" later in this chapter). IOOUTPUTAB's main purpose is to transfer data as Definite Length Arbitrary Block Data. It automatically determines the "<non-zero digit>" and "<digits>" and sends the complete "#<non-zero digit><digits><8-bit data bytes>" block to the AFG.

   Since the DAC codes are in a 16-bit integer format, the programs send 2 "<8-bit data bytes>" for each DAC code; all values are sent in one data block. The number of data bytes transferred depends on the number in num_bytes.

5. After all the data is sent, the function sends blank data using IOOUTPUTS(ADDR,"",0) to terminate the data transfer with a CR LF. This lets the AFG know that it can receive a new command.

```
void   send_data(char *commands, int   *Wave_seg, int   num_bytes, int
swap)
{
        /* First disable EOI and EOL to send continuous data to the AFG;
then sent the data */
   IOEOI (ISC, 0);IOEOL (ISC, " ", 0);
   IOOUTPUTS (ADDR, commands, strlen(commands));

        /* Send the last command and data */
   IOOUTPUTAB(ADDR, Wave_seg, num_bytes, swap);

        /* Re-enable EOL and EOI for normal HP-IB operation; then send CR/LF */
   IOEOI (ISC, 1);IOEOL (ISC, state, 2);
   IOOUTPUTS(ADDR,"",0);
}
```


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Transferring Data in QuickBASIC

To transfer Definite Length Block Data to the AFG requires that the data sent with the [SOURce:]LIST[:SEGMent]:VOLTage:DAC command must be contiguous. To do this, send no carriage return (CR) and line feed (LF) before transferring all the data. The SendData routine does this as follows (refer to the QuickBASIC routine below):

1. Disable EOI and EOL using IOEOI (ISC&, 0) and IOEOL (ISC&, " ", 0), respectively. ISC& contains the HP-IB select code, and the 0 and " " (NULL) values disables the carriage return (CR) and line feed (LF) to allow the AFG to receive a command string without a terminator.

2. Next, sent to the AFG the SCPI [SOURce:]LIST[1][:SEGment]:VOLTage:DAC command string using IOOUTPUTS(ADDR&, Commands$, LEN(Commands$). ADDR& contains the AFG HP-IB address, Commands$ contains the SCPI command string, and LEN(Commands$) contains the string length of Commands$. This enables the AFG to receive voltage data. Since CR or LF is disabled, the AFG holds execution until all the data is sent.

3. Enable EOI and EOL using IOEOI(ISC&, 1) and IOEOL(ISC&, Endline$, LEN(Endline$)), respectively. The variable Endline$ contains the decimal codes for CR and LF. Although EOL and EOI are enabled, no CR and LF is sent until all voltage data transfer is completed (next step).

4. The DAC data values are sent next using the array WaveSeg%(1) in IOOUTPUTAB(ADDR&, SEG WaveSeg%(1), NumSize%, SwapSize%). WaveSeg% contains the <8-bit data bytes>, NumSize% contains the value for the number of bytes to be transferred, and SwapSize% contains the swap value (see "Swapping the Data Bytes" on the following page).

   IOOUTPUTAB's main purpose is to transfer data as Definite Length Arbitrary Block Data. It automatically determines the "<non-zero digit>" and "<digits>" and sends the complete "#<non-zero digit><digits><8-bit data bytes>" block to the AFG.

   Since the DAC codes are in a 16-bit integer format, the programs send 2 "<8-bit data bytes>" for each DAC code; all values are sent in one data block. The number of data bytes transferred depends on the number in NumSize%.

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5. After all the data is sent, the function sends blank data using IOOUTPUTS(ADDR&,“”,0) to terminate the data transfer with a CR LF. This lets the AFG know that it can receive a new command.

```
SUB SendData (Commands$, WaveSeg%(), NumSize%, SwapSize%)

Endline$ = CHR$(13) + CHR$(10)

' First disable EOI and EOL to send continuous data to the AFG; then send the last command
CALL IOEOI(ISC&, 0)
CALL IOEOL(ISC&, " ", 0)
CALL IOOUTPUTS(ADDR&, Commands$, LEN(Commands$))

    ' Send the data
CALL IOOUTPUTAB(ADDR&, SEG WaveSeg%(1), NumSize%, SwapSize%)

    ' Re-enable EOL and EOI for normal HP-IB operation; then send CR/LF
CALL IOEOI(ISC&, 1)
CALL IOEOL(ISC&, Endline$, LEN(Endline$))
CALL IOOUTPUTS(ADDR&, "", 0)

END SUB
```

Swapping the Data Bytes

The C and QuickBASIC programs used with a PC type computer sends the least significant bit (LSB) of the data byte first and the most significant bit (MSB) last. Thus, IOOUTPUTAB must swap the data bytes in order to send the LSB last. To do this, set swap in IOOUTPUTAB(ADDR, Wave_seg, num_bytes, swap) (C program) or SwapSize% in IOOUTPUTAB(ADDR&, SEG WaveSeg%(1), SwapSize%) (QuickBASIC program) to the size of the Wave_seg or WaveSeg% array type (not the size of the array). Since the DAC code is a 16-bit integer, the array type is an integer. The swap or SwapSize% value is thus the size of an integer (i.e., 2). This lets IOOUTPUTAB know when to swap the byte.

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Using the VXIbus Backplane

You can use the VXIbus Backplane to download or transfer segment data to the AFG.

Using the VXIbus Backplane to Download Segment Data

There are two ways to use the VXIbus backplane to download the data:

- downloading the list into memory to be executed later
- downloading directly to the DAC for immediate execution

Downloading Segment Data into Memory

This method downloads the segment data as DAC codes (see "Using DAC Data to Generate Waveforms" on page 109). The method transfers the codes as 16-bit integers in the Definite Length Arbitrary Block data format. The upper 4 bits of the integers must be set to 0.

Send the segment data directly into the AFG's register address 12 decimal (0C hex) offset in the AFG's A16 address space (see Appendix C for information on registers).

Downloading Directly into the DAC

This method immediately outputs the DAC data point when received. The DAC code received by the AFG sets the DAC to output to the received value. Send the DAC codes as 16-bit integers with the upper 4 bits set to 0.

Send the DAC data directly into the AFG's register with address 12 decimal (0C hex) offset in the AFG's A16 address space (see Appendix C for information on registers).

Program that Downloads and Executes Waveform Segments in Memory

This program shows how to download multiple waveform segments into the AFG's memory.

The example generates a 5 V sine wave and a 0 to +5 V triangle wave (see next figure). The commands are:

1. Reset the AFG - *RST
2. Setup the AFG for Output -
   [SOURce:]FREQuency[:CW|FIXed] <*frequency*>
   [SOURce:]FUNCtion[:SHAPe] USER
   [SOURce:]VOLTage[:LEVel][:IMMediate][:AMPLitude] <*amplitude*>

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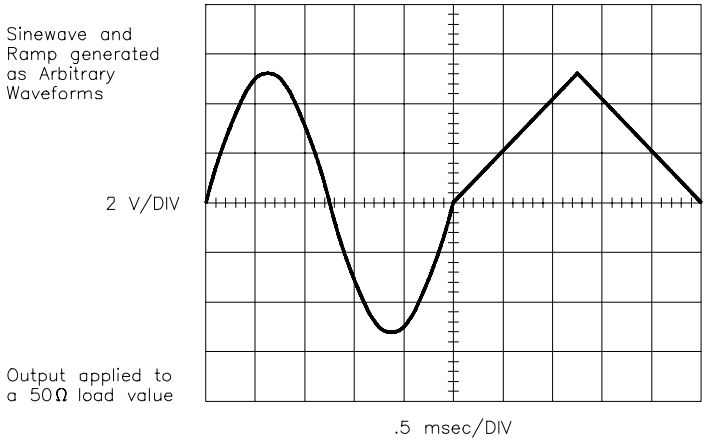

3. Select the DAC Data Source -
   [SOURce:]ARBitrary:DAC:SOURce INTernal

   This command selects the source that transfers data to the DAC (see "Program Comments"). Use INTernal to transfer the data using the [SOURce:]FUNCtion USER subsystem.

4. Setup the AFG to Store the First Waveform Segment -
   [SOURce:]ARBitrary:DOWNload <*source*>, <*dest*>, <*length*>

   The <*source*> is "VXI" for the VXIbus, the <*dest*> is the name of the waveform segment to receive the data (i.e., A, B, C, or D), and <*length*> is the segment size (i.e., 4096).

5. Wait Until All Commands are Executed - *OPC?

   This command allows the AFG to wait until it has executed all commands before the computer begins sending the data. If the computer sends the data too soon, it will be lost.

6. Setup the AFG to Store the Second Waveform Segment -
   [SOURce:]ARBitrary:DOWNload <*source*>, <*dest*>, <*length*>

   The <*source*> is "VXI" for the VXIbus, the <*dest*> is the name of the waveform segment to receive the data (i.e., A, B, C, or D), and <*length*> is the segment size (i.e., 4096).

7. Wait Until All Commands are Executed - *OPC?

   This command allows the AFG to wait until it has executed all commands before the computer begins sending the data. If the computer sends the data too soon, it will be lost.

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8. Generate, Download, and Store the First Waveform Segment as DAC Codes -

   This step stores the DAC codes of the Waveform Segment into memory. The command or downloading method used depends on the device that downloads the data. For example, the device may be an embedded controller like the HP E1480A V360/Controller. (You can also use the HP E1405A/E1406A Command Module or HP E1300A/E1301A Mainframe, but at a slower data transfer rate.)

9. Notify the AFG that Downloading is Completed -
   [SOURce:]ARBitrary:DOWNload:COMPlete

   Send this command to the AFG after all data is downloaded.

10. Generate, Download, and Store the Second Waveform Segment as DAC Codes -

    This step stores the DAC codes of the Waveform Segment into memory. The command or downloading method used depends on the device that downloads the data. For example, the device may be an embedded controller like the HP E1480A V360/Controller. (You can also use the HP E1405A/E1406A Command Module or HP E1300A/E1301A Mainframe, but at a slower data transfer rate.)

11. Notify the AFG that Downloading is Completed -
    [SOURce:]ARBitrary:DOWNload:COMPlete

    Send this command to the AFG after all data is downloaded.

12. Generate the Output -
    [SOURce:]FUNCtion:USER *<name>*
    INITiate[:IMMediate]

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HP IBASIC Program Example (VXIDOWN)

This program is similar to the DACBLOK program on page 115, except on how the data is transferred to the AFG. The program uses IBASIC to download the data using the VXIbus.

```
1     !RE-SAVE“VXIDOWN”
2     !This program generates an arbitrary waveform comprised of two
3     !waveform segments. The segment data (DAC codes) are transferred
4     !from IBASIC to the AFG’s input data register over the VXI backplane.
5     !This method of data transfer is recommended when amplitude data
6     !computation (by IBASIC) is not intensive, but fast downloading is
7     !required.
8     !
10    !Assign I/O path between IBASIC and the E1340A.
20    ASSIGN @Afg TO 80910
30    !
40    !Compute the E1340 base address in A16 address space. The base
50    !address is used with the AFG’s input data register offset to form
60    !the complete register address.
70    Base_addr=DVAL(“1FC000”,16)+(80*64)
80    !
90    COM @Afg,Base_addr,INTEGER Wave1(1:4096),INTEGER
      Wave2(1:4096)
100   !
110   !Set up error checking
120   ON INTR 8 CALL Errmsg
130   ENABLE INTR 8;2
140   OUTPUT @Afg;“*CLS”
150   OUTPUT @Afg;“*SRE 32”
160   OUTPUT @Afg;“*ESE 60”
170   !
180   !Call the subprogram which resets the AFG.
190   CALL Rst
200   !
210   !Set AFG parameters
220   OUTPUT @Afg;“SOUR:FREQ:FIX 10E3;”;!frequency
230   OUTPUT @Afg;“:SOUR:FUNC:SHAP USER;”;!function
240   OUTPUT @Afg;“:SOUR:VOLT:LEV:IMM:AMPL 5.1175V”  !scale
                                                      amplitude
250   !
260   !Call subprogram which defines waveform segments A and B.
270   CALL Sine_tri_wave
280   !
290   !Select output sequence and initiate waveform
300   OUTPUT @Afg;“SOUR:FUNC:USER AB”
310   OUTPUT @Afg;“INIT:IMM”          !wait-for-arm state
```

Continued on next page

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```
320   !
330   WAIT .1                          !allow interrupt to be serviced
340   OFF INTR 8
350   END
360   !
370   SUB Sine_tri_wave
380 Sine_tri_wave:  !Subprogram which defines and downloads waveforms
390       COM @Afg,Base_addr,INTEGER Wave1(*),INTEGER Wave2(*)
400       FOR I=1 TO 4096  !calculate waveform points as dac codes
410           Wave1(I)=(5*(SIN(2*PI*(I/4096)))/.0025)+2048
420       NEXT I
430       !
440       OUTPUT @Afg;"SOUR:ARB:DAC:SOUR INT" !dac data source
                                                    (internal)
450       OUTPUT @Afg;"SOUR:ARB:DOWN VXI,A,4096"!enable
                                                    download mode
460       OUTPUT @Afg;"*OPC?"          !allow AFG set up to complete
470       ENTER @Afg;Ready
480       FOR I=1 TO 4096
490           WRITEIO -9826,Base_addr+12;Wave1(I) !load waveform
                                                    points
500       NEXT I
510       OUTPUT @Afg;"*OPC?"          !allow downloading to complete
520       ENTER @Afg;Ready
530       OUTPUT @Afg;"SOUR:ARB:DOWN:COMP"!disable
                                                    downloading from VXIbus
540       !
550       FOR I=1 TO 2047    !calculate waveform points as dac codes
560           Wave2(I)=((I*.0024414)/.0025)+2048
570       NEXT I
580       FOR I=2048 TO 4096
590           Wave2(I)=(((4096-I)*.0024414)/.0025)+2048
600       NEXT I
610       !
620       OUTPUT @Afg;"SOUR:ARB:DAC:SOUR INT"!dac data source
                                                    (internal)
630       OUTPUT @Afg;"SOUR:ARB:DOWN VXI,B,4096"!enable
                                                    download mode
640       OUTPUT @Afg;"*OPC?"          !allow AFG set up to complete
650       ENTER @Afg;Ready
660       FOR I=1 TO 4096
670           WRITEIO -9826,Base_addr+12;Wave2(I)!load waveform
                                                    points
680       NEXT I
690       OUTPUT @Afg;"*OPC?"          !allow downloading to complete
700       ENTER @Afg;Ready
```

Continued on next page

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```
710        OUTPUT @Afg;"SOUR:ARB:DOWN:COMP"!disable
                                    downloading from VXIbus
720    SUBEND
730    !
740    SUB Rst
  •
  •
810    SUB Errmsg
  •
  •
```

C and QuickBASIC Program Version

The C example program, VXIDOWN.C, is in directory "CPROG" and the QuickBASIC example program, VXIDOWN.BAS, is in directory "QBPROG" on the C and QuickBASIC example disk (part number E1340-10036).

The C and QuickBASIC example programs use the HP E1405A/E1406A Command Module (version A.06.00 or above) or the HP E1300A/E1301A Mainframe (version A.06.00 or above) to download the data into memory. However, the command module/mainframe is only used to demonstrate the downloading method for C and QuickBASIC. A better method is to use an embedded controller. If you wish to use the HP E1405A/E1406A Command Module or HP E1300A/E1301A Mainframe to download data, use the method described in "Using Definite Length Blocks to Transfer Data" on page 113.

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Program to Download Directly to the DAC

This program shows how to download segment data directly to the DAC as DAC codes.

The program downloads waveform segments using the VXIbus. The example program generates 500, 4096 point triangle waves.

1. Reset the AFG - *RST
2. Setup the AFG for Output -
   [SOURce:]VOLTage[:LEVel][:IMMediate][:AMPLitude] <*amplitude*>
3. Turn Amplitude Correction Off -
   CALibration:STATe:AC OFF

   The AFG cannot correct the amplitude when transferring data directly to the DAC and thus must be turned off.
4. Select the DAC Data Source -
   [SOURce:]ARBitrary:DAC:SOURce VXI

   This command selects the source that transfers data to the DAC (see "Program Comments"). Use VXI to transfer the data directly to the DAC.
5. Wait Until All Commands are Executed - *OPC?

   This command allows the AFG to wait until it has executed all commands before the computer begins sending the data. If the computer sends the data too soon, it will be lost.
6. Generate and Download the DAC Codes -

   This step transfers the DAC codes to the DAC. The command or downloading method used depends on the device that downloads the data. For example, the device may be an embedded controller like the HP E1480A V360/Controller, or IBASIC installed in the HP E1300/E1301 Mainframe or HP E1405/E1406 Command Module. (You can also use an external HP-IB computer connected to the HP E1405A/E1406A Command Module or HP E1300A/E1301A Mainframe, but at a slower data transfer rate.)

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HP IBASIC Program Example (VXISRCE)

This program uses the input data register to download the data directly to the DAC over the VXIbus (see Appendix C for register programming information).

```
1     !RE-SAVE“VXISRCE”
2     !This program downloads dac codes to the AFG dac from the input
3     !data register. Corresponding amplitude points are output as the
4     !codes are received.
5     !
10    !Assign I/O path between IBASIC and the E1340A.
20    ASSIGN @Afg TO 80910
30    !
40    !Compute the E1340 base address in A16 address space. The base
50    !address is used with the input data register offset to form the
60    !complete register address.
70    Base_addr=DVAL(“1FC000”,16)+(80*64)
80    !
90    COM @Afg,Base_addr,INTEGER Waveform(1:4096)
100   !
110   !Set up error checking
120   ON INTR 8 CALL Errmsg
130   ENABLE INTR 8;2
140   OUTPUT @Afg;“*CLS”
150   OUTPUT @Afg;“*SRE 32”
160   OUTPUT @Afg;“*ESE 60”
170   !
180   !Call the subprogram which resets the AFG.
190   CALL Rst
200   !Set AFG parameters
210   OUTPUT @Afg;“SOUR:VOLT:LEV:IMM:AMPL 5.1175V” !scale amplitude
220   !
230   !Call subprogram which defines a triangle waveform.
240   CALL Triwave
250   !
260   WAIT .1                                    !allow interrupt to be serviced
270   OFF INTR 8
280   END
290   !
300   SUB Triwave
```

Continued on next page

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```
310  Triwave:  !Subprogram which defines a triangle waveform and
320            ! downloads it continuously to the DAC.
330       COM @Afg,Base_addr,INTEGER Waveform(*)
340       !
350       FOR I=1 TO 2047              !calculate waveform points as dac
                                       codes
360            Waveform(I)=((I*.0024414)/.0025)+2048
370       NEXT I
380       FOR I=2048 TO 4096
390            Waveform(I)=(((4096-I)*.0024414)/.0025)+2048
400       NEXT I
410       !
420       OUTPUT @AFG;"CAL:AC:STAT OFF"! turn ac cal off
430       OUTPUT @Afg;"SOUR:ARB:DAC:SOUR VXI" !dac data source
440       OUTPUT @Afg;"INIT:IMM"       !wait-for-arm state
450       OUTPUT @Afg;"*OPC?"          !allow AFG setup to complete
460       ENTER @Afg;Ready
470       LOOP
480            FOR I=1 TO 4096         !continually download dac codes
490                 WRITEIO -9826,Base_addr+12;Waveform(I)
500            NEXT I
510       END LOOP
520  SUBEND
530  !
540  SUB Rst
  •
  •
610  SUB Errmsg
  •
  •
```

C and QuickBASIC Program Version

The C example program, VXISRCE.C, is in directory "CPROG" and the QuickBASIC example program, VXISRCE.BAS, is in directory "QBPROG" on the C and QuickBASIC example disk (part number E1340-10036).

The C and QuickBASIC example programs use the HP E1405A/E1406A Command Module or HP E1300A/E1301A Mainframe (version A.06.00 or above) to download the data to the DAC. However, the command module/mainframe is only used to demonstrate the downloading method for C and QuickBASIC. A better method is to use an embedded controller.

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Program Comments

The following comments give additional details on the program examples in this chapter.

Amplitude Effects on DAC Codes

The AFG stores the DAC codes directly into memory. Thus, the amplitude setting has no affect on the codes. Unlike sending a voltage list, the output amplitude can be set to any of the values listed in Appendix B. The amplitude does not have to be ≥ to the maximum DAC code value.

Incorrect AFG Operation from Incorrect DAC Codes

The AFG requires that the data it receives must be correct, or it will not execute it correctly. Unlike using other data transfer methods, the AFG does not perform any error checking on the data when it is directly downloaded.

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Chapter Contents

This chapter describes the **Standard Commands for Programmable Instruments** (SCPI) command set and the **IEEE 488.2 Common Commands** for the HP E1340A Arbitrary Function Generator (AFG). Included in this chapter are the following sections:

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Command Types

Commands are separated into two types: IEEE 488.2 Common Commands and SCPI Commands.

Common Command Format

The IEEE 488.2 standard defines the Common Commands that perform functions like reset, self-test, status byte query, etc. Common Commands are four or five characters in length, always begin with the asterisk character (*), and may include one or more parameters. The command keyword is separated from the first parameter by a space character. Some examples of Common Commands are shown below:

*RST, *CLS, *ESE <*unmask*>, *OPC?, *STB?

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SCPI Command Format

The functions of the AFG are programmed using SCPI commands. SCPI commands are based on a hierarchical structure, also known as a tree system. In this system, associated commands are grouped together under a common node or root, thus, forming subtrees or subsystems. An example is the AFG's 'ARM' subsystem shown below.

```
ARM
    [:STARt|SEQuence[1]]
        [:LAYer[1]]
            :COUNt <number>
        :LAYer2
            :COUNt <number>
            :SLOPe <edge>
            :SOURce <source>
```

ARM is the root keyword of the command, :STARt|SEQuence1 is the second level keyword, :LAYer1 and :LAYer2 are third level keywords, and so on.

Command Separator

A colon (**:**) always separates one command keyword from a lower level command keyword as shown below:

```
ARM:LAY2:SOUR  EXT
```

Abbreviated Commands

The command syntax shows most commands as a mixture of upper and lower case letters. The upper case letters indicate the abbreviated spelling for the command. For shorter program lines, send the abbreviated form. For better program readability, you may send the entire command. The AFG will accept either the abbreviated form or the entire command.

For example, if a command's syntax contains the keyword COUNt, then COUN and COUNT are acceptable forms. Other forms of COUNt such as COU will generate an error.

You can use upper or lower case letters. Therefore, COUNT, coun, or Coun are all acceptable.

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Implied (Optional) Keywords

Implied or optional keywords are those which appear in square brackets ([ ]) in the command syntax. The brackets are not part of the command, and are not sent to the AFG. Suppose you send the following command:

```
ARM:COUN 100
```

In this case, the AFG responds as if you had executed the command as:

```
ARM:STARt:LAYer1:COUN 100
```

SCPI Command Parameters

The following information contains explanations and examples of the parameter types found in this chapter.

Parameter Types, Explanations, and Examples

- Numeric

  Accepts all commonly used decimal representations of numbers including optional signs, decimal points, and scientific notation:

  123, 123E2, -123, -1.23E2, .123, 1.23E-2, 1.23000E-01.

  Special cases include MINimum, MAXimum, and INFinity. The Comments section within the Command Reference will state whether a numeric parameter can also be specified in hex, octal, and/or binary:

  #H7B, #Q173, #B1111011

- Boolean

  Represents a single binary condition that is either true or false. Any non-zero value is considered true:

  ON, OFF, 1, 0

- Discrete

  Selects from a finite number of values. These parameters use mnemonics to represent each valid setting. An example is the ARM[:STARt]:LAYer2:SOURce <*source*> command where *source* can be EXTernal or IMMediate.

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- Arbitrary Block Program Data

  This parameter type is used to transfer a block of data in the form of bytes. The block of data bytes is preceded by a header which indicates either:
  1) the number of data bytes which follow (definite length block), or
  2) that the following data block will be terminated upon receipt of a New Line message with the EOI signal true (indefinite length block).

  The syntax for data in the blocks is as follows:

  Definite length block:

  #<non-zero digit><digit(s)><data byte(s)>

  Where the value of <non-zero digit> equals the number of <digit(s)>. The value of <digit(s)> taken as a decimal integer indicates the number of <data byte(s)> in the block.

  Indefinite length block:

  #0<data byte(s)><NL^END>

  Examples of sending 4 data bytes:

  #14<byte><byte><byte><byte>
  #3004<byte><byte><byte><byte>
  #0<byte><byte><byte><byte><NL^END>

Optional Parameters

Command parameters shown within square brackets ([ ]) are optional. The brackets are not part of the parameter, and are not sent to the AFG. If you do not specify a value for an optional parameter, the instrument chooses a default value.

For example, consider the ARM[:STARt][:LAYer[1]]:COUNt? [<MIN|MAX>] command. If you send the command without specifying a parameter, the present ARM[:STARt][:LAYer[1]]:COUNt value is returned. If you send the MIN parameter, the command returns the minimum count available. If you send the MAX parameter, the command returns the maximum count available. There must be a space between the command and the parameter.

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Querying Parameter Settings

Unless otherwise noted in the reference section, parameter settings can be queried by adding a question mark (?) to the command which set the parameter. For example:

```
SOUR:FREQ:FIX 20E3
```

sets the frequency to 20 kHz. The value can be queried by executing:

```
SOUR:FREQ:FIX?
```

The MINimum or MAXimum value of a parameter is determined as follows:

```
SOUR:FREQ:FIX? MIN
SOUR:FREQ:FIX? MAX
```

The minimum and maximum values returned are based on the settings of other AFG commands at that time.

SCPI Command Execution

The following information should be remembered when executing SCPI commands.

Command Coupling

Many of the AFG SCPI commands are value coupled. This means that sending a command can change parameter values set by previous commands. Often, this results in "Settings Conflict" errors when the program executes. To prevent these errors the AFG commands must be executed in a "coupling group". The coupling group and associated commands are listed in Appendix B, Table B-2.

Commands not in the coupling group must precede or follow commands in the coupling group. Executing uncoupled commands in a coupling group breaks the coupling and can cause a "Settings Conflict" error. Command queries (commands with a question mark) are uncoupled commands and should be executed before or after coupled commands.

Chapter 1 also contains information on executing coupled commands.

MIN and MAX Parameters in Coupling Groups

When MINimum or MAXimum is the parameter of a command in the coupling group, that command should be the last command executed in the group. Unlike other parameters that are set when an end-of-line indication is received, MIN and MAX are evaluated when the command is parsed. Thus, the value of MIN or MAX is based on the values of the other (coupling group) commands at that time. "Settings conflict" errors will occur if the current values are incompatible with an intended MIN or MAX value. As a result, MIN and MAX are **not recommended** for specifying the value of a parameter.

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Linking Commands

Linking IEEE 488.2 Common Commands.

Use a semicolon between the commands. For example:

```
*RST;*CLS;*OPC?
```

Linking Multiple SCPI Commands.

Use a semicolon (;) and a colon (:) to link commands within different subsystems. For example:

```
SOUR:ROSC:SOUR INT;:ARM:STAR:LAY1:COUN 20
```

Commands within the same subsystem are linked with a semicolon (;). For example:

```
ARM:STAR:LAY1:COUN 20;LAY2:COUN 5
```

Command Choices

Some commands are listed as two commands separated with a vertical bar (|). This means that either command name can be used. For example, use either ":CW" or ":FIXed" when ":CW | FIXed" is shown.

SCPI Command Reference

This section contains the SCPI commands for the HP E1340A Arbitrary Function Generator. Commands are listed alphabetically by subsystem and also within each subsystem. A command guide is printed in the top margin of each page. The guide indicates the first command listed on that page.

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ABORt

The ABORt command places the trigger subsystem in the idle state, regardless of any other settings. The command halts waveform generation, but keeps the output voltage at the value generated when ABORt was executed. Only another INITiate:IMMediate command will restart waveform output.

Subsystem Syntax

ABORt [no query]

Comments

- ABORt does not affect any other settings of the HP E1340A.
- The Pending Operation Flag set true by the INITiate:IMMediate command will be set false as a consequence of entering the trigger idle state. Subsequent *OPC, *OPC?, and *WAI commands will therefore complete immediately.
- **Executable when initiated:** Yes
- **Coupled command:** No
- **Related Commands:** *OPC, *OPC?, *WAI, INITiate:IMMediate
- ***RST Condition:** *RST places the HP E1340A in the trigger idle state, as if executing an ABORt command.

Example

Aborting a waveform

```
ABOR                    Place HP E1340A in idle state
```


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ARM

The ARM subsystem operates with the TRIGger subsystem to control the starting of waveform output as follows:

- The source and slope for arming (starting) waveform generation.
- The number of waveform start arms the HP E1340A will accept before the trigger system returns to the idle state.
- The number of repetitions of a waveform that will be output for each start arm accepted.

Subsystem Syntax

```
ARM
    [:STARt|SEQuence[1]]
        [:LAYer[1]]
            :COUNt <number>
        :LAYer2
            :COUNt <number>
            :SLOPe <edge>
            :SOURce <source>
```

[:STARt][:LAYer[1]] :COUNt

ARM[:STARt][:LAYer[1]]:COUNt <*number*> selects the number of waveform repetitions to be output for each start arm accepted.

Parameter Name	Parameter Type	Range of Values	Default Units
number	numeric	*see below* | MINimum | MAXimum	none
Ramp, Sine, Square, and Triangle Outputs: MINimum selects 1 repetition; MAXimum selects 65534 repetitions. 9.9E+37 is equivalent to INFinity. **Arbitrary Waveform Output:** MINimum selects 1 repetition. If SOURce:FUNCtion:USER A | B | C | D | HOP_AB is selected, MAXimum selects 65534 repetitions. If SOURce:FUNCtion:USER AB is selected, MAXimum selects 32767 repetitions. If SOURce:FUNCtion:USER ABCD is selected, MAXimum selects 16383 repetitions.			

Comments

- Use the ABORt command to terminate the output when ARM:STARt:LAYer1:COUNt is set to INFinity.
- **Executable when initiated:** Query form only
- **Coupled command:** Yes
- **Related Commands:** ABORt
- ***RST Condition:** ARM:STARt:LAYer1:COUNt INFinity

Example

Setting waveform repetitions per arm

```
ARM:COUN 10                    Set 10 repetitions/arm
```


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[:STARt]:LAYer2 :COUNt

ARM[:STARt]:LAYer2:COUNt <*number*> specifies the number of waveform start arms the HP E1340A will accept after an INITiate:IMMediate command before returning the trigger system to the idle state.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
number	numeric	1 | 9.9e37 | INFinity| MINimum | MAXimum	none
MINimum and MAXimum select 1 arm. 9.9E+37 is equivalent to INFinity.			

Comments

- If ARM:STARt:LAYer2:COUNt 1 is set, then ARM:STARt:LAYer2:SOURce must be set to IMMediate. If ARM:STARt:LAYer2:COUNt INFinity is set, ARM:STARt:LAYer2:SOURce must be set to EXTernal.
- **Executable when initiated:** Query form only
- **Coupled command:** Yes
- **Related Commands:** ABORt, INITiate:IMMediate, ARM:STARt:LAYer2:SOURce
- ***RST Condition:** ARM:STARt:LAYer2:COUNt 1

Example

Setting the start arm count

```
ARM:LAY2:COUN INF;SOUR EXT      Start arm count is infinity, and
                                source is front panel "Aux In" BNC
```

[:STARt]:LAYer2 :SLOPe

ARM[:STARt]:LAYer2:SLOPe <*edge*> selects the edge (rising or falling) on the HP E1340A's front panel "Aux In" BNC which starts waveform generation. This edge is significant only with ARM:STARt:LAYer2:SOURce set to EXTernal. The programmed value is retained but not used when other sources are selected.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
edge	discrete	NEGative | POSitive	none

Comments

- **Executable when initiated:** Query form only
- **Coupled command:** Yes
- **Related Commands:** ARM:STARt:LAYer2:SOURce
- ***RST Condition:** ARM:STARt:LAYer2:SLOPe POSitive

Example

Setting the start arm slope

```
ARM:LAY2:SLOP NEG               Set negative start arm slope
```


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[:STARt]:LAYer2 :SOURce

ARM[:STARt]:LAYer2:SOURce <*source*> selects the source that will start waveform output. The available sources are:

EXTernal: The HP E1340A's front panel "Aux In" BNC connector.

IMMediate: Immediate arming. An arm is internally generated two to three reference oscillator cycles after the start trigger sequence enters the wait-for-arm state.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
source	discrete	EXTernal | IMMediate	none

Comments

- The "Aux In" BNC is a multiple-use input: for FSK control, for waveform hopping control, as a reference oscillator source, for reference oscillator gating, or as a start arm source. Only one of these uses may be active at any time.
- If ARM:STARt:LAYer2:SOURce IMMediate is set, then ARM:STARt:LAYer2:COUNt must be set to 1. If ARM:STARt:LAYer2:SOURce EXTernal is set, ARM:STARt:LAYer2:COUNt must be set to INFinity.
- The ARM:STARt:LAYer2:SLOPe command selects the active edge for the front panel "Aux In" BNC when used as the start arm source.
- **Executable when initiated:** Query form only
- **Coupled command:** Yes
- **Related Commands:** ARM:STARt:LAYer2:COUNt, ARM:STARt:LAYer2:SLOPe
- ***RST Condition:** ARM:STARt:LAYer2:SOURce IMMediate

Example

Setting the start arm source

```
ARM:LAY2:SOUR EXT;COUN INF      Start arm source is front panel
                                "Aux In" BNC, and count is infinity
```


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CALibration

The CALibration subsystem has commands that calibrates the HP E1340A. The subsystem also includes commands to prevent and detect accidental or unauthorized calibration of the HP E1340A.

Subsystem Syntax

```
CALibration
    :AC
        :BEGin                          [no query]
        :POINt? <value>                 [query only]
    :DATA
        :AC <block>
        [:DC] <block>
    [:DC]
        :BEGin                          [no query]
        :POINt? <value>                 [query only]
    :STATe
        :AC <state>
```

:AC:BEGin

CALibration:AC:BEGin starts the AC calibration procedure for the HP E1340A. It sets the HP E1340A up for the first of the measurements in the procedure. See the "Calibration" section of the *HP E1340A Service Manual* for detailed information on the use of this command.

Comments

- Most of the HP E1340A's commands cannot be executed while calibration is in progress. The *RST command may be used to prematurely terminate the calibration procedure without affecting the stored calibration constants.
- **Executable when initiated:** No
- **Coupled command:** No
- **Related commands:** CALibration:AC:POINt
- ***RST Condition:** none

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:AC:POINt

CALibration:AC:POINt <*value*> takes the measured value for the current AC calibration point, computes needed calibration constants, and sets up the HP E1340A for the next measurement. Each calibration constant is checked for validity when it is computed. When all measurements and computations are completed, the constants are stored in the HP E1340A's non-volatile calibration memory.

The *RST command should be sent after completing the calibration procedure to restore normal operation.

See the "Calibration" section of the *HP E1340A Service Manual* for detailed information on the use of this command.

Comments

- Most of the HP E1340A's commands cannot be executed while calibration is in progress. The *RST command may be used to prematurely terminate the calibration procedure without affecting the stored calibration constants.
- **Executable when initiated:** No
- **Coupled command:** No
- **Related commands:** CALibration:AC:BEGin
- ***RST Condition:** none

:DATA:AC

CALibration:DATA:AC <*block*> transfers the AC portion of the HP E1340A's calibration constants in IEEE-488.2 arbitrary block program data format. The query form returns this portion of the calibration constants in IEEE-488.2 definite block data format. See the "Calibration" section of the *HP E1340A Service Manual* for detailed information on the use of this command.

Comments

- **Executable when initiated:** No
- **Coupled command:** No
- **Related commands:** none
- ***RST Condition:** unaffected

:DATA[:DC]

CALibration:DATA[:DC] <*block*> transfers the DC portion of the HP E1340A's calibration constants in IEEE-488.2 arbitrary block program data format. The query form returns the current DC portion of the calibration constants in IEEE-488.2 definite block data format. See the "Calibration" section of the *HP E1340A Service Manual* for detailed information on the use of this command.

Comments

- **Executable when initiated:** No
- **Coupled command:** No
- **Related commands:** none
- ***RST Condition:** unaffected

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[:DC]:BEGin

CALibration[:DC]:BEGin starts the DC calibration procedure for the HP E1340A. It sets the HP E1340A up for the first of the measurements in the procedure. See the "Calibration" section of the *HP E1340A Service Manual* for detailed information on the use of this command.

Comments

- Most of the HP E1340A's commands cannot be executed while calibration is in progress. The *RST command may be used to prematurely terminate the calibration procedure without affecting the stored calibration constants.
- **Executable when initiated:** No
- **Coupled command:** No
- **Related commands:** CALibration:DC:POINt
- ***RST Condition:** none

[:DC]:POINt

CALibration[:DC]:POINt <*value*> takes the measured value for the current DC calibration point, computes needed calibration constants, and sets up the HP E1340A for the next measurement. Each calibration constant is checked for validity when it is computed. When all measurements and computations are completed, the constants are stored in the HP E1340A's non-volatile calibration memory.

The *RST command should be sent after completing the calibration procedure to restore normal operation.

See the "Calibration" section of the *HP E1340A Service Manual* for detailed information on the use of this command.

Comments

- Most of the HP E1340A's commands cannot be executed while calibration is in progress. The *RST command may be used to prematurely terminate the calibration procedure without affecting the stored calibration constants.
- **Executable when initiated:** No
- **Coupled command:** No
- **Related commands:** CALibration:DC:BEGin
- ***RST Condition:** none

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:STATe:AC

CALibration:STATe:AC <*state*> specifies whether AC amplitude correction using the calibration constants is enabled or disabled. If STATe is OFF, AC correction is disabled. If STATe is ON, AC correction is enabled.

AC amplitude correction is only possible when SOURce:ARBitrary:DAC:SOURce is set to INTernal and the current reference oscillator frequency is 42.94967296 MHz, either internal or external. CALibration:STATe:AC must be set to OFF when SOURce:ARBitrary:DAC:SOURce VXI is set or when a different external reference oscillator frequency is selected.

CAUTION **The HP E1340A uses an active amplitude correction technique, boosting the output signal to compensate for filter and other roll-offs. When waveform generation at high frequencies is halted either because ARM:LAYer1:COUNt cycles have been generated, or because an ABORt command was executed, filter loss disappears, and the output level may exceed the level specified by SOURce:VOLTage:LEVel:IMMediate:AMPLitude. It is recommended that AC amplitude correction be used only for continuous output.**

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
state	boolean	OFF | 0 | ON | 1	none

Comments

- **Executable when initiated:** Query form only
- **Coupled command:** Yes
- **Related commands:** SOURce:ROSCillator:FREQuency:EXTernal
- ***RST Condition:** CALibration:STATe:AC ON

Example

Disabling AC amplitude correction

```
CAL:STAT:AC OFF                    Disable amplitude correction
```


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INITiate

The INITiate subsystem initiates the trigger subsystem and prepares the HP E1340A for waveform generation. Once initiated, a start arm received from the programmed arm source (ARM:STARt:SOURce command) starts the waveform output.

For frequency sweeping, the initial waveform frequency is the STARt frequency when SOURce:SWEep:DIRection UP is set, or the STOP frequency when SOURce:SWEep:DIRection DOWN is set.

Subsystem Syntax

```
INITiate
    [:IMMediate]                    [no query]
```

[:IMMediate]

INITiate[:IMMediate] initiates the trigger system. Waveform generation begins immediately if ARM:STARt:SOURce IMMediate is set; otherwise, waveform generation begins when the first start arm is received. Only the ABORt and *RST commands or a Device Clear will halt waveform generation.

This command is an overlapped command as described by IEEE-488.2, Section 12. The exit from the idle state caused by INITiate:IMMediate shall cause its Pending Operation Flag to be set true. This Pending Operation Flag will be set false when the idle state is re-entered.

Comments

- Use the ABORt command to prematurely halt the waveform generation and place the trigger system in the idle state.
- Executing this command when SOURce:FUNCtion:SHAPe DC is set, when SOURce:ARBitrary:DAC:SOURce is not set to INTernal, or with the trigger system not in the idle state generates error -123, "Init ignored".
- **Executable when initiated:** No
- **Coupled command:** No
- **Related Commands:** *OPC, *OPC?, *RST, *WAI, ABORt, ARM subsystem, TRIGger subsystem
- ***RST Condition:** The trigger system is in the idle state.

Example

Initiating waveform generation

```
INIT                                *Initiate waveform generation*
```


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OUTPut

The OUTPut subsystem controls the characteristics of the output waveform. The subsystem sets the output source impedance, and enables or disables the output.

Subsystem Syntax

```
OUTPut
    :IMPedance <impedance>
    :LOAD <load>
```

:IMPedance

OUTPut:IMPedance <*impedance*> sets the HP E1340A's output impedance.

Since the HP E1340A only provides 50Ω output impedance, there is no need to send this command. It is provided for SCPI compatibility only.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
impedance	numeric	50 MINimum | MAXimum	Ohms
MINimum and MAXimum select 50Ω output impedance.			

Comments

- Impedance values between 25 and 62.5 will be accepted and rounded to 50 Ω. Values outside that range will cause error -222,"Argument out of range" to occur.
- **Executable when initiated:** Yes
- **Coupled command:** Yes
- **Related commands:** OUTPut:LOAD
- ***RST Condition:** OUTPut:IMPedance 50

Example

Querying output impedance

```
OUTP:IMP?                    50 will be returned with this query
```


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:LOAD

OUTPut:LOAD <*load*> indicates whether the actual load applied to the HP E1340A's "Aux Out" BNC is either matched to the output impedance specified by OUTPut:IMPedance or is an open circuit. The output voltage into an open circuit is twice that into a matched load. Setting OUTPut:LOAD INFinity compensates for this effect so that the SOURce:LIST:SEGMent:VOLTage and SOURce:VOLTage:LEVel:IMMediate:AMPLitude and OFFSet commands will output the specified voltages into an open circuit.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
load	numeric	50 | 9.9E+37 | INFinity | MINimum | MAXimum	Ohms
MINimum and MAXimum both select 50Ω load impedance. Use 9.9E+37 or INFinity to indicate an open circuit output.			

Comments

- **Executable when initiated:** Query form only
- **Coupled command:** Yes
- **Related commands:** OUTPut:IMPedance, SOURce:LIST subsystem, SOURce:VOLTage subsystem
- ***RST Condition:** OUTPut:LOAD 50

Example

Indicating open circuit output load

```
OUTP:LOAD INF                    Indicate open circuit
```


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[SOURce:]ARBitrary

The [SOURce:]ARBitrary subsystem controls:

- The DAC data source.
- Direct downloading of DAC data to the waveform segment memory.

Subsystem Syntax

```
[SOURce:]
    ARBitrary
        :DAC
            :SOURce <source>
        :DOWNload <source>,<dest>,<length>      [no query]
            :COMPlete                           [no query]
```

:DAC:SOURce

[SOURce:]ARBitrary:DAC:SOURce <*source*> selects the DAC's data source. The available sources are:

INTernal: The waveforms specified by the SOURce:FUNC or SOURce:FUNC:USER commands.

VXI: The VXIbus data transfer bus.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
source	discrete	INTernal | VXI	none

Comments

- When driving the DAC from the VXIbus data transfer bus, the address for writing the data is offset 12 decimal (0C hex) in the HP E1340A's A16 address space.
- Setting the DAC data source to a setting other than INTernal disables the ARM subsystem, the SOURce subsystem except for the SOURce:ARBitrary and SOURce:VOLTage subsystems, and the TRIGger subsystem. The HP E1340A immediately outputs each DAC data point when received. The DAC data must be provided as integer numbers between 0 and 4095; 0 generates negative full scale output, 4095 generates positive full scale. The SOURce:VOLTage:LEVel:IMMediate:AMPLitude specifies the positive full-scale output voltage, and must be specified in terms of volts or volts peak (V or VPK).
- **Executable when initiated:** Query form only
- **Coupled command:** Yes
- **Related commands:** SOURce:VOLTage:LEVel:IMMediate:AMPLitude
- ***RST Condition:** SOURce:ARBitrary:DAC:SOURce INTernal

Example

Setting the DAC data source

```
ARB:DAC:SOUR VXI        Select VXI A16 address space as data source
```


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:DOWNload

[SOURce:]ARBitrary:DOWNload <*source*>,<*dest*>,<*length*> enables the direct download mode to the waveform segment memory. It selects the download source, waveform segment name, and number of points. The available download sources are:

EEPRom<n>: EEPRom1 through EEPRom16, where <n> selects which block of the built-in waveform EPROM to use. These blocks contain 4096 points of the following waveforms:

EEPRom1: Sine wave

EEPRom2: Triangular wave

EEPRom3: Sin(x)/x for 8.25 radians

EEPRom4: Haversine

EEPRom5: Square wave

EEPRom6: First ten terms of a square wave

EEPRom7: First four terms of a square wave

EEPRom8: Falling ramp

EEPRom9: First 20 terms of a falling ramp

EEPRom10: Rising ramp

EEPRom11: First 20 terms of a rising ramp

EEPRom12: White noise

EEPRom13: Modulated white noise

EEPRom14: A 3rd, 4th, 5th harmonic chord

EEPRom15: 8 cycles of a linear rising sine wave

EEPRom16: Positive half-cycle sine wave

VXI: The VXIbus data transfer bus.

Waveform Data

The waveform data consists of a single 16-bit word for each voltage point (only 12 bits are used), with zero representing negative full scale and 4095 representing positive full scale. The most significant four bits of each 16-bit word are not used and must be zero.

With SOURce:VOLTage:LEVel:IMMediate AMPLitude 5.1175 V set and a matched output load, the least significant bit (LSB) represents 2.5 mV.

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When downloading waveform segment data from the VXIbus data transfer bus, the address for writing the data is offset 12 decimal (0C hex) in the HP E1340A's A16 address space.

Parameter Name	Parameter Type	Range of Values	Default Units
source	discrete	EEPRom1 through EEPRom16 | VXI	none
dest	char	A | B | C | D	none
length	numeric	4096 | MINimum | MAXimum	none

Comments

- When downloading from the VXIbus and downloading is complete, use the SOURce:ARBitrary:DOWNload:COMPlete command to restore normal operation. This command should not be sent when downloading from the built-in waveform EPROM blocks.
- No error checking is performed on downloaded data. Similarly, the number of points sent is not checked against the length specified. Erratic operation may occur if invalid data is downloaded.
- Waveform segment contents are unspecified at power-on and must be loaded before the segment may be output.
- **Executable when initiated:** No
- **Coupled command:** No
- **Related Commands:** SOURce:ARBitrary:DOWNload:COMPlete, SOURce:VOLTage:LEVel:IMMediate:AMPLitude
- ***RST Condition:** downloading disabled

Example

Download 4096 points from the VXI backplane to waveform segment "C"

```
ARB:DOWN VXI,C,4096          Set up for download
download data
ARB:DOWN:COMP                Indicate download complete
```

Example

Download 4096 points from EEPROM block 3 (Sine(x)/x) to waveform segment "C"

```
ARB:DOWN EEPR3,C,4096        Set up for download
```


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:DOWNload :COMPlete

[SOURce:]ARBitrary:DOWNload:COMPlete disables direct downloading from VXIbus mode. Send it when VXIbus downloading is complete.

Comments

- **Executable when initiated:** No
- **Coupled command:** No
- **Related Commands:** SOURce:ARBitrary:DOWNload
- ***RST Condition:** downloading disabled

Example

Download 4096 points from the VXI backplane to waveform segment "C"

```
ARB:DOWN VXI,C,4096          Set up for download
download data
ARB:DOWN:COMP                Indicate download complete
```


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[SOURce:]FREQuency

The [SOURce:]FREQuency subsystem controls the HP E1340A's frequency generator.

The generator uses a direct digital synthesis (NCO) technique to generate the specified frequencies. It has an upper frequency limit of the reference oscillator frequency multiplied by .468749999767 and has a resolution of .01 Hz when used with the built-in 42.94 MHz reference oscillator.

Coupling Rules

The swept commands STARt, STOP, CENTer, and SPAN are coupled commands. When sending these commands, the following rules apply:

- If either STARt or STOP is sent singly, the value of the other is preserved, but the CENTer and SPAN values will change according to the following equations:

  CENTer = (STARt + STOP)/2
  SPAN = STOP - STARt

- If either CENTer or SPAN is sent singly, the value of the other is preserved, but the STARt and STOP values will change according to the following equations:

  STARt = CENTer - (SPAN/2)
  STOP = CENTer + (SPAN/2)

- If any two commands are sent as part of a frequency-coupled group within a single program message, then these two will be set as specified, and the other two will change. If more than two are sent in the group, the sweep will be determined by the *last* two received.

When MINimum and MAXimum are used with these commands, the values that will be set are the minimum and maximum values that will not cause any of the STARt, STOP, CENTer, and SPAN values to go beyond the minimum and maximum possible frequencies, given the coupling equations above. For example, if SPAN is currently set to 1 MHz, FREQuency:CENTer MINimum would set 500 kHz. An exception to this rule exists, however: since the minimum SPAN is .01 Hz per sweep point (assuming the internal reference oscillator), a command string such as FREQuency:CENTer 0;SPAN MINimum has no valid value for SPAN, and will attempt to set the STARt frequency to a negative value. Similarly, FREQuency:STARt 15e6;STOP MINimum will attempt to set STOP to value greater than 15 MHz.

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The minimum possible frequency is 0 Hz. The maximum possible frequency depends on the frequency of the currently selected reference oscillator source (SOURce:ROSCillator:SOURce) and the waveform shape (SOURce:FUNCtion:SHAPe), according to the following rules:

- **Sine Wave Output:** the maximum possible frequency is the current reference oscillator frequency multiplied by .34924596548 (15 MHz when the 42.94967296 MHz internal reference oscillator is used).
- **Square Wave, Ramp, and Triangle Outputs:** the maximum possible frequency is the current reference oscillator frequency multiplied by 0.0232830643654 (1 MHz when the 42.94967296 MHz internal reference oscillator is used).
- **SOURce:FUNC:SHAPe:USER:** the maximum possible frequency depends upon how many segments are being output. For SOURce:FUNCtion:USER A | B | C | D | HOP_AB, only one segment is output, and the maximum possible frequency is the reference oscillator frequency multiplied by .34924596548 (15 MHz when the 42.94967296 MHz internal reference oscillator is used). For SOURce:FUNCtion:USER AB, two segments are output, and the maximum possible frequency is half the above value. For SOURce:FUNCtion:USER ABCD, four segments are output, and the maximum possible frequency is one-fourth the above value.
- Waveforms in the HP E1340A are generated by indexing through 4,096 points of memory data (8,192 for SOURce:FUNCtion:USER AB or 16,384 for SOURce:FUNCtion:USER ABCD) within the specified waveform period. At the frequency of (reference oscillator frequency / memory points) each point is output for exactly one reference oscillator period. At lower frequencies, some or all points are output for multiple clock periods, with all points being output for the same number of clock periods at frequencies that are a power of two (2, 4, 8, etc.) less than the above. At higher frequencies, some points are skipped on each repetition.

Subsystem Syntax

```
[SOURce:]
    FREQuency
        :CENTer <center_freq>
        [:CW|:FIXed] <frequency>
        :FSKey <frequency1>,<frequency2>
        :MODE <mode>
        :SPAN <freq_span>
        :STARt <start_freq>
        :STOP <stop_freq>
```


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:CENTer

[SOURce:]FREQuency:CENTer <*center_freq*> sets the center frequency for a frequency-swept waveform.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
center_freq	numeric	*see below* | MINimum | MAXimum	Hz
The legal range for *center_freq*, as well as the MINimum and MAXimum values, are context-dependent. See the section "Coupling Rules" at the beginning of the SOURce:FREQuency subsystem for a description of the coupling between STARt, STOP, CENTer, and SPAN.			

Comments

- **Executable when initiated:** Query form only
- **Coupled command:** Yes
- **Related Commands:** SOURce:FREQuency:MODE, SPAN, STARt, and STOP, SOURce:FUNCtion:SHAPe, SOURce:ROSCillator
- ***RST Condition:** SOURce:FREQuency:CENTer 7.5 MHz

Example

Setting the center frequency

```
FREQ:CENT 1E3                    Set center frequency to 1000 Hz
```

[:CW|:FIXed]

[SOURce:]FREQuency[:CW|:FIXed] <*frequency*> selects the non-swept waveform frequency.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
frequency	numeric	*see below* | MINimum | MAXimum	Hz
MINimum selects 0 Hz. MAXimum selects the current reference oscillator frequency multiplied by 0.468749999767. The above values bound the legal range for *frequency*.			

Comments

- **Executable when initiated:** Query form only
- **Coupled command:** Yes
- **Related Commands:** SOURce:FREQuency:MODE, SOURce:FUNCtion:SHAPe, SOURce:ROSCillator
- ***RST Condition:** SOURce:FREQuency:FIXed 10 kHz

Example

Setting the waveform frequency

```
FREQ 1E3                         Set frequency to 1000 Hz
```


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:FSKey

[SOURce:]FREQuency:FSKey <*frequency1*>,<*frequency2*> sets the two waveform frequencies for frequency-shift keying. A TTL-compatible high level on the "Aux In" BNC generates *frequency1*; a TTL-compatible low level generates *frequency2*.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
frequency1 *frequency2*	numeric	*see below* | MINimum | MAXimum	Hz
MINimum selects 0 Hz. MAXimum selects the current reference oscillator frequency multiplied by 0.468749999767. The above values bound the legal range for *frequency1* and *frequency2*.			

Comments

- **Executable when initiated:** Query form only
- **Coupled command:** Yes
- **Related Commands:** SOURce:FREQuency:MODE, SOURce:FUNCtion:SHAPe and USER, SOURce:ROSCillator
- ***RST Condition:** SOURce:FREQuency:FSKey 10 kHz, 15 MHz

Example

Setting the frequency-shift frequencies

```
FREQ:FSK 1E6,1 KHZ          Set 1 MHz and 1 kHz frequencies
```

:MODE

[SOURce:]FREQuency:MODE <*mode*> determines which set of commands control the frequency subsystem. The settings have the following meanings:

CW or FIXed: Selects single-frequency mode. SOURce:FREQuency:CW|FIXed selects the waveform frequency. CW and FIXed are equivalent.

FSKey: Selects frequency shift keying mode. SOURce:FREQuency:FSKey activates the mode, and TTL levels on the HP E1340A's front panel "Aux In" BNC are used to toggle between the two waveform frequencies.

SWEep: Selects frequency sweep mode. SOURce:FREQuency:CENTer, SPAN, STARt and STOP commands set the frequency range. The SOURce:SWEep subsystem controls the sweep.

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Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
mode	discrete	CW | FIXed | FSKey | SWEep	none

Comments

- The "Aux In" BNC is a multiple-use input: for FSK control, for waveform hopping control, as a reference oscillator source, for reference oscillator gating, or as a start arm source. Only one of these uses may be active at any time.
- **Executable when initiated:** Query form only
- **Coupled command:** Yes
- **Related Commands:** SOURce:FREQuency subsystem, SOURce:SWEep subsystem
- ***RST Condition:** SOURce:FREQuency:MODE FIXed

Example

Setting frequency sweep mode

```
FREQ:MODE SWEep          Set frequency sweep mode
```

:SPAN

[SOURce:]FREQuency:SPAN *<freq_span>* sets the frequency span for a frequency-swept waveform.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
freq_span	numeric	*see below* | MINimum | MAXimum	Hz
The legal range for *freq_span*, as well as the MINimum and MAXimum values, are context-dependent. See the section “Coupling Rules” at the beginning of the SOURce:FREQuency subsystem for a description of the coupling between STARt, STOP, CENTer, and SPAN.			

Comments

- **Executable when initiated:** Query form only
- **Coupled command:** Yes
- **Related Commands:** SOURce:FREQuency:CENTer, MODE, STARt, and STOP, SOURce:FUNCtion:SHAPe, SOURce:ROSCillator
- ***RST Condition:** SOURce:FREQuency:SPAN 15.0 MHz

Example

Setting the frequency span

```
FREQ:SPAN 1E3            Set frequency span to 1000 Hz
```


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:STARt

[SOURce:]FREQuency:STARt <*start_freq*> sets the starting frequency for a frequency-swept waveform.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
start_freq	numeric	*see below* | MINimum | MAXimum	Hz
The legal range for *start_freq*, as well as the MINimum and MAXimum values, are context-dependent. See the section "Coupling Rules" at the beginning of the SOURce:FREQuency subsystem for a description of the coupling between STARt, STOP, CENTer, and SPAN.			

Comments

- **Executable when initiated:** Query form only
- **Coupled command:** Yes
- **Related Commands:** SOURce:FREQuency:CENTer, MODE, SPAN, and STOP, SOURce:FUNCtion:SHAPe, SOURce:ROSCillator
- ***RST Condition:** SOURce:FREQuency:STARt 0.0 Hz

Example

Setting the starting frequency

```
FREQ:STAR 1 KHZ                    Set starting frequency to 1000 Hz
```

:STOP

[SOURce:]FREQuency:STOP <*stop_freq*> sets the stopping frequency for a frequency-swept waveform.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
stop_freq	numeric	*see below* | MINimum | MAXimum	Hz
The legal range for *stop_freq*, as well as the MINimum and MAXimum values, are context-dependent. See the section "Coupling Rules" at the beginning of the SOURce:FREQuency subsystem for a description of the coupling between STARt, STOP, CENTer, and SPAN.			

Comments

- **Executable when initiated:** Query form only
- **Coupled command:** Yes
- **Related Commands:** SOURce:FREQuency:CENTer, MODE, SPAN, and STARt, SOURce:FUNCtion:SHAPe, SOURce:ROSCillator
- ***RST Condition:** SOURce:FREQuency:STOP 15.0 MHz

Example

Setting the stopping frequency

```
FREQ:STOP 1E3                      Set stopping frequency to 1000 Hz
```


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[SOURce:]FUNCtion

The [SOURce:]FUNCtion subsystem controls which waveform shape (arbitrary, sinusoid, etc.) the HP E1340A generates. For arbitrary waveform generation, the subsystem controls which of the seven possible segment sequences are selected.

Subsystem Syntax

```
[SOURce:]
    FUNCtion
        [:SHAPe] <shape>
        :USER <name>
```

[:SHAPe]

[SOURce:]FUNCtion[:SHAPe] <*shape*> selects what waveform shape the HP E1340A generates, shown as follows:

DC: Generates a DC output voltage.

RAMP: Generates a stepped ramp. The SOURce:RAMP subsystem controls the polarity.

SINusoid: Generates a sinusoidal voltage.

SQUare: Generates a square wave.

TRIangle: Generates a stepped triangle wave.

USER: Generates an arbitrary waveform. The SOURce:FUNCtion:USER command selects the segment sequence to be generated.

Note Selecting a shape other than DC or USER causes the voltage data contained in waveform segment "D" to be overwritten by the voltage data for the selected waveform shape. Segment "D" must be reloaded before it can be output as part of a segment sequence.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
shape	discrete	DC | RAMP | SINusoid | SQUare | TRIangle | USER	none

Comments

- **For the DC function:** The voltage level is specified by SOURce:VOLTage:LEVel:IMMediate:AMPLitude.

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- **For the RAMP, SINusoid, SQUare, TRIangle, and USER functions:**
  - Use SOURce:VOLTage:LEVel:IMMediate:AMPLitude to set output amplitude. For arbitrary (USER) waveforms, this command specifies the full-scale output voltage.
  - SOURce:VOLTage:LEVel:IMMediate:OFFSet specifies the offset voltage.
  - The SOURce:FREQuency subsystem specifies the signal frequency for all waveform shapes.
- **Executable when initiated:** Query form only
- **Coupled command:** Yes
- ***RST Condition:** SOURce:FUNCtion:SHAPe SINusoid

Example **Selecting square wave generation mode**

```
FUNC SQU                    Select square wave mode
```

:USER

[SOURce:]FUNCtion:USER <*name*> selects which of the seven pre-defined segment sequences the HP E1340A will output when arbitrary waveform generation is selected by SOURce:FUNCtion:SHAPe USER.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
name	character data	A | B | C | D | AB | ABCD | HOP_AB | NONE	none
NONE selects no segment sequence			

Comments

- Segment sequences A, B, C, and D output the corresponding segments. Sequence AB outputs segments A and B. Sequence ABCD outputs all four segments. Sequence HOP_AB allows waveform hopping between segments A and B. The "Aux In" BNC selects which segment is output: a TTL high level selects segment A; a TTL low, segment B.
- The "Aux In" BNC is a multiple-use input: for FSK control, for waveform hopping control, as a reference oscillator source, for reference oscillator gating, or as a start arm source. Only one of these uses may be active at any time.
- **Executable when initiated:** Query form only
- **Coupled command:** Yes
- **Related Commands:** SOURce:FUNCtion:SHAPe
- ***RST Condition:** SOURce:FUNCtion:USER NONE

Example **Selecting an arbitrary waveform**

```
FUNC USER                   Select arbitrary waveform mode
FUNC:USER AB                Select segment sequence AB
```


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[SOURce:]LIST

The [SOURce:]LIST subsystem provides edit access to the waveform segments, and creation of segment sequences for arbitrary waveform generation.

There are four predefined segment names: A, B, C, and D. Each of these is 4096 points in length. There are six predefined segment sequences: A, B, C, D, AB, and ABCD. The sequences are predefined to output segment A, B, C, D, A and B, and all four segments, respectively.

Values may be loaded into segment memory by using the LIST:VOLT:DAC or LIST:VOLT commands in conjunction with LIST:SELect. The remaining commands are queries and are provided primarily for compatibility and completeness reasons.

Subsystem syntax

```
[SOURce:]
    LIST
        [:SEGMent]
            :CATalog?                    [query only]
            :DEFine?                     [query only]
            :SELect <name>
            :VOLTage <voltage_list>      [no query]
                :DAC <voltage_list>      [no query]
                :POINts?                 [query only]

        :SSEQuence
            :CATalog?                    [query only]
            :DEFine?                     [query only]
            :SELect <name>
            :SEQuence?                   [query only]
                :SEGMents?               [query only]
```

[:SEGMent] :CATalog?

[SOURce:]LIST[:SEGMent]:CATalog? returns a comma-separated list of four quoted strings containing the predefined waveform segment names: "A", "B", "C", "D".

Comments

- **Executable when initiated:** Yes
- **Coupled command:** No
- ***RST Condition:** none
- **Power-On Condition:** Segment names A, B, C, and D are defined

Example

Cataloging waveform segment names

```
LIST:CAT?                    Catalog waveform segments
```


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[:SEGMent]:DEFine?

[SOURce:]LIST[:SEGMent]:DEFine? returns the amount of the waveform segment memory allocated for the segment currently selected by SOURce:LIST:SEGMent:SELect. Since all waveform segments are 4096 points in length, this query will always return 4096.

Comments

- **Executable when initiated:** Yes
- **Coupled command:** No
- **Related Commands:** SOURce:LIST:SEGMent:SELect
- ***RST Condition:** unaffected
- **Power-On Condition:** Each waveform segment is defined to a length of 4096

Example

Querying the size of a waveform segment

```
LIST:SEL D          Select waveform segment D
LIST:DEF?           Query size of waveform segment D
```

[:SEGMent]:SELect

[SOURce:]LIST[:SEGMent]:SELect <*name*> selects a waveform segment for subsequent SOURce:LIST:SEGMent subsystem commands.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
name	discrete	A | B | C | D | NONE	none
NONE selects no waveform segment			

Comments

- There are only 4 legal segment names: A, B, C, D. Alphabetic character case (upper vs. lower) is ignored.
- **Executable when initiated:** Yes
- **Coupled command:** No
- ***RST Condition:** unaffected
- **Power-On Condition:** SOURce:SEGMent:SELect NONE

Example

Selecting a waveform segment

```
LIST:SEL A          Select waveform segment A
```


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[:SEGMent]:VOLTage

[SOURce:]LIST[:SEGMent]:VOLTage <*voltage_list*> defines the series of output voltage points that constitute a waveform segment. The points are specified in terms of volts.

Parameters

The *voltage_list* may be either a comma-separated list of voltage values or an IEEE-488.2 definite or indefinite length block containing the values in IEEE-754 64-bit floating-point format.

The legal range for voltage values is specified by the SOURce:VOLTage:LEVel:IMMediate:AMPLitude command. Default units are volts.

MINimum and MAXimum cannot be used with this command.

Comments

- If block format is used, the most significant byte of each voltage value must be sent first.
- The voltage point list length must contain exactly 4096 points.
- The voltage values specified by this command are scaled relative to the full-scale output voltage specified by SOURce:VOLTage:LEVel:IMMediate:AMPLitude in effect at the time the voltage point list is created. Subsequently changing the full-scale output voltage will change the actual output voltages that are generated.
- Waveform segment contents are unspecified at power-on and must be loaded before the segment may be output.
- **Executable when initiated:** No
- **Coupled command:** No
- **Related Commands:** SOURce:LIST:SEGMent:VOLTage:DAC, SOURce:VOLTage:LEVel:IMMediate:AMPLitude
- ***RST Condition:** unaffected
- **Power-On Condition:** waveform segment contents are unspecified

Example

Defining a waveform segment voltage point list

```
LIST:SEL B                    Select waveform segment B
LIST:VOLT .5,1,.5,0,-.5,.....,-1   Define 4096 waveform voltages
```


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[:SEGMent]:VOLTage:DAC

[SOURce:]LIST[:SEGMent]:VOLTage:DAC <*voltage_list*> defines the series of output voltage points that constitute a waveform segment. The points are specified in terms of digital-to-analog converter (DAC) codes.

Parameters

The *voltage_list* may be either a comma-separated list of DAC codes or an IEEE-488.2 definite length block containing the DAC codes in 16-bit integer format. The upper four bits of the 16-bit integer must be 0.

The DAC code is a 12-bit number, with 0 representing negative full scale, 4095 representing positive full scale, and 2048 representing zero. With SOURce:VOLTage:LEVel:IMMediate:AMPLitude 5.11750 V, and OUTPut:LOAD 50, the least significant bit (LSB) represents 2.50 mV.

MINimum and MAXimum cannot be used with this command.

Comments

- If block format is used, the most significant byte of each value must be sent first.
- Waveform segment contents are unspecified at power-on and must be loaded before the segment may be output.
- **Executable when initiated:** No
- **Coupled command:** No
- **Related Commands:** SOURce:LIST:SEGMent:VOLTage, SOURce:VOLTage:LEVel:IMMediate:AMPLitude
- ***RST Condition:** unaffected
- **Power-On Condition:** waveform segment contents are unspecified

Example

Defining a waveform segment voltage point list

```
LIST:SEL B                          Select waveform segment B
LIST:VOLT:DAC 4,1048,4095,.....,2048  Define 4096 waveform voltages
```

[:SEGMent]:VOLTage:POINts?

[SOURce:]LIST[:SEGMent]:VOLTage:POINts? returns a number indicating the length of the currently selected waveform segment's voltage point list. The length is considered 0 at power-on. For segment D, it is set to 0 when a waveform shape other than DC or USER is selected. The length is set to 4096 after the segment contents have been loaded via the SOURce:ARBitrary:DOWNload, SOURce:LIST:SEGMent:VOLTage, or SOURce:LIST:SEGMent:VOLTage:DAC commands.

Comments

- **Executable when initiated:** Yes
- **Coupled command:** No
- ***RST Condition:** unaffected
- **Power-On Condition:** waveform segment lengths are 0

Example

Query voltage point list length

```
LIST:SEL C                          Select waveform segment C
LIST:VOLT:POIN?                     Query voltage point list length
```


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:SSEQuence :CATalog?

[SOURce:]LIST:SSEQuence:CATalog? returns a comma-separated list of six quoted strings containing the predefined segment sequence names: "A", "B", "C", "D", "AB", "ABCD".

Comments

- **Executable when initiated:** Yes
- **Coupled command:** No
- ***RST Condition:** unaffected
- **Power-On Condition:** Sequence names A, B, C, D, AB, and ABCD are defined

Example

Cataloging segment sequence names

```
LIST:SSEQ:CAT?          Catalog segment sequence names
```

:SSEQuence :DEFine?

[SOURce:]LIST:SSEQuence:DEFine? returns the length of the segment sequence currently selected by SOURce:LIST:SSEQuence:SELect. Sequences A, B, C, and D have a length of 1; sequence AB has a length of 2; and sequence ABCD has a length of 4.

Comments

- **Executable when initiated:** Yes
- **Coupled command:** No
- **Related Commands:** SOURce:LIST:SSEQuence:SELect
- ***RST Condition:** unaffected
- **Power-On Condition:** segment sequence lengths are predefined as specified above

Example

Querying the length of a segment sequence

```
LIST:SSEQ:SEL AB        Select sequence AB
LIST:SSEQ:DEF?          Query the length of the segment sequence
```

:SSEQuence:SELect

[SOURce:]LIST:SSEQuence:SELect <*name*> selects a segment sequence for subsequent SOURce:LIST:SSEQuence subsystem commands.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
name	discrete	A | B | C | D | AB | ABCD | NONE	none
NONE selects no segment sequence			

Comments

- **Executable when initiated:** Yes
- **Coupled command:** No
- ***RST Condition:** unaffected
- **Power-On Condition:** SOURce:LIST:SSEQuence:SELect NONE

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Example **Selecting a segment sequence**

```
LIST:SSEQ:SEL AB          Select segment sequence AB
```

:SSEQuence :SEQuence?

[SOURce:]LIST:SSEQuence:SEQuence? returns a comma-separated list of the segment names comprising the currently selected segment sequence. Sequences A, B, C, and D contain only the same-named waveform segment. Sequence AB contains segments A and B. Sequence ABCD contains segments A, B, C, and D.

Comments

- **Executable when initiated:** Yes
- **Coupled command:** No
- ***RST Condition:** unaffected
- **Power-On Condition:** segment sequences are pre-defined as specified above

Example Querying a segment sequence

```
LIST:SSEQ:SEL AB          Select segment sequence AB
LIST:SSEQ:SEQ?            Query segment sequence
```

:SSEQuence :SEQuence :SEGMents?

[SOURce:]LIST:SSEQuence:SEQuence:SEGMents? returns a number indicating the number of waveform segments contained in the currently selected segment sequence. Sequences A, B, C, and D contain only 1 segment. Sequence AB contains 2 segments. Sequence ABCD contains 4.

Comments

- **Executable when initiated:** Yes
- **Coupled command:** No
- ***RST Condition:** none
- **Power-On Condition:** segment sequence lengths are predefined as specified above

Example **Query segment sequence length**

```
LIST:SSEQ:SEQ:SEGM?       Query segment sequence length
```


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[SOURce:]MARKer

The [SOURce:]MARKer subsystem controls:

- Which signal is routed to the "Aux Out" BNC.
- The polarity of the "Aux Out" BNC signal.

Subsystem Syntax

```
[SOURce:]
    MARKer
        :FEED <source>
        :POLarity <polarity>
```

:FEED

[SOURce:]MARKer:FEED <*source*> selects the source for the front panel "Aux Out" BNC. The available sources are:

"OUTPut:ZERO": Outputs marker pulses whenever the waveform crosses through zero. SOURce:MARKer:POLarity must be set to INVerted when using this source.

"SEGMent": Outputs a pulse at the completion of a segment. Note that multiple segment waveforms like AB or ABCD will have 2 and 4 marker pulses per cycle respectively. SOURce:MARKer:POLarity must be set to NORMal when using this source.

"[SOURce:]ROSCillator": The internal 42.94967296 MHz reference oscillator. SOURce:MARKer:POLarity must be set to NORMal when using this source.

"[SOURce:]SWEEP": Outputs a marker pulse on the last point of a frequency sweep. SOURce:MARKer:POLarity may be either NORMal or INVerted with this source.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
source	string	"OUTPut:ZERO" | "SEGMent" | "[SOURce:]ROSCillator" | "[SOURce:]SWEep"	none

Comments

- **Executable when initiated:** Query form only
- **Coupled command:** Yes
- **Related Commands:** SOURce:MARKer:POLarity
- ***RST Condition:** SOURce:MARKer:FEED "SEGMent"

Example

Setting the "Aux Out" BNC source

```
MARK:FEED "SOUR:ROSC"        Set marker reference oscillator as source
```


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:POLarity

[SOURce:]MARKer:POLarity <*polarity*> selects the polarity of the marker signal at the front panel "Aux Out" BNC. NORMal polarity selects an active high marker output; INVerted an active low output.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
polarity	discrete	INVerted | NORMal	none

Comments

- NORMal must be selected when MARKer:FEED "SEGMent" or "SOURce:ROSCillator" is selected. INVerted must be selected when MARKer:FEED "OUTPut:ZERO" is selected. Either NORMal and INVerted may be selected when MARKer:FEED "[SOURce:]SWEep" is selected.
- **Executable when initiated:** Query form only
- **Coupled command:** Yes
- **Related Commands:** SOURce:MARKer:FEED
- ***RST Condition:** SOURce:MARKer:POLarity NORMal

Example

Setting the "Aux Out" BNC polarity

```
MARK:FEED "SWE"          Generate marker pulse at start of sweep
MARK:POL INV             Set active low output
```


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[SOURce:]RAMP

The [SOURce:]RAMP subsystem selects the polarity of ramp waveforms.

Subsystem Syntax

```
[SOURce:]
    RAMP
        :POLarity <polarity>
```

:POLarity

[SOURce:]RAMP:POLarity <*polarity*> selects the polarity of the ramp waveform. NORMal generates a positive-going ramp; INVerted generates a negative-going ramp.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
polarity	discrete	INVerted | NORMal	none

Comments

- **Executable when initiated:** Query form only
- **Coupled command:** Yes
- **Related Commands:** SOURce:FUNCtion:SHAPe
- ***RST Condition:** SOURce:RAMP:POLarity NORMal

Example

Selecting ramp polarity

```
FUNC:SHAP RAMP          Select ramp output
RAMP:POL INV            Select negative-going ramp
```


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[SOURce:]ROSCillator

The [SOURce:]ROSCillator subsystem controls the reference oscillator's source and indicates the frequency of an external oscillator. The HP E1340A uses the source and frequency information to generate the waveform frequency for all waveform shapes.

Subsystem Syntax

```
[SOURce:]
    ROSCillator
        :FREQuency
            :EXTernal <frequency>
        :GATE
            :STATe <state>
        :SOURce <source>
```

:FREQuency :EXTernal

[SOURce:]ROSCillator:FREQuency:EXTernal <*frequency*> indicates to the HP E1340A the frequency of an external reference oscillator source. The SOURce:FREQuency subsystem uses this value to generate the waveform frequency when SOURce:ROSCillator:SOURce is set to EXTernal.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
frequency	numeric	1 Hz through 42.94967296 MHz | MINimum | MAXimum	Hz
MINimum selects 1 Hz; MAXimum selects 42.94967296 MHz.			

Comments

- AC amplitude correction can only be made if the current reference oscillator frequency is 42.94967296 MHz, either internal or external. CALibration:STATe:AC must be set to OFF when a different external reference oscillator frequency is selected.
- Indicating an incorrect frequency for an external reference oscillator will cause incorrect sample rate and waveform frequencies to be generated by the SOURce:FREQuency subsystem.
- **Executable when initiated:** Query form only
- **Coupled command:** Yes
- **Related commands:** CALibration:STATe:AC, SOURce:ROSCillator:SOURce
- ***RST Condition:** SOURce:ROSCillator:FREQuency:EXTernal 42.94967296 MHz

Example

Specifying the external reference oscillator frequency

```
ROSC:FREQ:EXT 5 MHZ          External oscillator is 5 MHz
```


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:GATE:STATe

[SOURce:]ROSCillator:GATE:STATe <*state*> indicates whether gating of the reference oscillator is enabled or disabled. When gating is enabled, a TTL high signal on the "Aux In" BNC will stop the waveform output at the present point; a TTL low on the "Aux In" BNC will resume/continue normal operation.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
state	boolean	ON|OFF|0|1	none

Comments

- The "Aux In" BNC is a multiple-use input: for FSK control, for waveform hopping control, as a reference oscillator source, for reference oscillator gating, or as a start arm source. Only one of these uses may be active at any time.
- **Executable when initiated:** Query form only
- **Coupled command:** No
- ***RST Condition:** SOURce:ROSCillator:GATE:STATe OFF

Example

Enable gating of the waveform via the "Aux In" BNC

```
ROSC:GATE:STATe ON                    Enable gating
```

:SOURce

[SOURce:]ROSCillator:SOURce <*source*> selects the reference oscillator source. The available sources are:

EXTernal: The HP E1340A's front panel "Aux In" BNC.

INTernal: The internal 42.94967296 MHz oscillator. Using this oscillator with the SOURce:FREQuency subsystem gives a frequency resolution of .01 Hz.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
source	discrete	EXTernal|INTernal	none

Comments

- The reference oscillator is used to generate the waveform frequencies specified in the SOURce:FREQuency subsystem.
- Use SOURce:ROSCillator:FREQuency:EXTernal to indicate the frequency of an external reference oscillator.
- The "Aux In" BNC is a multiple-use input: for FSK control, for waveform hopping control, as a reference oscillator source, for reference oscillator gating, or as a start arm source. Only one of these uses may be active at any time.
- **Related Commands:** SOURce:ROSCillator:FREQuency:EXTernal, SOURce:FREQuency

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- **Executable when initiated:** Query form only
- **Coupled command:** Yes
- ***RST Condition:** SOURce:ROSCillator:SOURce INTernal

Example **Setting the reference oscillator source**

```
ROSC:SOUR EXTernal          Select an external oscillator source
```


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[SOURce:]SWEep

The [SOURce:]SWEep subsystem selects:

- The number of points in a frequency sweep.
- The sweep rate for frequency sweeps.

Frequency sweeping generation requires that SOURce:FREQuency:MODE SWEep be set.

Sweep Considerations

Frequency sweeping is controlled entirely by the on-board microprocessor on the HP E1340A module. Only continuous repetitive sweeping is supported. A sweep is started by the INITiate:IMMediate command and advances at a fixed rate determined by the number of points in the sweep and the sweep time.

The minimum and maximum number of frequency points in a sweep are constrained by the frequency span and the sweep time.

Looking at the span considerations, and assuming that the internal 42.94967296 MHz reference oscillator is used, the minimum and maximum frequency increments per frequency point of a 4,096 point waveform are .01 Hz and 15 MHz. Thus, when sweeping a 4,096 point waveform from 1 kHz to 10 kHz, the minimum number of points is 2, and the maximum is (10 kHz - 1 kHz) / .01 Hz + 1, or 900,001 points.

Considering sweep time, the fastest the HP E1340A can sweep is 187 µS per frequency point with AC amplitude correction disabled, or 250 µS per point with AC amplitude correction enabled. Up to 25.5 mS additional delay per frequency point is possible in 100 µS increments. Thus, the fastest amplitude corrected sweep will proceed at a rate of 15 MHz/point / 250 µS/point or 60 GHz per second. The slowest non-amplitude corrected sweep will proceed at a rate of .01 Hz/point / 25.687 mS/point or about 0.3893 Hz per second.

Also, sweeps are limited to a minimum of 2 points (the start and stop frequencies) and a maximum of 1,073,741,825 points (not a real concern, since each sweep would take a minumum of 3.1 days to complete).

The SOURce:SWEep:POINts command considers all these constraints when MINinum or MAXimum is specified. The SOURce:SWEep:TIME command considers the currently specified number of points and whether AC amplitude correction is enabled when MINinum or MAXimum is specified.

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Subsystem Syntax

```
[SOURce:]
    SWEep
        :COUNt <number>
        :POINts <number>
        :TIME <time>
```

:COUNt

[SOURce:]SWEep:COUNt <*number*> specifies the number of sweeps the HP E1340A will perform.

Since the only valid value for this count is INFinity, there is no need to send this command. It is included for SCPI compatibility purposes only.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
number	numeric	9.9E+37 | INFinity| MINimum | MAXimum	none
MINimum and MAXimum both select INFinity sweeps. 9.9E+37 is equivalent to INFinity.			

Comments

- **Executable when initiated:** Yes
- **Coupled command:** Yes
- **Related Commands:** INITiate:IMMediate, ABORt
- ***RST Condition:** SOURce:SWEep:COUNt INFinity

Example

Setting the sweep count

```
SWE:COUN INF                    Set infinite sweeps
```


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:POINts

[SOURce:]SWEep:POINts <*number*> selects the number of points in a frequency sweep.

The frequencies generated by the sweep are evenly spaced linearly between the frequencies specified by SOURce:FREQuency:STARt and STOP, or CENTer and SPAN, inclusive.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
number	numeric	*see below* | MINimum | MAXimum	none
The legal range for *number*, as well as the MINimum and MAXimum values, is context-dependent. See the section "Sweep Considerations" at the beginning of the SOURce:SWEep subsystem for a description of the dependencies.			

Comments

- **Executable when initiated:** Query form only
- **Coupled command:** Yes
- **Related Commands:** SOURce:FREQuency:CENTer, MODE, SPAN, START, and STOP
- ***RST Condition:** SOURce:SWEep:POINts 1001

Example

Setting the number of points in the sweep

```
SWE:POIN 100                    Set 100 points in sweep
```

:TIME

[SOURce:]SWEep:TIME <*time*> selects the duration of the sweep. The duration is the time from the start of the sweep until when the last frequency begins to be output.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
time	numeric	*see below* | MINimum | MAXimum	seconds
With CALibration:STATe:AC OFF set: MINimum selects 0.187 mS * (*points* - 1); MAXimum selects 25.687 mS * (*points* - 1). **With CALibration:STATe:AC ON set:** MINimum selects 0.250 mS * (*points* - 1); MAXimum selects 25.75 mS * (*points* - 1). *points* is specified by the SOURce:SWEep:POINts command. The above values bound the valid range for *time*.			

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Comments

- The last frequency point is output for the same length of time as all other points. The SWEep:TIME value is the time from the start of each sweep until the last frequency begins to be output and does not include the time for the last frequency point. Therefore, if a specific sweep repetition time is desired, SWEep:TIME should be set according to the following equation:

  SWEep:TIME = *time* * (*points* - 1) / *points*

  Thus, to set a repetition time of 1 S for a 100 point sweep, SWEep:TIME should be set to .99 S.
- **Executable when initiated:** Query form only
- **Coupled command:** Yes
- **Related Commands:** SOURce:SWEep:POINts, CAL:STATe:AC
- ***RST Condition:** SOURce:SWEep:TIME 1.05

Example

Setting the duration of the sweep

```
SWE:TIME 20                    Set sweep to take 20 seconds
```


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[SOURce:]VOLTage

The [SOURce:]VOLTage subsystem controls the amplitude and offset values for all output waveform shapes.

Amplitude and Offset Considerations

Amplitude control is accomplished by the combination of an analog multiplier and a 20 dB attenuator. The analog multiplier scales the output of the main output DAC. It has a resolution of 11 bits where 2047 represents maximum output and 0 no output. Any specified offset voltage is summed with the multiplier output before the 20 dB attenuator. If **both** the output amplitude and offset are less than or equal to 10% of full scale (.51175 V into a 50 Ω load), the 20 dB attenuator will be used, and the analog multiplier and offset DAC values will be scaled up by a factor of 10. This results in finer low-level amplitude and offset control, as well as reduced noise on the output. If **either** the output amplitude or offset values are greater than 10% of full scale, the 20 dB attenuator will not be used. Thus, a very small amplitude signal riding on a large offset will have relatively poor amplitude resolution and will tend to be noisy.

Subsystem Syntax

```
[SOURce:]
    VOLTage
        [:LEVel]
            [:IMMediate]
                [:AMPLitude] <amplitude>
                    :UNIT
                        [:VOLTage] <units>
                :OFFSet <offset>
```

[:LEVel][:IMMediate][:AMPLitude]

[SOURce:]VOLTage[:LEVel][:IMMediate][:AMPLitude] <*amplitude*> sets the output amplitude when SOURce:FUNCtion:SHAPe is set to DC, RAMP, SINusoid, SQUare, TRIangle. It sets the positive full-scale output amplitude for arbitrary waveforms (SOURce:FUNCtion:SHAPe USER set); the least significant DAC code bit represents 1/2047 of this value.

Output amplitude for ramp, sine, square and triangle wave output may be programmed in volts, peak volts, peak-to-peak volts, RMS volts, or dBM. Output amplitude for DC must be programmed in volts; for arbitrary waveform output, volts or peak volts.

The query form returns the amplitude in terms of the default units, specified by the SOURce:VOLTage:LEVel:IMMediate:AMPLitude:UNIT:VOLTage command.

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Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
amplitude	numeric	*see below* | MINimum | MAXimum	*see below*

DC Output: When a matched load has been specified, MINimum selects -5.12 V; MAXimum selects 5.11750 V.

Arbitrary Waveform, Ramp, Sine, Square, and Triangle Outputs: MINimum will select the equivalent of 0 V in the current default units. MAXimum selects the equivalent of the lesser of (+6.0 V - output offset value) and +5.11750 V.

For all waveform shapes, when an open circuit load has been specified, double all the above voltages.

These values bound the legal range of values for *amplitude*.

Default units are specified by the SOURce:VOLTage:LEVel:IMMediate:AMPLitude:UNIT:VOLTage command.

For DC output, the amplitude is generated using the DAC; resolution is .0025 V into a matched load, .005 V into an open circuit. For all other waveform shapes, output amplitude control is implemented via a output multiplier circuit, followed by a switchable 20 dB step attenuator. The step attenuator is used only when both amplitude and offset are each below one tenth of their full scale values.

For DC output, acceptable units are V (volts). For arbitrary waveform output, acceptable units are V (volts) and VPK. For ramp, sine, square, and triangle outputs, acceptable units are V (volts), VPK (volts peak), VPP (volts peak-to-peak), VRMS (volts RMS), W (watts) and DBM or DBMW (dB referenced to 1 milliwatt). For W, DBM, and DBMW, the amplitude is referenced to a 50 ohm load.

Comments

- An amplitude of -9.9e37 DBM or DBMW is equivalent to 0 V.
- **Related Commands:** SOURce:FUNCtion:SHAPe, SOURce:VOLTage:LEVEL:IMMediate:OFFSet
- **Executable when initiated:** Query form only
- **Coupled command:** Yes
- ***RST Condition:** SOURce:VOLTage:LEVel:IMMediate:AMPLitude 0 V

Example

Setting output voltage

```
VOLT 5 VPP          Set output amplitude to 5 volts peak-to-peak
```


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[:LEVel][:IMMediate] [:AMPLitude]:UNIT [:VOLTage]

[SOURce:]VOLTage[:LEVel][:IMMediate][:AMPLitude]:UNIT[:VOLTage] <*units*> sets the default units for subsequent SOURce:VOLTage:LEVel:IMMediate:AMPLitude commands. The available default units are:

DBM|DBMW: dB referenced to 1 milliwatt.

V: Volts. This is equivalent to VPK for time-varying waveforms.

VPK: Volts peak

VPP: Volts peak-to-peak

VRMS: Volts RMS

W: Watts

For W, DBM, and DBMW, the amplitude is referenced to the OUTPut:LOAD value; they are meaningless and therefore unavailable if OUTPut:LOAD INFinity is set. These units are also meaningless and unavailable for user-defined waveforms (SOURce:FUNCtion:USER set) and when directly driving the DAC from the VXIbus (SOURce:ARBitrary:DAC:SOURce VXI set).

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
units	discrete	DBM | DBMW | V | VPK VPP | VRMS | W	none

Comments

- **Related Commands:** OUTPut:LOAD, SOURce:VOLTage:LEVEL:IMMediate:AMPLitude
- **Executable when initiated:** Yes
- **Coupled command:** No
- ***RST Condition:** SOURce:VOLTage:LEVel:IMMediate:AMPLitude:UNIT:VOLTage V

Example

Setting the default voltage units

```
VOLT:UNIT:VOLT VPP          Set default units to volts peak-to-peak
```


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[:LEVel][:IMMediate]:OFFSet

[SOURce:]VOLTage[:LEVel][:IMMediate]:OFFSet <*offset*> sets the output offset voltage for all waveform shapes except DC. Output offset amplitude is programmed in volts.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
offset	numeric	*see below* | MINimum | MAXimum	volts

DC Output: When a matched load has been specified, MINimum selects -5.12 V; MAXimum selects +5.11750 V.

Arbitrary Waveform, Ramp, Sine, Square, and Triangle Outputs: When a matched load has been specified, MINimum selects the greater of (-6.0 V + output amplitude value) and -5.12 V, rounded down if needed to a multiple of 2.5 mV; MAXimum selects the lesser of (+6.0 V - output amplitude value) and +5.1175 V, again rounded down.

For all waveform shapes, when an open circuit load has been specified, double all the voltage values above.

The above values bound the legal range for *offset*.

Comments

- **Related Commands:** SOURce:VOLTage:LEVEL:IMMediate:AMPLitude
- **Executable when initiated:** Query form only
- **Coupled command:** Yes
- ***RST Condition:** SOURce:VOLTage:LEVel:IMMediate:OFFSet 0 V

Example

Setting offset voltage

```
VOLT:OFFS 3                    Set offset voltage to 3 volts
```


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STATus

The STATus subsystem controls the SCPI-defined Operation and Questionable Signal Status Registers. Each is comprised of a Condition Register, an Event Register, an enable mask, and negative and positive transition filters.

Each Status Register works as follows: when a condition occurs, the appropriate bit in the Condition Register is set or cleared. If the the corresponding transition filter is enabled for that bit, the same bit is set in the associated Event Register. The contents of the Event Register and the enable mask are logically ANDed bit-for-bit; if any bit of the result is set, the summary bit for that register is set in the status byte. The status byte summary bit for the Operation Status Register is bit 7; for the Questionable Signal Status Register, bit 3.

Operation Status Register

Only bits 0 (CALibrating), 3 (SWEeping), and 8 (INITiated) are defined for the HP E1340A. All other bits are always zero.

Bit 0 - CALibrating: Set (1) during calibration. Cleared (0) otherwise.

Bit 3 - SWEeping: Set (1) while a frequency sweep or list is in progress. Cleared (0) when waveform generation is halted, when frequency sweeping or lists are not selected, and at the end of each sweep or list.

Bit 8 - INITiated: Set (1) by the INITiate:IMMediate command. Cleared (0) by the ABORt command. When outputting a single burst of waveform repetitions (ARM:LAYer2:COUNt 1 set and ARM:LAYer1:COUNt not set to INFinity), it is also cleared by any other command executed after waveform generation completes.

Questionable Signal Status Register

All bits are always 0. This register is implemented only for SCPI compatibility purposes.

Subsystem Syntax

```
STATus
    :OPERation|QUEStionable
        :CONDition?                    [query only]
        :ENABle <unmask>
        [:EVENt]?                      [query only]
        :NTRansition <unmask>
        :PTRansition <unmask>
    :PRESet                            [no query]
```


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:OPERation |QUEStionable :CONDition?

STATus:OPERation|QUEStionable:CONDition? returns the contents of the appropriate Condition Register. Reading the register does not affect its contents.

Comments

- **Executable when initiated:** Yes
- **Coupling group:** none
- **Related commands:** STATus subsystem, *SRE, *STB?
- ***RST Condition:** all bits of both Condition Registers are cleared as a result of the state present after *RST.

Example

Querying the Operation Condition Register

```
STAT:OPER?                    Query Operation Condition Register
```

:OPERation |QUEStionable :ENABle

STATus:OPERation|QUEStionable:ENABle <*unmask*> specifies which bits of the associated Event Register are included in its summary bit. The summary bit is the bit-for-bit logical AND of the Event Register and the unmasked bit(s).

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
unmask	numeric or non-decimal numeric	0 through +32767	none

The non-decimal numeric forms are the #H, #Q, or #B formats specified by IEEE-488.2.

Comments

- **Executable when initiated:** Yes
- **Coupling group:** none
- **Related commands:** STATus subsystem, *SRE, *STB?
- ***RST Condition:** unaffected
- **Power-on Condition:** STATUS:OPERation|QUEStionable:ENABLE 0

Example

Setting the Operation Register enable mask

```
STAT:OPER:ENAB #H0100         Enable summary on Initiated bit
```


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:OPERation |QUEStionable [:EVENt]?

STATus:OPERation|QUEStionable[:EVENt]? returns the contents of the appropriate Event Register. Reading the register clears it to 0.

Comments

- Both Event Registers are also cleared to 0 by the *CLS common command.
- **Executable when initiated:** Yes
- **Coupling group:** none
- **Related commands:** STATus subsystem, *SRE, *STB?
- ***RST Condition:** unaffected
- **Power-on Condition:** Both Event Registers are cleared to 0.

Example

Querying the Operation Event Register

```
STAT:EVEN?                    Query Operation Event Register
```

:OPERation |QUEStionable :NTRansition

STATus:OPERation|QUEStionable:NTRansition <*unmask*> sets the negative transition mask. For each bit unmasked, a 1-to-0 transition of that bit in the associated Condition Register will set the same bit in the associated Event Register.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
unmask	numeric or non-decimal numeric	0 through +32767	none

The non-decimal numeric forms are the #H, #Q, or #B formats specified by IEEE-488.2.

Comments

- **Executable when initiated:** Yes
- **Coupling group:** none
- **Related commands:** STATus subsystem, *SRE, *STB?
- ***RST Condition:** unaffected
- **Power-on Condition:** STATUS:OPERation|QUEStionable:NTRansition 0

Example

Setting the Operation Register negative transition mask

```
STAT:OPER:NTR #H0008          Set event bit when sweeping
                              condition is cleared
```


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:OPERation |QUEStionable :PTRansition

STATus:OPERation|QUEStionable:PTRansition <*unmask*> sets the positive transition mask. For each bit unmasked, a 0-to-1 transition of that bit in the associated Condition Register will set the same bit in the associated Event Register.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
unmask	numeric or non-decimal numeric	0 through +32767	none

The non-decimal numeric forms are the #H, #Q, or #B formats specified by IEEE-488.2.

Comments

- **Executable when initiated:** Yes
- **Coupling group:** none
- **Related commands:** STATus subsystem, *SRE, *STB?
- ***RST Condition:** unaffected
- **Power-on Condition:** STATUS:OPERation|QUEStionable:PTRansition 32767

Example

Setting the Operation Register positive transition mask

```
STAT:OPER:PTR #H0100          Set event bit when initiated condition is set
```

:PRESet

STATus:PRESet initializes the Enable Registers and transition masks for the Operation and Questionable Signal Status Registers and sets STATus:OPC:INITiate ON. For both Status Registers, the Enable Registers are set to 0, the negative transition masks are set to 0, and the positive transition masks are set to 32767.

Comments

- **Executable when initiated:** Yes
- **Coupling group:** none
- **Related commands:** STATus subsystem, *SRE, *STB?
- ***RST Condition:** none

Example

Presetting the STATus subsystem

```
STAT:PRES                     Preset STATus subsystem
```


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SYSTem

The SYSTem subsystem returns error messages and the SCPI version number to which the HP E1340A complies.

Subsystem Syntax

```
SYSTem
    :ERRor?          [query only]
    :VERSion?        [query only]
```

:ERRor?

SYSTem:ERROR? returns the error messages in the error queue. See Table B-4 in Appendix B for a listing of possible error numbers and messages.

Comments

- The HP E1340A places any generated errors into the error queue. The queue is first-in, first out. With several errors waiting in the queue, the SYSTem:ERRor? returns the oldest unread error message first.
- The error queue can hold 30 error messages. If the HP E1340A generates more than 30 messages that are not read, it replaces the last error message in the queue with error -350,"Too many errors". No additional messages are placed into the queue until SYSTem:ERRor? reads some messages or the *CLS (clear status) command clears the queue.
- When the error queue is empty, SYSTem:ERRor? returns +0,"No error".
- **Executable when initiated:** Yes
- ***RST Condition:** unaffected
- **Power-On Condition:** no errors are in the error queue

Example

Reading the error queue

```
SYST:ERR?                    Query the error queue
```

:VERSion?

SYSTem:VERSion? returns the SCPI version number to which the HP E1340A complies: "1991.0".

Comment

- **Executable when initiated:** Yes
- ***RST Condition:** none

Example

Querying the SCPI revision

```
SYST:VERS?                   Query SCPI revision
```


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TRIGger

The TRIGger subsystem operates with the ARM subsystem to control the behavior of the trigger system, as follows:

- The source for generating the individual samples of a waveform.
- The total number of samples (triggers).

Subsystem Syntax

```
TRIGger
    [:STARt|SEQuence[1]]
        :COUNt <number>
        :SOURce <source>
```

[:STARt]:COUNt

TRIGger[:STARt]:COUNt *<number>* would normally specify the number of triggers the HP E1340A would accept after an INITiate:IMMediate command before returning the start trigger sequence to the wait-for-arm state. However, since this is equal to the length of the current waveform, and is not configurable here, the only legal value for this command is 9.91e37 or NaN (not a number).

There is no need to send this command. It is included for SCPI compatibility purposes only.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
number	numeric	9.91e37 | NAN | MINimum | MAXimum	none
MINimum and MAXimum select 9.91e37 triggers. 9.91E+37 is equivalent to NAN.			

Comments

- **Executable when initiated:** Yes
- **Coupled command:** No
- **Related Commands:** ABORt, INITiate:IMMediate
- ***RST Condition:** TRIGger:STARt:COUNt 9.91e37

Example

Setting the start trigger count

```
TRIG:COUN NAN
```


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[:STARt]:SOURce

TRIGger[:STARt]:SOURce <*source*> selects the source that advances the waveform to the next sample point. The only available source is INTernal.

There is no need to send this command. It is included for SCPI compatibility purposes only.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
source	discrete	INTernal	none

Comments

- **Executable when initiated:** Yes
- **Coupled command:** No
- **Related Commands:** ABORt
- ***RST Condition:** TRIGger:STARt:SOURce INTernal

Example

Setting the start trigger source

```
TRIG:SOUR INT                    Trigger source is internal
```


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IEEE-488.2 Common Commands

This section describes the IEEE-488.2 Common Commands implemented in the HP E1340A. The table below shows the commands listed by functional group; however, commands are listed alphabetically in the reference. Examples are shown in the reference when the command has parameters or returns a non-trivial response; otherwise, the command string is as shown in the table. For additional information, refer to IEEE Standard 488.2-1987.

Category	Command	Title
System Data	*IDN?	Identification Query
Internal Operations	*LRN? *RST *TST?	Learn Device Setup Query Reset Command Self Test Query
Synchronization	*OPC *OPC? *WAI	Operation Complete Command Operation Complete Query Wait-to-Continue Command
Macro	*DMC <*name*>,<*data*> *EMC <*enable*> *EMC? *GMC? <*name*> *LMC? *PMC *RMC <*name*>	Define Macro Command Enable Macro Command Enable Macro Query Get Macro Contents Query Learn Macro Query Purge Macros Command Remove Individual Macro Command
Status & Event	*CLS *ESE <*mask*> *ESE? *ESR? *SRE *SRE? *STB?	Clear Status Command Standard Event Status Enable Command Standard Event Status Enable Query Standard Event Status Register Query Service Request Enable Command Service Request Enable Query Read Status Byte Query
Stored Settings	*RCL *SAV	Recall Command Save Command

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*CLS

***CLS** clears the Standard Event Status Register, the Operation Status Register, the Questionable Signal Register, and the error queue. This clears the corresponding summary bits (3, 5, and 7) in the Status Byte Register.
c *CLS does not affe t the enable masks of any of the Status Registers.

Comments

- **Executable when initiated:** Yes
- **Coupled command:** No
- **Related Commands:** STATus:PRESet
- ***RST Condition:** none

*DMC

***DMC <*name*>,<*data*>** creates a macro with the specified name and assigns zero, one, or a sequence of commands to the name. The sequence may be composed of SCPI and/or Common Commands. The sequence may be sent in IEEE-488.2 definite or indefinite block format or as a quoted string.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
name	character data	1 through 12 characters	none
data	block data	any valid command sequence	none

Comments

- Legal macro names must start with an alphabetic character and contain only alphabetic, numeric, and underscore ("_") characters. Alphabetic character case (upper vs. lower) is ignored.

  The name is allowed to be the same as a SCPI command, but may be not be the same as a Common Command. When the name is the same as a SCPI command, the macro rather than the command will be executed when the name is received if macro usage is enabled. The SCPI command will be executed if macro usage is disabled.
- **Executable when initiated:** Yes
- **Coupled command:** No
- **Related Commands:** *EMC, *GMC, *LMC, *RMC
- ***RST Condition:** none; macro defintions are unaffected
- **Power-On Condition:** no macros are defined

Example

Define macro to restart waveform

```
*DMC RESTART,#19ABOR;INIT          Define macro
```


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*EMC and *EMC?

***EMC <*enable*>** enables and disables macro usage. When *enable* is zero, macros usage is disabled. Any non-zero value in the range of -32768 through +32767 enables macro usage.

The query form returns 1 if macro usage is enabled, 0 if disabled.

Comments

- Macro definitions are not affected by this command.
- **Executable when initiated:** Yes
- **Coupled command:** No
- ***RST Condition:** macro usage is disabled
- **Power-On Condition:** macro usage is enabled

*ESE and *ESE?

***ESE <*mask*>** enables one or more event bits of the Standard Event Status Register to be reported in bit 5 (the Standard Event Status Summary Bit) of the Status Byte Register. *Mask* is the sum of the decimal weights of the bits to be enabled.

The query form returns the current enable mask.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
mask	numeric	0 through 255	none

A 1 in a bit position enables the corresponding event; a 0 disables it.

Comments

- **Executable when initiated:** Yes
- **Coupled command:** No
- **Related Commands:** *ESR?, *SRE, *STB?
- ***RST Condition:** unaffected
- **Power-On Condition:** no events are enabled

Example

Enable all error events

```
*ESE 60                    Enable error events
```

*ESR?

***ESR?** returns the value of the Standard Event Status Register. The register is then cleared (all bits 0).

Comments

- **Executable when initiated:** Yes
- **Coupled command:** No
- ***RST Condition:** none
- **Power-On Condition:** register is cleared

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*GMC?

***GMC? <*name*>** returns the definition of the specified macro in IEEE-488.2 definite block format.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
name	character data	*defined macro name*	none

Comments

- **Executable when initiated:** Yes
- **Coupled command:** No
- **Related Commands:** *DMC
- ***RST Condition:** none
- **Power-On Condition:** no macros are defined

Example

Query macro definition

```
*GMC? RESTART                    Query macro definition
```

*IDN?

***IDN?** returns indentification information for the E1340A. The response consists of four fields:

```
HEWLETT-PACKARD,E1340A,0,A.01.00
```

The first two fields identify this instrument as model number E1340A manufactured by Hewlett-Packard. The third field is 0 since the serial number of the E1340A is unknown to the firmware. The last field indicates the revision level of the firmware.

Note

The firmware revision field will change whenever the firmware is revised. A.01.00 is the initial revision. The first two digits indicate the major revision number, and increment when functional changes are made. The last two digits indicate bug fix level.

Comments

- **Executable when initiated:** Yes
- **Coupled command:** No
- ***RST Condition:** none
- **Power-On Condition:** register is cleared

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*LMC?

***LMC?** returns a comma-separated list of quoted strings, each containing the name of a macro. If no macros are defined, a single null string ("") is returned.

Comments

- **Executable when initiated:** Yes
- **Coupled command:** No
- **Related Commands:** *DMC
- ***RST Condition:** none
- **Power-On Condition:** no macros are defined

*LRN?

***LRN?** returns a sequence of commands that may be resent to the HP E1340A to return it to its current programming state.

Only those commands that are affected by *RST are included in the sequence. Notable exceptions include the DAC code format (signed vs. unsigned), the SOURce:LIST1|2 commands, including waveform segment, segment sequence, and frequency list definitions, the STATus subsystem commands, and the CALibration:STATe and SECurity command states.

Note

*LRN? should be sent singly in a program message, since the number of commands in the returned sequence is large, and may vary depending on firmware revision.

Comments

- **Executable when initiated:** Yes
- **Coupled command:** No
- **Related commands:** *RCL, *RST, *SAV
- ***RST Condition:** none

*OPC

***OPC** causes the E1340A to wait for all pending operations to complete. The Operation Complete bit (bit 0) in the Standard Event Status Register is then set.

If STATus:OPC:INITiate OFF is set, the Operation Complete bit will be set when all commands received prior to the *OPC have been executed. If ON is set, *OPC waits for waveform generation to complete before setting the Operation Complete bit. No other commands will be executed until the Operation Complete bit is set.

Comments

- **Executable when initiated:** Yes
- **Coupled command:** No
- **Related commands:** *OPC?, *WAI
- ***RST Condition:** none

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*OPC?

***OPC?** causes the E1340A to wait for all pending operations to complete. A single ASCII "1" is then placed in the output queue.

If STATus:OPC:INITiate OFF is set, the ASCII "1" will be placed in the output queue when all commands received prior to the *OPC? have been executed. If ON is set, *OPC? waits for waveform generation to complete before placing the "1" in the output queue. No other commands will be executed until the "1" is placed in the output queue.

Comments

- **Executable when initiated:** Yes
- **Coupled command:** No
- **Related commands:** *OPC, *WAI
- ***RST Condition:** none

*PMC

***PMC** purges all macro definitions.

Comments

- Use the *RMC command to purge an single macro definition.
- **Executable when initiated:** Yes
- **Coupled command:** No
- **Related commands:** *DMC, *RMC
- ***RST Condition:** none

*RCL

***RCL <*number*>** restores a previously stored programming state from one of the 10 possible stored state areas. *Number* indicates which of the stored state areas should be used.

This command affects the same command settings as does *RST. Notable exceptions include the SOURce:LIST commands, including waveform segment definitions, the STATus subsystem commands, and the CALibration:STATe:AC state.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
number	numeric	0 through 9	none

Comments

- **Executable when initiated:** No
- **Coupled command:** No
- **Related Commands:** *LRN?, *RST, *SAV
- ***RST Condition:** all saved states set to the same state as the *RST state

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*RMC

***RMC <*name*>** purges only the specified macro definition.

NOTE: At printing time, *RMC is a command proposed and accepted for a revision and re-designation of IEEE-488.2.

Comments

- Use the *PMC command to purge all macro definitions in one command.
- **Executable when initiated:** Yes
- **Coupled command:** No
- **Related commands:** *DMC, *PMC
- ***RST Condition:** none

*RST

***RST** resets the HP E1340A as follows:

- Sets all commands to their *RST state.
- Aborts all pending operations including waveform generation.
- Sets all stored (*SAV) states to the same state as the *RST state.

*RST does not affect:

- The state of VXIbus word serial protocol
- The output queue
- The Service Request Enable Register
- The Standard Event Status Enable Register
- The enable masks for the Operation Status and Questionable Signal Registers
- Calibration data
- Waveform segment definitions

Comments

- **Executable when initiated:** Yes
- **Coupled command:** No
- ***RST Condition:** none

*SAV

***SAV <*number*>** stores the current programming state into one of the 10 possible stored state areas. *Number* indicates which of the stored state areas should be used.

This command stores the states of all commands affected by *RST. Notable exceptions the SOURce:LIST commands, including waveform segment definitions, the STATus subsystem commands, and the CALibration:STATe:AC state.

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Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
number	numeric	0 through 9	none

Comments

- **Executable when initiated:** No
- **Coupled command:** No
- **Related Commands:** *LRN?, *RCL, *RST
- ***RST Condition:** all saved states set to the same state as the *RST state

*SRE and *SRE?

***SRE <*mask*>** specifies which bits of the Status Byte Register are enabled to generate a IEEE-488.1 service request. Event and summary bits are always set and cleared in the Status Byte Register regardless of the enable mask. *Mask* is the sum of the decimal weights of the bits to be enabled.

The query form returns the current enable mask.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
mask	numeric	0 through 255	none

A 1 in a bit position enables service request generation when the corresponding Status Byte Register bit is set; a 0 disables it.

Comments

- **Executable when initiated:** Yes
- **Coupled command:** No
- ***RST Condition:** unaffected
- **Power-On Condition:** no bits are enabled

Example

Enable service request on Message Available bit

```
*SRE 16                    Enable request on MAV
```

*STB?

***STB?** returns the value of the Status Byte Register. Bit 6 (decimal weight 64) is set if a service request is pending.

Comments

- **Executable when initiated:** Yes
- **Coupled command:** No
- **Related commands:** *SRE
- ***RST Condition:** none

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*TST?

***TST?** causes the E1340A to execute its internal self-test and returns a value indicating the results of the test. The test includes only a test of the command module-to-card microprocessor communications.

A zero response indicates that the self-test passed. Any non-zero reponse indicates that the test failed. See the HP E1340A service manual for information on interpreting non-zero self-test responses.

The settings for all SCPI commands are unchanged by this command.

Comments

- **Executable when initiated:** No
- **Coupled command:** No
- ***RST Condition:** none

*WAI

***WAI** causes the E1340A to wait for all pending operations to complete before executing any further commands.

If STATus:OPC:INITiate OFF is set, command execution resumes when all commands received prior to the *WAI have been executed. If ON is set, *WAI waits for waveform generation to complete before resuming command execution.

Comments

- **Executable when initiated:** Yes
- **Coupled command:** No
- **Related commands:** *OPC, *OPC?
- ***RST Condition:** none

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Table 7-1. HP E1340A Command Quick Reference

Subsystem	Commands
TRIGger	ABORt
ARM	ARM[:STARt][:LAYer[1]]:COUNt <*number*>
	ARM[:STARt]:LAYer2:COUNt <*number*>
	ARM[:STARt]:LAYer2:SLOPe <*edge*>
	ARM[:STARt]:LAYer2:SOURce <*source*>
CALibration	CALibration:AC:BEGin
	CALibration:AC:POINt? <*value*>
	CALibration:DATA:AC <*block*>
	CALibration:DATA[:DC] <*block*>
	CALibration[:DC]:BEGin
	CALibration[:DC]:POINt? <*value*>
	CALibration:STATe:AC <*state*>
INITiate	INITiate[:IMMediate]
OUTPut	OUTPut:IMPedance <*impedance*>
	OUTPut:LOAD <*load*>
[SOURce:]ARBitrary	[SOURce:]ARBitrary:DAC:SOURce <*source*>
	[SOURce:]ARBitrary:DOWNload <*source*>,<*dest*>,<*length*>
	[SOURce:]ARBitrary:DOWNload:COMPlete
[SOURce:] FREQuency	[SOURce:]FREQuency:CENTer <*center_freq*>
	[SOURce:]FREQuency[:CW|:FIXed] <*frequency*>
	[SOURce:]FREQuency:FSKey <*frequency1*>,<*frequency2*>
	[SOURce:]FREQuency:MODE <*mode*>
	[SOURce:]FREQuency:SPAN <*freq_span*>
	[SOURce:]FREQuency:STARt <*start_freq*>
	[SOURce:]FREQuency:STOP <*stop_freq*>
[SOURce:]FUNCtion	[SOURce:]FUNCtion[:SHAPe] <*shape*>
	[SOURce:]FUNCtion:USER <*name*>

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Table 7-1. HP E1340A Command Quick Reference (continued)

Subsystem	Commands
[SOURce:]LIST	[SOURce:]LIST[:SEGMent]:CATalog?
	[SOURce:]LIST[:SEGMent]:DEFine?
	[SOURce:]LIST[:SEGMent]:SELect <*name*>
	[SOURce:]LIST[:SEGMent]:VOLTage <*voltage_list*>
	[SOURce:]LIST[:SEGMent]:VOLTage:DAC <*voltage_list*>
	[SO]LIST[:SEGMent]:VOLTage:POINts?
	SOURce:]LIST:SSEQuence:CATalog?
	[SOURce:]LIST:SSEQuence:DEFine?
	[SOURce:]LIST:SSEQuence:SELect <*name*>
	[SOURce:]LIST:SSEQuence:SEQuence?
	[SOURce:]LIST:SSEQuence:SEQuence:SEGMents?
[SOURce:]MARKer	[SOURce:]MARKer:FEED <*source*>
	[SOURce:]MARKer:POLarity <*polarity*>
[SOURce:]RAMP	[SOURce:]RAMP:POLarity <*polarity*>
[SOURce:] ROSCillator	[SOURce:]ROSCillator:FREQuency:EXTernal <*frequency*>
	[SOURce:]ROSCillator:GATE:STATe <*state*>
	[SOURce:]ROSCillator:SOURce <*source*>
[SOURce:]SWEep	[SOURce:]SWEep:COUNt <*number*>
	[SOURce:]SWEep:POINts <*number*>
	[SOURce:]SWEep:TIME <*time*>
[SOURce:]VOLTage	[SOURce:]VOLTage[:LEVel][:IMMediate][:AMPLitude] <*amplitude*>
	[SOURce:]VOLTage[:LEVel][:IMMediate][:AMPLitude]:UNIT[:VOLTage] <*units*>
	[SOURce:]VOLTage[:LEVel][:IMMediate]:OFFSet <*offset*>

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Table 7-1. HP E1340A Command Quick Reference (continued)

Subsystem	Commands
STATus	STATus:OPERation|QUEStionable:CONDition?
	STATus:OPERation|QUEStionable:ENABle <*unmask*>
	STATus:OPERation|QUEStionable[:EVENt]?
	STATus:OPERation|QUEStionable:NTRansition <*unmask*>
	STATus:OPERation|QUEStionable:PTRansition <*unmask*>
	STATus:PRESet
SYSTem	SYSTem:ERRor?
	SYSTem:VERsion?
TRIGger	TRIGger[:STARt]:COUNt <*number*>
	TRIGger[:STARt]:SOURce <*source*>

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SCPI Conformance Information

The HP E1340A Arbitrary Function Generator conforms to the SCPI-1991.0 standard.

The following tables list all the SCPI confirmed, approved, and non-SCPI commands that the HP E1340A can execute.

Table 7-2. SCPI Confirmed Commands

```
ABORt

ARM
    [:START | SEQuence[1]]
        [:LAYer[1]]
            :COUNt <number>
        :LAYer2
            :COUNt <number>
            :SLOPe <edge>
            :SOURce<source>

INITiate
    [:IMMediate]

OUTPut
   :IMPedance <impedance>

[SOURce:]
    FREQuency
        :CENTer <center_freq>
        [:CW | FIXed] <frequency>
        :MODE <mode>
        :SPAN <freq_span>
        :STARt <start_freq>
        :STOP <stop_freq>
    FUNCtion
        [:SHAPe] <shape>

[SOURce:]
    ROSCillator
        :SOURce <source>
    SWEep
        :COUNt <number>
        :POINts <number>
        :TIME <time>

STATus
    :OPERation | QUEStionable
        :CONDition?
        :ENABle <unmask>
        :NTRansition <unmask>
        :PTRansition <unmask>
    :PRESet

SYSTem
    :ERRor?
    :VERSion?

TRIGger
    [:STARt | SEQuence[1]]
        :COUNt <number>
        :SOURce <source>
```


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Table 7-3. Non-SCPI Commands

```
CALibration
      :AC
          :BEGin
          :POINt? <value>
    :DATA
          :AC <block>
          [:DC] <block>
    [:DC]
          :BEGin
          :POINt? <value>
    :STATe
          :AC <state>

OUTPut
    :LOAD <load>

[SOURce:]
    ARBitrary
          :DAC
               :SOURce <source>
          :DOWNload <source>,<dest>,<length>
               :COMPlete
    FUNCtion
          :USER <name>

[SOURce:]
    LIST
          [:SEGMent]
               :CATalog?
               :DEFine?
               :SELect <name>
               :VOLTage <voltage_list>
                    :DAC <voltage_list>
                    :POINts?
          :SSEQuence
               :CATalog?
               :DEFine?
               :SELect <name>
               :SEQuence?
                    :SEGMents?
    MARKer
               :FEED <source>
               :POLarity <polarity>
    RAMP
          :POLarity <polarity>
    ROSCillator
          :FREQuency
               :EXTernal <frequency>
          :GATE
               :STATe <state>
```


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Chapter 8
HP E1340A AFG Status

Introduction

This chapter describes the HP E1340A Arbitrary Function Generator status system. Included is information on the status groups used by the AFG, the conditions monitored by each group, and information on how to enable a condition to interrupt the computer.

This main sections of this chapter include:

Status System Registers

Operating conditions within the AFG are monitored by registers in various status groups. The status groups implemented by the AFG are:

- Operation Status Group
  - Condition Register
  - Transition Filter
  - Event Register
  - Enable Register
- Standard Event Status Group
  - Standard Event Status Register
  - Standard Event Status Enable Register
- Status Byte Status Group
  - Status Byte Register
  - Service Request Enable Register

The relationship between the registers and filters in these groups is shown in Figure 8-1.

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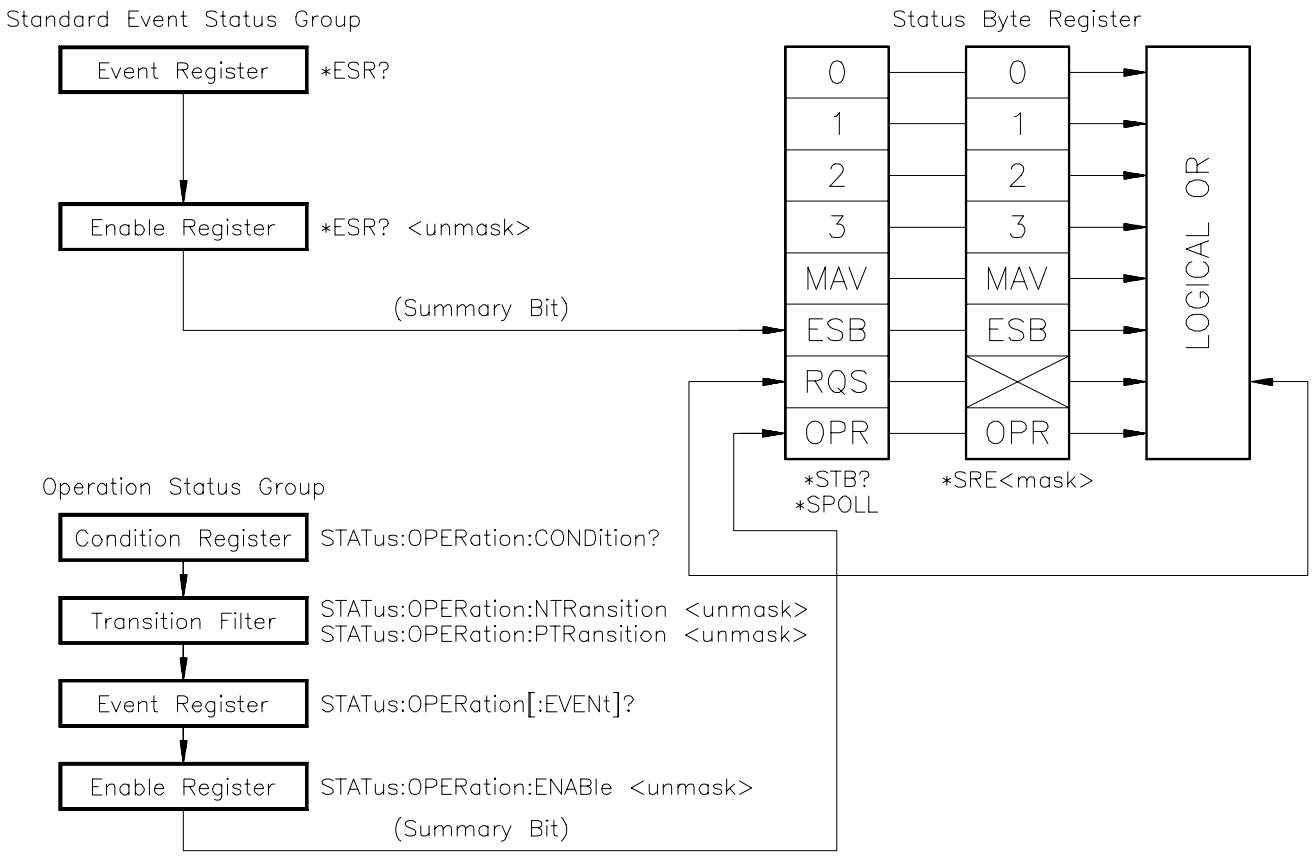

Figure 8-1. HP E1340A Status Groups and Associated Registers

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The Operation Status Group

The Operation Status Group monitors current operating conditions within the AFG. The specific conditions include: CALibrating, SWEeping, and execution of the INITiate:IMMediate command.

The Condition Register

Calibration, sweeping, and the INITiate:IMMediate command are monitored with the following bits in the Condition Register. All other bits are unused.

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
unused							INIT	unused				SWE	unused		CAL

CALibrating: Bit 0 is set (1) during the execution of the CALibration:ALL? query. The bit is cleared (0) otherwise.

SWEeping: Bit 3 is set (1) while a frequency sweep is in progress. The bit is cleared (0) when waveform generation is halted and frequency sweeping is not selected.

INITiated: Bit 8 is set (1) when the INITiate:IMMediate command is executed. Waveform generation begins immediate if ARM:STARt:SOURce IMMediate is set; otherwise waveform generation begins when the AFG receives the first start arm. The bit is cleared (0) when waveform generation is complete after the waveform is aborted (by an ABORt, or *RST command, or a Device Clear). The AFG then returns to the Idle state.

Reading the Condition Register

Bit settings in the Condition Register can be determined with the command:

```
STATus:OPERation:CONDition?
```

Bits 0, 3, and 8 have corresponding decimal values of 1, 8, and 256. Reading the Condition Register does not affect the bit settings. The bits are cleared following a reset (*RST).

The Transition Filter

The Transition Filter specifies which type of bit transition in the Condition Register will set corresponding bits in the Event Register. Transition Filter bits may be set for positive transitions (0 to 1), or negative transitions (1 to 0). The commands used to set the transitions are:

```
STATus:OPERation:NTRansition <unmask>
STATus:OPERation:PTRansition <unmask>
```

NTRansition sets the negative transition. For each bit unmasked, a 1 to 0 transition of that bit in the Condition Register sets the associated bit in the Event Register.

PTRansition sets the positive transition. For each bit unmasked, a 0 to 1 transition of that bit in the Condition Register sets the associated bit in the Event Register.

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<*unmask*> is the decimal, hexadecimal (#H), octal (#Q), or binary (#B) value of the Condition Register bit to be unmasked. (Bits 0, 3, and 8 have corresponding decimal values of 1, 8, and 256.)

The Event Register

The Event Register latches transition events from the Condition Register as specified by the Transition Filter. Bits in the Event Register are latched and remain set until the register is cleared by one of the following commands:

```
STATus:OPERation[:EVENt]?
*CLS
```

The Enable Register

The Enable Register specifies which bits in the Event Register can generate a summary bit which is subsequently used to generate a service request. The AFG logically ANDs the bits in the Event Register with bits in the Enable Register, and ORs the results to obtain a summary bit.

The bits in the Enable Register that are to be ANDed with bits in the Event Register are specified (*unmasked*) with the command:

```
STATus:OPERation:ENABle <unmask>
```

<*unmask*> is the decimal, hexadecimal (#H), octal (#Q), or binary (#B) value of the Enable Register bit to be *unmasked*. (Bits 0, 3, and 8 have corresponding decimal values of 1, 8, and 256.)

The Enable Register is cleared at power-on, or by specifying an <*unmask*> value of 0.

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The Standard Event Status Group

The Standard Event Status Group monitors command execution, programming errors, and the power-on state. It is the status group used by the error checking routine in the HP IBASIC example programs found throughout the manual.

The Standard Event Status Register

The conditions monitored by the Standard Event Status Register are identified below.

7	6	5	4	3	2	1	0
PON	unused	CME	EXE	DDE	QYE	unused	OPC

Power-on (PON): Bit 7 is set (1) when an off-to-on transition has occurred.

Command Error (CME): Bit 5 is set (1) when an incorrect command header is received, or if an un-implemented common command is received.

Execution Error (EXE): Bit 4 is set (1) when a command parameter is outside its legal range.

Device Dependent Error (DDE): Bit 3 is set (1) when an error other than a command error, execution error, or query error has occurred.

Query Error (QYE): Bit 2 is set (1) when the AFG output queue is read and no data is present, or when data in the output queue has been lost.

Operation Complete (OPC): Bit 0 is set (1) when the *OPC command is received. *OPC is used to indicate when all pending (or previous) AFG commands have completed.

Note that bits 7, 5, 4, 3, 2, and 0 have corresponding decimal values of 128, 32, 16, 8, 4, and 1.

Reading the Standard Event Status Register

The settings of the Standard Event Status Register can be read with the command:

```
*ESR?
```

The bits are cleared at power-on, or by *ESR? or *CLS.

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The Standard Event Status Enable Register

The Standard Event Status Enable Register specifies which bits in the Standard Event Status Register can generate a summary bit which is subsequently used to generate a service request. The AFG logically ANDs the bits in the Event Register with bits in the Enable Register, and ORs the results to obtain a summary bit.

The bits in the Enable Register that are to be ANDed with bits in the Event Register are specified (*unmasked*) with the command:

*ESE <*unmask*>

<*unmask*> is the decimal, hexadecimal (#H), octal (#Q), or binary (#B) value of the Enable Register bit to be *unmasked*. (Bits 7, 5, 4, 3, 2, 0 have corresponding decimal values of 128, 32, 16, 8, 4, 1.)

All unmasked bits in the Enable Register can be determined with the command:

*ESE?

The Standard Event Status Enable Register is cleared at power-on, or with an <*unmask*> value of 0.

The Status Byte Status Group

The registers in the Status Byte Status Group enable conditions monitored by the other status groups to generate a service request.

The Status Byte Register

The Status Byte Register contains the summary bits of the Questionable Signal Status Group (QUES), the Operation Status Group (OPER), and the Standard Event Status Group (ESB). The register also contains the message available bit (MAV) and the service request bit (RQS).

7	6	5	4	3	2	1	0
OPER	RQS	ESB	MAV	QUES	unused		

Questionable Signal Summary Bit (QUES): Bit 3 is set (1) when a condition monitored by the Questionable Signal Status Group is present, when the appropriate bit is latched into the group's Event Register, and when the bit is unmasked by the group's Enable Register.

Message Available Bit (MAV): Bit 4 is set (1) when data, such as a query response, is in the AFG's output queue.

Standard Event Summary Bit (ESB): Bit 5 is set (1) when a condition monitored by the Standard Event Status Group is present and the appropriate bit is set in the group's Event Register, and when the bit is unmasked by the group's Enable Register.

Service Request Bit (RQS): Bit 6 is set (1) when any other bit in the Status Byte Register is set.

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Operation Status Summary Bit (OPER): Bit 7 is set (1) when a condition monitored by the Operation Status Group is present, when the appropriate bit is latched into the group's Event Register, and when the bit is unmasked by the group's Enable Register.

Reading the Status Byte Register

The Status Byte Register can be read with either of the following commands:

```
*STB?
SPOLL
```

Both commands return the decimal weighted sum of all set bits in the register. The difference between the commands is that *STB? does not clear bit 6 (RQS service request). The serial poll (SPOLL) does clear bit 6.

MAV is cleared when data is read from the output queue.

The Service Request Enable Register

The Service Request Enable Register specifies which (status group) summary bit(s) will send a service request message to the computer over HP-IB. The bits are specified (*unmasked*) with the command:

```
*SRE <unmask>
```

All unmasked bits in the Enable Register can be determined with the command:

```
*SRE?
```

The Service Request Enable Register is cleared at power-on, or by specifying an <*unmask*> value of 0.

Presetting the Enable Register and Transition Filter

The Enable Registers and Transition Filters in the Questionable Signal and Operation Status Groups can be preset (initialized) with the command:

```
STATus:PRESet
```

All bits in the Enable Registers are masked (i.e. <*unmask*> is 0), and all bits in the Condition Registers set corresponding bits in the Event Registers on positive (0 to 1) transitions.

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Using the Standard Event Status Group

The following program sets up the Standard Event Status Group Registers to monitor programming errors. When a command error, execution error, device dependent error, or query error occurs, a service request interrupt is sent to the computer which then reads the AFG error queue and displays the error code and message.

The steps of the program are:

1. Unmask bits 5 (CME), 4 (EXE), 3 (DDE), 2 (QYE) in the Standard Event Status Enable Register so that the error will generate a Standard Event Status Group summary bit.

   *ESE <*unmask*>

2. Unmask bit 5 (ESB) in the Service Request Enable Register so that a service request is generated when the Standard Event Status Group summary bit is received.

   *SRE <*unmask*>

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Chapter 9
HP E1340A Block Diagram Description

Chapter Contents

This chapter shows how the HP E1340A 12-Bit Arbitrary Function Generator (AFG) operates. The sections are as follows:

AFG Description

The AFG is a register-based VXIbus B-size card that can output standard waveforms, like SINusoid, SQUare, TRIangle, and RAMP waveforms, various arbitrary, and user defined arbitrary (i.e., USER function) waveforms. The AFG can also perform frequency sweeping, frequency-shift-keying, and output DC volts.

All waveforms that the AFG generates, except DC volts, are arbitrary waveforms. The only difference is that the user supplies the data for the arbitrary waveforms while the standard waveforms are already stored in an EPROM.

What is an Arbitrary Waveform?

Refer to Figure 9-1. An arbitrary waveform is equally divided into points that are the actual voltage points of the waveform. The AFG stores these points as a waveform segment in memory. The waveform segme ts are stored as Digital-to-Analog Converter (DAC) codes. The codes set the output DAC to the voltage values of the waveform. Each waveform segment consists of 4096 points.

n

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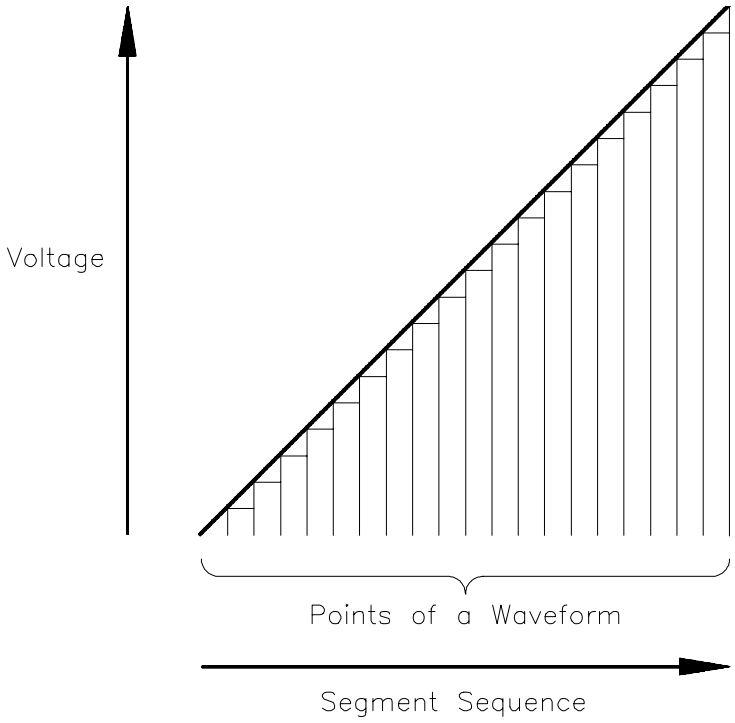

Figure 9-1. Arbitrary Waveform

Refer to Figure 9-2. The following describes the blocks that generate waveforms.

Output DAC

The AFG uses a 12-bit DAC to generate the waveforms. Each time the AFG's frequency generator clocks the DAC latch, the DAC outputs a voltage value that corresponds to the point value in memory. The bits set in the DAC determine the voltage value. The DAC codes in memory set the appropriate bits of the DAC. The RAM receives its data either from EPROMs or over the VXIbus through a register.

Besides receiving data from memory, the DAC can also receive segment data directly over the VXIbus. In this case, the data on the VXIbus immediately set the DAC to an output voltage that corresponds to the DAC code value sent. Each time the DAC receives a new code, the DAC's output is set to the value in the new code. Thus, the waveform frequency depends on the rate at which the DAC receives the codes.

The output DAC's voltage range is from -5.12 V to +5.1175 V.

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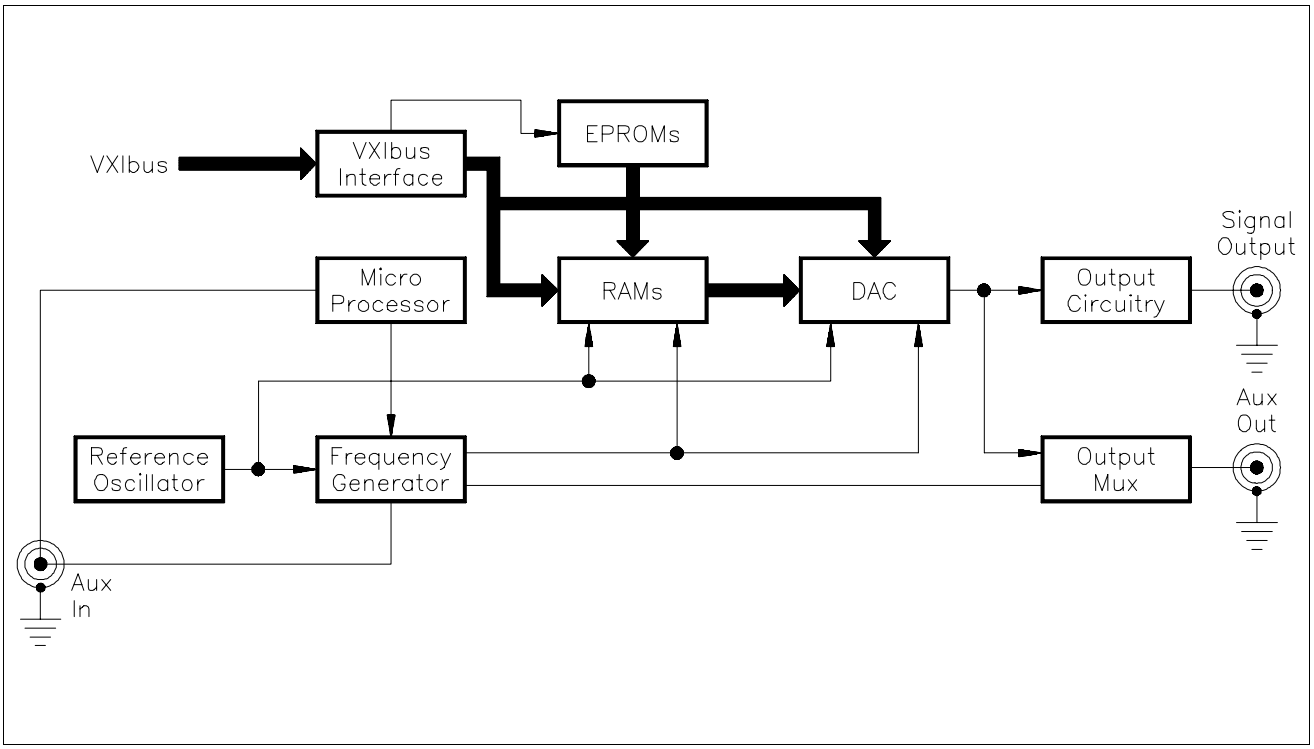

Figure 9-2. AFG Simplified Block Diagram

Memory

The memory consists of four areas of RAM in which the AFG stores the DAC codes. Concurrently with the DAC, the frequency generator also clocks a latch to output the next code in the RAM to set the DAC bits to the next point on the waveform.

The standard waveform DAC codes are stored in EPROMs. To output a standard waveform, the codes in the EPROMs are transferred to the RAM. For user generated arbitrary waveforms, the DAC codes are directly stored into the RAMs. The same operation then takes place as stated above.

Reference Oscillator

The reference oscillator provides the clock signal for the frequency generator. Thus, frequency stability depends on the stability of the reference oscillator. The AFG allows for user supplied reference oscillator sources for custom frequency values. The reference oscillator also clocks the RAM and the DAC.

Frequency Generators

The frequency generator sets the waveform frequency by determining the speed at which the RAM address is addressed.

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Output Circuitry

The output circuitry outputs the waveform at the front panel's "Signal Output" connector. The circuitry sets the output amplitude, offset voltages, and output impedance.

Attenuator

The attenuator provides 20 dB attenuation for the output voltage. The AFG automatically sets the attenuator to the appropriate value dependent on the output amplitude selected by the user.

Output Amplifier

The output amplifier provides the necessary current to drive output loads of 50Ω. For matched loads, the output amplitude is from -5.12 V to +5.11875 V. In addition, the amplifier can also be set for open circuit or infinite loads applied to the "Signal Output" connector. For open circuit outputs, the amplitude range is twice the matched load values.

Offset Circuitry

This circuitry offsets the output amplifier to provide an offset voltage.

Microprocessor

The purpose of the microprocessor is to monitor the "Aux In" input line to help control frequency-shift keying, burst, and waveform hopping operation. It also interprets low-level commands received over the VME bus.

Input/Output Connectors

The AFG uses three connectors, a "Signal Output", "Aux In", and "Aux Out" connector.

Signal Output

This connector outputs the AFG's standard and arbitrary waveforms.

Aux In

This connector is used for frequency-shift keying control, waveform hopping, reference oscillator gating, reference oscillator source, or arm start source.

Aux Out

This connector outputs the marker sources selected by the [SOURce:]MARKer command. The Output MUX connects the appropriate signals to the connector.

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Appendix A
HP E1340A Specifications

Appendix Contents

This appendix contains the HP E1340A Arbitrary Function Generator operating specifications. Except as noted, the specifications apply under the following conditions:

- **Period:** 1 year
- **Temperature:** 0° - 55° C
- **Relative humidity:** 65% @ 0° - 40° C
- **Warm up time:** 1 hour

"Typical", "typ", or "nominal" values are non-warranted supplementary information provided for application assistance.

Instrument Specifications

Amplitude Resolution: 12 bits

Timebase: Frequency: 42.949673 MHz ±50 PPM

Number of Active Waveforms in Memory: 4

Maximum Voltage Amplitude: 10.24V

DC Offset Range: ±5.11 V into 50Ω

Built-in Waveforms: Sine, Square, Ramp, Triangle, Sin(x)/x Noise, Haversine

Maximum Waveform Frequency: 15 MHz - Sine
1 MHz Square, Ramp, Triangle

Output Impedance: 50Ω ±1%

Fine Attenuator Resolution: 11 bits

Coarse Attenuator: 0 or 20 dB

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DC Accuracy: ±2.7% Full Scale

AC Accuracy: ±0.43 dB

Total Harmonic Distortion (Sine):

Frequency	Amplitude (dBm) +23 to -20	Amplitude (dBm) 10
1 to 100 kHz	-60 dB	-63 dB
100 kHz to 1 MHz	-49 dB	-54 dB
1 MHz to 10 MHz	-33 dB	-47 dB
10 MHz to 15 MHz	-30 dB	-41 dB

ic

Sine Non-Harmon Distortion:

0 to 1 MHz: -65 dBc or -45 dBm, whichever is greater
1 MHz to 10 MHz: -43 dBc or -45 dBm, whichever is greater
10 MHz to 15 MHz: -34 dBc or -45 dBm, whichever is greater

Sine Flatness:
(referenced to 1 kHz)

+23 dBm to -20 dBm
frequency up to 10 MHz: ±0.2 dB
frequency up to 15 MHz: ±0.5 dB

Note: Maximum output at 11 MHz to 15 MHz is only guaranteed to +20 dBm.

Integral Non-Linearity: ±5 lsb

Differential Non-Linearity: ±5 lsb

Jitter: 23 nS

Frequency Sweep Range: 0.01 Hz to 15 MHz

Sweep Rate of Change: 0.4 Hz/sec to 2.6 MHz/sec

Frequency-Shift (FSK) Rate: to 4 kHz

Waveform Repetitions: 1 to 64534 or continuous

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General and VXI Characteristics

Module Size: B

Device Type: Register-Based

Connectors Used: P1

Number Slots: 1

VXIbus Interface Capability: A16

Interrupt Level: Not Used

Power Requirements:

Voltage:	+5 V	+12 V
Peak Module Current:	1.2 A	0.6 A
Peak Dynamic Current:	0.01 A	0.15 A

Watts per Slot: 13.2

Cooling per Slot: 0.11 mm H_2O @ 1.06 liters/s

Storage Temperature: -40° to 75° C

EMC. RFI, Safety: meets: FTZ 1046/1984
CSA 556B
IEC 348
UL 1244

Net Weight: 0.6 kg

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Appendix B
HP E1340A Useful Tables

Appendix Contents

The tables in this appendix contain information often referred to during E1340A programming. The tables in this appendix include:

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Table B-1. HP E1340A Example Program Listing

Program Type	Program Name	Language	Description
Introductory (Chapter 1)	SLFTST	HP IBASIC, C, QuickBASIC	E1340A Self Test.
	RSTCLS	"	Resetting and clearing the AFG.
	LRN	"	Power-on/reset configuration.
	ERRORCHK	HP IBASIC	Error checking program.
	RSTSINE	HP IBASIC, C, QuickBASIC	Sine wave output from reset settings.
Standard Waveforms (Chapter 2)	DCVOLTS	HP IBASIC, C, QuickBASIC	+5V DC voltage.
	SINEWAVE	"	1kHz, 5Vp sine wave.
	RAMPWAVE	"	4V,10 kHz negative-going ramp.
	OUTPUNIT	"	Sets amplitude units to volts peak-to-peak.
Arbitrary Waveforms (Chapter 3)	ARB_GEN	HP IBASIC, C, QuickBASIC	Procedure for generating an arbitrary waveform (0 to 5V ramp waveform).
	MULSEG	"	Arbitrary waveform with two segments.
	ARB_HOP	"	Selects between two waveforms based on the level of the signal on the 'Aux In' BNC.
	ROM_DOWN	"	Downloads a waveform to waveform segment memory from the waveform EPROM.
	SIN_D	"	Damped sine wave arbitrary waveform.
	CHARGE	"	Exponential charge/dischargewpaveform.
	SPIKES	"	Sine wave with spikes.
	SIN_R	"	1/2 wave rectified sine wave.
Sweeping and Frequency-Shift Keying (Chapter 4)	SMPLSWP1	HP IBASIC, C, QuickBASIC	0 Hz to 1 MHz sweep using start and stop frequencies.
	SMPLSWP2	"	1 kHz to 21 kHz sweep using start and span frequencies.
	SWP_PVST	"	Setting the sweep time (5 kHz to 15 kHz in 0.5 seconds).
	FSK1	"	Frequency-shift keying.

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Table B-1. HP E1340A Example Program Listing (Cont'd)

Program Type	Program Name	Language	Description
Arming and Marker Outputs (Chapter 5)	EXT_ARM	HP IBASIC, C, QuickBASIC	Arming the AFG with a signal applied to the 'Aux In' BNC.
	BURST	"	5 cycle burst for each external arm.
	GATE_SIG	"	Gating the output on and off.
	MARK_OUT	"	Outputs marker pulses with all amplitude points less than 0V.
High-Speed Operation (Chapter 6)	UNS_DAT	HP IBASIC, C, QuickBASIC	Downloads arbitrary waveform data as (unsigned) DAC codes.
	DACBLOK	"	Downloads arbitrary waveform data as DAC codes in a definite length block.
	VXIDOWN	"	Downloading to the AFG's Input Data register from the VXI backplane.
	VXISRCE	"	Downloading directly to the DAC from the Input Data register.
AFG Status (Chapter 9)	ERRORCHK	HP IBASIC	Monitors programming errors using the Standard Event Status Group.

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Table B-2. Coupled Commands

Group	Commands
Coupled Commands	ARM[:STARt][:LAYer[1]]:COUNt ARM[:STARt]:LAYer2:COUNt ARM[:STARt]:LAYer2:SLOPe ARM[:STARt]:LAYer2:SOURce OUTPut:IMPedance OUTPut:LOAD [SOURce:]ARBitrary:DAC:SOURce [SOURce:]FREQuency:CENTer [SOURce:]FREQuency[:CW|FIXed] [SOURce:]FREQuency:FSKey [SOURce:]FREQuency:MODE [SOURce:]FREQuency:SPAN [SOURce:]FREQuency:STARt [SOURce:]FREQuency:STOP [SOURce:]FUNCtion[:SHAPe] [SOURce:]FUNCtion:USER [SOURce:]MARKer:FEED [SOURce:]MARKer:POLarity [SOURce:]RAMP:POLarity [SOURce:]ROSCillator:FREQuency:EXTernal [SOURce:]ROSCillator:SOURce [SOURce:]SWEep:COUNt [SOURce:]SWEep:POINts [SOURce:]SWEep:TIME [SOURce:]VOLTage[:LEVel][:IMMediate][:AMPLitude] [SOURce:]VOLTage[:LEVel][:IMMediate]:OFFSet
Un-coupled Commands	ABORt INITiate[:IMMediate] [SOURce:]ARBitrary:DOWNload [SOURce:]ARBitrary:DOWNload:COMPlete [SOURce:]LIST[:SEGMent]:CATalog? [SOURce:]LIST[:SEGMent]:DEFine? [SOURce:]LIST[:SEGMent]:SELect [SOURce:]LIST[:SEGMent]:VOLTage [SOURce:]LIST[:SEGMent]:VOLTage:DAC [SOURce:]LIST[:SEGMent]:VOLTage:POINts? [SOURce:]LIST:SSEQuence:CATalog? [SOURce:]LIST:SSEQuence:DEFine [SOURce:]LIST:SSEQuence:SELect [SOURce:]LIST:SSEQuence:SEQuence? [SOURce:]LIST:SSEQuence:SEQuence:SEGMents? [SOURce:]ROSCillator:GATE:STATe [SOURce:]VOLTage[:LEVel][:IMMediate][:AMPLitude]:UNIT[:VOLTage] TRIGger[:STARt]:COUNt TRIGger[:STARt]:SOURce

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Table B-3. HP E1340A Power-On/Reset Configuration (as returned by *LRN?)

Parameter	Command	Power-on/Reset Setting
Macro usage	*EMC	+0
AC calibration	:CAL:STAT:AC	1 (enabled)
DAC data source	:ARB:DAC:SOUR	INTernal
Waveform amplitude units	:VOLT:AMPL:UNIT:VOLT	V
External reference osc. frequency	:ROSC:FREQ:EXT	+4.294967296E+007
Reference oscillator source	:ROSC:SOUR	INTernal
Gating State	GATE:STAT	0 (off)
Output frequency	:FREQ:FIX	+1.000000000E+004
Frequency-shift keying (FSK) frequencies	FSK	+1.000000000E+004, +1.500000000E+007
Frequency mode	MODE	FIXed
Sweep start frequency	STAR	+0.000000000E+000
Sweep stop frequency	STOP	+1.500000000E+007
Sweep count	:SWE:COUN	+9.900000000E+037
Sweep points	POIN	+1.00100000E+003
Sweep time	TIME	+1.05000000E+000
Function	:FUNC:SHAP	SINusoid
Ramp waveform polarity	:RAMP:POL	NORMal
Output amplitude	:VOLT:AMPL	+0.000000000E+000
DC offset	OFFS	+0.000000000E+000
Output load	:OUTP:LOAD	+5.000000000E+001
Waveform repetitions (burst)	:ARM:COUN	+9.900000000E+037
Waveform arm count	LAY2:COUN	+1.000000000E+000
External arm slope	SLOP	POSitive
Arm source	SOUR	IMMediate
'Aux Out' BNC source	:MARK:FEED	"SEGM"
'Aux Out' signal polarity	POL	NORMal
Arbitrary waveform sequence	:FUNC:USER	NONE

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Table B-4. HP E1340A Error Messages

Code	Message	Description
-101	Invalid character	Unrecognized character in parameter.
-102	Syntax error	Command is missing a space or comma between parameters.
-103	Invalid separator	Parameter is separated by a character other than a comma.
-104	Data type error	The wrong data type (number, character, string, expression) was used when specifying the parameter.
-108	Parameter not allowed	Parameter specified in a command which does not require one.
-109	Missing parameter	Command requires a parameter(s).
-112	Program mnemonic too long	Command keyword > 12 characters.
-113	Undefined header	Command header (keyword) was incorrectly specified.
-121	Invalid character in number	A character other than a comma or number is in the middle of a number.
-123	Numeric overflow	A parameter value is greater than what can be represented with the number format.
-124	Too many digits	More than 256 digits were used to specify a number.
-128	Numeric data not allowed	A number was specified when a letter was required.
-131	Invalid suffix	Parameter suffix incorrectly specified (e.g. VO rather than VP).
-138	Suffix not allowed	Parameter suffix is specified when one is not allowed.
-141	Invalid character data	Discrete parameter specified is not a valid choice.
-144	Character data too long	A segment or sequence name is too long, or a discrete parameter is > 12 characters. Segment and sequence names must be 12 characters or less.
-148	Character data not allowed	Discrete parameter was specified when another type (e.g. numeric, boolean) is required.
-151	Invalid string data	The string data specified (e.g. for the SOUR:MARK:FEED <source> command is not a valid choice.
-158	String data not allowed	A string was specified when another parameter type (i.e. discrete, numeric, boolean) is required.

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Table B-4. HP E1340A Error Messages (Cont'd)

Code	Message	Description
-161	Invalid block data	The number of bytes in a definite length data block does not equal the number of bytes indicated by the block header.
-168	Block data not allowed	Block data was specified when another parameter type (i.e. discrete, numeric, boolean) is required.
-178	Expression data not allowed	The parameter was specified as an expression (e.g. SOUR:FREQ1:FIX (A*B).
-183	Invalid inside macro definition	Voltage or segment list is inside a macro.
-213	Init ignored	INITiate:IMMediate received while the AFG was currently initiated.
-221	Settings conflict	See "Settings Conflict Error Messages" at the end of this table.
-222	Data out of range	Parameter value is out of range for any AFG configuration (e.g. SOUR:FREQ1:FIX 1E9).
-240	Hardware error	The HP E1340A is not responding. Possible hardware failure.
-270	Macro error	*RMC <name> was executed and name is not defined.
-272	Macro execution error	Macro program data sequence could not be executed due to a syntax error within the macro definition.
-273	Illegal macro label	The macro label defined in the *DMC command was too long, the same as a common command keyword, or contained invalid header syntax.
-276	Macro recursion error	A macro program data sequence could not be executed because the sequence leads to the execution of a macro being defined.
-277	Macro redefinition not allowed	A macro label in the *DMC command could not be executed because the macro label was already defined.
-330	Self-test failed	Note the information associated with the message for a description of the failure.
-350	Too many errors	The HP E1340A A error queue is full and additional errors have occurred.
-410	Query INTERRUPTED	The HP E1340A was sent a command before it was finished responding to a query command.
-420	Query UNTERMINATED	The controller (computer) attempts to read a query response from the HP E1340A without having first sent a complete query command.

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Table B-4. HP E1340A Error Messages (Cont'd)

Code	Message	Description
-430	Query DEADLOCKED	The HP E1340A's input and output buffers are full and the AFG cannot continue.
-440	Query UNTERMINATED after indefinite response	Occurs when the *IDN? query is not the last query executed in a command string.
1005	Calibration constant out of range	Illegal calibration constant was computed.
1006	Calibration constant conflict	Calibration constants used during calibration set an illegal condition.
1011	Illegal while download enabled	Commands such as SOUR:LIST cannot be executed under current conditions. Execute SOUR:ARB:DOWN:COMP to disable downloading.
1012	Illegal when not downloading	SOUR:ARB:DOWN:COMP disables downloading only after it has previously been enabled.
1014	Illegal while initiated	Command cannot be executed while the HP E1340A is in the initiated (instrument action) state.
1015	Illegal when SOUR:ARB:DAC not INT	SOUR:LIST command cannot be executed unless the DAC data source is internal.
1018	Illegal while calibrating	Command cannot be sent to the HP E1340A while the device is calibrating.
1019	Illegal while not calibrating	The command is only valid when the HP E1340A is calibrating.
1100	Illegal segment name	Attempting to download to a segment that doesn't exist, or selecting a segment name that's the same as an existing sequence name.
1102	Segment in use	Trying to delete a segment that is within a sequence.
1108	No segment name SELected	Trying to load a segment that has not been selected.
1110	Illegal sequence name	Attempting to download to a sequence that doesn't exist, or selecting a sequence name that's the same as an existing segment name.
1113	Sequence contains zero-length segment	Segment contains no voltage or DAC code data.
1118	No sequence name SELected	SOUR:LIST:SSEQ subsystem command executed without a segment sequence first selected by SOUR:LIST:SSEQ:SEL.
1119	No sequence name selected for output	INITiate command sent while SOUR:FUNC:USER NONE selected.

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Table B-4. HP E1340A Error Messages (Cont'd)

Settings Conflict Error Messages
The following shows the conflicting settings and the change(s) made internally by the AFG.
SOUR:FREQ:FIX frequency < minimum; SOUR:FREQ:FIX MIN set
SOUR:FREQ:FIX frequency > maximum; SOUR:FREQ:FIX MAX set
ARB:DAC:SOUR VXI and CAL:STAT:AC ON; CAL:STAT:AC OFF set
ROSC:SOUR EXT and ROSC:FREQ:EXT not 42.94967296 MHz and CAL:STAT:AC ON; CAL:STAT:AC OFF set
multiple Aux In BNC uses; SOUR:ROSC:GATE:STAT OFF set
multiple Aux In BNC uses; ARM:LAY2:SOUR IMM set
multiple Aux In BNC uses; SOUR:FREQ:MODE FIX set
multiple Aux In BNC uses; SOUR:FUNC:USER A set
SOUR:FREQ:MODE FSK and ARM:LAY1:COUN not INF; ARM:LAY1:COUN INF set
SOUR:FREQ:FSK frequency < minimum; SOUR:FREQ:FSK MIN set
SOUR:FREQ:FSK frequency > maximum; SOUR:FREQ:FSK MAX set
ARM:LAY1:COUN INF and ARM:LAY2:SOUR EXT; ARM:LAY2:SOUR IMM set
FUNC:USER:AB and ARM:LAY1:COUN >32767; ARM:LAY1:COUN 32767 set
FUNC:USER:ABCD and ARM:LAY1:COUN > 16383; ARM:LAY1:COUN 16383 set
OUTP:LOAD INF and SOUR:VOLT unit W, DBM, or DBMW; SOUR:VOLT:AMPL MIN (in V) set
ARM:LAY2:COUN 1 and ARM:LAY2:SOUR EXT; ARM:LAY2:SOUR IMM set
ARM:LAY2:COUN >1 and ARM:LAY2:SOUR IMM; ARM:LAY2:SOUR EXT set
SOUR:FREQ:MODE SWE and ARM:LAY1:COUN not INF; ARM:LAY1:COUN INF set
SOUR:FREQ:MODE SWE and ARM:LAY2:SOUR not IMM; ARM:LAY2:SOUR IMM set
SOUR:FREQ:SPAN frequency < minimum; SOUR:FREQ:MODE FIX set

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Table B-4. HP E1340A Error Messages (Cont'd)

Settings Conflict Error Messages (Cont'd)
SOUR:FREQ:STAR > SOUR:FREQ:STOP; values exchanged
SOUR:FREQ:STAR frequency < minimum; SOUR:FREQ:STAR MIN set
SOUR:FREQ:STAR frequency > maximum; SOUR:FREQ:STAR MAX set
SOUR:FREQ:STOP frequency < minimum; SOUR:FREQ:STOP MIN set
SOUR:FREQ:STOP frequency > maximum; SOUR:FREQ:STOP MAX set
SWE:POIN > maximum; SWE:POIN MAX set
SWE:TIME < minimum; SWE:TIME MIN set
SWE:TIME > maximum; SWE:TIME MAX set
SOUR:VOLT+SOUR:VOLT:OFFS < minimum; SOUR:VOLT:OFFS MIN set
SOUR:VOLT+SOUR:VOLT:OFFS > maximum; SOUR:VOLT:OFFS MAX set
SOUR:VOLT voltage < minimum; SOUR:VOLT MIN set
SOUR:VOLT voltage > maximum; SOUR:VOLT MAX set
SOUR:FUNC:SHAP not DC and SOUR:VOLT voltage < 0.0V; absolute value of SOUR:VOLT set
SOUR:ARB:DAC:SOUR not INT or SOUR:FUNC:SHAP USER and SOUR:VOLT unit not V/VPK; SOUR:VOLT:AMPL MIN (in V) set
SOUR:FUNC:SHAP DC and SOUR:VOLT unit not V: SOUR:VOLT value converted to volts
MARK:FEED "ROSC" and MARK:POL INV; MARK:POL NORM set
MARK:FEED "SEGM" and MARK:POL INV; MARK:POL NORM set
MARK:FEED "OUTP:ZERO" and MARK:POL NORM; MARK:POL INV set

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Appendix C
HP E1340A Register-Based Programming

Appendix Contents

The HP E1340A Arbitrary Function Generator (AFG) is a register-based device which does not support the VXIbus word serial protocol. When a SCPI command is sent to the AFG, the AFG driver in the HP E1300/01 Mainframe (Series B) or in the HP E1405/E1406 Command Module (Series C) parses the command and writes the information to the AFG registers.

Register-based programming is a series of reads and writes **directly** to the AFG registers. This increases throughput speed since command parsing is eliminated and the registers can be accessed from the VXI backplane (with IBASIC or an embedded controller).

This appendix contains the information you need for register-based programming. The contents include:

Register Addressing

Register addresses for register-based devices are located in the upper 25% of VXI A16 address space. Every VXI device (up to 256 devices) is allocated a 32 word (64 byte) block of addresses. The AFG uses six of the 64 addresses allocated.

Figure C-1A shows the register address location within A16. Figure C-1B shows the location of A16 address space in the HP E1300/01 Mainframe and HP E1405/E1406 Command Module.

The Base Address

When you are reading or writing to an AFG register, a hexadecimal or decimal register address is specified. This address consists of a A16 base address plus a register offset or register number.

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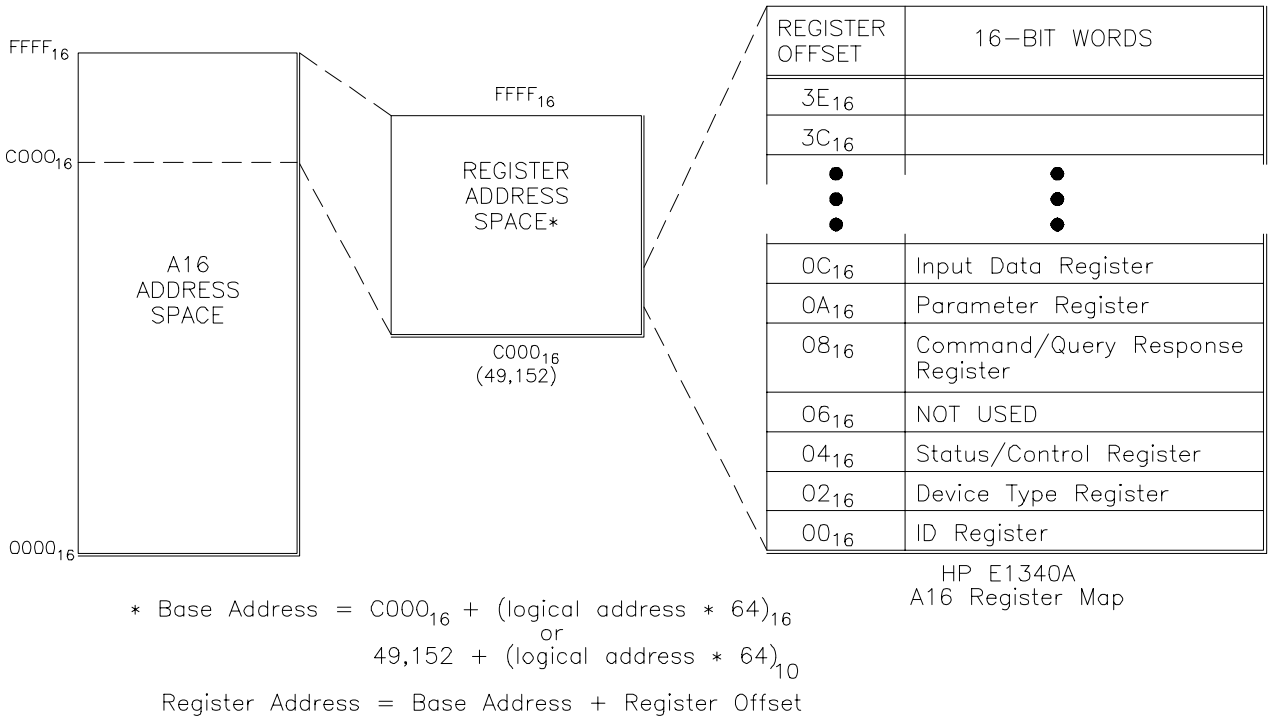

Figure C-1A. HP E1340A AFG Registers within A16 Address Space

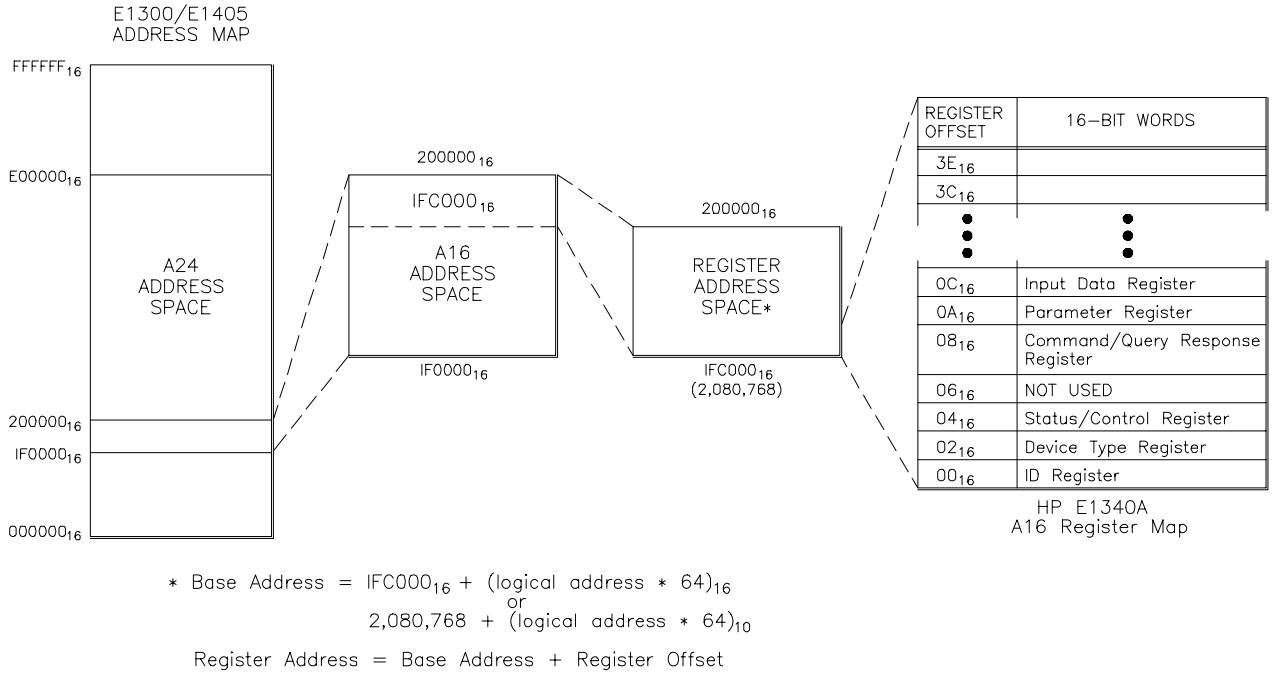

Figure C-1B. AFG Registers within HP E1300/E1405 A16 Address Space

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The A16 base address used in register-based programming depends on whether the A16 address space is located inside the E1300(01) Mainframe/E1405/E1406 Command Module or elsewhere (e.g. embedded computer). Figures C-1A, C-1B, and Table C-1 enable you to determine the base address for the following computer configurations:

- E1300/E1301 Instrument BASIC (IBASIC)
- External Computer over HP-IB to E1300/E1301 Mainframe or E1405/E1406 Command Module
- V/360 Embedded Controller (C-Size system)

Table C-1. Computer Configurations used with the HP E1340A

Computer	Programming Method	Base Address
E1300/E1301 IBASIC (Absolute Addressing)	READIO (-9826,Base_addr + offset) WRITEIO -9826,Base_addr + offset;data (positive select code = byte read or write negative select code = word read or write)	Base_addr = $1FC000_{16}$ + (LADDR * 64)$_{16}$ or = 2,080,768 + (LADDR * 64) offset = register offset (Figure C-1A)
(Select Code 8)	READIO (8,Base_addr + reg number) WRITEIO 8,Base_addr + reg number;data	Base_addr = LADDR * 256 reg number = offset (Figure C-1A)/2
External Computer (over HP-IB to E1300/E1301 Mainframe or E1405/E1406 Command Module)	VXI:READ? logical_address,offset VXI:WRITE logical_address,offset,data DIAG:PEEK? Base_addr + offset,width DIAG:POKE Base_addr + offset,width,data	AFG logical address setting (LADDR) offset = register offset (Figure C-1A) Base_addr = $1FC000_{16}$ + (LADDR * 64)$_{16}$ or = 2,080,768 + (LADDR * 64) offset = register offset (Figure C-1A)
V/360 Embedded Computer (C-Size system)	READIO (-16,Base_addr + offset) WRITEIO -16,Base_addr + offset;data (positive select code = byte read or write negative select code = word read or write)	Base_addr = $C000_{16}$ + (LADDR *64)$_{16}$ or = 49,152 + (LADDR * 64) offset = register offset (Figure C-1B)
LADDR : AFG logical address. (LADDR * 64)$_{16}$: multiply quantity, then convert to a hexadecimal number (e.g. 80 * 64)$_{16}$ = 1400_{16}. When using DIAG:PEEK? and DIAG:POKE, the width (number of bits) is 8 or 16.		

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Computer Configurations

This section contains performance and functional information on the computer configurations that can be used with register-based programming.

Throughput Speed

Throughput speed is based on the amount of command parsing and whether the registers are accessed from the VXI backplane or from the HP-IB. The computer configurations which allow faster throughput relative to each other are summarized below:

1. HP E1480A V/360 Controller with READIO and WRITEIO (register access is from VXI backplane).
2. E1300/01 IBASIC absolute addressing with READIO and WRITEIO (register access is from VXI backplane).
3. E1300/01 IBASIC select code 8 with READIO and WRITEIO (register access is from VXI backplane).
4. External Computer using DIAG:PEEK? and DIAG:POKE (register access is over HP-IB).
5. External Computer using VXI:READ? and VXI:WRITE (register access is over HP-IB).

Embedded Computer Programming (C-Size Systems)

If the E1340A AFG is part of a C-Size VXI system, the fastest throughput is achieved using an embedded computer such as the HP E1480 V/360. The embedded computer allows you to access the registers from the VXIbus backplane, and since READIO and WRITEIO are used, there is no parsing of SCPI command headers.

IBASIC Programming

When the E1340A AFG is programmed using the E1300/E1301 Mainframe's Instrument BASIC (IBASIC), two methods of accessing the registers are through absolute addressing or using select code 8.

Absolute Addressing and Select Code 8

Absolute addressing is faster than select code 8 since the complete register address (including the A16 starting location $1FC000_{16}$) is specified. When select code 8 is used, the IBASIC processor must calculate the complete register address based on the logical address specified (Table C-1).

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The Register Offset and Register Number

Depending on whether absolute addressing or select code 8 is used, either a register offset or register number is specified as part of the register address. Absolute addressing specifies a register offset, which is the register's location in the block of 64 address bytes. For example, the AFG's Command Register has an offset of 08_{16}. When you write a command to this register, the offset is added to the base address to form the register address (using a logical address of 80):

register address = base address + register offset

$= 1FC000_{16} + (80 * 64)_{16} + 08_{16}$

$= 1FC000_{16} + 1400_{16} + 08_{16} =$ **$1FD408_{16}$**

or

$= 2{,}080{,}768 + (80 * 64) + 8$

$= 2{,}080{,}768 + 5120 + 8 =$ **2,085,896**

Using select code 8 requires that you specify a **register number**. The register number is the register offset/2. Referring to Figure C-1A, the Command Register with an offset of 08, is register number 4.

Note The example programs found in this appendix are IBASIC programs using absolute addressing.

External Computer Programming

When the AFG is programmed by an external computer through the E1300/E1301 mainframe or E1405/E1406 Command Module, the registers are accessed using DIAG:PEEK? and DIAG:POKE, or VXI:READ? and VXI:WRITE.

DIAG:PEEK?/DIAG:POKE and VXI:READ?/VXI:WRITE

Throughput speed using DIAG:PEEK? and DIAG:POKE is faster than VXI:READ? and VXI:WRITE because the complete register address (including the A16 starting location $1FC000_{16}$) is specified. VXI:READ? and VXI:WRITE specify the device logical address and register offset only. Thus, the E1300/01/E1405/06 processor must calculate the complete register address which decreases throughput speed.

IBASIC programming using absolute addressing or select code 8 is faster than either DIAG:PEEK? and DIAG:POKE or VXI:READ? and VXI:WRITE because the registers are accessed from the VXIbus backplane rather than from the HP-IB. Also, READIO and WRITEIO are not parsed.

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Programming Guidelines

As noted, the example programs in this appendix are written in IBASIC. If your application involves arbitrary waveforms, and waveform computation is intensive and download time is not critical, an external controller should be used. If download time is important and computation time is not critical, IBASIC enables fast downloading through direct access to the VXI backplane.

Declaring IBASIC Variables in COM (common) Memory

When writing or modifying IBASIC programs, array variables can be declared in COM (common) memory. Variables not in COM memory reside in the IBASIC stack. The "stack" is a 32 kByte (default) segment of memory which contains components such as pointers and local variables for subprograms and declarations. When too many variables (or too large an array) are in the stack, Error 2 - "Memory Overflow" will occur. If a memory overflow occurs, the stack size can be changed with the command PROGram:MALLocate <*nbytes*> (see the *Instrument BASIC User's Manual* for more information).

Register Descriptions

There are four READ and four WRITE registers on the AFG. This section contains a description and a bit map of each register.

The READ Registers

The following READ registers are located on the AFG.

- ID Register (base + 00_{16})
- Device Type Register (base + 02_{16})
- Status Register (base + 04_{16})
- Query Response Register (base + 08_{16})

Examples and program statements in this appendix use 16-bit reads. In most cases, however, only the lower eight bits are used.

The ID Register

The AFG's ID Register indicates the classification, addressing mode, and the manufacturer of the device.

Address	15	14	13	12	11 - 0
base + 00_{16}	Device Class		Address Mode		Manufacturer ID

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Device Classification. Bits 15 and 14 classify a device as one of the following:

0	0	memory device
0	1	extended device
1	0	message-based device
1	1	register-based device

The HP E1340 Arbitrary Function Generator is a register-based device.

Addressing Mode. Bits 13 and 12 indicate the addressing mode used by the device:

0	0	A16/A24 address mode
0	1	A16/A32 address mode
1	0	RESERVED
1	1	A16 address mode

The HP E1340 AFG uses the A16 address mode.

Manufacturer ID. Bits 11 through 0 identify the manufacturer of the device. Hewlett-Packard's ID number is 4095, which corresponds to bits 11 - 0 being set to "1".

Given the device classification, addressing space, and manufacturer of the HP E1340 AFG, reading the ID register returns $FFFF_{16}$.

The Device Type Register

The Device Type Register contains a model code which identifies the device.

Address	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
base + 02_{16}	Model Code															

Model Code. The model code of the HP E1340 AFG is $FFA0_{16}$.

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The Status Register

The flow and control of register-based programs are determined by the Status Register. This register is continually monitored to determine when to send a command, when to send a parameter, and when data is available.

Address	15 - 8	7	6	5	4	3	2	1	0
base + 04_{16}	FF_{16}	DONE	1	Burst Status	0	Pass/ SysFail	Pass/Sys Fail	Resp Buffer Full	Cmd Buffer empty

DONE. A zero (0) in bit 7 indicates that the operation performed by the current command has finished. Bit 7 is set to one (1) when a command is received and is being processed.

The validity of this bit is determined by bit 0. See "Status Bit Precedence" for more information.

Burst Status. A zero (0) in bit 5 indicates the burst mode is set and a burst is in progress. A one (1) indicates the burst mode is set and the burst is complete. The bit is undefined if the burst mode is not set.

Pass/SysFail. A zero (0) in bit 3 indicates the AFG is executing a reset, or is executing or has failed its self-test. A one (1) indicates the reset is finished or the self-test passed.

Bit 2 performs the same function.

Response Buffer Full. A one (1) in bit 1 indicates data returned by a query is in the Query Response Register. The bit is cleared (0) when the response is read from the register.

Command Buffer Empty. A one (1) in bit 0 indicates a command or parameter can be written to the Command or Parameter Register. The bit is cleared (0) when the command or parameter is received. Bit 0 also determines the validity of bit 7. See "Status Bit Precedence" for more information.

Status Bit Precedence

In addition to the conditions the bits monitor, certain status bits indicate the validity of other bits in the Status Register. This solves race situations between selected bits.

When bit 0 is zero (0), **bit 7** is **invalid**. This allows the AFG to set bit 7 (set it to one (1)) to indicate that a command or parameter is being processed. When **Bit 7** is zero (0), **bit 1** is **invalid.** This allows the AFG time to set those bits to the correct states based on the conditions they represent.

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The Query Response Register

When the AFG's configuration (e.g. function, frequency,…) is queried, the response is sent to the Query Response Register.

Address	15 - 8	7	6	5	4	3	2	1	0
base + 08_{16}	not used	Query Response							

Query Response. The response returned to the register is the contents of an AFG memory location containing information about the queried parameter. Responses are 16-bits, of which only the lower eight bits are used. See the "Example Programs" section for more information.

The WRITE Registers

The following WRITE registers are located on the AFG.

- Control Register (base + 04_{16})
- Command Register (base + 08_{16})
- Parameter Register (base + $0A_{16}$)
- Input Data Register (base + $0C_{16}$)

Examples and program statements in this appendix use 16-bit writes. Except for the Input Data Register, the WRITE registers only use the lower eight bits.

The Control Register

The Control Register is used to perform a hardware reset of the AFG and to disable the AFG from driving the SYSFAIL line.

Address	15 - 8	7	6	5	4	3	2	1	0
base + 04_{16}	Not Used	X	X	X	X	X	X	SYSFAIL Inhibit	Reset

Resetting the AFG. Writing a one (1) to bit 0 (hardware) resets the AFG. Writing a zero (0) turns the reset function off. Bit 0 must be a "1" for at least 2 µs for the reset to occur. If bit 0 remains a 1, the AFG continually resets.

Inhibiting SYSFAIL. Writing a one (1) to bit 1 prevents the AFG from driving the SYSFAIL line. Writing a zero (0) allows the AFG to drive SYSFAIL during a reset.

Every program (except "Querying AFG Parameters") in the "Programming Examples" section begins by resetting the AFG.

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The Command and Parameter Registers

Commands and parameters are opcodes or data bytes written to the Command and Parameter Registers.

Address	15 - 8	7	6	5	4	3	2	1	0
base + 08_{16}	not used	Command Opcode							

Address	15 - 8	7	6	5	4	3	2	1	0
base + $0A_{16}$	not used	Parameter Byte							

Command Format. A command consists of an opcode written to the Command Register, plus zero to six parameters written to the Parameter Register. A command opcode written to the Command Register might appear as:

8,1

where "8" is the offset of the Command Register and "1" is the opcode. A parameter might appear as:

10,128

where "10" is the offset of the Parameter Register and 128 is the value of the parameter byte.

The AFG commands and parameters are covered in the section "Command Descriptions and Formats". The sequence and timing involved in sending commands are covered in the section "Program Timing and Execution".

The Input Data Register

The Input Data Register is used to download amplitude points to RAM or directly to the AFG DAC.

Address	15 - 12	11	10	9	8	7	6	5	4	3	2	1	0
Base + $0C_{16}$	Not Used	Amplitude data											

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Command Descriptions and Formats

The AFG commands and parameters are in the form of opcodes and data bytes. Table C-2 lists the command opcodes and the format of the parameters.

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Table C-2. HP E1340A Command Opcodes and Parameter Formats

Setting the function and loading RAM					Command Opcode = 5			
Bit	7	6	5	4	3	2	1	0
Bit Weight	128	64	32	16	8	4	2	1
Purpose	DAC Source	Download Mode	Waveform selection (waveform EEPROM)				RAM	
Setting	0 - Input Data Register 1 - waveform EEPROM	0 - waveform appears at output as it is loaded into RAM from the Input Data Register. 1 - output remains at 0V as waveform is loaded into RAM from the Input Data Register.	0 0 0 0 - Sine wave 0 0 0 1 - Triangle wave 0 0 1 0 - Sin (x)/x for 8.25 radians 0 0 1 1 - Haversine 0 1 0 0 - Square wave 0 1 0 1 - First 10 terms of a square wave 0 1 1 0 - First 4 terms of a square wave 0 1 1 1 - Falling ramp 1 0 0 0 - First 20 terms of a falling ramp 1 0 0 1 - Rising ramp 1 0 1 0 - First 20 terms of a rising ramp 1 0 1 1 - White noise 1 1 0 0 - Modulated white noise 1 1 0 1 - A 3rd, 4th, 5th harmonic chord 1 1 1 0 - 8 cycles of linear rising sine wave 1 1 1 1 - Positive half-cycle sine wave				0 0 - RAM 0 0 1 - RAM 1 1 0 - RAM 2 1 1 - RAM 3	

Setting Frequency Register 1: Fixed frequency (CW) Sweep start frequency 1st FSK frequency					Command Opcode = 1			
Bits	7	6	5	4	3	2	1	0
Byte 1 ------->	Most Significant Byte of Frequency							
Byte 2 ------->	2nd Significant Byte of Frequency							
Byte 3 ------->	3rd Significant Byte of Frequency							
Byte 4 ------->	Least Significant Byte of Frequency							

Setting Frequency Register 2: Fixed frequency (CW) Sweep stop frequency 2nd FSK frequency					Command Opcode = 2			
Bits	7	6	5	4	3	2	1	0
Byte 1 ------->	Most Significant Byte of Frequency							
Byte 2 ------->	2nd Significant Byte of Frequency							
Byte 3 ------->	3rd Significant Byte of Frequency							
Byte 4 ------->	Least Significant Byte of Frequency							

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Table C-2. HP E1340A Command Opcodes and Parameter Formats (Cont'd)

Setting the Attenuation									Command Opcode = 4
Bit	7	6	5	4	3	2	1	0	
Bit Weight	128	64	32	16	8	4	2	1	
Byte 1 ------->	Atten	Corr	not used		MS nibble of attenuation				
Setting	0 - enable 20 dB attenuator 1 - disable 20 dB attenuator	0 - enable sine wave correction 1 - disable sine wave correction	X						
Byte 2 ------->	Least Significant Byte of Attenuation								

Setting the Offset:									Command Opcode = 3
Bits	7	6	5	4	3	2	1	0	
Byte 1 ------->	not used				MS Nibble of Offset				
Byte 2 ------->	Least Significant Byte of Offset								

Setting the Sweep Rate									Command Opcode = 7
Bits	7	6	5	4	3	2	1	0	
Byte 1 ------->	Most Significant Byte of Phase Increment								
Byte 2 ------->	2nd Significant Byte of Phase Increment								
Byte 3 ------->	3rd Significant Byte of Phase Increment								
Byte 4 ------->	Least Significant Byte of Phase Increment								
Byte 5 ------->	Delay (tic) Count								
Byte 6 ------->	0 (Linear Sweep)								

Setting the Burst Count									Command Opcode = 8
Bits	7	6	5	4	3	2	1	0	
Byte 1 ------->	Most Significant Byte of Burst Count								
Byte 2 ------->	Least Significant Byte of Burst Count								

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Table C-2. HP E1340A Command Opcodes and Parameter Formats (Cont'd)

Setting the Clock Source and Output Mode								Command Opcode = 9
Byte 1								
Bit	7	6	5	4	3	2	1	0
Bit Weight	128	64	32	16	8	4	2	1
Purpose	Aux Out Level	Aux In Level	Clock Source			Aux Out (Marker)		Aux In
Setting	0 - Normal 1 - Inverted	0 - Normal 1 - Inverted	0 0 0 - External 0 0 1 - Gated 0 1 0 - Burst 0 1 1 - Internal 1 0 0 - Input Data Register (base + $0C_{16}$) 1 0 1 - reserved 1 1 0 - No clock 1 1 1 - No clock			0 0 - 42 MHz osc 0 1 - Pulse/cycle 1 0 - Zero cross 1 1 - Sweep sync		0 - Wave hop - FSK - Triggered Burst 1 - External Clock - Gate (internal clock)
Byte 2								
Bit	7	6	5	4	3	2	1	0
Bit Weight	128	64	32	16	8	4	2	1
Purpose	RAM Bank		Frequency Register	Output Mode			RAM Size	
Setting	0 0 - RAM 0 0 1 - RAM 1 1 0 - RAM 2 1 1 - RAM 3		0 - Register 1 1 - Register 2	0 0 0 - Continuous (fixed) 0 0 1 - FSK 0 1 0 - Wave hop 0 1 1 - Internal burst 1 0 0 - External burst 1 0 1 - Sweep 1 1 0 - Direct DAC access 1 1 1 - Fast frequency change			0 0 - 4k 0 1 - 8k 1 0 - 16k	

Reading AFG Settings					Command Opcode = 13			
Bits	7	6	5	4	3	2	1	0
Byte 1 ------->	Query Byte							

Soft Reset					Command Opcode = 14			
Bits	7	6	5	4	3	2	1	0
	no parameter							

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Setting the Output Function and Loading RAM

The output function is set by selecting the DAC source, selecting a waveform from the waveform EPROM, and then loading the waveform into RAM.

The function is a **one byte** parameter. The value of the byte is the sum of the bits set (bit weights). For example, to set a sine wave as the output function and to load it into RAM 0, the value of the byte would be 128 which sets the bit pattern:

1 0 0 0 0 0 0 0

To set a triangle wave as the output function and load it into RAM 1, the value of the byte would be 133, which sets the bit pattern:

1 0 0 0 0 1 0 1

Downloading an Arbitrary Waveform

The DAC source when downloading an arbitrary waveform into RAM is the Input Data Register (base + $0C_{16}$). Arbitrary waveforms are loaded into RAM in the same manner as standard waveforms from the waveform EPROM. For example, to download an arbitrary waveform into RAM 0, the value of the "function" byte would be 0 which sets the bit pattern:

0 0 0 0 0 0 0 0

Arbitrary waveforms must have exactly 4096 points. Undefined points appear at the output as random values. The “Example Programs” section demonstrates how to download and output arbitrary waveforms.

Download Mode

Bit 6 of the "setting the function and loading RAM" byte (Table C-2) is used to control whether or not arbitrary waveform data appears at the output as the data is loaded into RAM from the Input Data Register. Setting bit 6 to "1" sets the output to 0V as the waveform is downloaded into RAM. When bit 6 is set to "0", the output tracks the Input Data Register as the data is loaded into RAM.

Multiple Waveforms in a Single Output Sequence

The AFG’s output signal can consist of up to four waveform segments (RAM 0 through RAM 3). Each RAM is loaded from the waveform EPROM, from the Input Data Register, or from both. An example of this feature is located in the “Example Programs” section.

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Setting the Signal Frequency

There are five frequency parameters used with the AFG:

- fixed (continuous) frequency
- sweep start frequency
- sweep stop frequency
- FSK frequency 1
- FSK frequency 2

Frequency Register 1 (command opcode 1) is used to set a fixed frequency, the sweep start frequency, and the first FSK frequency. Frequency Register 2 (command opcode 2) is used to set a fixed frequency, the sweep stop frequency, and the second FSK frequency.

Format

The frequency is a **four-byte** parameter expressed in 10's of millihertz. The format of the frequency value set from the Parameter Register is as follows:

$$\text{Frequency} = (F_o * 2^{32}/\text{Ref osc})$$

Where F_o is the output frequency and Ref osc is the reference oscillator frequency. If the AFG's internal 42.94967296 MHz oscillator is used, the equation simplifies to:

$$\text{Frequency} = (F_o * 100)$$

Frequency is converted to the form:

$$(F_1*2^{24} + F_2*2^{16} + F_3*2^8 + F_4)/100$$

For example, to send 1kHz in four bytes (using the AFG internal oscillator):

Frequency = (1E3 * 100) = 100,000

= 00	01	86	$A0_{16}$
= 0	1	134	160_{10}
byte 1	byte 2	byte 3	byte 4

Arbitrary Waveform Frequency

The maximum frequency of an arbitrary waveform using the AFG internal oscillator is 10.48576 kHz (42.94967296E6/4096). Higher frequencies can be achieved, however; the arbitrary waveform cannot contain frequency components greater that 15 MHz. At 10.48576 kHz, each amplitude point is output once. At lower frequencies, some or all points may be output more than once. At higher frequencies, some points are skipped on each repetition.

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Frequency of Multiple Segment Waveforms

When two or four waveform segments make up the output waveform, the waveform repetition frequency is 1/2 or 1/4 of the programmed frequency. For example, if the RAM size is 8k, the waveforms in RAM 1 and RAM 2 comprise the output waveform. If the programmed frequency is 1 kHz, the output frequency is 500 Hz. Similarly, if the RAM size is 16k, the waveforms in RAM 0 through RAM 3 make up the output waveform. If the programmed frequency is 1 kHz, the output frequency is 250 Hz. For 1 kHz, you must either double or quadruple the programmed frequency.

Setting the Output Attenuation

The maximum output voltage is +5.1175V / -5.12V into 50 Ω.

The amplitude is controlled by the 12-bit output attenuator. The attenuation value written to the AFG is based on the desired amplitude (volts peak) and the output load:

Amplitude > + 0.51175 into 50 Ω:

Atten = (Ampl / 5.1175) * 2047 (no attenuation)

Amplitude < + 0.51175 into 50 Ω:

Atten = (Ampl / 0.51175) * 2047 (20 dB attenuation)

Amplitude > + 1.0235 into open circuit:

Atten = (Ampl / 10.235) * 2047 (no attenuation)

Amplitude < + 1.0235 into open circuit:

Atten = (Ampl / 1.0235) * 2047 (20 dB attenuation)

Atten is the attenuation value set from the Parameter Register and Ampl is the desired output amplitude in volts peak.

Format

The attenuation is a **two-byte** parameter whose bits are defined in Table C-2. The attenuation value (Atten) is converted to the form:

$A_1 * 2^8 + A_2$

As an example, to set 2 V_{pk} into 50Ω:

Atten = (2 / 5.1175) * 2047

= 03 20_{16}

= 3 32_{10} + 128

= 131 32_{10}

byte 1 byte 2

128 is added to set bit 7, which turns the 20 dB attenuator off.

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Turning Attenuation Off

Setting bit 7 (Atten) of the MSB to "1" sets no attenuation (Table C-2). Bit 7 should be set to "1" for amplitudes > 0.51175V into 50 Ω, or for amplitudes > 1.0235V into an open circuit. Setting bit 7 to "0" attenuates the output by 20 dB. Bit 7 should be set to "0" for amplitudes < 0.51175V into 50Ω, or for amplitudes < 1.0235V into an open circuit.

Amplitude Correction

Setting bit 6 (Corr) to "1" (adding 64) turns off amplitude correction (Table C-2). Setting bit 6 to "0" enables amplitude correction. When enabled, the output is corrected such that the amplitude remains level for all frequencies up to 15 MHz. The correction computation is only valid and should only be enabled with a reference oscillator frequency (internal or external) of 42.94967296 MHz.

Caution

If amplitude correction is in effect for a programmed number of cycles (burst), correction will remain in effect after the burst completes. This can result in an output signal 2.5 times the programmed value. Sine wave correction is recommended for a continuous signal only.

Setting the Amplitude Offset

The offset of the output signal is controlled by the 12-bit DAC. The offset value written to the AFG is based on the desired offset and the output load:

Offset with no signal attenuation into 50 Ω:

Offset = (Voff / .0025) + 2048

Offset with no signal attenuation into open circuit:

Offset = (V_{off} / .005) + 2048

Offset with 20 dB attenuation into 50 Ω:

Offset = ((V_{off} / .0025) * 10) + 2048

Offset with 20 dB attenuation into open circuit:

Offset = ((V_{off} / .005) * 10) + 2048

Offset is the offset value set from the Parameter Register and V_{off} is the desired offset.

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Format

The offset is a **two-byte** parameter whose bits are defined in Table C-2. The offset value (Offset) is converted to the form:

$A_1 * 2^8 + A_2$

For example, to add a 1V dc offset to a 2 Vp signal (into 50 Ω):

Offset = (1 / .0025) + 2048

= 09 90_{16}

= 9 144_{10}

byte1 byte 2

Setting the Sweep Rate

The AFG can sweep (linearly) from 0.01 Hz to 15 MHz. The fastest the AFG can sweep is 187 µS per frequency point with amplitude correction disabled, or 250 µS per point with amplitude correction enabled. Up to 25.5 mS additional delay per frequency point is possible in 100 µS increments (tic count).

Format

The sweep rate is a **six-byte** parameter (Table C-2). The first four bytes contain the frequency increment. The fifth byte (tic count) controls how often the increment occurs. An increment occurs every 187 or 250 µS plus (tic count - 1) delays of 100 µS. The sixth byte is always 0 for a linear sweep.

Setting the Burst Count

The burst count specifies the number of waveform cycles to occur when the "burst" output mode is set. For all other output modes the burst count need not be set since an infinite number of cycles are output.

Format

The burst count is a **two-byte** parameter (Table C-2). The count is converted to the form:

$A_1 * 2^8 + A_2$

For example, a 1,000 cycle burst is sent as:

1,000 cycles = 03 $E8_{16}$

= 3 232_{10}

byte 1 byte 2

Internal and External Triggered Bursts

The AFG burst modes are "internal" and "external". An internal burst of the specified burst count occurs when an internal trigger is received. An external burst of the specified burst count occurs when the signal on the "Aux In" BNC port is low. The burst mode is set with the output mode bytes covered in the next section. The “Example Programs” section demonstrates how to set up internal and external triggered bursts.

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The AFG Output Mode

The AFG output mode consists of the following:

- Setting the "Aux In" BNC port function.
- Setting the "Aux Out" (marker) BNC port condition.
- Setting the time base (reference) source.
- Setting the "Aux In" and "Aux Out" sense levels.
- Setting the waveform length
- Setting the output mode
- Selecting the Frequency Register
- Selecting the RAM to output to the DAC.

Format

The output mode is a **two byte** parameter. The format of the bytes is shown in Table C-2.

Aux Out/Aux In Level

Bit 7 of byte 1 sets the polarity of the signal at the "Aux Out" (marker) BNC for the selected condition (bits 2 and 1). Bit 6 sets the polarity which activates the selected event (bit 0). For bits 7 and 6, normal ("0") sets an "active high" (positive transition) signal. Inverted ("1") sets an "active low" (negative transition) signal.

Clock Source

The clock source bits (5 - 3) specify and control the AFG's reference clock (oscillator). The sources:

External - external source is applied to the "Aux In" BNC. Bit 0 must be set to "1".

Gated - allows the reference to be gated by a gate signal applied to the "Aux In" BNC. Bit 0 must be set to "1". A TTL "high" level stops the output. A TTL "low" level enables the output.

Burst - allows a counted burst (see "Setting the Burst Count") of cycles to occur when an internal or external trigger is received. This source is set together with either the "internal burst" or "external burst" mode (bits 4 - 2 of byte 2).

Internal - this source is the AFG's internal 42.94 MHz oscillator.

Input Data Register - allows waveform data to be downloaded to the AFG's DAC through the Input Data Register (base + $0C_{16}$). This source is set for the "direct DAC access" mode (bits 4 - 2 of byte 2).

No clock - setting this condition stops the internal reference clock or the acceptance of an external clock.

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Aux Out The AFG's "Aux Out" BNC port outputs the following TTL level signals. The polarity of the signal is set by bit 7.

42 MHz osc. - this square wave signal is the AFG's internal 42.94 MHz reference clock. Bit 7 (polarity) is ignored.

Pulse/cycle - this signal is a marker pulse that is output at the beginning of each waveform output segment (1 pulse per 4k RAM bank). Bit 7 (polarity) is ignored.

Zero Cross - this signal is a marker pulse that is output each time the output waveform crosses through 0V (positive or negative transition). Bit 7 (polarity) is ignored.

Sweep sync - this signal is a marker pulse that is output at the beginning of each sweep. Bit 7 (polarity) can be used.

Aux In The "Aux In" BNC connector accepts TTL level signals which activate the following events based on the setting of bit 0. The bit is set based on the clock source setting and mode setting.

Setting bit 0 to "0" enables an external signal to select the output signal (wave hop), to select the output frequency (FSK), or to trigger a counted burst. The external signal's rising edge selects the waveform in RAM 0. Its falling edge selects the waveform in RAM 1. Similarly, its rising edge selects FSK frequency 1, and its falling edge selects FSK Frequency 2. The sensing of the signal for wave hopping , FSK, and external bursts can be inverted with bit 6.

Setting bit 0 to "1" enables an external reference clock to be applied to the port. Bit 0 is also set to "1" when the output is to be gated on and off.

RAM Bank The RAM Bank bits (bits 7 - 6 of byte 2) are used to select the waveform stored in the RAM bank when the output function is set (see "Setting the Output Function"). The output mode (bits 4 - 2) or RAM size (bits 1 - 0) may override the RAM bank bits.

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Frequency Register

The Frequency Register bit (bit 5) selects the output frequency stored in Frequency Register 1 or Frequency Register 2 (command opcodes 1 and 2).

Frequency Register 1 contains:

- fixed (continuous) frequency
- sweep start frequency
- first FSK frequency

Frequency Register 2 contains:

- fixed (continuous) frequency
- sweep stop frequency
- second FSK frequency

Output Mode

The AFG output modes (bits 4 - 2) are:

Continuous (fixed) - output signal has a continuous (fixed) frequency. This is the default mode.

FSK - output mode is frequency-shift keying. Bit 0 of byte 1 must be set to "0" in order for a control signal (applied to the "Aux In" BNC) to shift frequencies. The rising edge of the control signal selects the frequency in Frequency Register 1. The falling edge of the control signal selects Frequency Register 2. When this mode is set, the Frequency Register bit (bit 5) is ignored.

Wave hop - output mode is wave hopping. Bit 0 of byte 1 must be set to "0" in order for a control signal (applied to the "Aux In" BNC) to select the output waveform. The rising edge of the control signal selects the waveform in RAM 0. The falling edge of the control signal selects the waveform in RAM 1. When this mode is set, the RAM bank bits (7 - 6) and the RAM size bits (1 - 0) are ignored.

Internal burst - this mode will output the number of cycles specified by the burst count (opcode 8) and stop. This mode is set together with the "burst" clock source (bits 5 - 3 of byte 1).

External burst - this mode will output the number of cycles specified by the burst count (opcode 8) each time an external trigger is received ("Aux In" BNC). This mode is set together with the "burst" clock source (bits 5 - 3 of byte 1).

Sweep - this mode sets a linear sweep from the (start) frequency in Frequency Register 1 to the (stop) frequency in Frequency Register 2. The RAM bank bits (7 -6) select the waveform which is swept.

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The Frequency Register (bit 5) and RAM size (bits 1 - 0) bits are ignored.

Direct DAC access - this mode sends waveform data to the DAC directly from the Input Data Register (base + $0C_{16}$). When this mode is set, the RAM bank, Frequency Register, and RAM size bits are ignored. The frequency is set to DC, and the output remains at the given voltage until the Input Data Register is written to again. This mode is used to generate an arbitrary waveform whose frequency and size (number of points) is limited by a controller's speed and its amount of memory. This mode is set together with the "Input Data Register" clock source (bits 5 -3 of byte 1).

Fast Frequency change - this mode is used to continuously change the output signal frequency in order to make custom frequency profiles. The AFG outputs a new frequency each time four (frequency) bytes are written to the Parameter Register. This mode uses the 4k RAM size. The Frequency Register and RAM size bits are ignored.

RAM Size

The RAM size (bits 1 - 0 of byte 2) specifies whether one, two, or four waveforms will comprise the output waveform. If the RAM size is 8k or 16k, the RAM bank (bits 7 - 6) is ignored.

Starting the Waveform

When register-based programming, the waveform is output when byte 2 of the output mode is processed by the AFG. If the "external burst" mode is set, the waveform is output when an external trigger is received.

Querying the AFG

AFG parameters are queried by sending command opcode 13 followed by a query opcode. The response to the query is returned to the Query Response Register (base + 08_{16}).

The AFG parameters that can be queried include:

- function
- frequency (registers 1 and 2)
- attenuation
- offset
- burst count
- sweep rate
- mode

Each time opcode 13 and a query opcode are sent one byte is returned. For example, to query the frequency, opcode 13 must be sent four times (with a different query code) to return the four bytes which set the frequency.

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The "Program Timing and Execution" section shows the register access sequence used to query the parameters. Examples of querying parameters are contained in the "Example Programs" section. The query opcodes are listed in Table C-4.

AFG Soft Reset

Sending command opcode 14 sets all AFG parameters to their power-on values. This command does not reset the AFG hardware as does the (hardware) reset described in the "Program Timing and Execution" section and used in the example programs.

Aborting the Waveform

Sending command opcode 6 halts waveform generation by stopping the clock. No other AFG settings are affected.

Program Timing and Execution

When programming the AFG at the register level, the structure of the program will generally be as follows:

- Resetting the AFG
- Setting the function
- Setting the frequency
- Setting the attenuation and offset
- Setting the sweep rate
- Setting the burst count
- Setting the output mode

This section contains generalized flowcharts and comments for performing these and other procedures such as querying parameters. The flowcharts identify the registers used and the status bits monitored to ensure proper execution of the program.

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AFG Reset Sequence

The AFG is reset as indicated in Figure C-2.

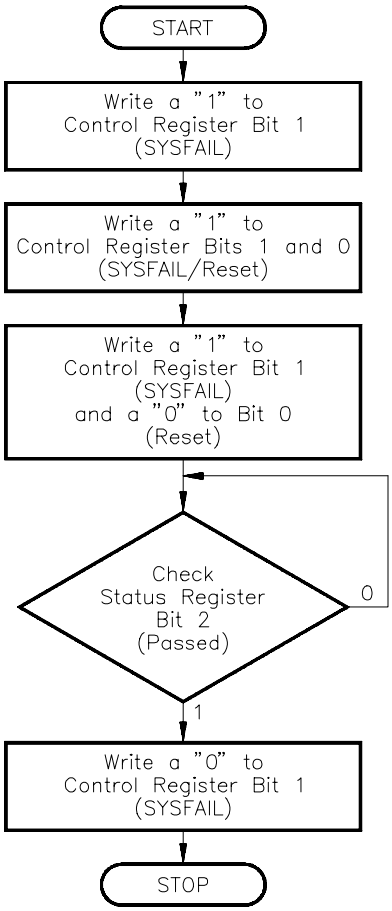

Figure C-2. Register Access to Reset the AFG

Comments

1. The registers used are:

   - Control Register (base + 04_{16})
   - Status Register (base + 04_{16})

2. Writing a "1" to bit 1 prevents the AFG from asserting the SYSFAIL line when it is reset. If SYSFAIL is enabled when a reset occurs, the AFG is taken off-line by the system Resource Manager.

3. Writing a "1" to bits 1 and 0 resets the AFG while preventing the AFG from asserting SYSFAIL . Writing a "0" to bit 0 turns the reset function off.

4. Bit 2 of the Status Register is monitored to determine when the reset is finished.

5. Writing a "0" to bit 1 re-enables SYSFAIL.

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Configuring the AFG

The (suggested) register-based programming sequence and register access sequence is shown in Figure C-3.

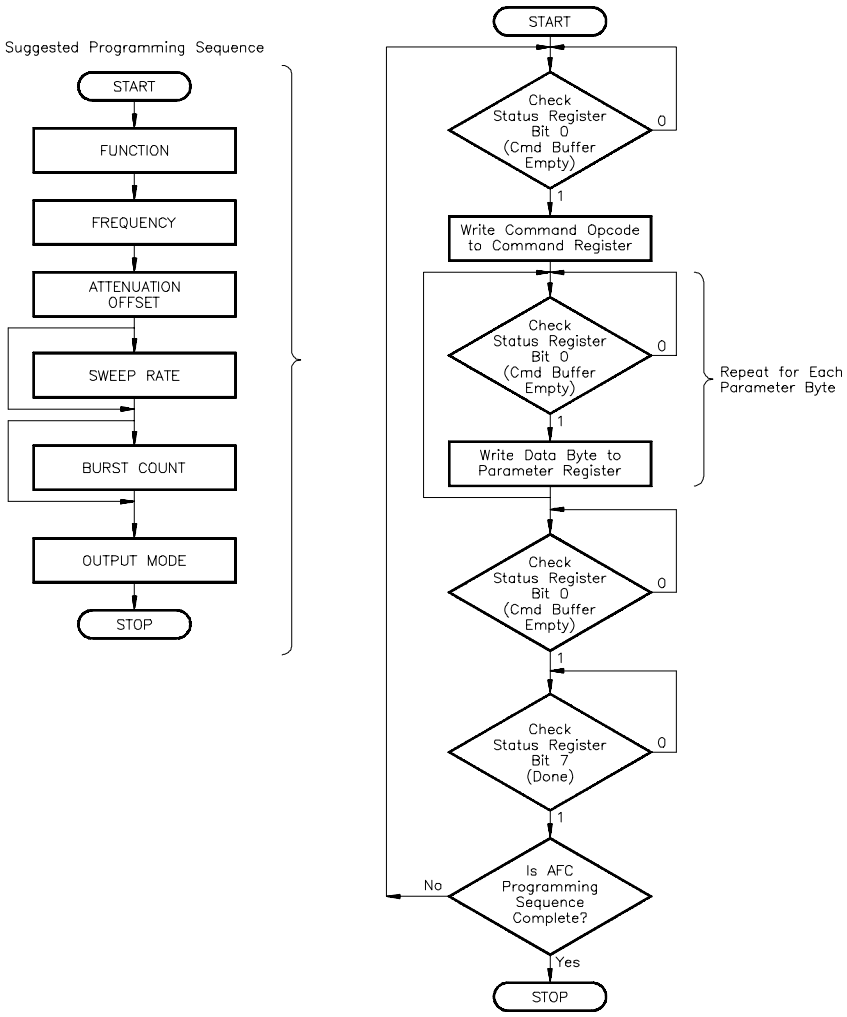

Figure C-3. Register Access to Configure the AFG

Comments

1. The registers used are:

   - Status Register (base + 04_{16})
   - Command Register (base + 08_{16})
   - Parameter Register (base + $0A_{16}$)

2. Status Register bit 0 is monitored to determine when a command and parameters can be written to the Command and Parameter Registers.

3. Status Register bit 7 is monitored to determine when the AFG has finished processing the current command and parameter(s) and when the next command can be sent.

4. Repeated passes through the flowchart are made until each AFG parameter (e.g. function, frequency, etc.) has been set.

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Querying AFG Parameters

The register access sequence for querying the AFG is shown in Figure C-4.

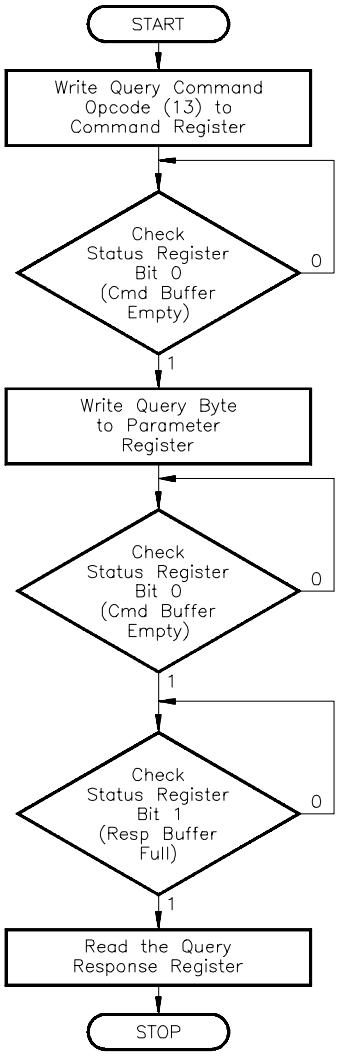

Figure C-4. Register Access to Query the AFG

Comments

1. The registers used are:
   - Status Register (base + 04_{16})
   - Command Register (base + 08_{16})
   - Parameter Register (base + $0A_{16}$)
   - Query Response Register (base +08_{16})
2. Command opcode 13 is written to the Command Register.
3. Status Register bit 0 is monitored to determine when the query opcode can be written to the Parameter Register.
4. Status bit 1 is monitored to determine when the response to the query is in the Query Response Register.

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Example Programs

The examples in this section program the E1340A AFG at the register level. The program listings are HP Instrument BASIC (IBASIC) programs, and are contained on the example programs disk HP P/N E1340-10035. C and QuickBASIC versions of these programs are on example programs disk HP P/N E1340-10036.

The examples in this section include:

- Generating a Sine Wave
- Multiple Waveforms
- Internally Triggering a Burst of Cycles
- Externally Triggering a Burst of Cycles
- Frequency-Shift Keying
- Waveform Hopping
- Sweeping
- Gating the Output
- Downloading an Arbitrary Waveform
- Fast Frequency Changes
- Sending Data Directly to the DAC
- Querying AFG Settings

IBASIC Subprograms

The IBASIC programs, which are based on the flowcharts found in the "Program Timing and Execution" section, pass opcodes and parameters to a series of subprograms. The subprograms are in a separate file (file name "SUBS") that is accessed by each IBASIC program. The subprograms are listed after the program "Sending Data Directly to the DAC".

Opcode/Parameter Quick Reference

Table C-3 lists the command opcodes and parameter values (where applicable) as they are used in the example programs.

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Table C-3. Command Opcode and Parameter Quick Reference

Setting	Opcode	Parameter
Function	5	**Function:** 0 - Sine wave 1 - Triangle wave 2 - Sin(x)/x for 8.25 radians 3 - Haversine 4 - Square wave 5 - 10 terms of square wave 6 - 4 terms of square wave 7 - Falling ramp 8 - 20 terms of falling ramp 9 - Rising ramp 10 - 20 terms of rising ramp 11 - White noise 12 - Modulated white noise 13 - 3rd, 4th, 5th harm chord 14 - 8 cycle rising sine wave 15 - Pos. 1/2 cycle sine wave **RAM:** 0 - RAM 0 1 - RAM 1 2 - RAM 2 3 - RAM 3
Frequency Register 1	1	four bytes
Frequency Register 2	2	four bytes
Attenuation	4	**Attenuation:** 0 - 20 dB attenuation 1 - 0 dB attenuation **Correction**: 0 - enable amplitude correction 1 - disable amplitude correction
Offset	3	two bytes
Sweep Rate	7	six bytes
Burst Count	8	two bytes
Clock Source/ Output Mode	9	**Aux Out/Aux In level:** 0 - Normal 1 - Inverted **Clock Source:** 0 - External 1 - Gated 2 - Burst 3 - Internal 4 - Input Data Register **Aux Out:** 0 - 42 MHz osc. 1 - Pulse/cycle 2 - Zero cross 3 - Sweep sync **RAM Bank:** 0 - RAM 0 1 - RAM 1 2 - RAM 2 3 - RAM 3 **Frequency Register:** 1 - Register 1 2 - Register 2 **RAM Size:** 0 - 4k 1 - 8k 2 - 16k **Mode:** 0 - Continuous (fixed) 1 - FSK 2 - Wave hop 3 - Single burst 4 - Triggered burst 5 - Sweep 6 - Direct DAC access 7 - Fast frequency change

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Generating a Sine Wave

This program generates a 4 Vp-p, 10 kHz sine wave. The program selects the sine wave in the waveform EPROM and places it in RAM 0. The frequency, attenuation (amplitude), and the various mode parameters are set in the sequence indicated in Figure C-3.

HP IBASIC (RGBSINE)

```
1     !RE-SAVE"RGBSINE"
2     GET "SUBS",500,3 !place subprograms at line 500, continue w/line 3
3     !Program which demonstrates how to output a sine wave using register
4     !reads and writes.
5     !
10    !Compute the E1340 base address in E1300 A16 address space
20    COM Base_addr
30    Base_addr=DVAL("1FC000",16)+(80*64)    !base address
40    !
50    !Reset the AFG
60    Afg_reset
70    !Set the function and load RAM
80    Function(0,0) !sine wave in RAM 0
90    !Set the frequency (frequency register 1)
100   Frequency1(1000.)  !1 kHz
110   !Set amplitude, offset, impedance, correction
120   Amplitude(2,0,50,0)  !2 Vpk, 0V, 50 ohms, correction enabled
130   !Set the Aux Out level, Aux In level, clock source, Aux Out signal,
140   !RAM bank, frequency register, and output mode.
150   Mode(0,0,3,1,0,0,0) !norm,norm,internal,pulse/cycle,bank 0,reg 1,cont
160   END
170   !
```

C and QuickBASIC Programs

The C program RGBSINE.C is in directory "CPROG", and the QuickBASIC program RGBSINE.BAS is in directory "QBPROG" on the example program disk HP P/N E1340-10036.

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Multiple Waveforms

This program loads RAM 0 through RAM 3 from the waveform EPROM and outputs each waveform as part of a single waveform sequence.

HP IBASIC (MULTFUNC)

```
1    !RE-SAVE"MULTFUNC"
2    GET "SUBS",500,3 !place subprograms at line 500, continue w/line 3
3    !Program which demonstrates loading memory (RAM 0 through RAM 3)
4    !and then outputting the waveforms in a single sequence.
5    !
10   !Compute the E1340 base address in E1300 A16 address space
20   COM Base_addr
30   Base_addr=DVAL("1FC000",16)+(80*64)   !base address
40   !
50   !Reset the AFG
60   Afg_reset
70   !Load RAM 0 - RAM 3 from the waveform EEPROM
80   Function(9,0) !rising ramp in RAM 0
90   Function(10,1) !first 20 terms of rising ramp in RAM 1
100  Function(7,2)  !falling ramp in RAM 2
110  Function(8,3)  !first 20 of falling ramp in RAM 3
120  !Set the frequency (frequency register 1)
130  Frequency1(1000.)  !1 kHz (output frequency is 250 Hz)
140  !Set amplitude, offset, impedance, correction
150  Amplitude(5,0,50,0)  !5 Vpk, 0V, 50 ohms, correction enabled
160  !Set the Aux Out level, Aux In level, clock source, Aux Out signal,
170  !RAM bank, frequency register, and output mode.
180  Mode(0,0,3,1,16,0,0) !norm,norm,internal,pulse/cycle,16k,reg 1,cont
190  END
200  !
```

Comments

1. To output waveforms from RAM 0 - RAM 3 in a single sequence, the RAM size must be set to 16k, which overrides the RAM bank setting. In line 180, "16" is passed to the "Mode" subprogram which sets RAM size to 16k (see "SELECT Ram_bank" in subprogram "Mode").

2. When register-based programming, if two waveform segments (RAM 1 and RAM 2)comprise the output waveform, the frequency is 1/2 of the programmed frequency. If four waveform segments (RAM 0 through RAM 3) are used, the output frequency is 1/4 of the programmed frequency. The actual frequency of the waveform in this program is 250 Hz.

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C and QuickBASIC Programs

The C program MULTFUNC.C is in directory "CPROG", and the QuickBASIC program MULTFUNC.BAS is in directory "QBPROG" on the example program disk HP P/N E1340-10036.

Internally Triggering a Burst of Cycles

The following program outputs a burst of 50,000 waveform cycles when the AFG's internal trigger occurs.

HP IBASIC (INT_BRST)

```
1    !RE-SAVE"INT_BRST"
2    GET "SUBS",500,3 !place subprograms at line 500, continue w/line 3
3    !Program which demonstrates how to output a burst of waveform cycles
4    !when an internal trigger is received.
5    !
10   !Compute the E1340 base address in E1300 A16 address space
20   COM Base_addr
30   Base_addr=DVAL("1FC000",16)+(80*64)   !base address
40   !
50   !Reset the AFG
60   Afg_reset
70   !Set function and load RAM
80   Function(0,0) !sine wave in RAM 0
90   !Set the frequency (frequency register 2)
100  Frequency2(10000.)  !10 kHz
110  !Set amplitude, offset, impedance, correction
120  Amplitude(5,0,50,0)  !5 Vpk, 0V, 50 ohms, correction enabled
130  !Set the burst count
140  Burst(5.0E+4) !50k cycles
150  !Set the Aux Out level, Aux In level, clock source, Aux Out signal,
160  !RAM bank, frequency register, and output mode.
170  Mode(0,0,2,1,0,1,3) !norm,norm,burst,pulse/cycle,bank 0,reg 2,inbrst
180  END
190  !
```

Comments

1. To output a counted burst, the clock source must be set to "Burst" and the output mode set to "Internal Burst". The burst count range is 1 to 65534. The reset value is undefined (register-based).

2. This program sets the output frequency from Frequency Register 2. Either Frequency Register 1 or Register 2 and be used to set a continuous (fixed) frequency.

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C and QuickBASIC Programs

The C program INT_BRST.C is in directory "CPROG", and the QuickBASIC program INT_BRST.BAS is in directory "QBPROG" on the example program disk HP P/N E1340-10036.

Externally Triggering a Burst of Cycles

The following program outputs a burst of 50,000 waveform cycles when an external trigger is received.

HP IBASIC (EXT_BRST)

```
1    !RE-SAVE"EXT_BRST"
2    GET "SUBS",500,3 !place subprograms at line 500, continue w/line 3
3    !Program which demonstrates how to output a burst of waveform cycles
4    !when an external trigger is received.
5    !
10   !Compute the E1340 base address in E1300 A16 address space
20   COM Base_addr
30   Base_addr=DVAL("1FC000",16)+(80*64)   !base address
40   !
50   !Reset the AFG
60   Afg_reset
70   !Set function and load RAM
80   Function(0,0) !sine wave in RAM 0
90   !Set the frequency (frequency register 1)
100  Frequency1(10000.)  !10 kHz
110  !Set amplitude, offset, impedance, correction
120  Amplitude(5,0,50,0)  !5 Vpk, 0V, 50 ohms, correction enabled
130  !Set the burst count
140  Burst(5.0E+4) !50k cycles
150  !Set the Aux Out level, Aux In level, clock source, Aux Out signal,
160  !RAM bank, frequency register, and output mode.
170  Mode(0,0,2,1,0,0,4) !norm,norm,burst,pulse/cycle,bank 0,reg 1,exbrst
180  END
190  !
```

Comments

1. To output a counted burst, the clock source must be set to "Burst" and the output mode set to "External Burst". The burst count range is 1 to 65534. The reset value is undefined (register-based).

2. The external burst occurs when the signal on the "Aux In" BNC port goes low (TTL levels). The "Aux In level" parameter can be used to invert the sensing of the "Aux In" port in order to start a burst when the "Aux In" port goes high.

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C and QuickBASIC Programs

The C program EXT_BRST.C is in directory "CPROG", and the QuickBASIC program EXT_BRST.BAS is in directory "QBPROG" on the example program disk HP P/N E1340-10036.

Frequency-Shift Keying

The following program sets the AFG's frequency-shift keying mode. The frequency of the output signal switches between 1 kHz and 10 kHz depending on the level of the signal applied to the "Aux In" BNC port.

HP IBASIC (FSK)

```
1    !RE-SAVE"FSK"
2    GET "SUBS",500,3 !place subprograms at line 500, continue w/line 3
3    !Program which demonstrates frequency-shift keying (FSK).
4    !
10   !Compute the E1340 base address in E1300 A16 address space
20   COM Base_addr
30   Base_addr=DVAL("1FC000",16)+(80*64)   !base address
40   !
50   !Reset the AFG
60   Afg_reset
70   !Set function and load RAM
80   Function(0,0) !sine wave in RAM 0
90   !Set the first FSK frequency (frequency register 1)
100  Frequency1(1000.)  !1 kHz
110  !Set the second FSK frequency (frequency register 2)
120  Frequency2(1.0E+4)!10 kHz
130  !Set amplitude, offset, impedance, correction
140  Amplitude(5,0,50,0)  !5 Vpk, 0V, 50 ohms, correction enabled
150  !Set the Aux Out level, Aux In level, clock source, Aux Out signal,
160  !RAM bank, frequency register, and output mode.
170  Mode(0,0,3,1,0,0,1) !norm,norm,internal,pulse/cycle,bank 0,reg 1,FSK
180  END
```

Comments

1. The first FSK frequency is set with Frequency Register 1. The second FSK frequency is set with Frequency Register 2. A control signal applied to the "Aux In" BNC port selects the current output frequency. A rising edge selects Frequency Register 1. A falling edge selects Frequency Register 2. The "Aux In level" parameter can be used to invert the sensing of the "Aux In" port in order to select a frequency with the other edge.

2. Since the output frequency is selected by the "Aux In" port, the Frequency Register parameter (bit 5 of byte 2 - Table C-2) is ignored. Sending any command to the AFG while the FSK mode is set aborts the mode.

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C and QuickBASIC Programs

The C program FSK.C is in directory "CPROG", and the QuickBASIC program FSK.BAS is in directory "QBPROG" on the example program disk HP P/N E1340-10036.

Waveform Hopping

The following program selects between two waveforms based on the level of a control signal applied to the "Aux In" BNC.

HP IBASIC (WAVE_HOP)

```
1    !RE-SAVE"WAVE_HOP"
2    GET "SUBS",500,3 !place subprograms at line 500, continue w/line 3
3    !Program which demonstrates switching between waveforms in RAM 0
4    !and RAM 1.
5    !
10   !Compute the E1340 base address in E1300 A16 address space
20   COM Base_addr
30   Base_addr=DVAL("1FC000",16)+(80*64)   !base address
40   !
50   !Reset the AFG
60   Afg_reset
70   !Load sine wave into RAM 0
80   Function(0,0)
90   !Load triangle wave into RAM 1
100  Function(1,1)
110  !Set the frequency (frequency register 1)
120  Frequency1(1000.)  !1 kHz
130  !Set amplitude, offset, impedance, correction
140  Amplitude(5,0,50,1)  !5 Vpk, 0V, 50 ohms, correction disabled
150  !Set the Aux Out level, Aux In level, clock source, Aux Out signal,
160  !RAM bank, frequency register, and output mode.
170  Mode(0,0,3,1,0,0,2) !norm,norm,internal,pulse/cycle,bank 0,reg 1,w_hop
180  END
190  !
```

Comments

1. The waveforms used in waveform hopping are stored in RAM 0 and RAM 1. The waveforms can be waveforms from the waveform EPROM or arbitrary waveforms loaded from the Input Data Register. The output waveform is selected by the "Aux In" BNC port. The rising edge of the control signal selects RAM 0. The falling edge selects RAM 1. The "Aux In level" parameter can be used to invert the sensing of the "Aux In" port in order to select a waveform with the other edge.

2. Sending any command to the AFG while the Wave hop mode is set aborts the mode.

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3. When the "Wave hop" mode is set, the RAM bank and RAM size bits (Table C-2) are not used.

C and QuickBASIC Programs

The C program WAVE_HOP.C is in directory "CPROG", and the QuickBASIC program WAVE_HOP.BAS is in directory "QBPROG" on the example program disk HP P/N E1340-10036.

Sweeping

The following program generates a linear sweep from 1 kHz to 10 kHz in 5 seconds.

HP IBASIC (LINSWEEP)

```
1     !RE-SAVE"LINSWEEP"
2     GET "SUBS",500,3 !place subprograms at line 500, continue w/line 3
3     !Program which demonstrates how to set up a linear sweep.
4     !
10    !Compute the E1340 base address in E1300 A16 address space
20    COM Base_addr
30    Base_addr=DVAL("1FC000",16)+(80*64)   !base address
40    !
50    !Reset the AFG
60    Afg_reset
70    !Set function and load RAM
80    Function(0,0) !sine wave in RAM 0
90    !Set amplitude, offset, impedance, correction
100   Amplitude(2,0,50,0)  !2 Vpk, 0V, 50 ohms, correction enabled
110   !Set the start and stop frequency, sweep rate, and sweep type
120   Linsweep(1000,10000.,5)!start freq, stop freq, rate
130   !Set the Aux Out level, Aux In level, clock source, Aux Out signal,
140   !RAM bank, frequency register, and output mode.
150   Mode(0,0,3,3,0,0,5) !norm,norm,internal,sweep sync,bank 0,reg 1,sweep
160   END
170   !
```

C and QuickBASIC Programs

The C program LINSWEEP.C is in directory "CPROG", and the QuickBASIC program LINSWEEP.BAS is in directory "QBPROG" on the example program disk HP P/N E1340-10036.

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Gating the Output

The following program sets the AFG's gating mode. The internal 42 MHz oscillator is gated on and off based on the level of a control signal applied to the 'Aux In' BNC.

HP IBASIC (GATE)

```
1    !RE-SAVE"GATE"
2    GET "SUBS",500,3 !place subprograms at line 500, continue w/line 3
3    !Program which demonstrates how to gate the output signal on and off.
4    !A "low" on the 'Aux In' BNC enables the AFG output. A "high" gates
5    !the output off.
6    !
10   !Compute the E1340 base address in E1300 A16 address space
20   COM Base_addr
30   Base_addr=DVAL("1FC000",16)+(80*64)   !base address
40   !
50   !Reset the AFG
60   Afg_reset
70   !Set function and load RAM
80   Function(1,3) !triangle wave in RAM 3
90   !Set the frequency (frequency register 1)
100  Frequency1(5.0E+4) !50 kHz
110  !Set amplitude, offset, impedance, correction
120  Amplitude(2.5,0,50,0)  !2.5 Vpk, 0V, 50 ohms, correction enabled
130  !Set the Aux Out level, Aux In level, clock source, Aux Out signal,
140  !RAM bank, frequency register, and output mode.
150  Mode(0,0,1,1,3,0,0) !norm,norm,gate,pulse/cycle,bank 3,reg 1,cont
160  END
170  !
```

Comments

1. Gating is enabled by setting the clock source to 'Gated' and the 'Aux In' bit (bit 0) to '1' (Table C-2). When the signal applied to the 'Aux In' BNC is low, the clock (reference oscillator) is allowed to run. When the signal is high, the clock is halted. The output remains at the last amplitude point clocked. The waveform resumes with the next point when the clock is enabled.

C and QuickBASIC Programs

The C program GATE.C is in directory "CPROG", and the QuickBASIC program GATE.BAS is in directory "QBPROG" on the example program disk HP P/N E1340-10036.

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Downloading an Arbitrary Waveform

The following program downloads an arbitrary waveform (sine wave with a spike) to RAM 0 from the Input Data Register.

HP IBASIC (ARBWAVE)

```
1    !RE-SAVE"ARBWAVE"
2    !Program which demonstrates how to download an arbitrary waveform
3    !to the AFG.
4    !
10   !Compute the E1340 base address in E1300 A16 address space
20   COM Base_addr,REAL Waveform(0:4095)
30   Base_addr=DVAL("1FC000",16)+(80*64)   !base address
40   !
50   !Compute the arbitrary waveform points
60   FOR I=0 TO 4095
70     Waveform(I)=SIN(2*PI*(I/4095))
80   NEXT I
90   Width=50
100  FOR J=1 TO (Width/2)
110    Waveform(J+1023)=Waveform(J+1023)+J*.04
120  NEXT J
130  FOR J=1 TO (Width/2)
140    Waveform(J+1023+Width/2)=Waveform(J+1023+Width/2)+1-(J*.04)
150  NEXT J
160  !
170
Scale_factor=2047/(MAX(MAX(Waveform(*),ABS(MIN(Waveform(*))))))
180  FOR I=0 TO 4095
190    Waveform(I)=(Waveform(I)*Scale_factor)+2047
200  NEXT I
210  !
220  !Reset the AFG
230  Afg_reset
240  !Set function and load RAM
250  Function(16,0) !arbitrary waveform in RAM 0
260  !Load RAM 0 from the Input Data Register
270  FOR I=0 TO 4095
280    WRITEIO -9826,Base_addr+12;Waveform(I)
290  NEXT I
300  !Set the frequency (frequency register 1)
310  Frequency1(10000) !10 kHz
320  !Set amplitude, offset, impedance, correction
330  Amplitude(5,0,50,0)  !5 Vpk, 0V, 50 ohms, correction enabled
```


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```
340   !Set the Aux Out level, Aux In level, clock source, Aux Out signal,
350   !RAM bank, frequency register, and output mode.
360   Mode(0,0,3,1,0,0,0) !norm,norm,internal,pulse/cycle,bank 0,reg 1,cont
370   END
380   !
500  !Subprograms used for register-based programming (file name 'SUBS').
501   !
509   SUB Function(Function,Ram)
519 Function: !Subprogram which selects the output waveform and places it
529                !in the specified RAM
539    COM Base_addr,Waveform(*)
```

Comments

1. Before running this program, type ' GET "SUBS",500 '. This adds the subprograms to program ARBWAVE starting at line 500. Add the array variable "Waveform(*)" to the COM statement found in selected subprograms.

2. Arbitrary waveforms are loaded into RAM from the Input Data Register (base + $0C_{16}$). Arbitrary waveforms must be 4096 points long. Undefined points are output as random amplitudes. Since arbitrary waveforms are 4096 points, the frequency of the waveform is the repetition rate, rather than the sample rate of each point.

3. The 'Function' subprogram used with program ARBWAVE sets bit 6 of the 'output function and RAM' byte (Table C-2). This sets the output to 0V as the waveform data is downloaded into RAM from the Input Data Register. When bit 6 is not set (0), the output tracks the Input Data Register as the data is loaded.

4. All AFG clock sources and modes (Table C-2) are applicable for arbitrary waveforms.

C and QuickBASIC Programs

The C program ARBWAVE.C is in directory "CPROG", and the QuickBASIC program ARBWAVE.BAS is in directory "QBPROG" on the example program disk HP P/N E1340-10036.

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Fast Frequency Changes

The following program demonstrates the 'fast frequency change' mode. The program outputs 20 frequencies with durations between one and two seconds. The frequencies and durations are computed with the program 'FREQ_GEN' and stored in the file Fdata. Program 'FASTFREQ' reads the file and writes the frequencies (4 bytes at a time) to Frequency Register 1.

HP IBASIC (FASTFREQ)

```
1     !RE-SAVE"FASTFREQ"
2     !Program which demonstrates how to use the AFG's fast frequency
3     !change mode. The program outputs 20 frequencies between 10 kHz
4     !and 20 kHz, for periods between 1 and 2 seconds. The frequencies are
5     !generated by the program 'FREQ_GEN'.
6     !
10    !Compute the E1340 base address in E1300 A16 address space
20    COM Base_addr
30    Base_addr=DVAL("1FC000",16)+(80*64)   !base address
40    !
50    !Reset the AFG
60    Afg_reset
70    !Set the function and load RAM
80    Function(4,0) !square wave in RAM 0
90    !Set amplitude, offset, impedance, correction
100   Amplitude(5,0,50,1)  !5 Vpk, 0V, 50 ohms, correction disabled
110   !Set the Aux Out level, Aux In level, clock source, Aux Out signal,
120   !RAM bank, frequency register, and output mode.
130   Mode(0,0,3,1,0,0,7) !norm,norm,internal,pulse/cycle,bank 0,xxx,ffreq
140   !
150   !Write frequency data to the AFG
160   ASSIGN @F TO "Fdata" !path to frequency file
170   DIM S$[100]
180   ON ERROR GOTO Done
190   LOOP
200     ENTER @F;S$ !enter frequency
210     IF POS(S$,"!") THEN S$=S$[POS(S$,"!")+1] !set string not to include !
220     ENTER S$;Freq,Duration !enter frequency and duration
230     Frequency1(Freq) !write frequency byte
240     WAIT Duration
250   END LOOP
260   Check_done
270 Done:DISP "END OF FREQUENCY FILE REACHED"
280   END
```


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```
290   !
      •
1059   SUB Frequency1(Freq1)
1069 Frequency1:  !Subprogram which sets the output frequency using frequency
1079              !register 1.
1089    COM Base_addr
1099    Freq=(Freq1*100)
1109    C$=DVAL$(Freq,16)
1119    !
1129  !Load the frequency value
1139 !  Write_reg(8,1)
1149    Write_reg(10,IVAL(C$[1;2],16))
1159    Write_reg(10,IVAL(C$[3;2],16))
1169    Write_reg(10,IVAL(C$[5;2],16))
1179    Write_reg(10,IVAL(C$[7;2],16))
1189  !  Check_done
```

The following program generates the frequencies used by the program "FASTFREQ".

HP IBASIC (FREQ_GEN)

```
1     !RE-SAVE "FREQ_GEN"
2     !This program generates the frequencies used by example program 'FASTFREQ'.
3     !
10    DIM Line$[100]
20    CREATE ASCII "Fdata",10
30    ASSIGN @F TO "Fdata"
40    FOR I=1 TO 20
50      Freq=10000.+RND*10000.
60      Duration=1+RND
70      OUTPUT @F;VAL$(Freq)&","&VAL$(Duration)
80    NEXT I
90    !
100   ASSIGN @F TO *
110   ASSIGN @F TO "Fdata"
120   FOR I=1 TO 20
130     ENTER @F;Line$
140     PRInt   Line$
150   NEXT I
160   END
```


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Comments

1. Before running this program, type ’ GET "SUBS",500 ’. This adds the subprograms to program "FASTFREQ" starting at line 500.
2. Fast frequency changes are enabled by setting the ’Fast frequency change’ mode. The frequency changes after the fourth frequency byte is written to the Frequency Register (1 or 2).
3. Once the mode is set, frequencies (bytes) are written to the Frequency Register without writing the command opcode (line 1139 is commented ’!’), and without checking for the ’done’ condition (line 1189 is commented’!’). The frequency will continue to be changed after every four bytes until the mode is changed. Amplitude correction is not available with this mode.
4. This mode uses the 4k RAM size. The Frequency Register and RAM size bits (Table C-2) are ignored.

C and QuickBASIC Programs

The C program FASTFREQ.C is in directory "CPROG", and the QuickBASIC program FASTFREQ.BAS is in directory "QBPROG" on the example program disk HP P/N E1340-10036.

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Sending Data Directly to the DAC

The following program downloads data directly to the DAC from the Input Data Register (base $+0C_{16}$). The data are a series of random numbers (amplitudes). Since the data is not stored in RAM, it is output as it is received by the DAC.

HP IBASIC (DACDRIVE)

```
1    !RE-SAVE"DACDRIVE"
2    GET "SUBS",500,3 !place subprograms at line 500, continue w/line 3
3    !Program which demonstrates how to download amplitude data directly
4    !to the DAC. The data sent is a series of random amplitudes.
5    !
10   !Compute the E1340 base address in E1300 A16 address space
20   COM Base_addr
30   Base_addr=DVAL("1FC000",16)+(80*64)   !base address
40   !
50   !Compute data to be downloaded to the DAC.
60   INTEGER Voltage(1:10000)
70   FOR I=1 TO 10000
80     Voltage(I)=1024*RND+2048
90   NEXT I
100  !
110  !Reset the AFG
120  Afg_reset
130  !Set amplitude, offset, impedance, correction
140  Amplitude(10,0,50,0)  !10 Vpk, 0V, 50 ohms, correction enabled
150  !Set the Aux Out level, Aux In level, clock source, Aux Out signal,
160  !RAM bank, frequency register, and output mode.
170  Mode(0,0,4,1,0,0,6) !norm,norm,in data reg,pulse/cycle,xxx,xxx,dirDAC
180  !
190  !Write data to the DAC
200  FOR I=1 TO 10000
210    WRITEIO -9826,Base_addr+12;Voltage(I)
220  NEXT I
230  END
240  !
```

Comments

1. In the 'Direct DAC access' mode, the frequency and length of the arbitrary waveform are limited by the controller (computer). The AFG frequency is set to DC. The attenuation and offset can be programmed as required. The output remains at the last level written to the DAC. The 'Direct DAC access' mode is useful for setting the output to a given level before a burst occurs.

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2. In this mode, the Frequency Register, RAM bank, and RAM size bits (Table C-2) are not used.

C and QuickBASIC Programs

The C program DACDRIVE.C is in directory "CPROG", and the QuickBASIC program DACDRIVE.BAS is in directory "QBPROG" on the example program disk HP P/N E1340-10036.

Example Program Subprograms

The following file contains the subprograms used by the preceding example programs.

```
1     !Subprograms used for register-based programming (file name 'SUBS').
2     !
10    SUB Function(Function,Ram)
20 Function:   !Subprogram which selects the output waveform and places it
30             !in the specified RAM.
40      COM Base_addr
50      SELECT Function   !128 + waveform selection
60      CASE 0            !Sine wave
70        Eeprom=128
80      CASE 1            !Triangle wave
90        Eeprom=132
100     CASE 2            !Sin(x)/x
110       Eeprom=136
120     CASE 3            !Haversine
130       Eeprom=140
140     CASE 4            !Square wave
150       Eeprom=144
160     CASE 5            !First 10 terms of square wave
170       Eeprom=148
180     CASE 6            !First 4 terms of square wave
190       Eeprom=152
200     CASE 7            !Falling ramp
210       Eeprom=156
220     CASE 8            !First 20 terms of falling ramp
230       Eeprom=160
240     CASE 9            !Rising ramp
250       Eeprom=164
260     CASE 10           !First 20 terms of rising ramp
270       Eeprom=168
280     CASE 11           !White noise
290       Eeprom=172
300     CASE 12           !Modulated white noise
310       Eeprom=176
```


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```
320    CASE 13          !3rd, 4th, 5th harmonic chord
330      Eeprom=180
340    CASE 14          !8 cycles linear rising sine wave
350      Eeprom=184
360    CASE 15          !Positive 1/2 cycle sine wave
370      Eeprom=188
380    CASE ELSE          !Input Data Register (arbitrary waveform)
390      Eeprom=64       !Turn off output as waveform is downloaded
400    END SELECT
410    !
420    SELECT Ram
430    CASE 1           !RAM 1
440      Eeprom=Eeprom+1
450    CASE 2           !RAM 2
460      Eeprom=Eeprom+2
470    CASE 3           !RAM 3
480      Eeprom=Eeprom+3
490    END SELECT
500    !
510    Write_reg(8,5)
520    Write_reg(10,Eeprom)
530    Check_done
540  SUBEND
550  !
560  SUB Frequency1(Freq1)
570 Frequency1:  !Subprogram which sets the output frequency using frequency
580              !register 1.
590    COM Base_addr
600    Freq=(Freq1*100)
610    C$=DVAL$(Freq,16)
620    !
630  !Load the frequency value
640    Write_reg(8,1)
650    Write_reg(10,IVAL(C$[1;2],16))
660    Write_reg(10,IVAL(C$[3;2],16))
670    Write_reg(10,IVAL(C$[5;2],16))
680    Write_reg(10,IVAL(C$[7;2],16))
690    Check_done
700  SUBEND
```


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```
710   !
720   SUB Frequency2(Freq2)
730 Frequency2:  !Subprogram which loads frequency register 2 with the
740              !second FSK frequency or the stop sweep frequency.
750    COM Base_addr
760    Freq=(Freq2*100)
770    C$=DVAL$(Freq,16)
780    !
790   !Load the frequency value
800    Write_reg(8,2)
810    Write_reg(10,IVAL(C$[1;2],16))
820    Write_reg(10,IVAL(C$[3;2],16))
830    Write_reg(10,IVAL(C$[5;2],16))
840    Write_reg(10,IVAL(C$[7;2],16))
850    Check_done
860   SUBEND
870   !
880   SUB Amplitude(Ampl,Offset,Imp,Corr)
890 Amplitude:  !Subprogram which sets the necessary attenuation for the
900             !specified amplitude. Also sets the DC offset and specifies
910             !the output impedance and sets frequency correction.
920    COM Base_addr
930    !
940    Atten=16384*(Corr<>0)  !turn off amplitude correction if Corr = 1
950    SELECT Imp
960    CASE 50
970      IF Ampl>.51175 OR Offset>.51175 THEN
980        Atten=Atten+(Ampl/5.1175)*2047
990        C$=DVAL$(Atten+32768,16)   !32768 = no attenuation
1000       Offset=(Offset/.0025)+2048
1010     ELSE
1020       Atten=Atten+(Ampl/.51175)*2047
1030       C$=DVAL$(Atten,16)
1040       Offset=((Offset/.0025)*10)+2048
1050     END IF
1060   CASE ELSE
1070     IF Ampl>1.0235 OR Offset>1.0235 THEN
1080       Atten=Atten+(Ampl/10.235)*2047
1090       C$=DVAL$(Atten+32768,16)    !32768 = no attenuation
1100       Offset=(Offset/.005)+2048
1110     ELSE
```


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```
1120       Atten=Atten+(Ampl/1.0235)*2047
1130       C$=DVAL$(Atten,16)
1140       Offset=((Offset/.005)*10)+2048
1150     END IF
1160   END SELECT
1170   !
1180  !Load the attenuation value
1190   Write_reg(8,4)
1200   Write_reg(10,IVAL(C$[5;2],16))
1210   Write_reg(10,IVAL(C$[7;2],16))
1220   Check_done
1230   !
1240  !Load the offset value
1250   C$=DVAL$(Offset,16)
1260   Write_reg(8,3)
1270   Write_reg(10,IVAL(C$[5;2],16))
1280   Write_reg(10,IVAL(C$[7;2],16))
1290   Check_done
1300  SUBEND
1310   !
1320  SUB Linsweep(Start_freq,Stop_freq,Rate)
1330 Linsweep: !Subprogram which sets up linear sweeps
1340   COM Base_addr
1350   !Set start and stop frequencies
1360   Frequency1(Start_freq)
1370   Frequency2(Stop_freq)
1380   !Calculate phase (frequency) increment
1390   Tic_cnt=256
1400   REPEAT
1410     Phase_inc=(Stop_freq-Start_freq)*(.00025+.0001*Tic_cnt)/Rate
1420     Tic_cnt=Tic_cnt-1
1430   UNTIL Phase_inc>=.01 AND Phase_inc<42949672.955 OR Tic_cnt=0
1440   C$=DVAL$(INT(100.*Phase_inc+.5),16)
1450   !
1460  !Load the phase increment, tic count, and sweep type value
1470   Write_reg(8,7)
1480   Write_reg(10,IVAL(C$[1;2],16))  !phase increment
1490   Write_reg(10,IVAL(C$[3;2],16))  !phase increment
1500   Write_reg(10,IVAL(C$[5;2],16))  !phase increment
1510   Write_reg(10,IVAL(C$[7;2],16))  !phase increment
1520   Write_reg(10,BINAND(Tic_cnt+1,255))  !tic count
1530   Write_reg(10,0)  !linear sweep
1540   Check_done
```


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```
1550  SUBEND
1560  !
1570  SUB Burst(Coun)
1580 Burst: !Subprogram which sets the burst (cycle) count
1590    COM Base_addr
1600    C$=DVAL$(Coun,16)
1610    !
1620    !Load burst count
1630    Write_reg(8,8)
1640    Write_reg(10,IVAL(C$[5;2],16))   !burst count
1650    Write_reg(10,IVAL(C$[7;2],16))   !burst count
1660    Check_done
1670  SUBEND
1680  !
1690  SUB Mode(Out_lvl,In_lvl,Clock_source,Aux_out,Ram_bank,Freq_reg,Mode)
1700 Mode: !Subprogram which sets the output mode
1710    COM Base_addr
1720    Clock=0
1730    Out_mode=0
1740    SELECT Out_lvl
1750    CASE 1              !Aux out signal inverted
1760      Clock=Clock+128
1770    END SELECT
1780    !
1790    SELECT In_lvl
1800    CASE 1              !Invert signal in to Aux In
1810      Clock=Clock+64
1820    END SELECT
1830    !
1840    SELECT Clock_source
1850    CASE 0              !External
1860      Clock=Clock+1
1870    CASE 1              !Gated
1880      Clock=Clock+9
1890    CASE 2              !Burst
1900      Clock=Clock+16
1910    CASE 3              !Internal (default)
1920      Clock=Clock+24
1930    CASE 4              !Input Data Register
1940      Clock=Clock+32
1950    END SELECT
```


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```
1960  !
1970  SELECT Aux_out
1980  CASE 1            !Pulse/cycle
1990    Clock=Clock+2
2000  CASE 2            !Zero cross
2010    Clock=Clock+4
2020  CASE 3            !Sweep sync
2030    Clock=Clock+6
2040  END SELECT
2050  !
2060  SELECT Ram_bank
2070  CASE 1              !RAM 1
2080    Out_mode=Out_mode+64
2090  CASE 2              !RAM 2
2100    Out_mode=Out-Mode+128
2110  CASE 3              !RAM 3
2120    Out_mode=Out_mode+192
2130  CASE 8              !RAM size = 8k, RAM bank not used
2140    Out_mode=Out_mode+1
2150  CASE 16             !RAM size = 16k, RAM bank not used
2160    Out_mode=Out_mode+2
2170  END SELECT
2180  !
2190  SELECT Freq_reg
2200  CASE 1              !Frequency Register 2
2210    Out_mode=Out_mode+32
2220  END SELECT
2230  !
2240  SELECT Mode
2250  CASE 1              !FSK
2260    Out_mode=Out_mode+4
2270  CASE 2              !Wave hop
2280    Out_mode=Out_mode+8
2290  CASE 3              !Single burst
2300    Out_mode=Out_mode+12
2310  CASE 4              !Triggered burst
2320    Out_mode=Out_mode+16
2330  CASE 5              !Sweep
2340    Out_mode=Out_mode+20
2350  CASE 6              !Direct dac access
2360    Out_mode=Out_mode+24
2370  CASE 7              !Fast frequency change
2380    Out_mode=Out_mode+28
```


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```
2390    END SELECT
2400    !
2410  !Enable waveform output
2420    Write_reg(8,9)
2430    Write_reg(10,Clock)
2440    Write_reg(10,Out_mode)
2450    Check_done
2460  SUBEND
2470  !
2480  SUB Afg_reset
2490 Afg_reset: !Subprogram which resets the AFG
2500    COM Base_addr
2510    WRITEIO -9826,Base_addr+4;2   !inhibit sysfail during reset
2520    WRITEIO -9826,Base_addr+4;3   !reset AFG (sysfail inhibited)
2530    WRITEIO -9826,Base_addr+4;2   !turn reset off (sysfail inhibited)
2540    Check_pass
2550    WRITEIO -9826,Base_addr+4;0   !enable sysfail
2560  SUBEND
2570  !
2580  SUB Write_reg(Reg,Cp_data)
2590 Write_reg: !Subprogram which writes data to command and parameter
2600            !registers
2610    COM Base_addr
2620    Check_ready
2630    WRITEIO -9826,Base_addr+Reg;Cp_data
2640  SUBEND
2650  !
2660  SUB Check_pass
2670 Check_pass: !Monitors completion of reset
2680    REPEAT
2690      CALL Read_status(Pass_fail,Ready,Done)
2700    UNTIL Pass_fail
2710  SUBEND
2720  !
2730  SUB Check_done
2740 Check_done: !Monitors command completion
2750    REPEAT
2760      CALL Read_status(Pass_fail,Ready,Done)
2770    UNTIL Done
2780  SUBEND
2790  !
2800  SUB Check_ready
```


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```
2810 Check_ready: !Monitors command and parameter execution
2820   REPEAT
2830     CALL Read_status(Pass_fail,Ready,Done)
2840   UNTIL Ready
2850 SUBEND
2860 !
2870 SUB Read_status(Pass_fail,Ready,Done)
2880 Read_status:!Subprogram which reads the arb's Status Register
2890   COM Base_addr
2900   Status=READIO(-9826,Base_addr+4)
2910   Ready=BIT(Status,0)
2920   Pass_fail=BIT(Status,2)
2930   Done=BIT(Status,7) AND Ready
2940   Qryrdy=BIT(Status,1) AND Done
2950 SUBEND
```


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Querying AFG Parameters

This program is used to query the following AFG parameters:

- function
- frequency (Registers 1 and 2)
- attenuation
- offset
- burst count
- sweep rate
- mode

The query opcodes used are shown in Table C-4 below.

Table C-4. AFG Query Opcodes

Parameter	Query Opcode	Description
Function	60	Returns the byte used to set the function and select RAM.
Frequency Register 1	48 49 50 51	Returns the most significant byte (MSB) used to set the output frequency. Returns the second significant byte (2SB) used to set the output frequency. Returns the third significant byte (3SB) used to set the output frequency. Returns the least significant byte (LSB) used to set the output frequency.
Frequency Register 2	52 53 54 55	Returns the most significant byte (MSB) used to set the output frequency. Returns the second significant byte (2SB) used to set the output frequency. Returns the third significant byte (3SB) used to set the output frequency. Returns the least significant byte (LSB) used to set the output frequency.
Attenuation	58 59	Returns the most significant byte (MSB) used to set the attenuation. Returns the least significant byte (LSB) used to set the attenuation.
Offset	56 57	Returns the most significant byte (MSB) used to set the DC offset. Returns the least significant byte (LSB) used to set the DC offset.
Burst Count	17 18	Returns the most significant byte (MSB) used to set the burst count. Returns the least significant byte (LSB) used to set the burst count.
Sweep Rate	40 41 62 63 16	Returns the most significant byte (MSB) used to set the phase increment. Returns the second significant byte (2SB) used to set the phase increment. Returns the third significant byte (3SB) used to set the phase increment. Returns the least significant byte (LSB) used to set the phase increment. Returns the tic count (sent as a one byte parameter query).
Mode	61 23	Returns 'Byte 1' (Table C-2) of the clock source and output mode. Returns 'Byte 2' (Table C-2) of the clock source and output mode.

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HP IBASIC (AFGQUERY)

```
1     !RE-SAVE"AFGQUERY"
2     !Program which queries the AFG parameters.
3     !
10    !Compute the E1340 base address in E1300 A16 address space
20    COM Base_addr
30    Base_addr=DVAL("1FC000",16)+(80*64)   !base address
40    !
50    Parm1(60)  !one byte parameter query
60    Parm2(58,59) !two byte parameter query
70    Parm4(48,49,50,51) !four byte parameter query
80    END
90    !
100   SUB Parm1(Byte)
110 Parm1:  !Subprogram which queries one byte parameters
120     COM Base_addr
130     Write_reg(8,13)
140     Write_reg(10,Byte)
150     Queryrdy
160     Byte=READIO(-9826,Base_addr+8)
170     Byte=BINAND(Byte,255)
180     PRInt    Byte
190   SUBEND
200   !
210   SUB Parm2(Byte1,Byte2)
220 Parm2:  !Subprogram which queries two byte parameters
230     COM Base_addr
240     Write_reg(8,13)
250     Write_reg(10,Byte1)
260     Queryrdy
270     Byte1=READIO(-9826,Base_addr+8)
280     Byte1=BINAND(Byte1,255)*2^8
290     !
300     Write_reg(8,13)
310     Write_reg(10,Byte2)
320     Queryrdy
330     Byte2=READIO(-9826,Base_addr+8)
340     Byte2=BINAND(Byte2,255)
350     Value=Byte1+Byte2
360     PRInt    Value
370     SUBEND
380     !
```


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```
390   SUB Parm4(Byte1,Byte2,Byte3,Byte4)
400 Parm4:  !Subprogram which queries four byte parameters
410         COM Base_addr
420     Write_reg(8,13)
430     Write_reg(10,Byte1)
440     Queryrdy
450     Byte1=READIO(-9826,Base_addr+8)
460     Byte1=BINAND(Byte1,255)*2^24
470     !
480     Write_reg(8,13)
490     Write_reg(10,Byte2)
500     Queryrdy
510     Byte2=READIO(-9826,Base_addr+8)
520     Byte2=BINAND(Byte2,255)*2^16
530     !
540     Write_reg(8,13)
550     Write_reg(10,Byte3)
560     Queryrdy
570     Byte3=READIO(-9826,Base_addr+8)
580     Byte3=BINAND(Byte3,255)*2^8
590     !
600     Write_reg(8,13)
610     Write_reg(10,Byte4)
620     Queryrdy
630     Byte4=READIO(-9826,Base_addr+8)
640     Byte4=BINAND(Byte4,255)
650     !
660     Value=(Byte1+Byte2+Byte3+Byte4)/100
670     PRInt    Value
680     SUBEND
690     !
700   SUB Write_reg(Reg,Cp_data)
710 Write_reg:  !Subprogram which writes data to command and parameter
720             !registers
730     COM Base_addr
740     Check_ready
750     WRITEIO -9826,Base_addr+Reg;Cp_data
760   SUBEND
770   !
780   SUB Check_ready
790 Check_ready:  !Monitors command and parameter execution
800     REPEAT
```


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```
810      CALL Read_status(Pass_fail,Ready,Done,Qryrdy)
820    UNTIL Ready
830  SUBEND
840  !
850  SUB Queryrdy
860    REPEAT
870      CALL Read_status(Pass_fail,Ready,Done,Qryrdy)
880    UNTIL Qryrdy
890  SUBEND
900  !
910  SUB Read_status(Pass_fail,Ready,Done,Qryrdy)
920 Read_status: !Subprogram which reads the arb's Status Register
930    COM Base_addr
940    Status=READIO(-9826,Base_addr+4)
950    Ready=BIT(Status,0)
960    Pass_fail=BIT(Status,2)
970    Done=BIT(Status,7) AND Ready
980    Qryrdy=BIT(Status,1) AND Done
990  SUBEND
```

Comments

1. The parameters shown in the program listing query the function (60), the attenuation (58,59), and the frequency in Frequency Register 1 (48,49,50,51). Other parameters can be queried by sending other opcodes to the subprograms. To query only one or two parameters, comment out (!) lines 50 through 70 as appropriate.

2. Query responses (bytes) are returned to the Query Response Register (base + 08_{16}). Each time command opcode 13 and a query opcode are sent, one byte is returned. Thus, for multiple byte parameters, command opcode 13 must be sent for each byte queried.

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