

## Errata

**Title & Document Type:** 8111A Pulse/Function Generator Operating & Service Manual

**Manual Part Number:** 08111-90002

**Revision Date:** September 1984

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### HP References in this Manual

This manual may contain references to HP or Hewlett-Packard. Please note that Hewlett-Packard's former test and measurement, semiconductor products and chemical analysis businesses are now part of Agilent Technologies. We have made no changes to this manual copy. The HP XXXX referred to in this document is now the Agilent XXXX. For example, model number HP8648A is now model number Agilent 8648A.

### About this Manual

We've added this manual to the Agilent website in an effort to help you support your product. This manual provides the best information we could find. It may be incomplete or contain dated information, and the scan quality may not be ideal. If we find a better copy in the future, we will add it to the Agilent website.

### Support for Your Product

Agilent no longer sells or supports this product. You will find any other available product information on the Agilent Test & Measurement website:

[www.tm.agilent.com](http://www.tm.agilent.com)

Search for the model number of this product, and the resulting product page will guide you to any available information. Our service centers may be able to perform calibration if no repair parts are needed, but no other support from Agilent is available.



# OPERATING AND SERVICE MANUAL

## 8111A PULSE/FUNCTION GENERATOR 20 MHz



**hp** HEWLETT  
PACKARD

**MANUAL CHANGES**

03/94

|                         |             |
|-------------------------|-------------|
| Manual for Model Number | 8111A       |
| Manual printed on       | Sept. 1984  |
| Manual Part Number      | 08111-90002 |

Make all ERRATA corrections.

Check the following table for your instrument serial prefix/serial number and make the listed changes to your manual.

**New Item**

| Serial Prefix or<br>Serial Number | Manual<br>Changes | Serial Prefix or<br>Serial Number | Manual<br>Changes |
|-----------------------------------|-------------------|-----------------------------------|-------------------|
| <b>ERRATA</b>                     |                   |                                   |                   |
| 2215G02366                        |                   |                                   | 1                 |
| 2215G02416                        | and above         |                                   | 1-2               |
| 2519G02591                        | and above         |                                   | 1-3               |
| 2519G02716                        | and above         |                                   | 1-4               |
| 2519G02816                        | and above         |                                   | 1-5               |
| 2519G03241                        | and above         |                                   | 1-6               |
| 2519G03661                        | and above         |                                   | 1-7               |
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| 2519G04021                        | and above         |                                   | 1-10              |
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| 2519G04761                        | and above         |                                   | 1-12              |
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| 2849G06841                        | and above         |                                   | 1-18              |
| 2849G07601                        | and above         |                                   | 1-19              |
| 2849G08081                        | and above         |                                   | 1-20              |
| 2849G08291                        | and above         |                                   | 1-21              |
| 2849G08471                        | and above         |                                   | 1-22              |

| MANUAL<br>CHANGE | MISCELLANEOUS                                      | FRAME                               | A1  | A2 |                              | A4                   | A5        | A6                     | A7               | A8                         | STANDARD   |
|------------------|----------------------------------------------------|-------------------------------------|-----|----|------------------------------|----------------------|-----------|------------------------|------------------|----------------------------|------------|
|                  |                                                    |                                     | A21 |    | A3                           |                      |           |                        |                  |                            | OPTION 001 |
| ERRATA           | Page 2-1<br>Page 8-57<br>Page 6-16<br>Page 5-4,5-5 |                                     |     |    |                              |                      |           |                        |                  |                            |            |
| 1                |                                                    |                                     |     |    | C1,3,4,9,<br>C10 thru<br>C13 | C13,16,19,<br>C21,22 | C20       | C2 thru 6,<br>C13,16   | C6,7,8           | C12,13,15,16,<br>C17,23    |            |
| 3                |                                                    | MP2,6,13,14,<br>MP15,17,18,<br>MP22 |     |    |                              |                      |           | Q1                     |                  |                            |            |
| 4                |                                                    |                                     |     |    |                              | R35                  |           |                        |                  |                            |            |
| 5                |                                                    |                                     |     |    |                              |                      |           |                        |                  | K 1,2,3                    |            |
| 6                | Page 6-12<br>Page 6-10                             |                                     |     |    |                              |                      |           | R3,13<br>*R3,13<br>C10 |                  |                            |            |
| 7                | Page 6-13                                          |                                     |     |    |                              |                      |           |                        |                  | MP5,6,7,8,9,<br>MP10,11,12 |            |
| 8                |                                                    | MP18                                |     |    |                              |                      |           |                        |                  |                            |            |
| 9                | Page 6-12                                          |                                     |     |    |                              |                      |           | U2                     |                  |                            |            |
| 10               | Page 6-15                                          |                                     |     |    | C4                           |                      |           |                        |                  |                            |            |
| 11               |                                                    |                                     |     |    |                              | C8,9,12              | C14,18,21 | C8,9,11,<br>C14,15     | C1,2,5,9,<br>C10 | C6,7,21,24,25              |            |

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INDEX OF MANUAL CHANGES

| MANUAL<br>CHANGE | MISCELLANEOUS | FRAME                                     | A1<br>A21 | A2     | A3  | A4  | A5               | A6  | A7 | A8 | STANDARD<br>OPTION 001 |
|------------------|---------------|-------------------------------------------|-----------|--------|-----|-----|------------------|-----|----|----|------------------------|
| 12               |               |                                           |           |        | C4  | C2  | R49,53,<br>R67,9 |     |    |    |                        |
| 14               |               |                                           |           |        | U17 |     |                  |     |    |    |                        |
| 15               |               | MP 20,17,<br>MP23,24,<br>MP25,14,<br>MP15 |           |        |     |     |                  |     |    |    |                        |
| 16               |               |                                           |           |        |     |     |                  | R51 |    |    |                        |
| 17               |               | J1-3                                      |           |        |     |     |                  |     |    |    |                        |
| 18               |               |                                           |           |        |     | C18 |                  | L2  |    |    |                        |
| 19               |               |                                           | A1,C2     | C15,18 |     |     |                  |     |    |    |                        |
| 20               |               |                                           |           |        |     |     | U1               | U2  |    |    |                        |
| 21               |               |                                           |           |        |     |     | U1<br>R6, R7     |     |    |    |                        |
| 22               |               |                                           |           |        |     |     | U1               |     |    |    |                        |
|                  |               |                                           |           |        |     |     |                  |     |    |    |                        |

## INDEX OF MANUAL CHANGES

Page 3

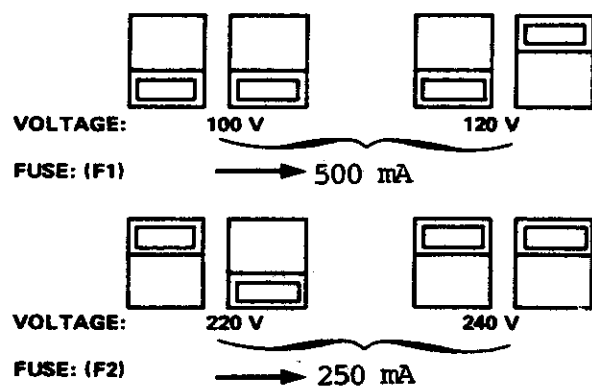
## ERRATA

On Page 2-1, Section II / Installation, change to read:

## CAUTION

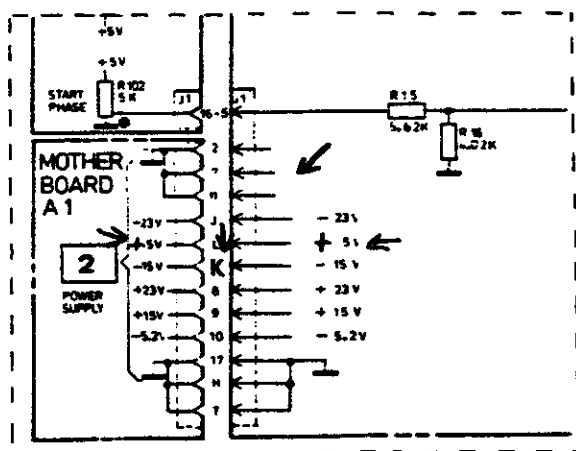
**Do not change the LINE SELECTOR switch settings with the instrument on or with power connected to the rear panel.**

**2-9** Figure 2-1 provides information for line voltage and fuse selection:



**Figure 2-1. Sliding Switches Positions for different Line Voltages**

On Page 8-57, VCO Board A5, change to read:



On Page 6-16, Replaceable parts list:

Delete: Q3,7 1853-0212  
A21Q4,8 1854-0368

ERRATA (Cont.)

Page 5-4 Shaper Adjustment

change step 6 to read:

Adjust A6R6 for 8V +100mV -  $\phi$ mV

add below step 12

NOTE: Steps 8 to 12 are interdependent and must therefore be repeated until the values are within tolerance.

Page 5-5

change step 14 to read:

Adjust A6R27 for 800mV +10mV -  $\phi$ mV

change the NOTE to read:

NOTE: Readjust steps 1 to 6. Recheck steps 7 to 14 and readjust if necessary.

add to step 30:

Check again steps 1 to 14.

Page 6-12

change the Table of Replaceable Parts to read:

|    |    |           |                 |
|----|----|-----------|-----------------|
| A8 | C4 | 0160-3874 | C-FXD 10PF 200V |
|----|----|-----------|-----------------|

ERRATA (Cont.)

On Page 4-8, Performance Tests 4-15, step 4., change to read:

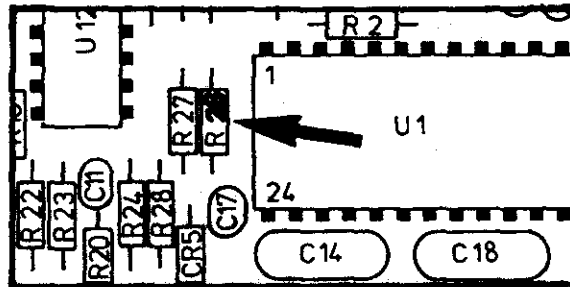
| 8111A | Counter Reading           |
|-------|---------------------------|
| 10%   | 4 $\mu$ s - 16 $\mu$ sec  |
| 20%   | 17 $\mu$ s - 23 $\mu$ sec |
| 50%   | 47 $\mu$ s - 53 $\mu$ sec |
| ---   | ---                       |
| ---   | ---                       |

On Page 4-15, Performance Tests Record, Step 4-15, change to read:

| Duty Cycle | Minimum    | Actual | Maximum    |
|------------|------------|--------|------------|
| 10%        | 4 $\mu$ s  |        | 16 $\mu$ s |
| 20%        | 17 $\mu$ s |        | 23 $\mu$ s |
| 50%        | 47 $\mu$ s |        | 53 $\mu$ s |
| ---        | ---        |        | ---        |
| ---        | ---        |        | ---        |

On Page 8-50 (Component Layout + Ref.Desig.List) change to read:

C25 to C26



On Page 6-15, Table 6-3 Replaceable Parts OPTION 001, add:

MP1      4040-1969      FRONT PANEL, OPTION 001

# MODEL 8111A

## MANUAL CHANGE 1

On Page 6-10 thru 6-16, change the Table of Replaceable Parts to read:

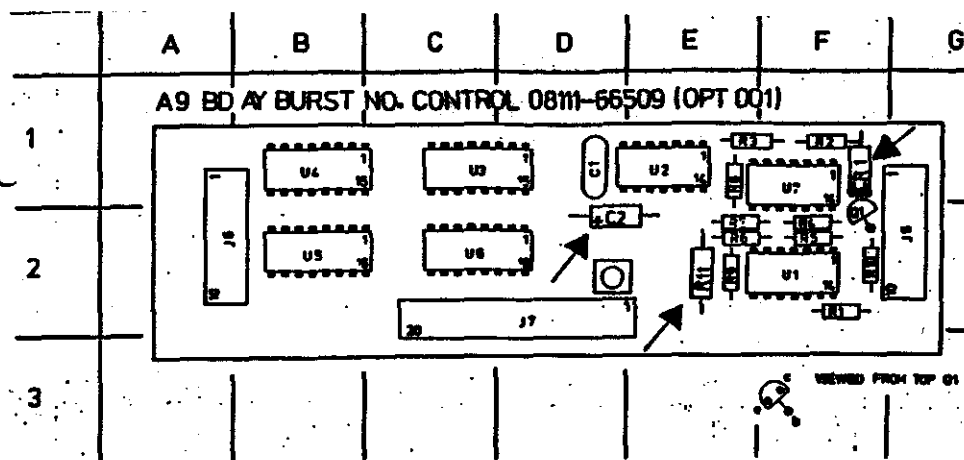
|     |                         |           |                 |
|-----|-------------------------|-----------|-----------------|
| A3  | C1,3,4,<br>C10 thru 13  |           |                 |
| A4  | C13,16,19,21,22         |           |                 |
| A5  | C20                     |           |                 |
| A6  | C2 thru 6<br>C13,16     | 0160-5746 | C-FXD 0.1UF 20% |
| A7  | C6,7,8                  |           |                 |
| A8  | C12,13,15,16,<br>C17,23 |           |                 |
| A10 | C5,8,9                  |           |                 |
| A30 | C5,8,9                  |           |                 |

## MANUAL CHANGE 2

On Page 6-15, change the Table of Replaceable Parts to read:

|      |     |             |                    |
|------|-----|-------------|--------------------|
| A9   |     | 08111-66519 | PC-BD              |
| Add: | C2  | 0180-0116   | C-FXD 6.8UF 35V TA |
|      | CR1 | 1901-0033   | DIO 180V .2A       |
|      | R11 | 0698-4477   | R-FXD 10.5K 1%     |

On Page 8-42, change Service Sheet 6 to read:

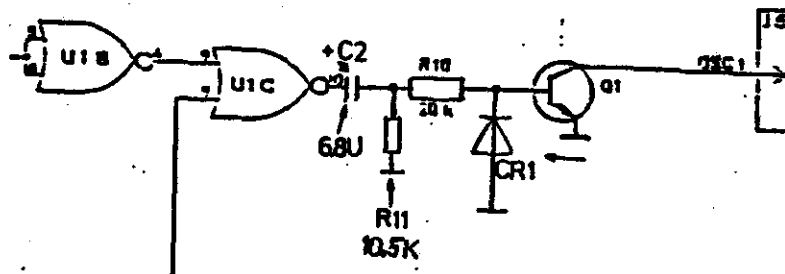


On Ref Des Table and Grid Loc add:

|     |    |
|-----|----|
| C2  | D1 |
| CR1 | F1 |
| R11 | E2 |

MANUAL CHANGE 2 (Cont.)

On Page 8-49, change Schematic to read:

MANUAL CHANGE 3

**IMPORTANT NOTE:** New part numbers assigned to the following items since all threaded holes or screws are now METRIC!

On Page 6-7, change the Table of Replaceable Parts to read:

|      |             |                 |
|------|-------------|-----------------|
| MP 2 | 08111-00211 | PANEL SUB       |
| MP 6 | 08111-01211 | BRKT FRONT      |
| MP13 | 08111-02315 | HT SNK OUT HLDR |
| MP14 | 08111-04111 | COVER TOP       |
| MP15 | 08111-04112 | COVER BOTTOM    |
| MP17 | 5021-5813   | FRAME FRONT     |
| MP18 | 5021-0512   | FRAME REAR      |
| MP22 | 5021-5830   | SIDE STRUT      |

On Page 6-12, change the Table of Replaceable Parts to read:

|      |           |             |
|------|-----------|-------------|
| A6Q1 | 1853-0589 | XSTR MD4260 |
|------|-----------|-------------|

MANUAL CHANGE 4

On Page 6-10, change the Table of Replaceable Parts to read:

|       |           |                                 |
|-------|-----------|---------------------------------|
| A4R35 | 0698-4460 | R-FXD 649 1 $\frac{1}{2}$ .125W |
|-------|-----------|---------------------------------|

MANUAL CHANGE 5

On Page 6-13, change the Table of Replaceable Parts to read:

|             |           |             |
|-------------|-----------|-------------|
| A 8 K 1,2,3 | 0490-1527 | RELAIS REED |
|-------------|-----------|-------------|

MANUAL CHANGE 6

On Page 6-12, Table 6-3., Replaceable Parts List:

|             |         |           |                |
|-------------|---------|-----------|----------------|
| <u>ADD:</u> | A6 *R3  | 0698-3202 | R-FXD 1.74K 1% |
|             | A6 -R3  | 0757-1094 | R-FXD 1.47K 1% |
|             | A6 *R13 | 0698-3136 | R-FXD 17.8K 1% |
|             | A6 -R13 | 0757-0441 | R-FXD 8.25K 1% |

DEL: A6 R3,13

On Page 6-10, change the Table of Replaceable Parts to read:

|        |           |                |
|--------|-----------|----------------|
| A5 C10 | 0180-3822 | C-FXD 39UF 15V |
|--------|-----------|----------------|

MANUAL CHANGE 7

On Page 6-13, change the Table of Replaceable Parts to read:

|                               |           |             |
|-------------------------------|-----------|-------------|
| A8 MP5,6,7,8,<br>MP9,10,11,12 | 1205-0662 | HT SINK SGL |
|-------------------------------|-----------|-------------|

MANUAL CHANGE 8

On Page 6-7, Replaceable Parts List, change to read:

|      |           |            |
|------|-----------|------------|
| MP18 | 5021-5814 | FRAME REAR |
|------|-----------|------------|

MANUAL CHANGE 9

On Page 6-12, change the Table of Replaceable Parts to read:

|       |           |         |
|-------|-----------|---------|
| A6 U2 | 1826-0923 | IC 1DC7 |
|-------|-----------|---------|

MANUAL CHANGE 10

On Page 6-15, change the Table of Replaceable Parts to read:

|       |           |                |
|-------|-----------|----------------|
| A3 C4 | 0160-0575 | C-FXD 47UF CER |
|-------|-----------|----------------|

MODEL 8111A

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MANUAL CHANGE 11

On Table 6-3, Replaceable Parts List, change to read:

|     |               |           |                 |
|-----|---------------|-----------|-----------------|
| A4  | C8,9,12       |           |                 |
| A5  | C14,18,21     |           |                 |
| A6  | C8,9,11,14,15 | 0160-6596 | C-FXD .47UF 20% |
| A7  | C1,2,5,9,10   |           |                 |
| A8  | C6,7,21,24,25 |           |                 |
| A9  | C1            |           |                 |
| A10 | C2,3          |           |                 |
| A30 | C2,3          |           |                 |

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MANUAL CHANGE 12

On Page 6-9, change the Table of Replaceable Parts to read:

|    |    |           |               |
|----|----|-----------|---------------|
| A4 | C2 | 0160-5739 | C-FXD 15PF 5% |
|----|----|-----------|---------------|

On Page 6-11, change the Table of Replaceable Parts to read:

|    |        |           |                |
|----|--------|-----------|----------------|
| A5 | R49    | 0757-0441 | R-FXD 8,25K 1% |
|    | R53,67 | 0698-0085 | R-FXD 2,61K 1% |
|    | R9     | 0757-0528 | R-FXD 1,62K 1% |
| A3 | C4     | 0160-0574 | C-F .022UF 20% |

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MANUAL CHANGE 13

On Page 6-14, Replaceable Parts List, change to read:

|     |    |           |         |
|-----|----|-----------|---------|
| A13 | S1 | 3101-2953 | SW-LINE |
|-----|----|-----------|---------|

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MANUAL CHANGE 14

On Page 6-14, change the Table of Replaceable Parts to read:

|    |     |           |            |
|----|-----|-----------|------------|
| A3 | U17 | 1820-3841 | IC 74AS168 |
|----|-----|-----------|------------|

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MODEL 8111A

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MANUAL CHANGE 15

On Page 1-2, 1-27. Accessories, change to read:

|           |    |           |
|-----------|----|-----------|
| 5061-2001 | to | 5062-4001 |
| 5061-0072 | to | 5062-3972 |
| 5061-0074 | to | 5062-3974 |

On Page 6-7, Replaceable Parts List, change to read:

|      |             |                  |
|------|-------------|------------------|
| MP20 | 5001-0538   | TRIM STRIP       |
| MP17 | 5021-8413   | FRAME FRONT 1/2M |
| MP23 | 5041-8801   | FOOT             |
| MP24 | 5041-8803   | TRIM STRIP       |
| MP25 | 5061-8822   | FOOT REAR N-SKID |
| MP14 | 08111-04121 | COVER TOP        |
| MP15 | 08111-04122 | COVER BOTTOM     |

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MANUAL CHANGE 16

On Page 6-12, Replaceable Parts List, change to read:

|        |           |           |
|--------|-----------|-----------|
| A6 R51 | 0757-0422 | R-FXD 909 |
|--------|-----------|-----------|

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MANUAL CHANGE 17

On Page 6-7, change the Table of Replaceable Parts to read:

|      |           |                |
|------|-----------|----------------|
| J1-3 | 1250-0083 | CONN BNC BLKHD |
|------|-----------|----------------|

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MANUAL CHANGE 18

On Page 6-10, change the Table of Replaceable Parts to read:

|        |           |               |
|--------|-----------|---------------|
| A4 C18 | 0160-5736 | C-FXD 22PF 5% |
|--------|-----------|---------------|

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## MODEL 8111A

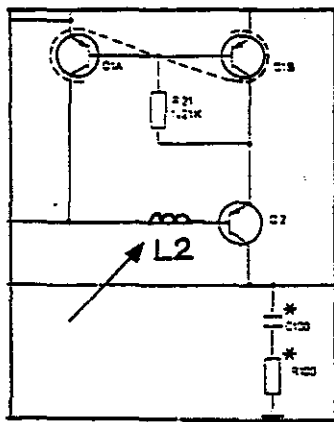
### MANUAL CHANGE 18 (Cont.)

On Page 6-11, Replaceable Parts List,

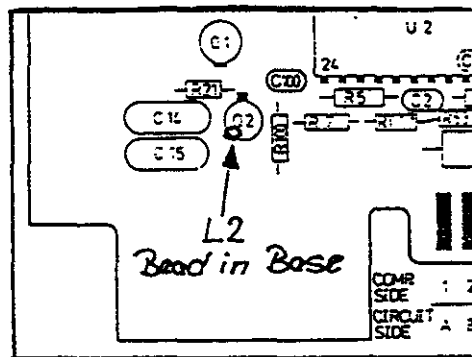
add:     A6       L2                    9170-0894                    BEAD

BEAD MUST BE INSERTED IN BASE-WIRE OF Q2!

Change Schematic, Page 8-71 to read:



Change Component Layout, Page 8-66, to read:



### MANUAL CHANGE 19

On Page 6-9, Change the Table of Repl.Parts to read:

|    |        |           |              |                  |
|----|--------|-----------|--------------|------------------|
| A1 | C2     | 0180-3158 | C-F 6800UF   | (EDC-LBL:A-3217) |
| A2 | C15,18 | 0180-3157 | C-F 47uF 40V | (EDC-LBL:A-3217) |

### MANUAL CHANGE 20

On Page 6-11, Repl.Parts List, Change to read:

|    |    |           |            |                  |
|----|----|-----------|------------|------------------|
| A5 | U1 | 1DB6-0001 | IC SNAKE   | (EDC-LBL:B-3310) |
| A6 | U2 | 1DC7-0001 | IC BOOSTER | (EDC-LBL:B-3310) |

### MANUAL CHANGE 21

On Page 6-11, Repl.Parts List, change to read:

|    |      |           |              |                  |
|----|------|-----------|--------------|------------------|
| A5 | R6,7 | 0757-0274 | RES 1.21k 1% | (EDC-LBL:B-3343) |
|----|------|-----------|--------------|------------------|

MODEL 8111A

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MANUAL CHANGE 22

On Page 6-11, Repl.Parts List change to read:

|    |    |           |         |                 |
|----|----|-----------|---------|-----------------|
| A5 | U1 | 1826-0955 | IC 1DB6 | EDC-LBL: B-3408 |
|----|----|-----------|---------|-----------------|

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**HEWLETT  
PACKARD**

Böblingen Instruments Division

### **Herstellerbescheinigung**

Hiermit wird bescheinigt, daß das Gerät/System

**Puls-Generator HP 8111A**

in Übereinstimmung mit den Bestimmungen von Postverfügung 1046/84 funkentstört ist.

Der Deutschen Bundespost wurde das Inverkehrbringen dieses Gerätes/Systems angezeigt und die Berechtigung zur Überprüfung der Serie auf Einhaltung der Bestimmungen eingeräumt.

### **Zusatzinformation für Meß- und Testgeräte**

Werden Meß- und Testgeräte mit ungeschirmten Kabeln und/oder in offenen Meßaufbauten verwendet, so ist vom Betreiber sicherzustellen, daß die Funk-Entstörbestimmungen unter Betriebsbedingungen an seiner Grundstücksgrenze eingehalten werden.

### **Manufacturer's declaration**

This is to certify that the equipment

**Pulse Generator HP 8111A**

is in accordance with the Radio Interference Requirements of Directive FTZ 1046/1984. The German Bundespost was notified that this equipment was put into circulation, the right to check the serie for compliance with the requirements was granted.

### **Additional Information for Test- and Measurement Equipment**

If Test- and Measurement Equipment is operated with unscreened cables and/or used for measurements on open set-ups, the user has to assure that under operating conditions the Radio Interference Limits are still met at the border of his premises.

Hewlett Packard GmbH, 30. Juni 1985



## SAFETY SUMMARY

*The following general safety precautions must be observed during all phases of operation, service, and repair of this instrument. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of design, manufacture, and intended use of the instrument. Hewlett-Packard Company assumes no liability for the customer's failure to comply with these requirements.*

**GENERAL** — This is a Safety Class I instrument (provided with terminal for protective earthing) and has been manufactured and tested according to international safety standards.

**OPERATION — BEFORE APPLYING POWER** comply with the installation section. Additionally, the following shall be observed:

Do not remove instrument covers when operating.

Before the instrument is switched on, all protective earth terminals, extension cords, auto-transformers and devices connected to it should be connected to a protective earth via a ground socket. Any interruption of the protective earth grounding will cause a potential shock hazard that could result in serious personal injury.

Whenever it is likely that the protection has been impaired, the instrument must be made inoperative and be secured against any unintended operation.

Make sure that only fuses with the required rated current and of the specified type (normal blow, time delay, etc.) are used for replacement. The use of repaired fuses and the short-circuiting of fuseholders must be avoided.

Adjustments described in the manual are performed with power supplied to the instrument while protective covers are removed. Energy available at many points may, if contacted, result in personal injury.

Any adjustment, maintenance, and repair of the opened instrument under voltage should be avoided as much as possible, and when inevitable, should be carried out only by a skilled person who is aware of the hazard involved. Do not attempt internal service or adjustment unless another person, capable of rendering first aid and resuscitation is present. Do not replace components with power cable connected.

Do not operate the instrument in the presence of flammable gases or fumes. Operation of any electrical instrument in such an environment constitutes a definite safety hazard.

Do not install substitute parts or perform any unauthorized modification to the instrument.

Capacitors inside the instrument may still be charged even if the instrument has been disconnected from its source of supply.

### SAFETY SYMBOLS



The apparatus will be marked with this symbol when it is necessary for the user to refer to the instruction manual in order to protect the apparatus against damage.



Indicates dangerous voltages.



Earth terminal

### WARNING

The WARNING sign denotes a hazard. It calls attention to a procedure, practice or the like, which, if not correctly performed or adhered to, could result in injury or loss of life. Do not proceed beyond a WARNING sign until the indicated conditions are fully understood and met.

### CAUTION

The CAUTION sign denotes a hazard. It calls attention to an operating procedure, practice, or the like, which, if not correctly performed or adhered to, could result in damage to or destruction of part or all of the equipment. Do not proceed beyond a CAUTION sign until the indicated conditions are fully understood and met.



WARNING



Dangerous voltages, capable of causing serious personal injury, are present in this instrument. Use extreme caution when handling, testing, and adjusting.



OPERATING AND SERVICE MANUAL

# **8111A PULSE/FUNCTION GENERATOR 20 MHz**

**(Including Option 001)**

## **SERIAL NUMBERS**

This manual applies directly to instrument with serial number 2215G01841 and higher. Any change made in instruments having serial numbers higher than the above number will be found in a "Manual Changes" supplement supplied with this manual. Be sure to examine the supplement for changes which apply to your instrument and record these changes in the manual. Backdating information for instruments with lower serial numbers can be found in Section 7 (yellow pages).

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HERRENBERGER STR. 130, D-7030 BOBLINGEN  
FEDERAL REPUBLIC OF GERMANY

MANUAL PART No. 08111-90002  
MICROFICHE PART No. 08111-95002

PRINTED: SEP 1984



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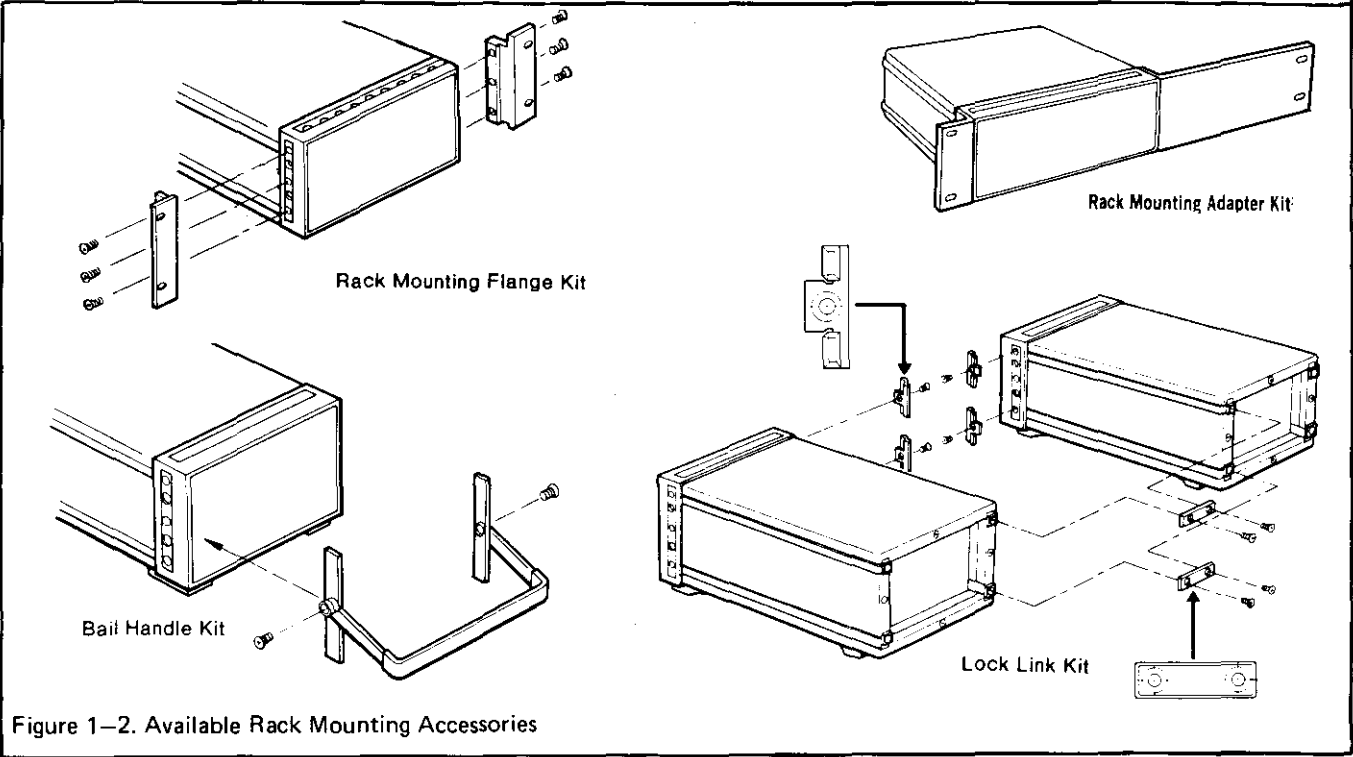
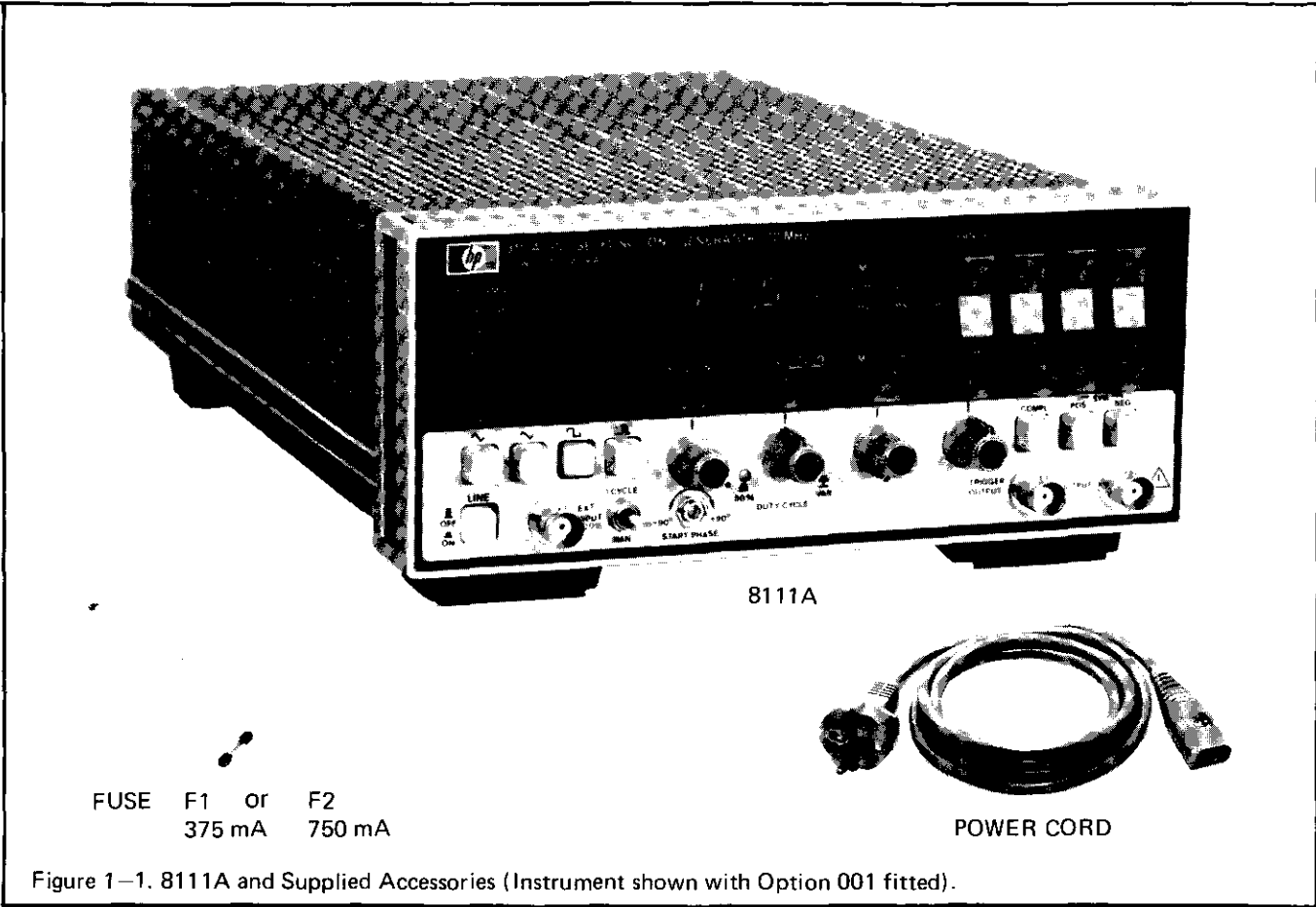
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## SECTION I GENERAL INFORMATION

### 1-1 INTRODUCTION

1-2 This Operating and Service Manual contains information required to install, operate, test, adjust and service the Hewlett-Packard Model 8111A. Figure 1-1 shows the mainframe and accessories supplied. This section covers instrument identification, description, accessories, specifications, and other basic information.

1-3 A Microfiche version of this manual is available on 4 x 6 inch microfilm transparencies (order number on title page). Each microfilm contains up to 60 photoduplicates of the manual pages. The microfiche package also includes the latest Manual Changes supplement as well as all pertinent Service Notes.

### 1-4 SPECIFICATIONS

1-5 Instrument specifications are listed in Table 1-2. These specifications are the performance standards or limits against which the instrument is tested.

### 1-6 SAFETY CONSIDERATIONS

1-7 The 8111A is a Safety Class 1 instrument (it has an exposed metal chassis that is directly connected to earth via the power supply cable). Before operation, the instrument and manual, including the red safety page, should be reviewed for safety markings and instructions. These must then be followed to ensure safe operation and to maintain the instrument in a safe condition.

### 1-8 INSTRUMENTS COVERED BY MANUAL

1-9 Attached to the rear of this instrument is a serial number plate (Figure 1-3). The first four digits of the serial number only change when there is a significant change to the instrument. The last five digits are assigned to instruments sequentially. The contents of this manual apply directly to the instrument serial number quoted on the title page. For instruments with lower serial numbers, refer to the backdating information in Section VII of this manual. For instruments with higher serial numbers, refer to the Manual Change sheets at the end of this manual. In addition to change information, the Manual Change sheets may contain information for correct-

ing errors in the manual. To keep this manual as up-to-date and accurate as possible, Hewlett-Packard recommends that you periodically request the latest Manual Change supplement. The supplement for this manual is identified with the manual's print date and part number, both of which appear on this manual's title page. Complimentary copies of the supplement are available from Hewlett-Packard.

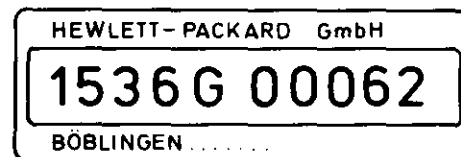


Figure 1-3. Serial Number Plate

### 1-10 DESCRIPTION

1-11 The 8111A is a 20 MHz, pulse/function generator suited to bench, production or service applications. It is available as either a standard instrument or, when fitted with option 001, as a pulse/function generator complete with counted burst mode capability. A carrying handle can be fitted and rackmounting adaptors are available.

1-12 The combination of front panel controls — pushbuttons and verniers — together with the digital display enables quick and easy setting up of complete waveforms with minimum (if any) requirement for additional test equipment.

### 1-13 8111A OPTIONS

1-14 **Option 001.** The standard 8111A can have its versatility further increased by the addition of option 001 which provides a counted burst mode capability. **Option 910** provides an extra copy of the Operating and Service Manual.

### 1-15 ACCESSORIES SUPPLIED

1-16 The 8111A is supplied complete with the following items:

| ITEM                    | HP PART NUMBER |
|-------------------------|----------------|
| 375 mA fuse for         |                |
| 220/240 V operation or, | 2110-0421      |
| 750 mA fuse for         |                |
| 100/120 V operation     | 2110-0360      |
| Power cable             | See Figure 2-2 |

## 1-17 ACCESSORIES AVAILABLE

| ITEM                                                                                                    | HP PART NUMBER         |
|---------------------------------------------------------------------------------------------------------|------------------------|
| Carrying handle -<br>Bail Handle Kit                                                                    | 5061-2001              |
| Rack mounting adaptors:<br>Rack mounting flange and<br>filler panel for rack mounting<br>a single 8111A | 5061-0072              |
| Rack mounting flange<br>and lock link kit<br>for rack mounting two 8111As                               | 5061-0074<br>5061-0094 |

## 1-18 RECOMMENDED TEST EQUIPMENT

1-19 Equipment required to maintain the 8111A is listed in Table 1-1. Alternative equipment can be substituted provided that it meets or exceeds the critical specifications listed in the table.

Table 1-1. Recommended Test Equipment

| INSTRUMENT             | RECOMMENDED MODEL                   | REQUIRED CHARACTERISTICS     | ADEQUATE SUBSTITUTE | USE *   |
|------------------------|-------------------------------------|------------------------------|---------------------|---------|
| Counter                | HP 5328A                            | 20 MHz, Start/Stop           | HP 5345A            | P, A    |
| DMM                    | HP3466                              | 0.1mA - 10mA, DC             | HP3465A             | T       |
| DVM                    | HP3455A                             | 0.1V - 32V, AC, DC           | HP3456A             | P, A, T |
| Real Time Scope        | HP 1740A                            | 100 MHz Bandwidth            | HP 1743A            | P, A, T |
| Sampling Scope         | Tek 7603 with<br>7T11/7S11 and S-3A | Dual channel                 | HP 140A/<br>1410A   | P, A, T |
| Spectrum<br>Analyzer   | HP 3580A                            | 1 kHz - 10 kHz               |                     | P, A    |
| or                     |                                     |                              |                     |         |
| Distortion<br>Analyzer | HP 339A                             | 1 kHz - 10 kHz               | HP 3585A            | P, A    |
| Spectrum<br>Analyzer   | HP 181T<br>8557A                    | 500 kHz - 20 MHz             |                     | P       |
| Pulse Generator        | HP 8012B                            | 1 Hz - 20 MHz                | HP 8011A            | P, A    |
| Logic Probe            | HP 545A                             | TTL, CMOS                    |                     | T       |
| Logic Probe            | HP 10525E                           | ECL                          |                     | T       |
| BNC 50 Ohm Term.       | 10100C                              | 50 Ohm, 2 W, 1 % Feedthrough |                     |         |
| Power Supply           | HP 6237B                            | 0 - 20 V                     | HP 6205B            | A       |
| Service Accessory      |                                     |                              |                     |         |
| Extender board         | 5060-5983                           | 2x18 pin                     |                     | T       |
| Extender brd           | 5061-2160                           | 2 x 25 pin                   |                     | T       |
| Extender cble          | 5180-2432                           |                              |                     | T       |

\* P = Performance Test; A = Adjustments; T = Troubleshooting

Table 1-2. Specifications

## SPECIFICATIONS

(Specifications describe the instrument's warranted performance)

The following specifications apply with 50 Ohm load resistance in a temperature range of 0° to 55°C. Output levels double when driving into high impedance (up to 32 Vpp).

### WAVEFORMS

Sine, Triangle, Ramp, Square, Pulse, Haversine, Havertriangle

### TIMING CHARACTERISTICS

#### Frequency

Range: 1.00 Hz to 20.0 MHz

Resolution: 3 digits

Accuracy:  $\pm 5\%$  of setting (10.0 Hz to 20.0 MHz)

(50% duty cycle)  $\pm 10\%$  of setting (1.00 Hz to 9.99 kHz)

Repeatability: Factor 2.5 better than accuracy

Jitter:  $< 0.1\% + 50$  ps

Stability:  $\pm 0.2\%$  (1 hour)

$\pm 0.5\%$  (24 hours)

#### Duty Cycle (sine, triangle, square)

Range: 10% to 90% (1 Hz to 999 kHz)

50% fixed (1 Hz to 20 MHz)

Resolution: 1%

Accuracy (1 Hz to 999 kHz):  $\pm 1$  digit, 50% fixed

$\pm 3$  digits, 20% to 80%

$\pm 6$  digits, 10% to 20% and 80% to 90%

#### Pulse Width

Range: 25 ns to 100 ms

Resolution: 3 digits

Accuracy:  $\pm 5\%$  of setting  $\pm 2$  ns

Repeatability: Factor 2.5 better than accuracy

Jitter:  $< 0.1\% + 50$  ps

Max. duty cycle:  $> 75\%$  (1 Hz to 1 MHz), decreasing to  $> 50\%$  at 20 MHz

### OUTPUT CHARACTERISTICS

Output Impedance: 50 Ohm  $\pm 5\%$ . Reflection  $< 10\%$

#### Amplitude/Offset

Amplitude and offset are independently variable within the following two level windows.

| Level window         | $\pm 80.0$ mV                                                | $\pm 8.00$ V                                                  |
|----------------------|--------------------------------------------------------------|---------------------------------------------------------------|
| Ampl. range          | 160 mVpp to 159.9 mVpp                                       | 160 mVpp to 16.00 Vpp                                         |
| Ampl. resolution     | 3 1/2 digits                                                 | 3 1/2 digits                                                  |
| Ampl. accuracy*      | $\pm 5\%$ [0.45 dB]                                          | $\pm 5\%$ [0.45 dB]                                           |
| Ampl. repeatability  | Factor 2.5 better than accuracy                              |                                                               |
| Offset range         | 0 to $\pm 80.0$ mV                                           | 0 to $\pm 8.00$ V                                             |
| Offset resolution    | 3 digits (best case 10 $\mu$ V)                              | 3 digits (best case 1 mV)                                     |
| Offset accuracy      | $\pm 5\%$ of setting<br>$\pm 2\%$ of amplitude<br>$\pm 1$ mV | $\pm 5\%$ of setting<br>$\pm 2\%$ of amplitude<br>$\pm 20$ mV |
| Offset repeatability | Factor 2.5 better than accuracy                              |                                                               |

\*The amplitude accuracy for sine and triangle is specified at 1 kHz. For other frequencies see the following flatness specifications.

| Amplitude Flatness (50% duty cycle) | Sine                 | Triangle                     |
|-------------------------------------|----------------------|------------------------------|
| 1.00 Hz to 999 kHz                  | $\pm 3\%$ [0.26 dB]  | $\pm 3\%$                    |
| 1.00 MHz to 20.0 MHz                | $\pm 10\%$ [0.92 dB] | $\pm 10\%$<br>+ 10%<br>- 15% |

### WAVEFORM CHARACTERISTICS

Sine (normal mode, 50% duty cycle, symmetrical mode)

Total Harmonic Distortion (THD):

$< 1\%$  [-40 dB], (10 Hz - 99.9 kHz)

$< 3\%$  [-30 dB], (100 kHz - 999 kHz)

Harmonic Signals: more than 26 dB below fundamental (1 MHz - 20 MHz) for amplitudes  $> 10$  mVpp

THD and Harmonic Signal Distortion may increase by 3 dB below 10°C and above 45°C

#### Triangle, Ramp

Non-linearity:  $< \pm 1\%$  (10 Hz to 99.9 kHz)

$< \pm 3\%$  (1 Hz to 9.9 kHz and 100 kHz to 1 MHz)

(measured between 10% to 90% of amplitude)

#### Square, Pulse

Rise/Fall time:  $< 10$  ns (10% to 90% of amplitude)

Pulse Perturbations:  $< \pm 5\%$  of amplitude ( $\geq 0.16$  Vpp)

$< \pm 10\%$  of amplitude ( $< 0.16$  Vpp)

#### Output Modes

Switchselectable POSITIVE, NEGATIVE, SYMMETRICAL and NORMAL/COMPLEMENT output signal.

### OPERATING MODES

**Normal:** Continuous waveform is generated

**Trigger:** Each input cycle generates a single output cycle

**Gate:** External signal enables oscillator. First output cycle synchronous with active trigger slope. Last cycle always completed.

**VCO:** External voltage linearly sweeps 2 full frequency decades. The actual frequency is displayed. Modulation range: 1:100 with 0.1V to 10V Modulation bandwidth: dc to 1 kHz

**Burst:** Each input cycle generates a preprogrammed number (1 to 1999) of periods. Minimum time between bursts is 200 ns. (Option 001)

### SUPPLEMENTARY PERFORMANCE CHARACTERISTICS

(Description of non-warranted typical performance parameters)

**Ext Input:** Threshold Level: 1.4V fixed

Max input voltage:  $\pm 20$  V

Sensitivity: 500 mVpp

Min pulse width: 25 ns

Input impedance: 10 kOhm

Trigger slope: positive

**Start Phase:** Adjustable from  $-90^\circ$  to  $+90^\circ$ .

Usable range may decrease

to  $-90^\circ$  to  $0^\circ$  at 20 MHz.

Haversine and Havertriangle can be generated.

**Trigger Output:** TTL compatible output signal.

**Man:** Simulates external input.

**1 Cycle:** Provides a single output period in TRIG, GATE and BURST mode.

### GENERAL

**Warm-up Time:** 15 min to meet all specifications.

**Environmental:** Storage temperature:  $-40^\circ$  C to  $75^\circ$  C

Operating temperature:  $0^\circ$  C to  $55^\circ$  C

Humidity range: 95% R.H.,

$0^\circ$  C to  $40^\circ$  C

**Power:** 100/120/220/240 V rms  $\pm 5\%$ , -10%, 48-440 Hz; 70 VA max.

**Weight:** Net 4.6 kg (10 lbs), Shipping 6.6 kg (15 lbs)

**Dimensions:** 89 mm high, 213 mm wide, 375 mm deep (3.5 x 8.4 x 14.8 in)

**Options:** 001 Counted Burst

910 Additional Operating & Service

Manual

Data subject to change



## SECTION II INSTALLATION

### 2-1 INTRODUCTION

2-2 This section provides installation instructions for the instrument and its accessories. It also includes information about initial inspection and damage claims, preparation for use, and packaging, storage and shipment.

### 2-3 INITIAL INSPECTION

2-4 Inspect the shipping container for damage. If the container or cushioning material is damaged, it should be kept until the contents of the shipment have been checked for completeness and the instrument has been checked mechanically and electrically. The contents of the shipment should be as shown in Figure 1-1 plus any accessories that were ordered with the instrument. Procedures for checking the electrical operation are given in Section 4. If the contents are incomplete, if there is a mechanical damage or defect, or if the instrument does not pass the operator's checks, notify the nearest Hewlett-Packard office. Keep the shipping materials for carrier's inspection. The HP office will arrange for repair or replacement without waiting for settlement.

### 2-5 PREPARATION FOR USE

#### WARNING

To avoid hazardous electrical shock, do not perform electrical tests when there are signs of shipping damage to any portion of the outer enclosure (covers, panels, meters).

### 2-6 Power Requirements

2-7 The instrument requires a power source of 100/120/220 or 240 Vrms (+5 % - 10 %) at a frequency of 48-440 Hz single phase. The maximum power consumption is 70 VA.

### 2-8 ⚠ Line Voltage Selection

#### CAUTION

BEFORE SWITCHING ON THIS INSTRUMENT make sure that the instrument is set to the local line voltage. The line voltage selector switches can be seen through the lefthand side of the instrument cover to the rear. The correct setting for the country of destination will have been made at the factory. The instrument power fuse is located behind a metal plate which can also be seen when the switches are viewed. To access the fuse and line selector switches, first DISCONNECT the power cord, then remove instrument top cover by releasing the captive securing screw at rear and sliding cover off. The fuse is accessed by removing the metal cover plate held by two securing screws (non-captive).

#### CAUTION

Do not change the LINE SELECTOR switch settings with the instrument on or with power connected to the rear panel.

2-9 Figure 2-1 provides information for line voltage and fuse selection:

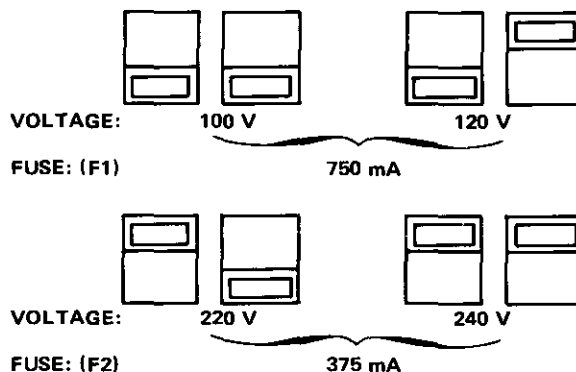


Figure 2-1. Sliding Switches Positions for different Line Voltages

## 2-10 Power Cable

### WARNING

To avoid the possibility of injury or death, the following precautions must be followed before the instrument is switched on:

- a. If this instrument is to be energized via an autotransformer for voltage reduction, make sure that the common terminal is connected to the grounded pole of the power source.
- b. The power cable plug shall only be inserted into a socket outlet provided with a protective ground contact. The protective action must not be negated by the use of an extension cord without a protective conductor.
- c. Before switching on the instrument, the protective ground terminal of the instrument must be connected to a protective conductor of the power cable. This is verified by checking that the resistance between the instrument chassis and the front panel and the ground pin of the power cable plug is zero ohms.

2-11 In accordance with international safety standards, this instrument is equipped with a three-wire power cable. When connected to an appropriate ac power receptacle, this cable grounds the instrument cabinet. The type of power cable shipped with each instrument depends on the country of destination. Refer to Figure 2-2 for the part number of the power cords available.

2-12 The following work should be carried out by a qualified electrician and all local electrical codes must be observed. If the plug on the cable supplied does not fit your power outlet, or if the cable is to be attached to a terminal block, then cut the cable at the plug end and re-wire it. The colour coding used in the cable will depend on the cable supplied (see Figure 2-2). If a new plug is to be connected, the plug should meet local safety requirements and include the following features:

- adequate load-carrying capacity (see table of specifications in Section 1)
- ground connection
- cable clamp

## 2-13 Operating Environment

The operating temperature limits are 0°C to 55°C. The specifications also apply over this temperature range.

## 2-14 CLAIMS AND REPACKAGING

### 2-15 Claims for Damage

2-16 If physical damage is evident or if the instrument does not meet specification when received, notify the carrier and the nearest Hewlett-Packard Sales/Service Office. The Sales/Service Office will arrange for repair or replacement of the unit without waiting for settlement of the claim against the carrier.

## 2-17 Storage and Shipment

2-18 The instrument can be stored or shipped at temperatures between -40°C and 75°C. The instrument should be protected from temperature extremes which cause condensation within it.

2-19 If the instrument is to be shipped to a Hewlett-Packard Sales/Service Office, attach a tag showing owner, return address, model number and full serial number and the type of service required. The original shipping carton

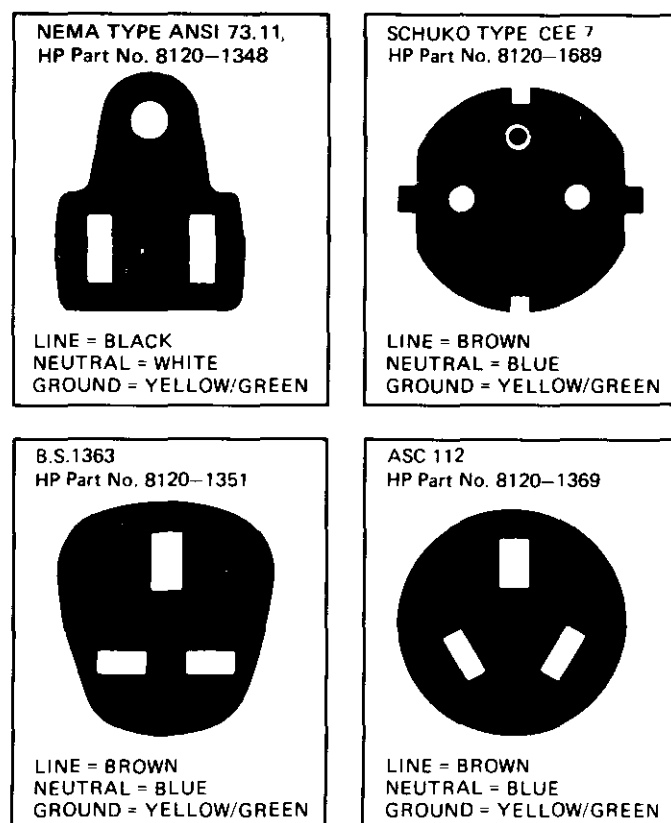


Figure 2-2. Power Cables Available: Plug Identification

and packaging material may be re-usable but the Hewlett-Packard Sales/Service Office will also provide information and recommendations on materials to be used if the original packing is not available or re-usable. General instructions for re-packing are as follows:

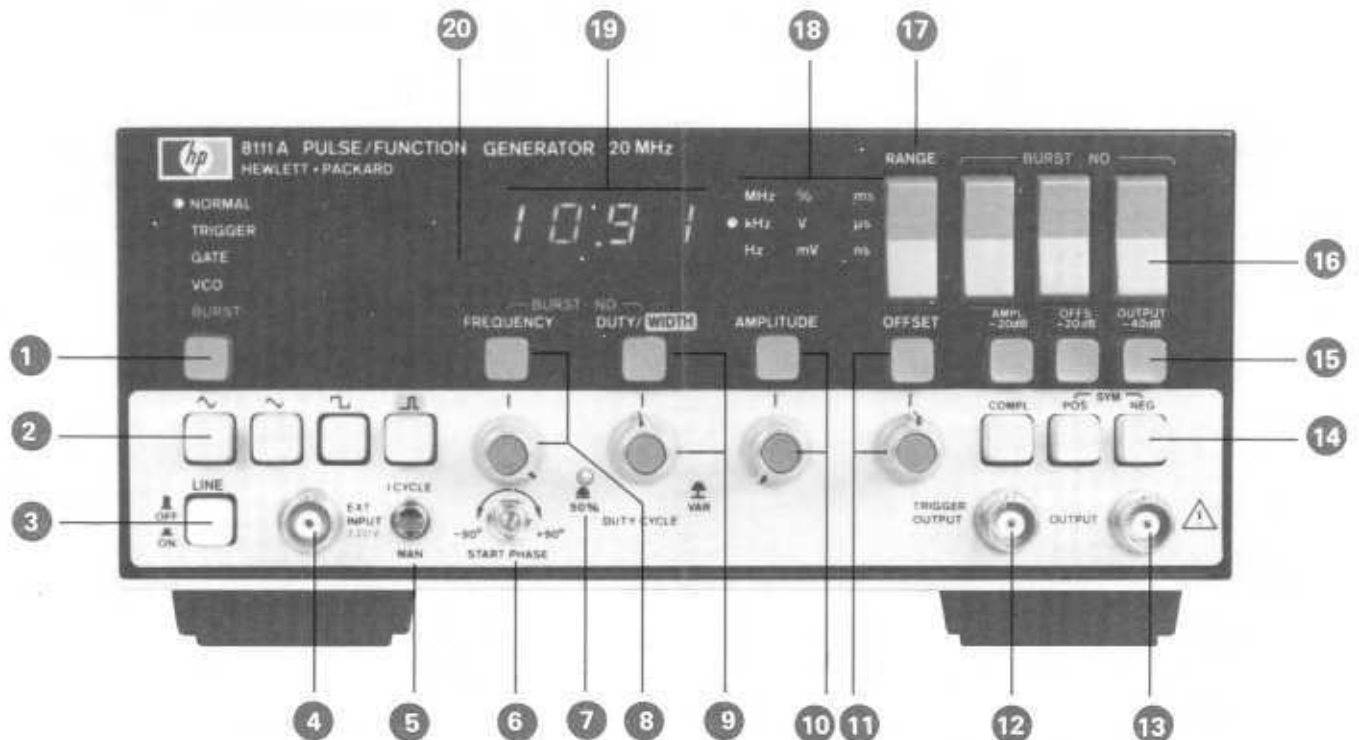
1. Wrap instrument in heavy paper or plastic.
2. Use strong shipping container. A double wall carton made of 200-pound test material is adequate.
3. Use enough shock-absorbing material

(3 to 4-inch layer) around all sides of instrument to provide firm cushion and prevent movement inside container. Protect control panel with cardboard.

4. Seal shipping container securely.
5. Mark shipping container FRAGILE to encourage careful handling.
6. In any correspondence, refer to instrument by model number and serial number.

## 8111A PULSE/FUNCTION GENERATOR

Controls and Connectors (Option 001 fitted)



**1** The pushbutton on the left-hand side of the front panel selects the operation mode. The selected mode is indicated by an LED. Each successive operation of the pushbutton changes the mode, starting from NORMAL, running through to BURST and back to NORMAL.

The operating modes are:

- NORMAL** — 8111A's internal rate generator free running
- TRIGGER** — trigger signal, either via EXT INPUT or toggle switch **5** initiates one output cycle
- GATE** — gate signal, either via EXT INPUT or toggle switch **5** initiates an output which is maintained as long as gate signal is present
- VCO** — signal applied to EXT INPUT determines the output frequency
- BURST** — (Option 001 only) a burst trigger either via the EXT INPUT or toggle switch initiates burst of output cycles

**2** Function pushbuttons select one of 4 possible functions: sine, triangle, square or pulse.

**3** LINE ON/OFF. Primary ac power switch.

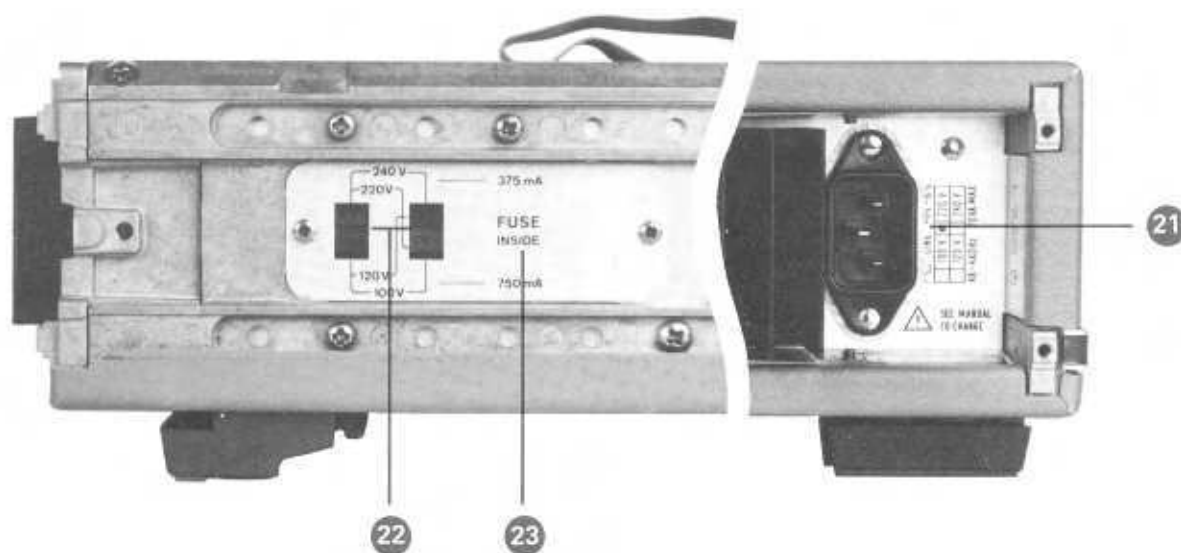
**4** EXT INPUT. Connector for external signal in TRIGGER, GATE, VCO and BURST (Option 001 only) modes.

**5** 1 CYCLE/MANUAL switch produces a single trigger pulse when switched to MAN in the TRIGGER, GATE and BURST modes or, initiates a single cycle when switched to 1 CYCLE.

**6** START PHASE. Vernier control enables variation of output signal start phase with respect to external trigger, gate or burst signal.

**7** 50 % DUTY CYCLE indicator, either automatically selected when frequency in MHz range or manually by pushing DUTY CYCLE vernier in. Inoperative in pulse mode.

Figure 3-1. Controls and Connectors.



**8 9 10 & 11** Parameter select pushbuttons and corresponding vernier controls which enable display and variation of the required parameter. In BURST mode, both the FREQUENCY and DUTY/WIDTH buttons must be pushed in. In sine, triangle and squarewave modes, the DUTY/WIDTH button and associated vernier (when pulled out) enable duty cycle variation (vernier pushed in and LED on for 50 % duty cycle). In pulse mode, they enable pulse width variation.

**12** TRIGGER OUTPUT. BNC connector providing a TTL compatible output signal.

**13** OUTPUT. BNC connector providing signal output (50 ohm source impedance).

**14** Output mode pushbuttons select POSitive or NEGative polarity, SYMmetrical (both buttons pushed or released) and normal or COMPLEMENT output signal.

**15** Amplitude and Offset attenuation controls. Pushbuttons select AMPlitude -20 dB, OFFset -20 dB and OUTPUT -40 dB attenuators.

**16** BURST NO. Rocker switches which enable setting up of number of pulses in a burst (Opt. 001).

**17** RANGE. Rocker switch enables range change of FREQUENCY or WIDTH parameters.

**18** Unit indicator. Indicates unit of currently selected parameter.

**19** Display. 3 1/2 digit LED display.

**20** ERROR indicator. LED out of limits indicator for incompatible period/width ratio settings or external trigger/8111A frequency setting.

**21** Line receptacle. Power Cord to be plugged in here. Chassis ground for operator protection provided through cord.

**22** Line voltage select sliding switches to be set to local line voltage.

**23** Fuse (under metal plate) protects instrument in case of current overload. 750 mA for 100/120 V operation, 375 mA for 220/240 V operation.

## SECTION III OPERATING INSTRUCTIONS

### 3-1 INTRODUCTION

3-2 The following sections describe the various operating modes and operation of the front panel controls. Pushbutton and/or vernier adjustment is described only where a more detailed description than that accompanying Figure 3-1 is considered necessary.

Numbers within circles — **1** — in text are for cross-reference to Figure 3-1.



### 3-3 SPECIAL OPERATING CONSIDERATIONS

3-4 Read the following sections (a, b, c & d) before applying power to the 8111A.

- Read the safety summary (red page) at the front of this manual.
- Ensure that the power selector switches are set properly for the power source being used to avoid instrument damage.

#### CAUTION

Do not change the LINE SELECTOR switch settings with the instrument on or with power connected to the rear panel.

c. Ensure load is not overdriven (up to 16 Vpp into 50 Ohm or 32 Vpp into high impedance).

d. Do not apply external voltage to the output connectors.

### 3-5 OPERATING INSTRUCTIONS

#### 3-6 Mode Selection **1**

#### 3-7 NORMAL Mode

3-8 In normal mode, (automatically selected on instrument switch-on), the internal rate generator is free running, the frequency being determined by the FREQUENCY setting and the output is continuous (Figure 3-2).

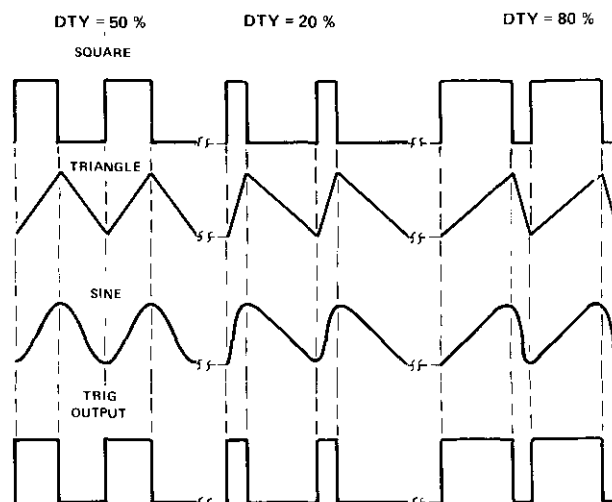


Figure 3-2. Normal Mode—various DUTY CYCLE values

#### 3-9 TRIGGER/GATE/BURST Input Modes **1**

3-10 In all three modes you can generate the trigger/gate signal either by applying an external signal to the EXT INPUT BNC connector or by switching the MAN/1 CYCLE switch to MAN. The external trigger signal frequency should not exceed the 8111A's frequency setting. If it does, the ERROR indicator will flash.

NOTE: For all three triggered modes see § 3-30 (first trigger output signal pulse width)

#### 3-11 External Trigger Mode (TRIGGER) **1**

3-12 In this mode the trigger signal initiates one complete output cycle (Figure 3-3).

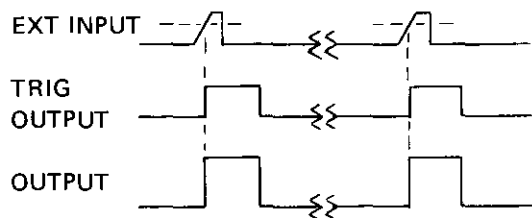


Figure 3-3. Trigger Mode (Squarewave, 50 % DUTY CYCLE)

### 3-13 Gate Mode (GATE) 1

3-14 In gate mode the leading edge of the gate signal enables the 8111A's rate generator and the trailing edge disables it (Figure 3-4). The first and last cycles are always complete.

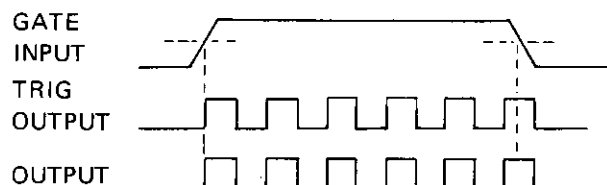


Figure 3-4. Gate Mode (Squarewave, 50 % DUTY CYCLE)

### 3-15 Burst Mode (BURST) 1

3-16 In burst mode, a preset number of cycles is generated on each leading edge of a positive-going trigger signal applied to EXT INPUT when BURST mode is selected (Figure 3-5). The burst length may be set from 1 to 1999 pulses by pressing both the FREQUENCY and DUTY/WIDTH pushbuttons and operating the BURST NO rocker switches as necessary, (single digit increment by individual pushes or continuous by constant pressure) until the required burst number is displayed.

Frequency and duty cycle/pulse width selection in BURST mode is as described in 3-21—3-25.

NOTE: At the end of a triggered burst length, single pulses can be added by operation of the 1 CYCLE/MAN switch in the 1 CYCLE mode.

See 53-30 for Start Phase variation details if applicable.

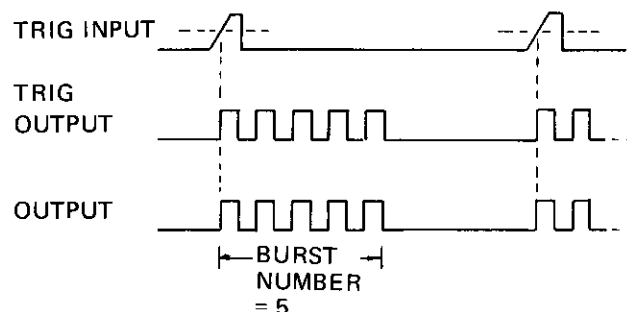


Figure 3-5. Burst Mode (Squarewave, 50 % DUTY CYCLE)

### 3-17 Voltage-controlled Oscillator Mode (VCO)

3-18 In VCO mode, a signal applied to the EXT INPUT connector determines the output frequency. The working range of input voltage (0.1 V to 10 V or 0.1 V to 2 V for 1.0 to 20 MHz range) sweeps the output frequency linearly over a maximum range of 2 decades. The actual range swept depends, as shown in Table 3-2, on the 8111A's frequency setting. The applied signal may change at up to 1 kHz. An example of the VCO mode is given in Table 3-1:

8111A Frequency range setting: 100 kHz – 1000 kHz

NOTE: Frequency range setting is easier to make in NORMAL mode than VCO mode.

Table 3-1. VCO Mode Example Values

| EXT INPUT VOLTAGE | OUTPUT FREQUENCY |
|-------------------|------------------|
| 0.1 V             | 10 kHz           |
| 1.0 V             | 100 kHz          |
| 10.0 V            | 1000 kHz         |

Table 3-2 shows the relationship between external control voltage and output frequency for all ranges.

Table 3–2. Sweepable Bands in VCO Mode

| 8111A FREQUENCY range setting | Sweepable band |               |              |               |
|-------------------------------|----------------|---------------|--------------|---------------|
|                               | From           |               | To           |               |
|                               | $V_{in}$ min   | $f_{out}$ min | $V_{in}$ max | $f_{out}$ max |
| 1 Hz — 10 Hz                  | 0.1 V          | 0.1 Hz        | 10 V         | 10 Hz         |
| 10 Hz — 100 Hz                | 0.1 V          | 1 Hz          | 10 V         | 100 Hz        |
| 100 Hz — 1000 Hz              | 0.1 V          | 10 Hz         | 10 V         | 1000 Hz       |
| 1 kHz — 10 kHz                | 0.1 V          | 0.1 kHz       | 10 V         | 10 kHz        |
| 10 kHz — 100 kHz              | 0.1 V          | 1 kHz         | 10 V         | 100 kHz       |
| 100 kHz — 1000 kHz            | 0.1 V          | 10 kHz        | 10 V         | 1000 kHz      |
| 1 MHz — 10 MHz                | 0.1 V          | 0.1 MHz       | 10 V         | 1 MHz         |
| 10 MHz — 20 MHz               | 0.1 V          | 1 MHz         | 2 V          | 20 MHz        |

### 3–19 Function, FREQUENCY and DUTY cycle/ WIDTH Selection 2 8 & 9

NOTE: Adjustment of any of the four vernier controls can be made without the corresponding display enable pushbutton being pressed. This allows a waveform which is displayed on an oscilloscope to be quickly and easily varied merely by vernier adjustment at any time.

3–20 Selection of the required function (sine, triangle, square wave or pulse) is by pressing the appropriately labelled front panel pushbutton.

### 3–21 FREQUENCY display and adjustment 8

NOTE: Frequency controls are non-functional in pulse mode.

3–22 This is enabled by pressing the FREQUENCY pushbutton. Adjustment of the FREQUENCY vernier will change the displayed value, range changing is accomplished by operating the RANGE rocker switch to change either the decimal point position and/or the frequency unit.

NOTE: Selection of a MHz range will cause the 50 % DUTY CYCLE LED to illuminate when sine, triangle or square wave function selected.

### 3–23 DUTY CYCLE display and adjustment 9

3–24 This is enabled by pressing the DUTY/WIDTH pushbutton. Duty cycle for sine, triangle or square-wave functions can be either a fixed 50 % over the frequency

range 1 Hz to 20 MHz, or 10 % to 90 % variable over 1 Hz to 999 kHz. When the DUTY CYCLE vernier is in the "pushed in" position a constant 50 % duty cycle is obtained (indicated by the 50 % LED). By pulling the vernier out, adjustment of the duty cycle within the limits detailed above is possible.

### 3–25 WIDTH display and adjustment 9

3–26 This is made (in pulse mode) by first pressing the DUTY/WIDTH pushbutton to display the width value and then adjusting the DUTY/CYCLE/width vernier (now functioning as a width vernier). Variation from 25 ns to 100 ms is possible (see Specification) by vernier adjustment and RANGE rocker switch operation.

### 3–27 ERROR Signal 20

3–28 In pulse mode, the flashing ERROR signal can be caused by either adjustment of the FREQUENCY or DUTY CYCLE/width verniers or RANGE changing, which results in the FREQUENCY/WIDTH settings being incompatible — width of pulse exceeds period ( $WIDTH \geq 1/FREQUENCY$ ).

3–29 In TRIGGER mode, the ERROR signal will occur if the external trigger frequency is incompatible with the 8111A pulse width setting (internal rate generator disabled in pulse mode) or, if it exceeds the 8111A frequency setting in function mode.

### 3-30 START PHASE Variation 6

3-31 In sine and triangular functions, the waveform start phase can be varied (with respect to an external trigger, gate or burst signal) by  $+90^\circ$  to  $-90^\circ$  by the appropriate front panel vernier. (Haversine and Haver-triangle waveforms can be generated).

NOTE: See Specification for usable range details. (At  $+90^\circ$  first trigger output signal pulse width is reduced to minimum at high frequencies, this may affect Burst mode)

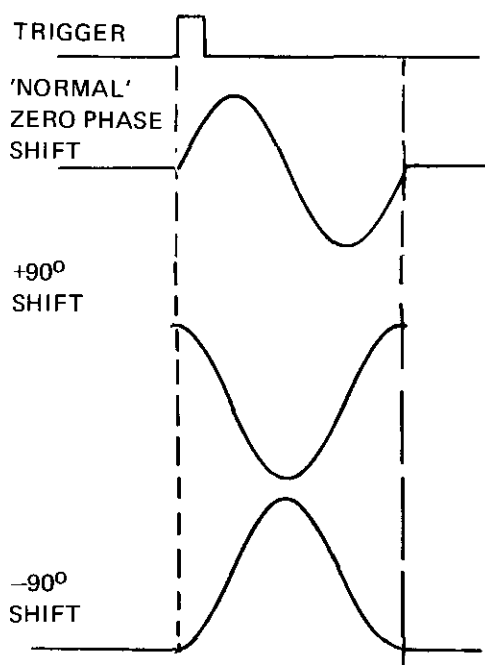


Figure 3-6. Start Phase Variation (Sinewave)

### 3-32 AMPLITUDE and OFFSET display and adjustment 10 & 11

3-33 Amplitude and offset values are displayed by pressing the AMPLITUDE or OFFSET pushbuttons. To vary either value, adjust the corresponding vernier until the desired figure is displayed. Range changing of either AMPLITUDE or OFFSET is made by pressing one of the three attenuator control pushbuttons as detailed in the following section (the RANGE rocker switch has no control over voltage ranges). Ensure that the maximum amplitude and offset settings do not result in the output signal exceeding the output window levels of  $\pm 8.00$  V into 50 Ohm.

### 3-34 AMPLITUDE, OFFSET and OUTPUT Attenuation 15

3-35 The three pushbutton controlled attenuators (AMPL-20 dB, OFFS-20 dB and OUTPUT -40 dB) can be enabled individually, or if necessary together. The two -20 dB attenuators attenuate either amplitude or offset and the -40 dB one attenuates both, so providing a maximum value of 60 dB attenuation for amplitude and offset.

### 3-36 OUTPUT MODE Selection 14

3-37 Three output mode pushbuttons enables normal/COMPLEMENTARY, Positive/negative or SYMMETRICAL output waveforms. If none of the buttons are pressed a normal symmetrical waveform will be output.

Examples of output mode differences are shown in Figure 3-7.

NOTE: Positive or negative offset can be added (or subtracted) irrespective of the selected output mode.

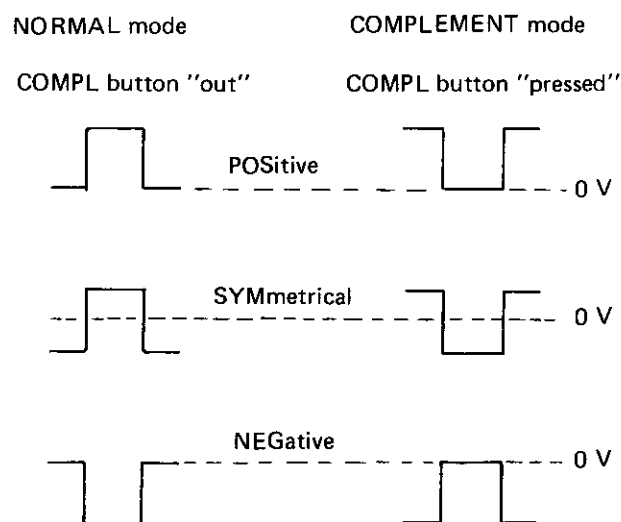


Figure 3-7. Output Mode Differences (no offset applied) (Squarewave, 50 % DUTY CYCLE)

## **SECTION IV PERFORMANCE TESTS**

### **4-1 INTRODUCTION**

4-2 The procedures in this section test the electrical performance of the instrument using the specifications of Table 1-2 as performance standards. All tests can be performed without access to the interior of the instrument.

### **4-3 EQUIPMENT REQUIRED**

4-4 Equipment required for the performance tests is listed in Table 1-1, Recommended Test Equipment. Any equipment that satisfies the critical specifications given in the table may be substituted for the recommended model(s).

### **4-5 TEST RECORD**

4-6 Results of the performance tests may be tabulated on the Test Record at the end of the test procedures. The Test Record lists all of the tested specifications and their acceptable limits. Test results recorded at incoming inspection

can be used for comparison in periodic maintenance, troubleshooting, and after repairs or adjustments.

### **4-7 PERFORMANCE TESTS**

4-8 The performance tests given in this section are suitable for incoming inspection, troubleshooting, or preventive maintenance. During any performance test, all shields and connecting hardware must be in place. The tests are designed to verify the published instrument specifications, perform the tests in the order given and record the data on the Test Record at the end of the test procedures.

4-9 Each test is arranged so that the specification is written as it appears in Table 1-2. Next, when necessary, a description of the test and any special instructions or problem areas are included. Each test that requires test equipment has a setup drawing and a list of the required equipment. The initial steps of each procedure give control settings required for that particular test.

## PERFORMANCE TESTS

### 4-10 FREQUENCY

#### SPECIFICATION

1.00 Hz – 10 Hz accuracy  $\pm 10\%$  of setting

10 Hz – 20 MHz accuracy  $\pm 5\%$  of setting

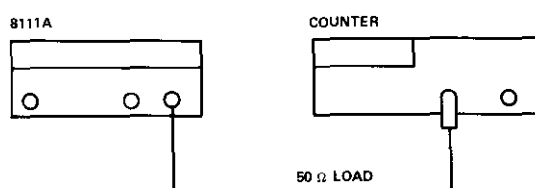


Figure 4-1. Frequency Test Set-up

#### EQUIPMENT

Counter  
Cable Assembly BNC  
Feedthrough Termination 50  $\Omega$

#### PROCEDURE

1. Connect equipment as shown.

2. Set 8111A as follows:

|                       |        |
|-----------------------|--------|
| INPUT MODE            | NORM   |
| FUNCTION              | SQUARE |
| DUTY CYCLE            | 50 %   |
| AMPLITUDE             | CW     |
| AMPLITUDE ATTENUATION | -20 dB |
| OFFSET                | 0 V    |
| OUTPUT MODE           | SYM    |

3. Set counter to frequency measurement.

## PERFORMANCE TESTS

---

4. Set 8111A frequency and verify counter frequency reading as follows:

Table 4–1. Frequency Limits

| 8111A SETTING | COUNTER READING        |
|---------------|------------------------|
| 1 Hz          | 0.900 Hz – 1.100 Hz    |
| 9.99 Hz       | 9.000 Hz – 11.000 Hz   |
| 10 Hz         | 9.500 Hz – 10.500 Hz   |
| 99.9 Hz       | 95.000 Hz – 105.00 Hz  |
| 100 Hz        | 95.00 Hz – 105.00 Hz   |
| 999 Hz        | 950.00 Hz – 1050.0 Hz  |
| 1 kHz         | 0.950 kHz – 1.050 kHz  |
| 9.99 kHz      | 9.500 kHz – 10.50 kHz  |
| 10 kHz        | 9.500 kHz – 10.50 kHz  |
| 99.9 kHz      | 95.00 kHz – 105.00 kHz |
| 100 kHz       | 95.00 kHz – 105.00 kHz |
| 999 kHz       | 950.0 kHz – 1050 kHz   |
| 1 MHz         | 0.950 MHz – 1.050 MHz  |
| 9.99 MHz      | 9.500 MHz – 10.50 MHz  |
| 10 MHz        | 9.500 MHz – 10.50 MHz  |
| 20 MHz        | 19.00 MHz – 21.00 MHz  |

## PERFORMANCE TESTS

### 4-12 OFFSET

#### SPECIFICATION

Offset Range 0 V to  $\pm 8$  V (into  $50\ \Omega$ ) accuracy  $\pm 5\%$  of setting and  $\pm 2\%$  of amplitude and  $\pm 20$  mV

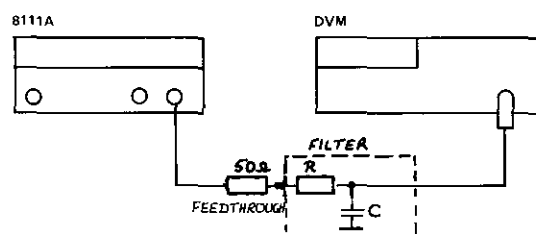


Figure 4-3. Offset Test Set-up

#### EQUIPMENT

DVM

Cable assembly BNC

Feedthrough Termination  $50\ \Omega$

Filter (suggested values:  $R = 20\ \text{k}\Omega$ ,  $C = 2.2\ \mu\text{F}$ ) NOTE: Cut off frequency of the filter should be  $< 10$  Hz

#### PROCEDURE

1. Connect equipment as shown.
2. Set 8111A as follows:

|                       |        |
|-----------------------|--------|
| INPUT MODE            | NORM   |
| FUNCTION              | SQUARE |
| DUTY CYCLE            | 50 %   |
| AMPLITUDE             | 2 V    |
| OUTPUT MODE           | SYM    |
| FREQUENCY             | 1 kHz  |
| AMPLITUDE ATTENUATION | -20 dB |

3. Set 3455A to DC measurement.
4. Set 8111A Offset and verify DVM offset reading as follows:

| 8111A | DVM READING         |
|-------|---------------------|
| 8 V   | 7.576 V - 8.424 V   |
| 4 V   | 3.776 V - 4.224 V   |
| 2 V   | 1.876 V - 2.124 V   |
| 0 V   | -24 mV 24 mV        |
| -2 V  | -1.876 V - -2.124 V |
| -4 V  | -3.776 V - -4.224 V |
| -8 V  | -7.576 V - -8.424 V |

## PERFORMANCE TESTS

### 4-13 PULSE CHARACTERISTICS

#### SPECIFICATION

Transition times (10 % to 90 %): < 10 nsec

Preshoot, Overshoot, Ringing:  $\pm 5\%$  of amplitude ( $\geq 0.16$  Vpp)

$\pm 10\%$  of amplitude (< 0.16 Vpp)

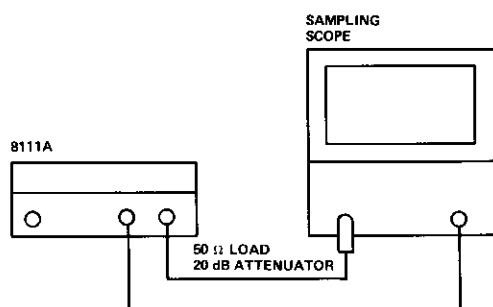


Figure 4-4. Pulse Characteristics Test Set-up

#### EQUIPMENT

Sampling oscilloscope  
Cable assembly 2 x BNC  
Feedthrough termination 50  $\Omega$   
Attenuator 20 dB

#### PROCEDURE

1. Connect the equipment as shown.
2. Set 8111A as follows:

|             |       |        |
|-------------|-------|--------|
| INPUT MODE  | ..... | NORM   |
| FUNCTION    | ..... | SQUARE |
| DUTY CYCLE  | ..... | 50 %   |
| AMPLITUDE   | ..... | 16 Vpp |
| OUTPUT MODE | ..... | SYM    |
| FREQUENCY   | ..... | 2 MHz  |

3. Set scope so that one cycle fills the display.

|                    |                             |
|--------------------|-----------------------------|
| leading edge       | $\leq 10$ nsec              |
| trailing edge      | $\leq 10$ nsec              |
| pulse perturbation | $\leq \pm 5\%$ of amplitude |

## PERFORMANCE TESTS

### 4-14 SINE CHARACTERISTIC

#### SPECIFICATION

Sine (normal mode, 50 % duty cycle, sym)

THD  $\left\{ \begin{array}{l} < 1 \% [-40 \text{ dB}], (10 \text{ Hz} - 99.9 \text{ kHz}) \\ < 3 \% [-30 \text{ dB}], (100 \text{ kHz} - 999 \text{ kHz}) \end{array} \right\}$  may increase by 3dB below 10° C and above 45° C.

for > 1 MHz to 20 MHz harmonic signals more than 26 dB below fundamental.

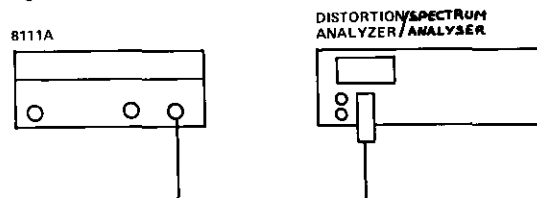


Figure 4-5. Sine Characteristics Test Set-up

#### EQUIPMENT

Distortion analyser / Spectrum Analyser

Cable assembly BNC to Banana

Feedthrough termination 50  $\Omega$

#### PROCEDURE

1. Connect the equipment as shown.

2. Set 8111A as follows:

|             |       |          |
|-------------|-------|----------|
| INPUT MODE  | ..... | NORM     |
| FUNCTION    | ..... | SINE     |
| DUTY CYCLE  | ..... | 50 %     |
| AMPLITUDE   | ..... | 16 V     |
| FREQUENCY   | ..... | 9.99 kHz |
| OUTPUT MODE | ..... | SYM      |
| OFFSET      | ..... | 0 V      |

3. Either, set the distortion analyser front panel controls as required (Distortion, Range—dB/%, input range etc.) or, if using a spectrum analyser, tune it for minimum display amplitude and adjust gain so that fundamental corresponds to 0 dB. Verify that the 2nd and 3rd harmonics do not exceed the -42 and -47 dB levels respectively.

4. Verify that THD < 1 %

$$\text{THD} = \frac{\sqrt{E_1^2 + E_2^2 + E_3^2 + \dots}}{E_0} \cdot 100 \%$$

where  $E_0$  = fundamental voltage amplitude and  $E_1, E_2$  etc are the 2nd, 3rd etc. harmonic amplitudes.

When the harmonics are expressed in dB the formula becomes:

$$\text{THD} = \sqrt{\frac{A_1}{10^{10}} + \frac{A_2}{10^{10}} + \frac{A_3}{10^{10}} + \dots} \cdot 100 \%$$

where  $A_1$  = first harmonic in dB etc.

5. Change 8111A frequency setting to 500 kHz.
6. Verify that 2nd and 3rd harmonics do not exceed the -32 dB and -37 dB levels.
7. Verify that THD < 3 % using previously stated formula.
8. Change 8111A frequency setting to 20 MHz.
9. Verify that all harmonics are less than -26 dB.

## PERFORMANCE TESTS

### 4-15 DUTY CYCLE

#### SPECIFICATION

Variable range: 10 % to 90 % (1 Hz to 999 kHz)  
50 % fixed (1 Hz to 20 MHz)

Accuracy:  $\pm 1$  digit, 50 % fixed  
 $\pm 3$  digit, 20 % to 80 %  
 $\pm 6$  digit, 10 % to 20 % and 80 % to 90 %

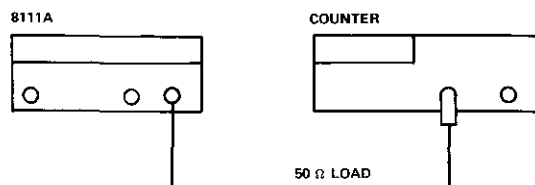


Figure 4-6. Duty Cycle Test Set-up

#### EQUIPMENT

Counter  
Cable assembly BNC  
Feedthrough termination 50  $\Omega$

#### PROCEDURE

1. Connect the equipment as shown.
2. Set 8111A as follows:

|                       |       |            |
|-----------------------|-------|------------|
| INPUT MODE            | ..... | NORM       |
| FUNCTION              | ..... | SQUARE     |
| AMPLITUDE             | ..... | 16 Vpp     |
| AMPLITUDE ATTENUATION | ..... | -20 DB     |
| FREQUENCY             | ..... | 10.000 kHz |
| VAR DUTY CYCLE        | ..... | 50 %       |

3. Set counter to TI avg, Slope A+, Slope B- measurement.
4. Set 8111A Duty cycle and verify counter duty cycle reading as follows:

| 8111A | COUNTER READING             |
|-------|-----------------------------|
| 10 %  | 4 $\mu$ sec - 16 $\mu$ sec  |
| 20 %  | 17 $\mu$ sec - 23 $\mu$ sec |
| 50 %  | 49 $\mu$ sec - 51 $\mu$ sec |
| 80 %  | 77 $\mu$ sec - 83 $\mu$ sec |
| 90 %  | 84 $\mu$ sec - 96 $\mu$ sec |

## PERFORMANCE TESTS

### 4-16 WIDTH

#### SPECIFICATION

Range: 25 nsec to 100 msec

Accuracy:  $\pm 5\%$  of setting  $\pm 2$  nsec

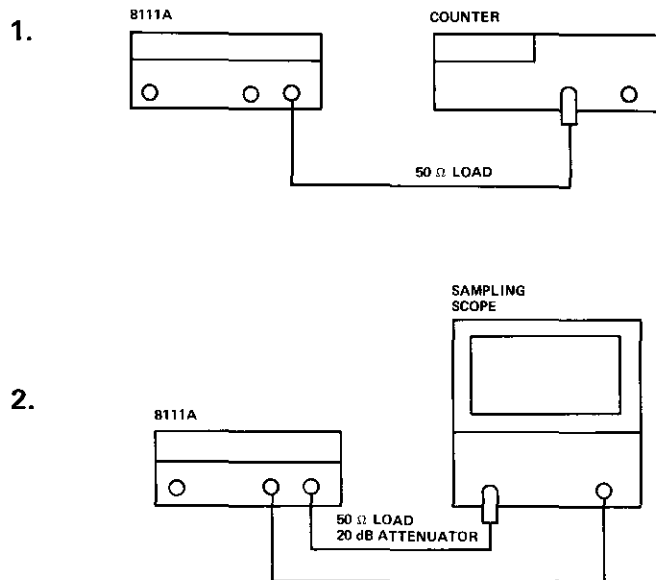


Figure 4-7. Width Test Set-up

#### EQUIPMENT

Counter  
Sampling scope  
Cable assembly 2 x BNC  
Attenuator 20 dB  
Feedthrough termination 50  $\Omega$

#### PROCEDURE

1. Connect the equipment as shown in Figure 4-7-1.
2. Set 8111A as follows:

|             |             |
|-------------|-------------|
| INPUT MODE. | NORM        |
| FUNCTION.   | PULSE       |
| WIDTH       | as required |
| AMPLITUDE   | 16 Vpp      |
| OUTPUT MODE | SYM         |

## PERFORMANCE TESTS

3. Set Counter to T.1. avg, Slope A+, Slope B— measurement.

4. Set 8111A Width and verify counter T.1 reading as follows:

| 8111A  |                | COUNTER READING |                   |
|--------|----------------|-----------------|-------------------|
| 5 kHz  | 100 nsec       | 93 nsec         | — 107 nsec        |
|        | 999 nsec       | 948 nsec        | — 1051 nsec       |
| 5 kHz  | 1 $\mu$ sec    | 0.948 $\mu$ sec | — 1.052 $\mu$ sec |
|        | 9.99 $\mu$ sec | 9.498 $\mu$ sec | — 10.5 $\mu$ sec  |
| 5 kHz  | 10 $\mu$ sec   | 9.50 $\mu$ sec  | — 10.5 $\mu$ sec  |
|        | 99.9 $\mu$ sec | 94.99 $\mu$ sec | — 104.9 $\mu$ sec |
| 500 Hz | 100 $\mu$ sec  | 95 $\mu$ sec    | — 105 $\mu$ sec   |
|        | 999 $\mu$ sec  | 949.9 $\mu$ sec | — 1049 $\mu$ sec  |
| 50 Hz  | 1 msec         | 0.95 msec       | — 1.05 msec       |
|        | 9.99 msec      | 9.499 msec      | — 10.49 msec      |
| 5 Hz   | 10 msec        | 9.5 msec        | — 10.5 msec       |
|        | 99.9 msec      | 94.9 msec       | — 104.9 msec      |

5. Connect the equipment as shown in Figure 4—7—2.

6. Set 8111A as follow:

|             |             |
|-------------|-------------|
| INPUT MODE. | NORM        |
| FUNCTION.   | PULSE       |
| WIDTH       | as required |
| AMPLITUDE   | 16 Vpp      |
| OUTPUT MODE | SYM         |
| FREQUENCY   | 1 MHz       |

7. Set scope so that one cycle fills the display.

8. Set 8111A Width and verify sampling scope width reading as follows:

| 8111A    | SAMPLING SCOPE          |
|----------|-------------------------|
| 25 nsec  | 21.75 nsec — 28.25 nsec |
| 100 nsec | 93 nsec — 107 nsec      |

## PERFORMANCE TESTS

### 4-17 TRIGGER, GATE, BURST

#### SPECIFICATION

Each input cycle generates a single output cycle.

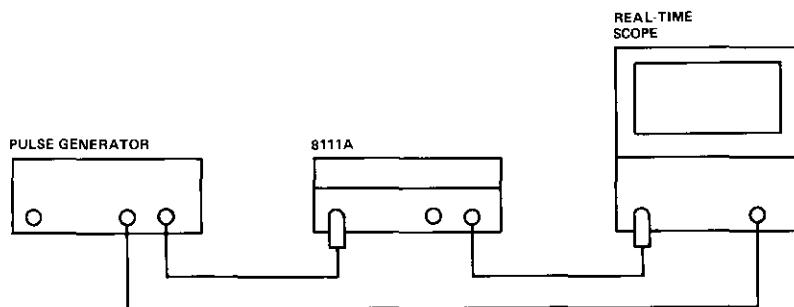


Figure 4-8. Trigger, Gate and Burst Test Set-up

#### EQUIPMENT

Pulse generator  
Realtime scope  
Cable assembly 3 x BNC  
2 x Feedthrough termination 50  $\Omega$

#### PROCEDURE (Trigger)

1. Connect the equipment as shown.
2. Set 8111A as follows:

|             |                    |
|-------------|--------------------|
| INPUT MODE  | TRIGGER            |
| FUNCTION    | SINE               |
| DUTY CYCLE  | 50 %               |
| AMPLITUDE   | 16 V <sub>pp</sub> |
| OUTPUT MODE | SYM                |
| FREQUENCY   | 10 kHz             |

3. Set pulse generator to 1 kHz and 100 nsec width.
4. Check on scope for 8111A output signals.

---

**PERFORMANCE TESTS**

---

**PROCEDURE (Gate)**

1. Connect the equipment as shown.
2. Set 8111A as follows:

|             |       |        |
|-------------|-------|--------|
| INPUT MODE  | ..... | GATE   |
| FUNCTION    | ..... | SINE   |
| DUTY CYCLE  | ..... | 50 %   |
| AMPLITUDE   | ..... | 16 Vpp |
| OUTPUT MODE | ..... | SYM    |
| FREQUENCY   | ..... | 10 kHz |
3. Set pulse generator to 1.0 kHz and 500  $\mu$ sec width.
4. Check on scope for 8111A output signals.

**PROCEDURE (Burst)**

1. Connect the equipment as shown.
2. Set 8111A as follows:

|             |       |        |
|-------------|-------|--------|
| INPUT MODE  | ..... | BURST  |
| FUNCTION    | ..... | SINE   |
| DUTY CYCLE  | ..... | 50 %   |
| AMPLITUDE   | ..... | 16 Vpp |
| OUTPUT MODE | ..... | SYM    |
| FREQUENCY   | ..... | 10 kHz |
| BURST       | ..... | 3      |
3. Set pulse generator to 1 kHz and 100 nsec width.
4. Check on scope for 8111A output signals.

## PERFORMANCE TESTS

### 4-18 VCO-MODE

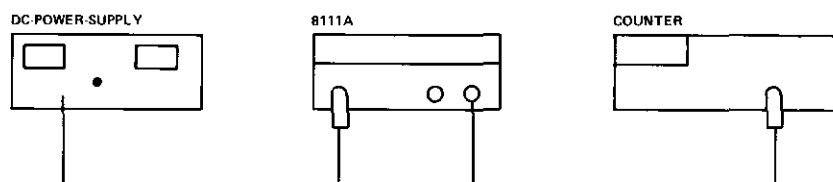


Figure 4-9. VCO-Mode Test Set-up

#### EQUIPMENT

DC Power Supply  
Counter  
Cable assembly BNC and BNC-Banana  
2 x Feedthrough termination 50  $\Omega$

#### PROCEDURE

1. Connect the equipment as shown.

2. Set 8111A as follows:

|                 |                    |
|-----------------|--------------------|
| INPUT MODE      | VCO                |
| FUNCTION        | SQUARE             |
| DUTY CYCLE      | 50 %               |
| AMPLITUDE       | 16 V <sub>pp</sub> |
| OUTPUT MODE     | SYM                |
| FREQUENCY RANGE | 1-10 kHz           |

3. Set counter to frequency.

4. Set DC Supply for .1 to 10 V and verify counter frequency (typical).

| DC POWER SUPPLY | 8111A     | COUNTER   |
|-----------------|-----------|-----------|
| .1 V            | .10 kHz   | .10 kHz   |
| 1 V             | 1.00 kHz  | 1.00 kHz  |
| 10 V            | 10.00 kHz | 10.00 kHz |

## PERFORMANCE TESTS RECORD

| Hewlett-Packard Company<br>Model 8111A/8111A Option 001<br>Pulse/Function Generator |                                       | Instrument Serial No. _____<br>Tested by _____<br>Date _____ |        |            |
|-------------------------------------------------------------------------------------|---------------------------------------|--------------------------------------------------------------|--------|------------|
| Paragraph No.                                                                       | Test Description and parameter values | Result                                                       |        |            |
|                                                                                     |                                       | Minimum                                                      | Actual | Maximum    |
| 4-10                                                                                | Frequency                             |                                                              |        |            |
|                                                                                     | 1 Hz                                  | 0.900 Hz                                                     |        | 1.100 Hz   |
|                                                                                     | 9.99 Hz                               | 9.000 Hz                                                     |        | 11.000 Hz  |
|                                                                                     | 10 Hz                                 | 9.500 Hz                                                     |        | 10.500 Hz  |
|                                                                                     | 99.9 Hz                               | 95.000 Hz                                                    |        | 105.00 Hz  |
|                                                                                     | 100 Hz                                | 95.00 Hz                                                     |        | 105.00 Hz  |
|                                                                                     | 999 Hz                                | 950.00 Hz                                                    |        | 1050.0 Hz  |
|                                                                                     | 1 kHz                                 | 0.950 kHz                                                    |        | 1.050 kHz  |
|                                                                                     | 9.99 kHz                              | 9.950 kHz                                                    |        | 10.50 kHz  |
|                                                                                     | 10 kHz                                | 9.950 kHz                                                    |        | 10.50 kHz  |
|                                                                                     | 99.9 kHz                              | 95.00 kHz                                                    |        | 105.00 kHz |
|                                                                                     | 100 kHz                               | 95.00 kHz                                                    |        | 105.00 kHz |
|                                                                                     | 999 kHz                               | 950.00 kHz                                                   |        | 1050.0 kHz |
|                                                                                     | 1 MHz                                 | 0.950 MHz                                                    |        | 1.050 MHz  |
|                                                                                     | 9.99 MHz                              | 9.500 MHz                                                    |        | 10.50 MHz  |
|                                                                                     | 10 MHz                                | 9.500 MHz                                                    |        | 10.50 MHz  |
|                                                                                     | 20 MHz                                | 19.00 MHz                                                    |        | 21.00 MHz  |
| 4-11<br>(1)                                                                         | Amplitude and Attenuation             |                                                              |        |            |
|                                                                                     | Amplitude                             |                                                              |        |            |
|                                                                                     | Square                                |                                                              |        |            |
|                                                                                     | 16 Vpp                                | 7.600 V                                                      |        | 8.40 V     |
|                                                                                     | 10 Vpp                                | 4.750 V                                                      |        | 5.25 V     |
|                                                                                     | 1.6 Vpp                               | 0.760 V                                                      |        | 0.84 V     |
|                                                                                     | Triangle                              |                                                              |        |            |
|                                                                                     | 16 Vpp                                | 4.388 V                                                      |        | 4.85 V     |
|                                                                                     | 10 Vpp                                | 2.742 V                                                      |        | 3.031 V    |
|                                                                                     | 1.6 Vpp                               | 0.439 V                                                      |        | 0.485 V    |
|                                                                                     | Sine                                  |                                                              |        |            |
|                                                                                     | 16 Vpp                                | 5.374 V                                                      |        | 5.940 V    |
|                                                                                     | 10 Vpp                                | 3.359 V                                                      |        | 3.712 V    |
|                                                                                     | 1.6 Vpp                               | 0.537 V                                                      |        | 0.594 V    |

## PERFORMANCE TESTS RECORD

| Paragraph No. | Test Description and parameter values                                                                                                                                                                                              | Result                                                                      |                                                                                              |                                                                                           |
|---------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------|----------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------|
|               |                                                                                                                                                                                                                                    | Minimum                                                                     | Actual                                                                                       | Maximum                                                                                   |
| 4-11 cont'd   | Amplitude and Attenuation<br>Attenuation<br>10 Vpp<br>-20 dB (1 Vpp)<br>-40 dB (100 mVpp)<br>-60 dB (10 mVpp)                                                                                                                      | 4.750 V<br>0.475 V<br>47.5 mV<br>4.75 mV                                    |                                                                                              | 5.250 V<br>0.525 V<br>52.5 mV<br>5.25 mV                                                  |
| 4-12          | Offset<br>8 V<br>4 V<br>2 V<br>0 V<br>-2 V<br>-4 V<br>-8 V                                                                                                                                                                         | 7.576 V<br>3.776 V<br>1.876 V<br>-24 mV<br>-1.876 V<br>-3.776 V<br>-7.576 V |                                                                                              | 8.424 V<br>4.224 V<br>2.124 V<br>24 mV<br>-2.124 V<br>-4.224 V<br>-8.424 V                |
| 4-13          | Pulse Characteristics<br>leading edge<br>trailing edge<br>pulse perturbation                                                                                                                                                       | $\leq 10$ nsec<br>$\leq 10$ nsec<br>$\leq \pm 5\%$ of amplitude             | yes <input type="checkbox"/><br>yes <input type="checkbox"/><br>yes <input type="checkbox"/> | no <input type="checkbox"/><br>no <input type="checkbox"/><br>no <input type="checkbox"/> |
| 4-14          | Sine Characteristics (Harmonic level)<br>Frequency<br>9.99 kHz (2nd Harmonic)<br>9.99 kHz (3rd Harmonic)<br>9.99 kHz (THD)<br><br>500 kHz (2nd Harmonic)<br>500 kHz (3rd Harmonic)<br>500 kHz (THD)<br><br>20 MHz (worst Harmonic) |                                                                             | <br><br><br>%<br><br><br>%<br><br>                                                           | -42 dB<br>-47 dB<br>< 1 %<br><br>-32 dB<br>-37 dB<br>< 3 %<br><br>-26 dB                  |
| 4-15          | Duty Cycle<br>10 %<br>20 %<br>50 %<br>80 %<br>90 %                                                                                                                                                                                 | 4 $\mu$ s<br>17 $\mu$ s<br>49 $\mu$ s<br>77 $\mu$ s<br>84 $\mu$ s           |                                                                                              | 16 $\mu$ s<br>23 $\mu$ s<br>51 $\mu$ s<br>83 $\mu$ s<br>96 $\mu$ s                        |

## PERFORMANCE TESTS RECORD

[illegible]

## SECTION V ADJUSTMENT PROCEDURE

### 5-0 GENERAL

The adjustment procedure is divided into the following sections:

- |                                  |           |
|----------------------------------|-----------|
| 1. Power supply regulator        | para. 5-1 |
| 2. Pre-adjustment                | para. 5-2 |
| 3. Voltage Controlled Oscillator | para. 5-3 |
| 4. Shaper                        | para. 5-4 |
| 5. Width generator               | para. 5-5 |

If the complete instrument needs to be recalibrated, it is recommended that the adjustments are made in the sequence as listed above.

If only a part of the instrument has to be recalibrated, for example after replacement of a faulty component on a board, the procedure should be started at the appropriate paragraph. Subsequent sections must be checked through and adjustments made if necessary. Checking and/or adjustment of values in previous sections is necessary only in the case of the Shaper board since it requires inputs from the VCO which might need to be adjusted for correct Shaper board calibration after repair or replacement.

**NOTE** the following points:

**Allow the instrument a 15 minute warm-up time with closed cover. Keep cover closed between adjustments.**

**An adjustment points location diagram (Figure 5-4) is given at the end of this section.**

**All measurements are made at the 8111A output except:**

- Power Supply output voltages
  - Control voltage for VCO
- which are made at special testpoints.

**All specification of the 8111A apply with 50 Ohms load resistance, so ensure that the 8111A output is terminated with 50 Ohms during amplitude and transistion time measurement.**

### 5-1 POWER SUPPLY REGULATOR ADJUSTMENT

**EQUIPMENT:**  
DVM

#### PROCEDURE

1. Connect DVM low terminal to ground (⏏) test point on board A2 and measure the output voltages at the other A2 test points.
2. Adjust +5V via A2 R5 for  $+5V \pm 10mV$  (TP+5V)
3. Adjust +15V via A2 R37 for  $+15V \pm 10mV$  (TP+15V)
4. Measure -5.2V. It should be  $-5.2V \pm 100mV$  (TP-5.2V)  
Measure -15V. It should be  $-15V \pm 750mV$  (TP-15V)  
Measure -23V. It should be  $-23V \pm 200mV$  (TP-23V)  
Measure +23V. It should be  $+23V \pm 200mV$  (TP+23V)

### 5-2 PRE-ADJUSTMENT

#### EQUIPMENT:

Oscilloscope, 50 Ohm feedthrough.

#### Waveform pre-adjustments

#### PROCEDURE

1. Set 8111A:

OPERATING MODE ..... NORMAL  
WAVEFORM ..... square  
FREQUENCY RANGE ..... 1-10kHz  
FREQUENCY (VERNIER) ..... approx. 2kHz  
DUTY CYCLE ..... fixed 50%  
AMPLITUDE (VERNIER) ..... approx. 8V  
AMPL ATTENUATOR ..... released  
OFFSET (VERNIER) ..... 0V  
OFFSET ATTENUATOR ..... released  
OUTPUT ATTENUATOR ..... released  
OUTPUT MODE ..... SYM, NORM

2. Connect 8111A output to Scope. Make sure, that the output is terminated with 50 Ohms.
3. Adjust A6R50 to its mid-position then adjust A6R33 for symmetrical square wave output.
4. Adjust A8 R14 for optimal square wave on scope (minimum distortion).
5. Disconnect Shaper Board A6 from connector. Adjust A8 R55 for  $0V \pm 1mV$  baseline offset.

**Amplitude pre-adjustment**

6. Reconnect A6.
7. Set 8111A :  
 AMPLITUDE (VERNIER) ..... CW  
 8. Adjust A6 R6 for  $16V \pm 500mV$  displayed on scope.
9. Set 8111A :  
 AMPLITUDE (VERNIER) ..... CCW  
 Adjust A6R23 for symmetrical output.
10. Turn A6 R27 fully CCW then adjust for  $1.6V \pm 100mV$ .
11. Set 8111A :  
 AMPLITUDE (VERNIER) ..... CW  
 12. If the amplitude is not  $16V \pm 500mV$ , repeat steps 8 to 11.
13. Set 8111A :  
 WAVEFORM ..... Triangle
14. Adjust A5 R10 for  $16V \pm 500mV$ .

The amplitude of the triangle should be the same as the amplitude of the square.

**5-3 VCO ADJUSTMENT****EQUIPMENT:**

Counter, DVM, Fine adjustable Power Supply, Sampling scope, 20dB Attenuator (2W)

**PROCEDURE**

1. Set 8111A :

OPERATING MODE ..... NORMAL  
 WAVEFORM ..... square  
 FREQUENCY RANGE ..... 1-10kHz  
 FREQUENCY (VERNIER) ..... CW  
 DUTY CYCLE ..... fixed 50%  
 AMPLITUDE (VERNIER) ..... CW  
 AMPL ATTENUATOR ..... -20dB  
 OFFSET (VERNIER) ..... 0V  
 OFFSET ATTENUATOR ..... released  
 OUTPUT ATTENUATOR ..... released  
 OUTPUT MODE ..... SYM, NORM

**Fixed 50% Duty Cycle Adjustment**

2. Set Counter: TIME INTERVAL A  $\rightarrow$  B Slope A  $\nearrow$  Slope B  $\searrow$   
 COM A, Trigger level 0V  
 If possible use an averaged TI measurement over 100 time intervals.
3. Connect 8111A output to Counter Input A.
4. Note value displayed by counter
5. Set Counter: Slope A  $\searrow$  Slope B  $\nearrow$ .
6. Adjust A5 R65 for same value as in 4.)  $\pm 10ns$ .

NOTE: This adjustment can also be made with the help of a spectrum analyser. For a 50% Duty Cycle the 2nd, 4th, etc., harmonics must disappear. This simplifies the minimizing of the difference between NORM and COMPL mode.

**Frequency Adjustment For Variable Duty Cycle**

7. Set Counter to PERIOD A. If possible use an averaged period-measurement over 100 periods.
8. Note value displayed by counter.
9. Set 8111A:

DUTY CYCLE MODE ..... variable  
 DUTY CYCLE (VERNIER) ..... 40-60%

10. Adjust A5 R50 for same value (as in 8.)  $\pm 100 ns$ .

**VCO Linearity adjustment**

11. Set 8111A:

OPERATING MODE ..... VCO  
 WAVEFORM ..... square  
 FREQUENCY RANGE ..... 1-10kHz  
 FREQUENCY (VERNIER) ..... CW  
 DUTY CYCLE ..... fixed 50%  
 AMPLITUDE (VERNIER) ..... CW  
 AMPL ATTENUATOR ..... -20dB  
 OFFSET (VERNIER) ..... 0V  
 OFFSET ATTENUATOR ..... released  
 OUTPUT ATTENUATOR ..... released  
 OUTPUT MODE ..... SYM, NORM

12. Connect DVM between A5 TP3 and TP4. The position of TP3 and TP4 is shown in Figure 5-1.

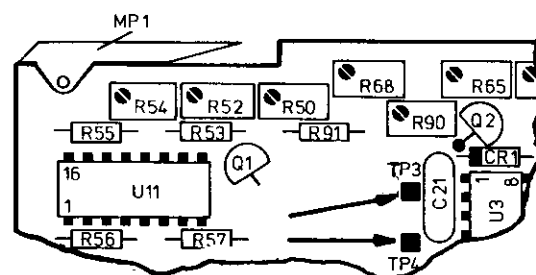


Figure 5-1.

13. Connect 10V DC  $\pm 50\text{mV}$  to EXT INPUT.
14. Note voltage between TP3 and TP4, displayed by the DVM
15. Connect 100mV DC  $\pm 0.5\text{mV}$  to EXT INPUT.
16. Adjust A5 R90 for 1/100 of value (from 14.) on DVM.
17. Disconnect DVM from TP3/TP4.

#### Positive Slope Timing Linearity Adjustment

18. Set Counter: TIME INTERVAL A  $\rightarrow$  B Slope A  $\nearrow$  Slope B  $\searrow$   
COM A, Trigger level 0V
19. Adjust A5 R86 for  $5000\mu\text{s} \pm 20\mu\text{s}$ .

#### Negative Slope Timing Linearity Adjustment

20. Set Counter: Slope A  $\searrow$  Slope B  $\nearrow$ .
21. Adjust A5 R88 for  $5000\mu\text{s} \pm 20\mu\text{s}$ .
22. Disconnect the external voltage.

#### Frequency Adjustment (1Hz-1000kHz)

23. Set 8111A:

OPERATING MODE ..... NORMAL  
 WAVEFORM ..... square  
 FREQUENCY RANGE ..... 1-10kHz  
 FREQUENCY (VERNIER) ..... 10.00kHz  
 DUTY CYCLE ..... fixed 50%  
 AMPLITUDE (VERNIER) ..... CW  
 AMPL ATTENUATOR ..... -20dB  
 OFFSET (VERNIER) ..... 0V  
 OFFSET ATTENUATOR ..... released  
 OUTPUT ATTENUATOR ..... released  
 OUTPUT MODE ..... SYM, NORM

24. Set Counter: FREQUENCY A.  
Adjust A5 R54 for 10.00 kHz  $\pm 0.1\text{kHz}$

#### Variable Duty Cycle Display Adjustment

25. Set 8111A:

DUTY CYCLE ..... variable  
 DUTY CYCLE VERNIER ..... as required

26. Set Counter: TIME INTERVAL A  $\rightarrow$  B, Slope A  $\nearrow$  Slope B  $\searrow$   
COM A, Trigger level 0V  
If possible, use an averaged time interval measurement over at least 10 time intervals.
27. Adjust 8111A DUTY CYCLE VERNIER for  $50\mu\text{s} \pm 0.1\mu\text{s}$  on counter.
28. Adjust A5 R68 for 50% duty cycle displayed by 8111A.

#### Overshoot & Transition Time

29. Set 8111A:

OPERATING MODE ..... NORMAL  
 WAVEFORM ..... square  
 FREQUENCY RANGE ..... 1-10MHz  
 FREQUENCY (VERNIER) ..... approx 2MHz  
 DUTY CYCLE ..... fixed 50%  
 AMPLITUDE (VERNIER) ..... CW  
 AMPL ATTENUATOR ..... released  
 OFFSET (VERNIER) ..... CCW  
 OFFSET ATTENUATOR ..... released  
 OUTPUT ATTENUATOR ..... released  
 OUTPUT MODE ..... POS,NORM

30. Connect 8111A output to sampling scope as shown in Fig. 5-2

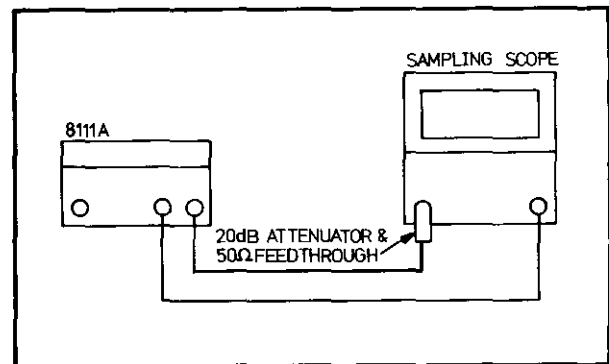


Figure 5-2

31. Adjust A8C14 for overshoot  $\leq 5\%$ .
32. Set 8111A:

OFFSET (VERNIER) ..... CW  
 OUTPUT MODE ..... NEG,NORM

33. Check that overshoot  $\leq 5\%$ .
34. Set 8111A:

AMPLITUDE (VERNIER) ..... CCW  
 OFFSET (VERNIER) ..... -7.2V  
 OUTPUT MODE ..... SYM,NORM

35. Check that transition times  $\leq 10\text{nS}$ .

**Flatness**

36. Set 8111A:

OPERATING MODE ..... NORMAL  
 WAVEFORM ..... Triangle  
 FREQUENCY RANGE ..... 100-1000kHz  
 FREQUENCY (VERNIER) ..... approx 500kHz  
 DUTY CYCLE ..... fixed 50%  
 AMPLITUDE (VERNIER) ..... CW  
 AMPL ATTENUATOR ..... released  
 OFFSET (VERNIER) ..... 0V  
 OFFSET ATTENUATOR ..... released  
 OUTPUT ATTENUATOR ..... released  
 OUTPUT MODE ..... SYM, NORM

37. Adjust Input Vernier of the Sampling scope for a 100% display of the waveform.

38. Set 8111A:

FREQUENCY RANGE ..... 10-20 MHz  
 FREQUENCY (VERNIER) ..... CW

39. Adjust A5 R5 for low level -4%.  
 Adjust A5 R8 for high level -4%.

**Frequency Adjustment (10-20MHz)**

40. Set 8111A:

FREQUENCY (VERNIER) ..... 20MHz

41. Set Counter: FREQUENCY A.

42. Connect 8111A output to Counter Input A.

43. Adjust A5 C3 for 20 MHz  $\pm 0.2$ MHz.**Frequency Adjustment (1-10 MHz)**

44. Set 8111A:

FREQUENCY RANGE ..... 1-10MHz  
 FREQUENCY (VERNIER) ..... 10.00MHz

45. Adjust A5 R52 for 10MHz  $\pm 0.1$ MHz.  
 Repeat 30-45 twice.

**5-4 SHAPER ADJUSTMENT****EQUIPMENT:**

DVM, Lowpass filter as shown in Figure 5-3, Scope,  
 Spectrum analyser (Distortion analyser)

**PROCEDURE****Square Amplitude Adjustment**

1. Set 8111A:

OPERATING MODE ..... NORMAL  
 WAVEFORM ..... square  
 FREQUENCY RANGE ..... 1-10kHz  
 FREQUENCY (VERNIER) ..... CW  
 DUTY CYCLE ..... fixed 50%  
 AMPLITUDE (VERNIER) ..... CW  
 AMPL ATTENUATOR ..... released  
 OFFSET (VERNIER) ..... 0V  
 OFFSET ATTENUATOR ..... released  
 OUTPUT ATTENUATOR ..... released  
 OUTPUT MODE ..... SYM, NORM

2. Set DVM to AC, 10V Range.

3. Connect 8111A output to DVM input.

4. Adjust A6 R24 for maximum amplitude

5. Set 8111A:

AMPLITUDE (VERNIER) ..... 16.00V

Adjust A6 R50 to its center position.

6. Adjust A6 R6 for 8V  $\pm 400$  mV.**Square Normal/Complement Error**

7. Set DVM to DC, 10V Range. Use DVM built in  
 filter function, otherwise use set-up as shown in  
 Figure 5-3

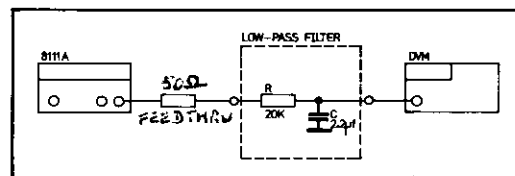


Figure 5-3

8. Change 8111A OUTPUT MODE from NORM to COMPL and back.

9. Check that the difference between NORM and  
 COMPL does not exceed 10mV. If necessary  
 adjust A6 R16 for minimum difference.

**Symmetry Adjustment**10. Adjust A6 R33 for 0V  $\pm 10$ mV.

11. Set 8111A:

AMPLITUDE VERNIER ..... 1.60V

12. Adjust A6 R23 for 0V  $\pm 10$ mV.

### Triangle Normal/Complement Error

- 24. Set 8111A:**

|                     |           |
|---------------------|-----------|
| OPERATING MODE      | NORMAL    |
| WAVEFORM            | Triangle  |
| FREQUENCY RANGE     | 1-10kHz   |
| FREQUENCY (VERNIER) | CW        |
| DUTY CYCLE          | fixed 50% |
| AMPLITUDE (VERNIER) | 16.00V    |
| AMPL ATTENUATOR     | released  |
| OFFSET (VERNIER)    | 0V        |
| OFFSET ATTENUATOR   | released  |
| OUTPUT ATTENUATOR   | released  |
| OUTPUT MODE         | SYM, NORM |

**15. Set 8111A:**

25. Set DVM to DC, 10V Range. Use built-in filter or set-up as shown in Figure 5-3-
26. Change output mode from NORM to COMPL and back.
27. Adjust A6 R15 for minimum difference between NORM and COMPL output mode

**18. Set 8111A:**

- ### Sine Normal/Complement Error

28. Set 8111A:  
WAVEFORM ..... Sine

29. Change output mode from NORM to COMPL and back.
30. Adjust A6 R14 for minimum difference between NORM and COMPL output mode.
- If difference >100mV, adjust A6R50 for <40mV difference and repeat the the procedure for Square Normal/Compl Error and Triangle Normal /Compl Error. Check again for minimum (>100mV) difference in Sine Normal/Compl Error.

**31. Set 8111A:**

32. Connect 8111A output to scope input.
33. Set Scope to 0.02V/Division.
34. Adjust A6 R36 for minimum baseline difference between POS and NEG output mode.

- 5-5

## 5-5 WIDTH ADJUSTMENT

### EQUIPMENT:

Counter

#### 1. Set 8111A:

OPERATING MODE ..... NORMAL  
 WAVEFORM ..... Pulse  
 FREQUENCY RANGE ..... 1-10kHz  
 FREQUENCY (VERNIER) ..... 5kHz  
 WIDTH RANGE ..... 10-100 $\mu$ s  
 WIDTH VERNIER ..... 40.0 $\mu$ s  
 AMPLITUDE (VERNIER) ..... CW  
 AMPL ATTENUATOR ..... -20dB  
 OFFSET (VERNIER) ..... 0V  
 OFFSET ATTENUATOR ..... released  
 OUTPUT ATTENUATOR ..... released  
 OUTPUT MODE ..... SYM, NORM

#### 2. Set Counter: TIME INTERVAL A $\rightarrow$ B Slope A Slope B COM A Trigger level 0V

If possible use an averaged TI- measurement over at least 10 time intervals.

3. Set A4 R34 to its mid position.
4. Adjust A4 R41 for 40 $\mu$ s  $\pm$ 0,4 $\mu$ s.
5. Set 8111A:

WIDTH RANGE ..... 100-1000ns  
 WIDTH (VERNIER) ..... 400ns

4. Adjust A4 C1 for 400ns  $\pm$ 4ns.
7. Set 8111A:

WIDTH RANGE ..... 25-100ns  
 WIDTH (VERNIER) ..... 100.0ns

8. Connect 8111 A OUTPUT to a sampling scope  
 (use 20dB attenuator)

9. Adjust A4 R34 for 100ns  $\pm$ 2ns.

#### 10. Set 8111A:

WIDTH (VERNIER) ..... 25.0ns

11. Check pulse width for 25ns  $\pm$ 2ns

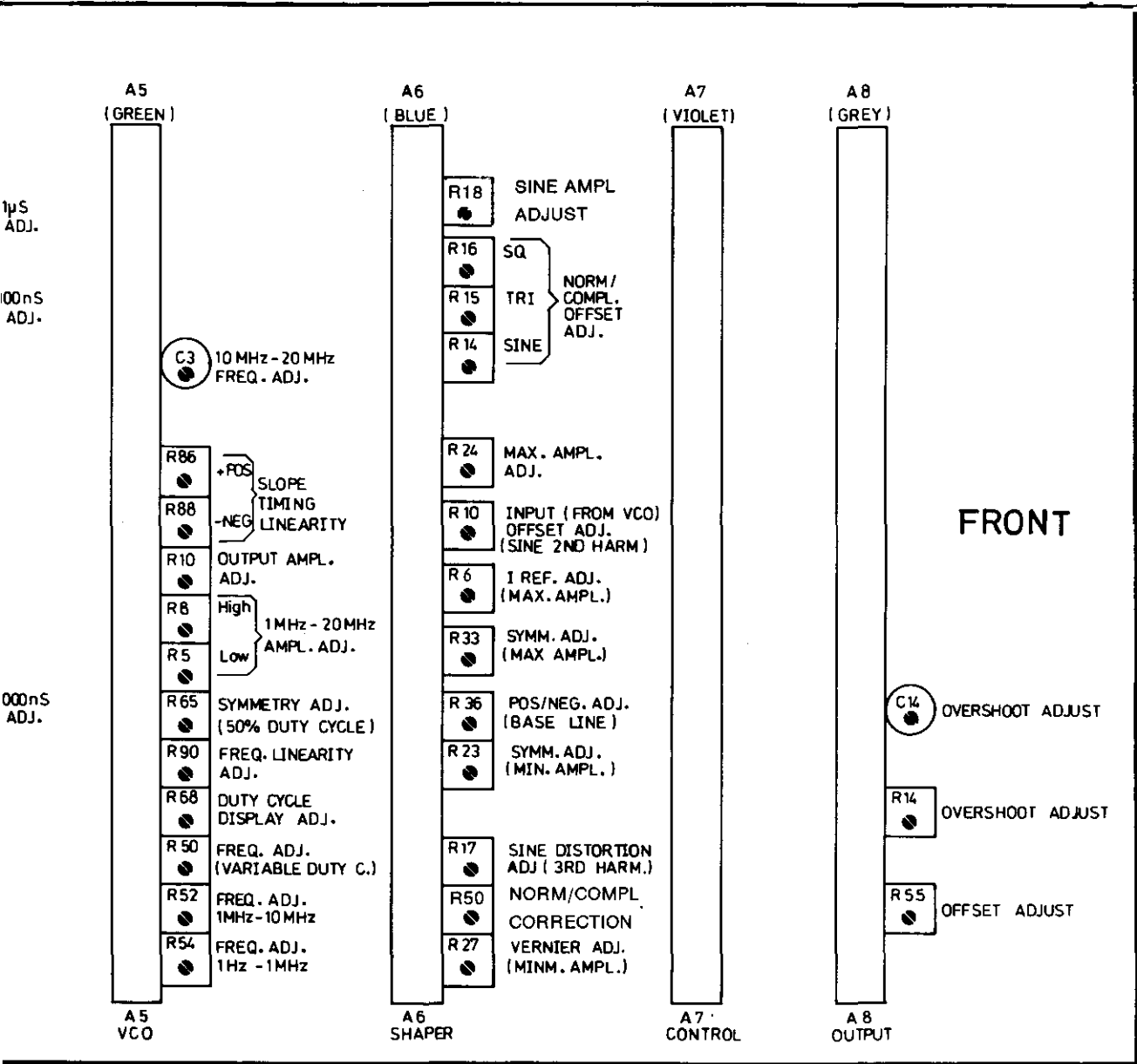
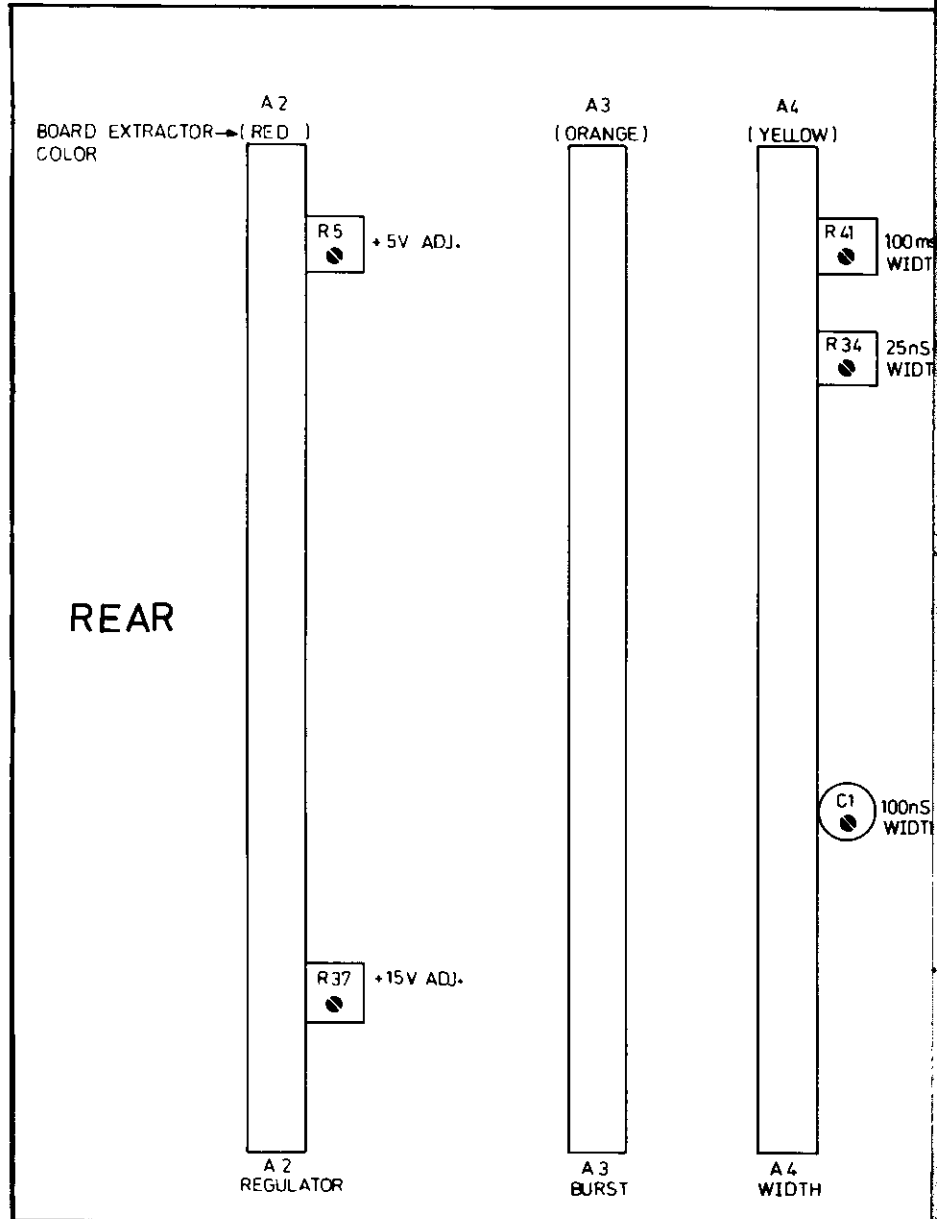


Figure 5-2. Adjustments point location diagram



## SECTION VI REPLACEABLE PARTS

### 6-1 INTRODUCTION

6-2 This section contains information for ordering parts. Table 6-1 lists abbreviations used in the parts lists and elsewhere in the manual. Table 6-2 contains the names and addresses that correspond to the manufacturer code numbers. Table 6-3 lists all replaceable parts in reference designator order.

### 6-3 ABBREVIATIONS

6-4 Table 6-1 lists abbreviations used in the parts lists, schematics and elsewhere in the manual. In some cases two forms of the abbreviations are used, one all in capital letters, and one partial or no capitals. This occurs because the abbreviations in the parts lists are always all capitals. However, in the schematics and other parts of the manual, the same abbreviations may have upper and lower case letters.

### 6-5 REPLACEABLE PARTS

6-6 Table 6-3 is the list of replaceable parts and is organised as follows:

- a. Mainframe (chassis) parts in alphanumerical order by reference designation.
- b. Electrical assemblies and their components in alpha-numerical order by reference designation.

Reference designators are of the form A5R9 i.e. resistor 9 assembly 5. The blue pages at the end of this section list the parts required for Option 001.

6-7 The information given for each part consists of the following:

- a. The Hewlett-Packard part number.
- b. The description of the part.
- c. Part number check digit (CD).

### 6-8 ORDERING INFORMATION

6-9 To order a part listed in the replaceable parts table, quote the Hewlett-Packard part number (with check digit), indicate the quantity required, and address the order to the nearest Hewlett-Packard office (list of Sales/Service offices at the rear of this manual). The check digit will ensure accurate and timely processing of your order.

6-10 To order a part that is not listed in the replaceable parts table, include the instrument model number, instrument serial number, the description and function of the part, and the number of parts required, address the order to the nearest Hewlett-Packard office.

### 6-11 DIRECT MAIL ORDER SYSTEM (USA)

6-12 Within the USA, Hewlett-Packard can supply parts through a direct mail order system. Advantages of using the system are as follows:

- a. Direct ordering and shipment from the HP Parts Center in Mountain View, California.
- b. No maximum or minimum on any mail order (there is a minimum order amount for parts ordered through a local HP office when the orders require billing and invoicing).
- c. Prepaid transportation (there is a small handling charge for each order).
- d. No invoices — to provide these advantages, a check or money order must accompany each order.

6-13 Mail order forms and specific ordering information is available through your local HP office. Addresses and phone numbers are located at the back of this manual.

Table 6-1. Abbreviations for Replaceable Parts List

## REFERENCE DESIGNATIONS

|                                                                           |                                                             |                                                          |                                                     |
|---------------------------------------------------------------------------|-------------------------------------------------------------|----------------------------------------------------------|-----------------------------------------------------|
| A . . . . . assembly                                                      | E . . . . . miscellaneous electrical part                   | P . . . . . electrical connector (movable portion); plug | VR . . . . . voltage regulator; breakdown diode     |
| AT . . . . . attenuator; isolator; termination                            | F . . . . . fuse                                            | Q . . . . . transistor; SCR; triode thyristor            | W . . . . . cable; transmission path; wire          |
| B . . . . . fan; motor                                                    | FL . . . . . filter                                         | R . . . . . resistor                                     | X . . . . . socket                                  |
| BT . . . . . battery                                                      | H . . . . . hardware                                        | RT . . . . . thermistor                                  | Y . . . . . crystal unit (piezo-electric or quartz) |
| C . . . . . capacitor                                                     | HY . . . . . circulator                                     | S . . . . . switch                                       | Z . . . . . tuned cavity; tuned circuit             |
| CP . . . . . coupler                                                      | J . . . . . electrical connector (stationary portion); jack | T . . . . . transformer                                  |                                                     |
| CR . . . . . diode; diode thyristor; varactor                             | K . . . . . relay                                           | TB . . . . . terminal board                              |                                                     |
| DC . . . . . directional coupler                                          | L . . . . . coil; inductor                                  | TC . . . . . thermocouple                                |                                                     |
| DL . . . . . delay line                                                   | M . . . . . meter                                           | TP . . . . . test point                                  |                                                     |
| DS . . . . . annunciator; signaling device (audible or visual); lamp; LED | MP . . . . . miscellaneous mechanical part                  | U . . . . . integrated circuit; microcircuit             |                                                     |
|                                                                           |                                                             | V . . . . . electron tube                                |                                                     |

## ABBREVIATIONS

|                                              |                                                           |                                                           |                                                                |
|----------------------------------------------|-----------------------------------------------------------|-----------------------------------------------------------|----------------------------------------------------------------|
| A . . . . . ampere                           | CW . . . . . continuous wave                              | h . . . . . hour                                          | MET OX . . . . . metallic oxide                                |
| ac . . . . . alternating current             | cw . . . . . clockwise                                    | HET . . . . . heterodyne                                  | MF . . . . . medium frequency; microfarad (used in parts list) |
| ACCESS . . . . . accessory                   | cm . . . . . centimeter                                   | HEX . . . . . hexagonal                                   | MFR . . . . . manufacturer                                     |
| ADJ . . . . . adjustment                     | D/A . . . . . digital-to-analog                           | HD . . . . . head                                         | mg . . . . . milligram                                         |
| A/D . . . . . analog-to-digital              | dB . . . . . decibel                                      | HDW . . . . . hardware                                    | MHz . . . . . megahertz                                        |
| AF . . . . . audio frequency                 | dBm . . . . . decibel referred to 1 mW                    | HF . . . . . high frequency                               | mH . . . . . millihenry                                        |
| AFC . . . . . automatic frequency control    | dc . . . . . direct current                               | HG . . . . . mercury                                      | mho . . . . . mho                                              |
| AGC . . . . . automatic gain control         | deg . . . . . degree (temperature interval or difference) | HI . . . . . high                                         | MIN . . . . . minimum                                          |
| AL . . . . . aluminum                        | ° . . . . . degree (plane angle)                          | HP . . . . . Hewlett-Packard                              | min . . . . . minute (time)                                    |
| ALC . . . . . automatic level control        | °C . . . . . degree Celsius (centigrade)                  | HPF . . . . . high pass filter                            | minute (plane angle)                                           |
| AM . . . . . amplitude modulation            | °F . . . . . degree Fahrenheit                            | HR . . . . . hour (used in parts list)                    |                                                                |
| AMPL . . . . . amplifier                     | °K . . . . . degree Kelvin                                | HV . . . . . high voltage                                 | MINAT . . . . . miniature                                      |
| APC . . . . . automatic phase control        | DEPC . . . . . deposited carbon                           | Hz . . . . . Hertz                                        | mm . . . . . millimeter                                        |
| ASSY . . . . . assembly                      | DET . . . . . detector                                    | IC . . . . . integrated circuit                           | MOD . . . . . modulator                                        |
| AUX . . . . . auxiliary                      | diam . . . . . diameter                                   | ID . . . . . inside diameter                              | MOM . . . . . momentary                                        |
| avg . . . . . average                        | DIA . . . . . diameter (used in parts list)               | IF . . . . . intermediate frequency                       | MOS . . . . . metal-oxide semiconductor                        |
| AWG . . . . . American wire gauge            | DIFF AMPL . . . . . differential amplifier                | IMPG . . . . . impregnated in . . . . . inch              | ms . . . . . millisecond                                       |
| BAL . . . . . balance                        | div . . . . . division                                    | INCD . . . . . incandescent                               | MTG . . . . . mounting                                         |
| BCD . . . . . binary coded decimal           | DPDT . . . . . double-pole, double-throw                  | INCL . . . . . include(s)                                 | MTR . . . . . meter (indicating device)                        |
| BD . . . . . board                           | DR . . . . . drive                                        | INP . . . . . input                                       | mV . . . . . millivolt                                         |
| BE CU . . . . . beryllium copper             | DSB . . . . . double sideband                             | INS . . . . . insulation                                  | mVac . . . . . millivolt, ac                                   |
| BFO . . . . . beat frequency oscillator      | DTL . . . . . diode transistor logic                      | INT . . . . . internal                                    | mVdc . . . . . millivolt, dc                                   |
| BH . . . . . binder head                     | DVM . . . . . digital voltmeter                           | kg . . . . . kilogram                                     | mVpk . . . . . millivolt, peak                                 |
| BKDN . . . . . breakdown                     | FCL . . . . . emitter coupled logic                       | kV . . . . . kilovolt                                     | mVp-p . . . . . millivolt, peak-to-peak                        |
| BP . . . . . bandpass                        | EMF . . . . . electromotive force                         | lb . . . . . pound                                        | mVrms . . . . . millivolt, rms                                 |
| BPF . . . . . bandpass filter                | EDP . . . . . electronic data processing                  | LC . . . . . inductance-capacitance                       | mW . . . . . milliwatt                                         |
| BRS . . . . . brass                          | ELECT . . . . . electrolytic                              | LED . . . . . light-emitting diode                        | MUX . . . . . multiplex                                        |
| BWO . . . . . backward-wave oscillator       | ENCAP . . . . . encapsulated                              | LF . . . . . low frequency                                | MY . . . . . mylar                                             |
| CAL . . . . . calibrate                      | EXT . . . . . external                                    | LG . . . . . long                                         | μA . . . . . microampere                                       |
| ccw . . . . . counter-clockwise              | F . . . . . farad                                         | LH . . . . . left hand                                    | μF . . . . . microfarad                                        |
| CER . . . . . ceramic                        | FET . . . . . field-effect transistor                     | LIM . . . . . limit                                       | μH . . . . . microhenry                                        |
| CHAN . . . . . channel                       | F/F . . . . . flip-flop                                   | LIN . . . . . linear taper (used in parts list)           | μmho . . . . . micromho                                        |
| cm . . . . . centimeter                      | FH . . . . . flatt head                                   | lin . . . . . linear                                      | μs . . . . . microsecond                                       |
| CMO . . . . . cabinet mount only             | FIL H . . . . . fillister head                            | LK WASH . . . . . lock washer                             | μV . . . . . microvolt                                         |
| COAX . . . . . coaxial                       | FM . . . . . frequency modulation                         | LO . . . . . low; local oscillator                        | μVac . . . . . microvolt, ac                                   |
| COEF . . . . . coefficient                   | FP . . . . . front panel                                  | LOG . . . . . logarithmic taper (used in parts list)      | μVdc . . . . . microvolt, dc                                   |
| COM . . . . . common                         | FREQ . . . . . frequency                                  | log . . . . . logarithm(ic)                               | μVp-p . . . . . microvolt, peak-to-peak                        |
| COMP . . . . . composition                   | FXD . . . . . fixed                                       | LPF . . . . . low pass filter                             | μVrms . . . . . microvolt, rms                                 |
| COMPL . . . . . complete                     | g . . . . . gram                                          | LV . . . . . low voltage                                  | μW . . . . . microwatt                                         |
| CONN . . . . . connector                     | GE . . . . . germanium                                    | m . . . . . meter (distance)                              | nA . . . . . nanoampere                                        |
| CP . . . . . cadmium plate                   | GHz . . . . . gigahertz                                   | mA . . . . . milliampere                                  | NC . . . . . no connection                                     |
| CRT . . . . . cathode-ray tube               | GL . . . . . glass                                        | MAX . . . . . maximum                                     | N/C . . . . . normally closed                                  |
| CTL . . . . . complementary transistor logic | GRD . . . . . ground(ed)                                  | MΩ . . . . . megohm                                       | NE . . . . . neon                                              |
|                                              | H . . . . . henry                                         | MEG . . . . . meg (10 <sup>6</sup> ) (used in parts list) | NEG . . . . . negative                                         |
|                                              |                                                           | MET FLM . . . . . metal film                              | nF . . . . . nanofarad                                         |
|                                              |                                                           |                                                           | NI PL . . . . . nickel plate                                   |
|                                              |                                                           |                                                           | N/O . . . . . normally open                                    |
|                                              |                                                           |                                                           | NOM . . . . . nominal                                          |

## NOTE

All abbreviations in the parts list will be in upper-case.

Table 6-1. Abbreviations for Replaceable Parts List (cont'd)

|                                                                     |                                                     |                                                           |                                                   |
|---------------------------------------------------------------------|-----------------------------------------------------|-----------------------------------------------------------|---------------------------------------------------|
| NORM . . . . . normal                                               | POT . . . . . potentiometer                         | SI . . . . . silicon                                      | VFO . . . . . variable-frequency oscillator       |
| NPN . . . . . negative-positive-negative                            | p-p . . . . . peak-to-peak                          | SIL . . . . . silver                                      | VHF . . . . . very-high frequency                 |
| NPO . . . . . negative-positive zero (zero temperature coefficient) | PP . . . . . peak-to-peak (used in parts list)      | SL . . . . . slide                                        | Vpk . . . . . volts, peak                         |
| NRFR . . . . . not recommended for field replacement                | PPM . . . . . pulse-position modulation             | SNR . . . . . signal-to-noise ratio                       | Vp-p . . . . . volts, peak-to-peak                |
| NSR . . . . . not separately replaceable                            | PREAMPL . . . . . preamplifier                      | SPDT . . . . . single-pole, double-throw                  | Vrms . . . . . volts, rms                         |
| ns . . . . . nanosecond                                             | PRF . . . . . pulse-repetition frequency            | SPG . . . . . spring                                      | VSWR . . . . . voltage standing wave ratio        |
| nW . . . . . nanowatt                                               | PRR . . . . . pulse repetition rate                 | SR . . . . . split ring                                   | VTO . . . . . voltage-tuned oscillator            |
| OBD . . . . . order by description                                  | ps . . . . . picosecond                             | SPST . . . . . single-pole, single-throw                  | VTVM . . . . . Vacuum-tube voltmeter              |
| OD . . . . . outside diameter                                       | PT . . . . . point                                  | SSB . . . . . single sideband                             | V(X) . . . . . volts, switched                    |
| OH . . . . . oval head                                              | PTM . . . . . pulse-time modulation                 | SST . . . . . stainless steel                             | W . . . . . watt                                  |
| OP AMPL . . . . . operational amplifier                             | PWM . . . . . pulse-width modulation                | STL . . . . . steel                                       | W . . . . . with                                  |
| OPT . . . . . option                                                | PWV . . . . . peak working voltage                  | SQ . . . . . square                                       | WIV . . . . . working inverse voltage             |
| OSC . . . . . oscillator                                            | RC . . . . . resistance-capacitance                 | SWR . . . . . standing-wave ratio                         | WW . . . . . wirewound                            |
| OX . . . . . oxide                                                  | RECT . . . . . rectifier                            | T . . . . . timed (slow-blow fuse)                        | W/O . . . . . without                             |
| oz . . . . . ounce                                                  | REF . . . . . reference                             | TA . . . . . tantalum                                     | YIG . . . . . yttrium-iron garnet                 |
| $\Omega$ . . . . . ohm                                              | REG . . . . . regulated                             | TC . . . . . temperature compensating                     | Z <sub>0</sub> . . . . . characteristic impedance |
| P . . . . . peak (used in parts list)                               | REPL . . . . . replaceable                          | TD . . . . . time delay                                   |                                                   |
| PAM . . . . . pulse-amplitude modulation                            | RF . . . . . radio frequency                        | TERM . . . . . terminal                                   |                                                   |
| PC . . . . . printed circuit                                        | RFI . . . . . radio frequency interference          | TFT . . . . . thin-film transistor                        |                                                   |
| PCM . . . . . pulse-code modulation; pulse-count modulation         | RH . . . . . round head; right hand                 | TGL . . . . . toggle                                      |                                                   |
| PDM . . . . . pulse duration modulation                             | RLC . . . . . resistance-inductance-capacitance     | THD . . . . . thread                                      |                                                   |
| pF . . . . . picofarad                                              | RMO . . . . . rack mount only                       | THRU . . . . . through                                    |                                                   |
| PH BRZ . . . . . phosphor bronze                                    | rms . . . . . root-mean-square                      | TI . . . . . titanium                                     |                                                   |
| PHL . . . . . Phillips                                              | RND . . . . . round                                 | TOL . . . . . tolerance                                   |                                                   |
| PIN . . . . . positive-intrinsic-negative                           | ROM . . . . . read-only memory                      | TRIM . . . . . trimmer                                    |                                                   |
| PIV . . . . . peak inverse voltage                                  | R&P . . . . . rack and panel                        | TSTR . . . . . transistor                                 |                                                   |
| pk . . . . . peak                                                   | RWV . . . . . reverse working voltage               | TTL . . . . . transistor-transistor logic                 |                                                   |
| PL . . . . . phase lock                                             | S . . . . . scattering parameter                    | TV . . . . . television                                   |                                                   |
| PLO . . . . . phase lock oscillator                                 | s . . . . . second (time)                           | TVI . . . . . television interference                     |                                                   |
| PM . . . . . phase modulation                                       | " . . . . . second (plane angle)                    | TWT . . . . . traveling wave tube                         |                                                   |
| PNP . . . . . positive-negative-positive                            | S-B . . . . . slow-blow (fuse) (used in parts list) | U . . . . . micro (10 <sup>6</sup> ) (used in parts list) |                                                   |
| P/O . . . . . part of                                               | SCR . . . . . silicon controlled rectifier; screw   | UF . . . . . microfarad (used in parts list)              |                                                   |
| POLY . . . . . polystyrene                                          | SE . . . . . selenium                               | UHF . . . . . ultrahigh frequency                         |                                                   |
| PORC . . . . . porcelain                                            | SECT . . . . . sections                             | UNREG . . . . . unregulated                               |                                                   |
| POS . . . . . positive; position(s) (used in parts list)            | SEMICON . . . . . semiconductor                     | V . . . . . volt                                          |                                                   |
| POSN . . . . . position                                             | SHF . . . . . superhigh frequency                   | VA . . . . . voltampere                                   |                                                   |
|                                                                     |                                                     | Vac . . . . . volts, ac                                   |                                                   |
|                                                                     |                                                     | VAR . . . . . variable                                    |                                                   |
|                                                                     |                                                     | VCO . . . . . voltage controlled oscillator               |                                                   |
|                                                                     |                                                     | Vdc . . . . . volts, dc                                   |                                                   |
|                                                                     |                                                     | VDCW . . . . . volts, dc, working (used in parts list)    |                                                   |
|                                                                     |                                                     | V(F) . . . . . volts, filtered                            |                                                   |

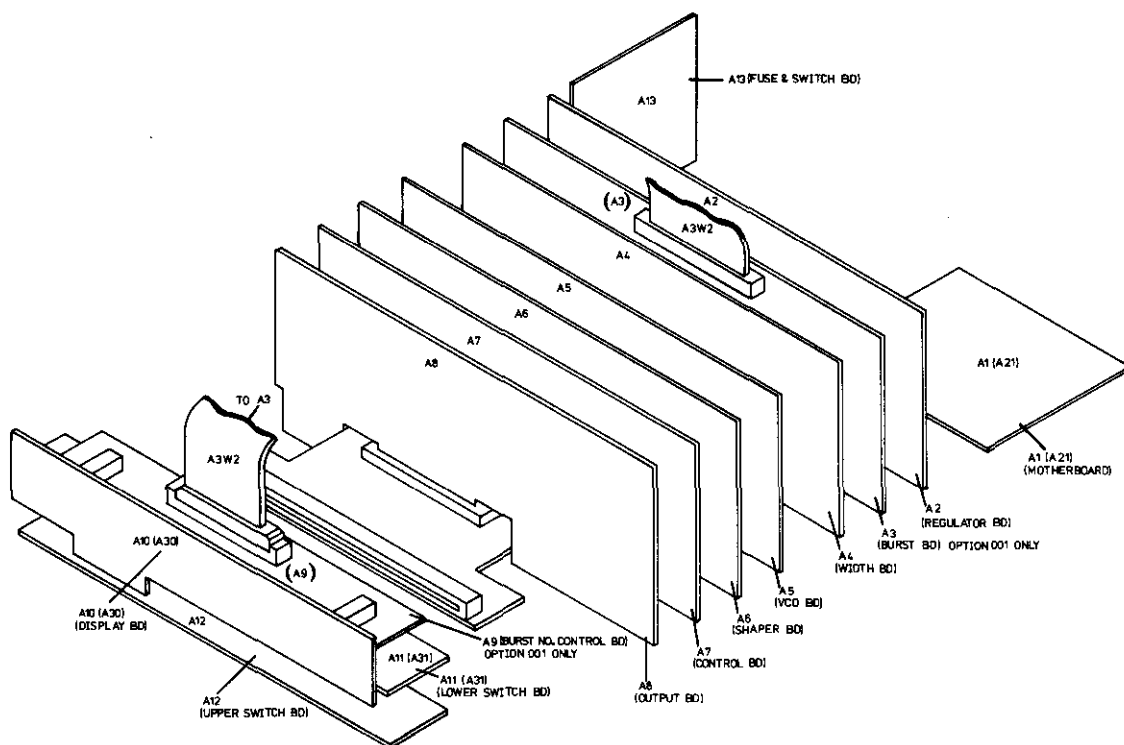
## MULTIPLIERS

| Abbreviation | Prefix | Multiple          |
|--------------|--------|-------------------|
| T            | tera   | 10 <sup>12</sup>  |
| G            | giga   | 10 <sup>9</sup>   |
| M            | mega   | 10 <sup>6</sup>   |
| k            | kilo   | 10 <sup>3</sup>   |
| da           | deka   | 10                |
| d            | deci   | 10 <sup>-1</sup>  |
| c            | centi  | 10 <sup>-2</sup>  |
| m            | milli  | 10 <sup>-3</sup>  |
| $\mu$        | micro  | 10 <sup>-6</sup>  |
| n            | nano   | 10 <sup>-9</sup>  |
| p            | pico   | 10 <sup>-12</sup> |
| f            | femto  | 10 <sup>-15</sup> |
| a            | atto   | 10 <sup>-18</sup> |

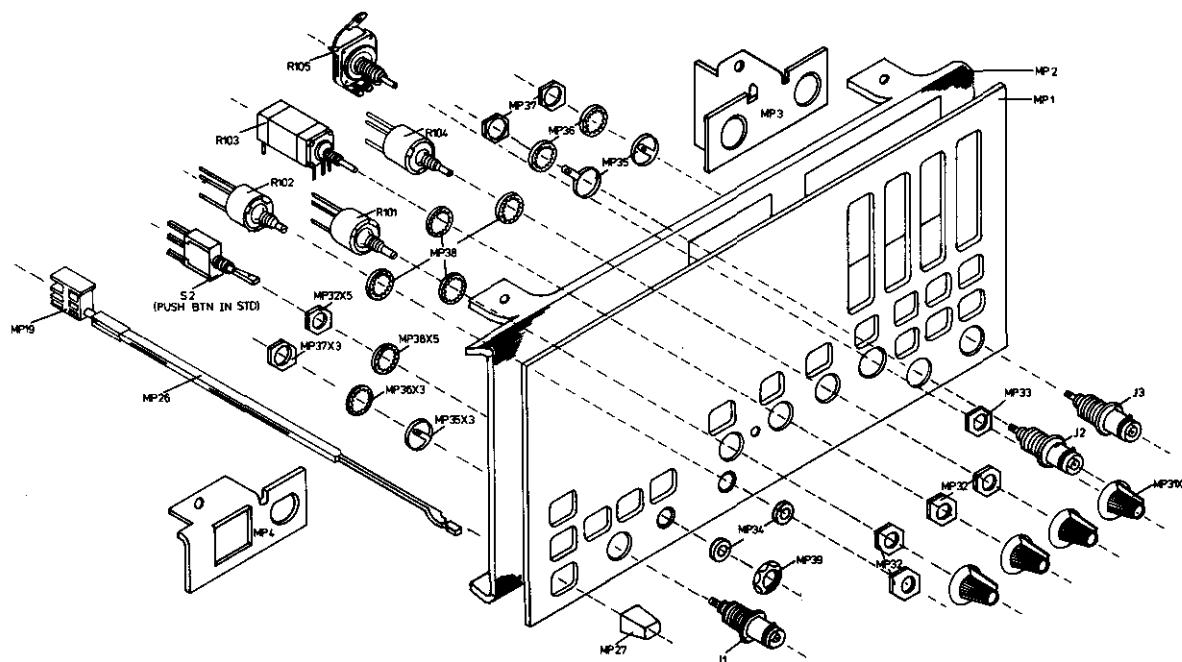
## NOTE

All abbreviations in the parts list will be in upper-case.





**NOTE:** BOARD NUMBERS IN BRACKETS e.g. (A30) ARE APPLICABLE TO OPTION 001 ONLY. A10 & A11 (A30 & A31) ARE SUB-ASSEMBLIES OF A40 & A41 RESPECTIVELY.



**NOTE:** DETAILS ON REMOVAL OF THE COMPLETE FRONT PANEL ASSEMBLY ARE GIVEN IN SERVICE BLOCK 3 (DISPLAY).

Figure 6-1. Frame Parts and Board Identification Diagram  
(Instrument shown with Option 001 fitted)



Table 6-3. Replaceable Parts

| REFERENCE DESIGNATOR | C D | H-P PART NUMBER | DESCRIPTION      | REFERENCE DESIGNATOR | C D | H-P PART NUMBER | DESCRIPTION     |
|----------------------|-----|-----------------|------------------|----------------------|-----|-----------------|-----------------|
| <b>FRAME</b>         |     |                 |                  |                      |     |                 |                 |
| A1                   | 0   | 08111-66501     | BD AY-MOTHER     | MP40                 | 8   | 08111-00606     | SHIELD FUSE     |
| A2                   | 1   | 08111-66502     | BD AY-REGULATOR  | MP42                 | 3   | 0340-1041       | INSULATOR       |
| A4                   | 3   | 08111-66504     | BD AY-WIDTH GEN  | MP43                 | 8   | 3101-0851       | CAP PUSH BUTTON |
| A5                   | 4   | 08111-66505     | BD AY VCO        |                      |     |                 |                 |
| A6                   | 5   | 08111-66506     | BD AY SHAPER     | Q3                   | 6   | 1853-0212       | XSTR 2N5194 SI  |
| A7                   | 6   | 08111-66507     | BD AY-CONTROL    | Q4                   | 5   | 1854-0368       | XSTR 2N5191     |
| A8                   | 7   | 08111-66508     | BD AY-OUTPUT     | Q7                   | 6   | 1853-0212       | XSTR 2N5194 SI  |
| A10                  | 1   | 08111-66510     | BD AY-DISPLAY    | Q8                   | 5   | 1854-0368       | XSTR 2N5191     |
| A11                  | 2   | 08111-66511     | BD AY-SWITCH UPR | R1                   | 4   | 0698-8827       | R-F 1M 1% .125W |
| A12                  | 3   | 08111-66512     | BD AY-SWITCH LOW | R101                 | 0   | 2100-3959       | R-VAR 5K 20%    |
|                      |     |                 |                  | R102                 | 3   | 2100-3960       | R-VAR 5K 20%    |
| A13                  | 4   | 08111-66513     | BD AY-SW & FUSE  | R103                 | 8   | 2100-3981       | R-VAR 10K 10%   |
|                      |     |                 |                  | R104                 | 9   | 2100-3958       | R-VAR 1K 20%    |
| C1                   | 8   | 0160-4323       | C-F 0.047UF 20%  | R105                 | 2   | 2100-3977       | R-VAR 10K 20%   |
| F1                   | 1   | 2110-0202       | FUSE .5A 250V    | S2                   | 6   | 3101-1261       | SW PBTN SPDT    |
| F2                   | 0   | 2110-0201       | FUSE 250V.25A SB |                      |     |                 |                 |
| J1                   | 3   | 1250-0118       | CONN BNC BLKHD   | T1                   | 6   | 08111-61101     | XFMR-PWR        |
| J2                   | 3   | 1250-0118       | CONN BNC BLKHD   |                      |     |                 |                 |
| J3                   | 3   | 1250-0118       | CONN BNC BLKHD   | W1                   | 1   | 08111-61601     | CBL AY SIG OUT  |
|                      |     |                 |                  | W2                   | 2   | 08111-61602     | CBL AY TRIG OUT |
| L1                   | 5   | 9170-0013       | CORE FERRA .375  |                      |     |                 |                 |
| L2                   | 5   | 9170-0013       | CORE FERRA .375  |                      |     |                 |                 |
| L3                   | 5   | 9170-0013       | CORE FERRA .375  |                      |     |                 |                 |
| MP1                  | 1   | 4040-1968       | PANEL FRONT      |                      |     |                 |                 |
| MP2                  | 9   | 08111-00201     | PANEL SUB        |                      |     |                 |                 |
| MP3                  | 8   | 08111-01208     | BRACKET-SUB-PNL  |                      |     |                 |                 |
| MP4                  | 9   | 08111-01209     | BRACKET-SUB PNL  |                      |     |                 |                 |
| MP6                  | 1   | 08111-01201     | BRKT-FRONT       |                      |     |                 |                 |
| MP7                  | 2   | 08111-01202     | BRKT-BOTTOM      |                      |     |                 |                 |
| MP8                  | 4   | 08111-01204     | BRKT-POWER       |                      |     |                 |                 |
| MP9                  | 5   | 08111-01205     | BRKT-XFMR        |                      |     |                 |                 |
| MP10                 | 6   | 08111-01206     | BRKT-SIDE LEFT   |                      |     |                 |                 |
| MP11                 | 7   | 08111-01207     | BRKT-SIDE RIGHT  |                      |     |                 |                 |
| MP12                 | 5   | 08111-02302     | HT-SNK-XSTR      |                      |     |                 |                 |
| MP13                 | 8   | 08111-02305     | HT-SNK OUT HLDR  |                      |     |                 |                 |
| MP14                 | 6   | 08111-04101     | COVER TOP        |                      |     |                 |                 |
| MP15                 | 7   | 08111-04102     | COVER BOTTOM     |                      |     |                 |                 |
| MP16                 | 2   | 08111-21101     | HEATSINK REAR    |                      |     |                 |                 |
| MP17                 | 8   | 5020-8813       | FRAME FRONT      |                      |     |                 |                 |
| MP18                 | 9   | 08116-21103     | FRM REAR(MODIFY) |                      |     |                 |                 |
| MP19                 | 5   | 5040-1135       | COUPLER PWR SW   |                      |     |                 |                 |
| MP20                 | 7   | 5001-0438       | TRIM STRIP       |                      |     |                 |                 |
| MP22                 | 9   | 5020-8830       | SIDE STRUTS      |                      |     |                 |                 |
| MP23                 | 8   | 5040-7201       | FOOT             |                      |     |                 |                 |
| MP24                 | 0   | 5040-7203       | TRIM STRIP       |                      |     |                 |                 |
| MP25                 | 3   | 5040-7222       | RR FEET NON-SKID |                      |     |                 |                 |
| MP26                 | 3   | 5040-9301       | PUSH ROD-SW      |                      |     |                 |                 |
| MP27                 | 9   | 5040-9323       | KEY CAP QUARTER  |                      |     |                 |                 |
| MP28                 | 7   | 8120-1689       | GERMAN PWR CORD  |                      |     |                 |                 |
| MP29                 | 5   | 1460-1345       | TILT STAND       |                      |     |                 |                 |
| MP30                 | 0   | 08111-00202     | PANEL REAR       |                      |     |                 |                 |
| MP31                 | 2   | 0370-1005       | KNOB BASE PTR    |                      |     |                 |                 |
| MP32                 | 3   | 2950-0072       | NUT HEX .25-32   |                      |     |                 |                 |
| MP33                 | 7   | 0535-0036       | NUT HEX M7X0.75  |                      |     |                 |                 |
| MP34                 | 8   | 08111-22501     | RING             |                      |     |                 |                 |
| MP35                 | 5   | 0360-1190       | TERM-LUG SLDR    |                      |     |                 |                 |
| MP36                 | 3   | 2190-0016       | WASH-LOCK INT3/8 |                      |     |                 |                 |
| MP37                 | 8   | 2950-0043       | NUT-HEX .375-32  |                      |     |                 |                 |
| MP38                 | 4   | 2190-0067       | WASH-LOCK .408ID |                      |     |                 |                 |
| MP39                 | 1   | 0590-0836       | NUT 1/4-40       |                      |     |                 |                 |

NOTE: A10 &amp; A11 ARE SUB-ASSEMBLIES OF

A40 (08111-66540) AND ARE NOT SEPARATELY

AVAILABLE.

dedicated / new parts  
-411/ 1984 -411/ 1987



Table 6-3. Replaceable Parts (cont'd)

| REFERENCE DESIGNATOR | C D | H-P PART NUMBER | DESCRIPTION      | REFERENCE DESIGNATOR | C D         | H-P PART NUMBER   | DESCRIPTION     |
|----------------------|-----|-----------------|------------------|----------------------|-------------|-------------------|-----------------|
| A1                   |     | 08111-66501     | BD AY-MOTHER     | A2                   | Q1          | 2 1853-0036       | XSTR SI 2N3906  |
| A1 C1                |     | 0180-3158       | C-F ELCO 6800UF  | A2 Q2                | 2 1853-0036 | XSTR SI 2N3906    |                 |
| A1 C2                |     | 0180-3162       | C-F ELCO 4700UF  | A2 Q5                | 1 1854-0215 | XSTR SI 2N3904    |                 |
| A1 C3                |     | 0180-3161       | C-F ELCO 3300VF  | A2 Q6                | 2 1853-0036 | XSTR SI 2N3906    |                 |
| A1 C4                |     | 0180-3161       | C-F ELCO 3300VF  | A2 Q9                | 1 1854-0637 | XSTR SI 2219A     |                 |
|                      |     |                 |                  | A2 Q10               | 9 1853-0314 | XSTR 2N2905A PNP  |                 |
| A1 CR1               | 3   | 1901-0638       | DIO AY-SI 100V   | A2 R1                | 5 0757-0349 | R-F 22.6K1%       |                 |
| A1 CR2               | 7   | 1906-0096       | DIO-FULL WAVE BR | A2 R2                | 0 0698-4483 | R-F 18.7K1%       |                 |
|                      |     |                 |                  | A2 R3                | 9 0698-4458 | R-F 590 1% .125W  |                 |
| A1 J1                | 7   | 1251-3825       | CONNECTOR, 5 PIN | A2 R4                | 2 0698-3495 | R-F 866 1% .125W  |                 |
| A1 J2                | 8   | 1251-2026       | CONN PC 36CONT R | A2 R5                | 2 2100-3349 | R-VAR 100 -+10%   |                 |
| A1 J4                | 8   | 1251-2026       | CONN PC 36CONT R |                      |             |                   |                 |
| A1 J5                | 8   | 1251-2026       | CONN PC 36CONT R | A2 R6                | 2 0698-4401 | R-F 95.3 1%       |                 |
| A1 J6                | 8   | 1251-2026       | CONN PC 36CONT R | A2 R7                | 5 0698-3456 | R-F 287K1% .125W  |                 |
|                      |     |                 |                  | A2 R8                | 7 0757-0200 | R-F 5.62K1%       |                 |
| A1 J7                | 8   | 1251-2026       | CONN PC 36CONT R | A2 R9                | 6 0698-4520 | R-F 143K1% .125W  |                 |
| A1 J8                | 8   | 1251-2026       | CONN PC 36CONT R | A2 R10               | 2 0757-0453 | R-F 30.1K1% .125W |                 |
| A1 J12               |     | 1251-7456       | CONN 25 CONT     |                      |             |                   |                 |
| A1 R12               | 1   | 0757-0197       | R-F 1.5K1% .5W   | A2 R14               | 8 0757-0178 | R-F 100 1% .25W   |                 |
| A1 R13               | 1   | 0757-0197       | R-F 1.5K1% .5W   | A2 R15               | 8 0757-0178 | R-F 100 1% .25W   |                 |
| A1 R20               | 6   | 0812-0045       | R-F .15 5% 3W    | A2 R16               | 2 0757-0411 | R-F 332 1% .125W  |                 |
| A1 R21               | 6   | 0812-0045       | R-F .15 5% 3W    | A2 R17               | 6 0698-3499 | R-F 40.2K1%       |                 |
| A1 R25               | 9   | 0757-0731       | R-F 825 1% .25W  | A2 R18               | 6 0698-3499 | R-F 40.2K1%       |                 |
|                      |     |                 |                  |                      |             |                   |                 |
| A1 R28               | 9   | 0757-0731       | R-F 825 1% .25W  | A2 R19               | 0698-4421   | R-F 249 1% .125W  |                 |
| A1 R31               | 4   | 0811-2455       | R-F 2 1% 3W      | A2 R22               | 9 0698-3153 | R-F 3.83K1%       |                 |
| A1 R32               | 4   | 0811-2455       | R-F 2 1% 3W      | A2 R23               | 4 0698-4502 | R-F 64.9K1%       |                 |
| A1 R39               | 3   | 0757-0280       | R-F 1K1% .125W F | A2 R24               | 2 0698-6887 | R-F 20.8K 5%      |                 |
| A1 R40               | 3   | 0757-0280       | R-F 1K1% .125W F | A2 R26               | 0 0757-0401 | R-F 100 1% .125W  |                 |
|                      |     |                 |                  |                      |             |                   |                 |
| A1 R41               | 3   | 0757-0280       | R-F 1K1% .125W F | A2 R27               | 0 0757-0401 | R-F 100 1% .125W  |                 |
| A1 R42               | 3   | 0757-0280       | R-F 1K1% .125W F | A2 R29               | 7 0698-8961 | R-F 909K 1% .125  |                 |
|                      |     |                 |                  | A2 R30               | 6 0698-8704 | R-F 665K          |                 |
|                      |     |                 |                  | A2 R33               | 7 0698-4521 | R-F 154K1% .125W  |                 |
|                      |     |                 |                  | A2 R34               | 9 0698-8038 | R-F 5.9K K%       |                 |
| A2                   |     | 08111-66502     | BD AY-REGULATOR  | A2 R35               | 2 0698-3247 | R-F 4.53K.25%     |                 |
| A2 C5                | 6   | 0180-0228       | C-F 22UF 15V     | A2 R36               | 0 0757-0401 | R-F 100 1% .125W  |                 |
| A2 C6                | 1   | 0160-3724       | C-F .47UF 40V    | A2 R37               | 5 2100-3350 | R-VAR 200 10%     |                 |
| A2 C7                |     | 0180-3163       | C-F 220UF 10V AL | A2 R38               | 3 0757-0280 | R-F 1K1% .125W F  |                 |
| A2 C9                | 8   | 0160-4365       | C-F 470PF 5%     | A2 R40               | 1810-0567   | R-NETWORK 8X20K   |                 |
| A2 C11               | 3   | 0160-2306       | CAP 27PF 5% 300V |                      |             |                   |                 |
|                      |     |                 |                  | A2 R41               | 3 1810-0037 | R-NETWORK DIP     |                 |
| A2 C12               | 5   | 0180-2207       | C-F 100UF 10V    |                      |             |                   |                 |
| A2 C14               | 0   | 0140-0193       | C-F 82PF 300V    | A2 U1                | 7 1826-0161 | IC-LM 324N        |                 |
| A2 C15               |     | 0180-3156       | C-F ELCO 47UF63V | A2 U2                | 7 1826-0161 | IC-LM 324N        |                 |
| A2 C17               | 3   | 0140-0196       | C-F 150PF 300V   | A2 U3                | 9 1826-0147 | IC V RGLTR        |                 |
| A2 C18               |     | 0180-3156       | C-F ELCO 47UF63V | A2 U4                | 6 1826-0277 | IC LM 320 V RGLT  |                 |
|                      |     |                 |                  |                      |             |                   |                 |
| A2 C20               | 3   | 0180-0291       | C-F 1UF 35V      | A2 VR1               | 7 1902-0680 | DIO 6.2V 5% .25W  |                 |
|                      |     |                 |                  | A2 VR2               | 8 1902-0962 | DIODE,ZENER       |                 |
| A2 CR3               | 1   | 1901-1098       | DIO-SWIT.1N4150  | A2 VR3               | 8 1902-0962 | DIODE,ZENER       |                 |
| A2 CR4               | 1   | 1901-1098       | DIO-SWIT.1N4150  |                      |             |                   |                 |
| A2 CR5               | 1   | 1901-1098       | DIO-SWIT.1N4150  | A4                   |             | 08111-66504       | BD AY-WIDTH GEN |
| A2 CR6               | 1   | 1901-1098       | DIO-SWIT.1N4150  | A4 C1                | 6 0121-0165 | C-VAR 7-25PF      |                 |
| A2 CR7               | 1   | 1901-1098       | DIO-SWIT.1N4150  | A4 C2                | 3 0160-3875 | C-F 22PF 5% 200V  |                 |
|                      |     |                 |                  | A4 C3                | 2 0160-2454 | C-F 620PF 300V    |                 |
| A2 CR8               | 1   | 1901-1098       | DIO-SWIT.1N4150  | A4 C4                | 7 0160-4348 | C-F 6800PF 100V   |                 |
| A2 CR9               | 1   | 1901-1098       | DIO-SWIT.1N4150  | A4 C5                | 9 0160-4580 | C-F .068UF 1%     |                 |
| A2 CR10              | 1   | 1901-1098       | DIO-SWIT.1N4150  |                      |             |                   |                 |
| A2 CR11              | 1   | 1901-1098       | DIO-SWIT.1N4150  | A4 C6                | 4 0160-4577 | C-F .68UF 1% 40V  |                 |
| A2 CR12              | 1   | 1901-1098       | DIO-SWIT.1N4150  | A4 C7                | 2 0160-4575 | C-F 6.8UF 2% 40V  |                 |
|                      |     |                 |                  | A4 C8                | 9 0160-0174 | C-F .47UF 25VCER  |                 |
| A2 CR13              | 1   | 1901-1098       | DIO-SWIT.1N4150  | A4 C9                | 9 0160-0174 | C-F .47UF 25VCER  |                 |
| A2 CR14              | 1   | 1901-1098       | DIO-SWIT.1N4150  | A4 C10               | 3 0160-4386 | C-F 33PF 5% 200V  |                 |
|                      |     |                 |                  |                      |             |                   |                 |
| A2 MP1               | 3   | 4040-0748       | PC EXTR BD BLK   |                      |             |                   |                 |
| A2 MP2               | 7   | 4040-0750       | PC EXTR BD RED   |                      |             |                   |                 |
| A2 MP3               |     | 1205-0295       | HEAT-SINK        |                      |             |                   |                 |
| A2 MP4               |     | 1205-0295       | HEAT-SINK        |                      |             |                   |                 |

Table 6-3. Replaceable Parts (cont'd)

| REFERENCE DESIGNATOR |      |   |           | H-P PART NUMBER |         |         |       | DESCRIPTION |     |           |                  | REFERENCE DESIGNATOR |        |         |    | H-P PART NUMBER |   |           |                 | DESCRIPTION |        |       |  |
|----------------------|------|---|-----------|-----------------|---------|---------|-------|-------------|-----|-----------|------------------|----------------------|--------|---------|----|-----------------|---|-----------|-----------------|-------------|--------|-------|--|
| C D                  |      |   |           |                 |         |         |       |             |     |           |                  | C D                  |        |         |    |                 |   |           |                 |             |        |       |  |
| A4                   | C11  | 7 | 0160-3879 | C-F             | .01UF   | 100V    | A4    | R31         | 5   | 0698-4123 | R-F              | 499                  | 1%     | .125W   | A4 | R32             | 0 | 0757-0401 | R-F             | 100         | 1%     | .125W |  |
| A4                   | C12  | 9 | 0160-0174 | C-F             | .47UF   | 25VCER  | A4    | R33         | 5   | 0757-0290 | R-F              | 6.19K1%              |        |         | A4 | R34             | 5 | 2100-3350 | R-VAR           | 200         | 10%    |       |  |
| A4                   | C13  | 5 | 0160-0576 | C-F             | .1UF    | 20% CER | A4    | R35         | 9   | 0757-0418 | R-F              | 619                  | 1%     | .125W   | A4 | R36             | 9 | 0757-0442 | R-F             | 10K1%       | .125W  |       |  |
| A4                   | C14  | 1 | 0180-0116 | C-F             | 6.8UF   | 35V TA  | A4    | R37         | 9   | 0757-0442 | R-F              | 10K1%                | .125W  |         | A4 | R39             | 3 | 0698-4428 | R-F             | 1.69K1%     |        |       |  |
| A4                   | C15  | 7 | 0160-3879 | C-F             | .01UF   | 100V    | A4    | R40         | 0   | 0698-4433 | R-F              | 2.26K1%              |        |         | A4 | R41             | 1 | 2100-3273 | R-VAR           | 2K          | 10%    |       |  |
| A4                   | C16  | 5 | 0160-0576 | C-F             | .1UF    | 20% CER | A4    | R42         | 5   | 0757-0274 | R-F              | 1.21K1%              |        |         | A4 | R43             | 0 | 0698-3245 | R-F             | 20.5K1%     |        |       |  |
| A4                   | C17  | 3 | 0180-0291 | C-F             | .1UF    | 35V     | A4    | R44         | 3   | 0757-0438 | R-F              | 5.11K1%              |        |         | A4 | R45             | 9 | 0698-0084 | R-F             | 2.15K       | 1%     | .125  |  |
| A4                   | C18  | 4 | 0160-4527 | C-F             | 56PF    | 5% 200V | A4    | R47         | 9   | 0757-0442 | R-F              | 10K1%                | .125W  |         | A4 | R55             | 7 | 0698-3432 | R-F             | 26.1        | 1%     |       |  |
| A4                   | C19  | 5 | 0160-0576 | C-F             | .1UF    | 20% CER | A4    | R57         | 3   | 0698-4014 | R-F              | 787                  | 1%     | .125W   | A4 | R60             | 9 | 0757-0442 | R-F             | 10K1%       | .125W  |       |  |
| A4                   | C21  | 5 | 0160-0576 | C-F             | .1UF    | 20% CER | A4    | R62         | 6   | 0757-0465 | R-F              | 100K1%               | .125W  |         | A4 | R63             | 4 | 0757-0405 | RES             | 162         | 1%     | .125W |  |
| A4                   | C22  | 5 | 0160-0576 | C-F             | .1UF    | 20% CER | A4    | U1          | 7   | 1826-0111 | IC-DUAL OP AMPL  |                      |        |         | A4 | U2              | 7 | 1826-0111 | IC-DUAL OP AMPL |             |        |       |  |
| A4                   | CR2  | 8 | 1901-0047 | DIO SI          | 20V     | 10NS    | A4    | U3          | 7   | 1826-0161 | IC-LM 324N       |                      |        |         | A4 | U4              | 7 | 1826-0161 | IC-LM 324N      |             |        |       |  |
| A4                   | CR3  | 1 | 1901-1098 | DIO-SWIT.       | 1N4150  |         | A4    | U5          | 3   | 1820-1216 | IC-SN74LS138     |                      |        |         | A4 | U6              | 1 | 1820-0802 | IC-ECL 10102    |             |        |       |  |
| A4                   | CR4  | 1 | 1901-1098 | DIO-SWIT.       | 1N4150  |         | A4    | U7          | 8   | 1820-0817 | IC DGTL MC 10131 |                      |        |         | A4 | U8              | 3 | 1826-0026 | IC-DGTL LM311H  |             |        |       |  |
| A4                   | CR5  | 1 | 1901-1098 | DIO-SWIT.       | 1N4150  |         | A4    | VR1         | 6   | 1902-0944 | DIODE-ZENER      |                      |        |         | A4 | VR2             | 2 | 1902-0958 | DIO ZNR 10V 5%  |             |        |       |  |
| A4                   | CR8  | 1 | 1901-1098 | DIO-SWIT.       | 1N4150  |         | A5    |             |     |           |                  |                      |        |         |    |                 |   |           |                 |             |        |       |  |
| A4                   | CR9  | 1 | 1901-1098 | DIO-SWIT.       | 1N4150  |         |       |             |     |           |                  |                      |        |         |    |                 |   |           |                 |             |        |       |  |
| A4                   | CR10 | 1 | 1901-1098 | DIO-SWIT.       | 1N4150  |         |       |             |     |           |                  |                      |        |         |    |                 |   |           |                 |             |        |       |  |
| A4                   | CR11 | 1 | 1901-1098 | DIO-SWIT.       | 1N4150  |         |       |             |     |           |                  |                      |        |         |    |                 |   |           |                 |             |        |       |  |
| A4                   | CR12 | 7 | 1901-0179 | DIO SI          | 15V     | .75NS   |       |             |     |           |                  |                      |        |         |    |                 |   |           |                 |             |        |       |  |
| A4                   | L1   | 0 | 9100-2251 | COIL-CHOKE      | .22UH   |         |       |             |     |           |                  |                      |        |         |    |                 |   |           |                 |             |        |       |  |
| A4                   | MP1  | 3 | 4040-0748 | PC EXTR BD      | BLK     |         |       |             |     |           |                  |                      |        |         |    |                 |   |           |                 |             |        |       |  |
| A4                   | MP2  | 9 | 4040-0752 | PC EXTR BD      | YEL     |         |       |             |     |           |                  |                      |        |         |    |                 |   |           |                 |             |        |       |  |
| A4                   | Q1   | 2 | 1854-0795 | XSTR MPS-H10    |         |         |       |             |     |           |                  |                      |        |         |    |                 |   |           |                 |             |        |       |  |
| A4                   | Q2   | 2 | 1854-0795 | XSTR MPS-H10    |         |         |       |             |     |           |                  |                      |        |         |    |                 |   |           |                 |             |        |       |  |
| A4                   | Q3   | 2 | 1854-0795 | XSTR MPS-H10    |         |         |       |             |     |           |                  |                      |        |         |    |                 |   |           |                 |             |        |       |  |
| A4                   | Q4   | 2 | 1853-0036 | XSTR SI 2N3906  |         |         |       |             |     |           |                  |                      |        |         |    |                 |   |           |                 |             |        |       |  |
| A4                   | Q5   | 2 | 1853-0036 | XSTR SI 2N3906  |         |         |       |             |     |           |                  |                      |        |         |    |                 |   |           |                 |             |        |       |  |
| A4                   | Q6   | 2 | 1853-0036 | XSTR SI 2N3906  |         |         |       |             |     |           |                  |                      |        |         |    |                 |   |           |                 |             |        |       |  |
| A4                   | Q7   | 2 | 1853-0036 | XSTR SI 2N3906  |         |         |       |             |     |           |                  |                      |        |         |    |                 |   |           |                 |             |        |       |  |
| A4                   | Q8   | 2 | 1853-0036 | XSTR SI 2N3906  |         |         |       |             |     |           |                  |                      |        |         |    |                 |   |           |                 |             |        |       |  |
| A4                   | Q9   | 2 | 1853-0036 | XSTR SI 2N3906  |         |         |       |             |     |           |                  |                      |        |         |    |                 |   |           |                 |             |        |       |  |
| A4                   | Q10  | 7 | 1853-0354 | XSTR MPS H81    |         |         |       |             |     |           |                  |                      |        |         |    |                 |   |           |                 |             |        |       |  |
| A4                   | Q11  | 7 | 1853-0354 | XSTR MPS H81    |         |         |       |             |     |           |                  |                      |        |         |    |                 |   |           |                 |             |        |       |  |
| A4                   | Q14  | 2 | 1853-0036 | XSTR SI 2N3906  |         |         |       |             |     |           |                  |                      |        |         |    |                 |   |           |                 |             |        |       |  |
| A4                   | Q15  | 7 | 1853-0354 | XSTR MPS H81    |         |         |       |             |     |           |                  |                      |        |         |    |                 |   |           |                 |             |        |       |  |
| A4                   | R1   | 6 | 0757-0407 | R-F             | 200     | 1%      | .125W | A5          | C1  | 0         | 0160-4383        | C-F                  | 6.8PF  | 200V    | A5 | C2              | 8 | 0160-4521 | C-F             | 12PF        | 5%     | 200V  |  |
| A4                   | R2   | 9 | 0698-3442 | R-F             | 237     | 1%      | .125W | A5          | C3  | 6         | 0121-0165        | C-VAR                | 7-25PF |         | A5 | C4              | 1 | 0160-4318 | C-F             | 330PF       | 1%     |       |  |
| A4                   | R3   | 8 | 0757-0417 | R-F             | 562     | 1%      | .125W | A5          | C5  | 9         | 0160-2675        | C-F                  | 3900PF | 300V    | A5 | C6              |   | 0160-5423 | C-F             | .039UF      | 2%     |       |  |
| A4                   | R4   | 2 | 0698-3437 | R-F             | 133     | 1%      | .125W | A5          | C7  |           | 0160-5425        | C-F                  | .39UF  | 2% 40V  | A5 | C8              |   | 0160-5460 | C-F             | 3.9UF       | 63VDC  |       |  |
| A4                   | R5   | 9 | 0757-0278 | R-F             | 1.78K1% |         |       | A5          | C10 | 9         | 0180-0354        | C-F                  | 40UF   | 10V     | A5 | C11             | 2 | 0160-4492 | C-F             | 40UF        | 10V    |       |  |
| A4                   | R6   | 8 | 0757-0433 | R-F             | 3.32K1% |         |       | A5          | C13 | 4         | 0160-0575        | C-F                  | .047UF | CER     | A5 | C14             | 9 | 0160-0174 | C-F             | .47UF       | 25VCER |       |  |
| A4                   | R7   | 0 | 0698-4425 | R-F             | 1.54K1% |         |       | A5          | C15 | 1         | 0160-0572        | C-F                  | 2200PF | CER     | A5 | C16             | 7 | 0160-3879 | C-F             | .01UF       | 100V   |       |  |
| A4                   | R8   | 0 | 0698-4037 | R-F             | 46.4    | 1%      |       | A5          | C17 | 4         | 0160-0575        | C-F                  | .047UF | CER     | A5 | C18             | 9 | 0160-0174 | C-F             | .47UF       | 25VCER |       |  |
| A4                   | R9   | 7 | 0698-3432 | R-F             | 26.1    | 1%      |       | A5          | C20 | 5         | 0160-0576        | C-F                  | .1UF   | 20% CER | A5 | C21             | 1 | 0160-3097 | C-F             | .47UF       | CER    |       |  |
| A4                   | R10  | 6 | 0698-3431 | R-F             | 23.7    | 1%      |       | A5          | C22 | 7         | 0160-3879        | C-F                  | .01UF  | 100V    | A5 | C24             | 7 | 0160-3879 | C-F             | .01UF       | 100V   |       |  |
| A4                   | R11  | 2 | 0698-3495 | R-F             | 866     | 1%      | .125W | A5          | CR1 | 1         | 1901-1098        | DIO-SWIT.            | 1N4150 |         | A5 | CR2             | 1 | 1901-1098 | DIO-SWIT.       | 1N4150      |        |       |  |
| A4                   | R12  | 6 | 0698-3150 | R-F             | 2.37K1% |         |       | A5          | CR3 | 1         | 1901-1098        | DIO-SWIT.            | 1N4150 |         | A5 | CR4             | 1 | 1901-1098 | DIO-SWIT.       | 1N4150      |        |       |  |
| A4                   | R13  | 0 | 0698-3443 | R-F             | 287     | 1%      | .125W | A5          | CR5 | 1         | 1901-1098        | DIO-SWIT.            | 1N4150 |         | A5 | CR6             | 8 | 1901-0047 | DIO SI          | 20V         | 10NS   |       |  |
| A4                   | R14  | 3 | 0698-4379 | R-F             | 44.2    | 1%      |       | A5          | L1  | 9         | 9100-2250        | COIL-CHOKE           | .18UH  |         | A5 | MP1             | 3 | 4040-0748 | PC EXTR BD      | BLK         |        |       |  |
| A4                   | R15  | 5 | 0699-0070 | R-F             | 3.16M   | 1%      |       | A5          |     |           |                  |                      |        |         |    |                 |   |           |                 |             |        |       |  |
| A4                   | R16  | 5 | 0699-0070 | R-F             | 3.16M   | 1%      |       |             |     |           |                  |                      |        |         |    |                 |   |           |                 |             |        |       |  |
| A4                   | R17  | 5 | 0699-0070 | R-F             | 3.16M   | 1%      |       |             |     |           |                  |                      |        |         |    |                 |   |           |                 |             |        |       |  |
| A4                   | R18  | 5 | 0699-0070 | R-F             | 3.16M   | 1%      |       |             |     |           |                  |                      |        |         |    |                 |   |           |                 |             |        |       |  |
| A4                   | R19  | 5 | 0699-0070 | R-F             | 3.16M   | 1%      |       |             |     |           |                  |                      |        |         |    |                 |   |           |                 |             |        |       |  |
| A4                   | R20  | 1 | 1810-0337 | R-NETWORK       | 8X4.7K  |         |       |             |     |           |                  |                      |        |         |    |                 |   |           |                 |             |        |       |  |
| A4                   | R21  | 4 | 0757-0398 | R-F             | 75      | 1%      | .125W |             |     |           |                  |                      |        |         |    |                 |   |           |                 |             |        |       |  |
| A4                   | R22  | 6 | 0698-3431 | R-F             | 23.7    | 1%      |       |             |     |           |                  |                      |        |         |    |                 |   |           |                 |             |        |       |  |
| A4                   | R25  | 0 | 0757-0394 | R-F             | 51.1    | 1%      |       |             |     |           |                  |                      |        |         |    |                 |   |           |                 |             |        |       |  |
| A4                   | R26  | 2 | 0698-3437 | R-F             | 133     | 1%      | .125W |             |     |           |                  |                      |        |         |    |                 |   |           |                 |             |        |       |  |
| A4                   | R27  | 1 | 1810-0275 | R-NETW          | 9X1KOHM |         |       |             |     |           |                  |                      |        |         |    |                 |   |           |                 |             |        |       |  |

Table 6-3. Replaceable Parts (cont'd)

| REFERENCE DESIGNATOR | C   | D | H-P PART NUMBER | DESCRIPTION       | REFERENCE DESIGNATOR | C   | D | H-P PART NUMBER | DESCRIPTION         |
|----------------------|-----|---|-----------------|-------------------|----------------------|-----|---|-----------------|---------------------|
| A5                   | MP2 | 0 | 4040-0753       | PC EXTR BD GRN    | A5                   | R65 | 5 | 2100-3350       | R-VAR 200 10%       |
| A5                   | Q1  | 5 | 1854-0392       | XSTR ST 2N 5088   | A5                   | R67 | 4 | 0757-0281       | R-F 2.74K1%         |
| A5                   | Q2  | 2 | 1853-0086       | XSTR SI 2N5087    | A5                   | R68 | 7 | 2100-3352       | R-VAR 1K .5W        |
| A5                   | Q3  | 2 | 1853-0086       | XSTR SI 2N5087    | A5                   | R69 | 0 | 0698-3451       | RES 133K 1% .125W   |
| A5                   | Q4  | 2 | 1853-0086       | XSTR SI 2N5087    | A5                   | R70 | 4 | 0698-8827       | R-F 1M 1% .125W     |
| A5                   | Q5  | 2 | 1853-0086       | XSTR SI 2N5087    | A5                   | R71 | 4 | 0698-8827       | R-F 1M 1% .125W     |
| A5                   | Q6  | 7 | 1853-0354       | XSTR MPS H81      | A5                   | R72 | 4 | 0698-8827       | R-F 1M 1% .125W     |
| A5                   | Q7  | 7 | 1853-0354       | XSTR MPS H81      | A5                   | R73 | 4 | 0698-8827       | R-F 1M 1% .125W     |
| A5                   | Q8  | 1 | 1854-0215       | XSTR SI 2N3904    | A5                   | R74 | 4 | 0698-8827       | R-F 1M 1% .125W     |
| A5                   | Q9  | 1 | 1854-0215       | XSTR SI 2N3904    | A5                   | R75 | 4 | 0698-8827       | R-F 1M 1% .125W     |
| A5                   | Q10 | 1 | 1854-0215       | XSTR SI 2N3904    | A5                   | R76 |   | 1810-0470       | R-NETWORK 8X2.2K    |
| A5                   | Q11 | 1 | 1854-0215       | XSTR SI 2N3904    | A5                   | R82 | 4 | 0757-0273       | R-F 3.01K1%         |
| A5                   | Q12 | 1 | 1854-0215       | XSTR SI 2N3904    | A5                   | R86 | 0 | 2100-3355       | R-VAR 100K          |
| A5                   | Q13 | 1 | 1854-0215       | XSTR SI 2N3904    | A5                   | R87 | 9 | 0698-8913       | RES.FXD. 1.5MOHM    |
| A5                   | R1  | 5 | 0698-7226       | R-F 383 1% .05W   | A5                   | R88 | 0 | 2100-3355       | R-VAR 100K          |
| A5                   | R2  | 4 | 0698-4453       | R-F 402 1% .125W  | A5                   | R89 | 9 | 0698-8913       | RES.FXD. 1.5MOHM    |
| A5                   | R3  | 0 | 0757-0401       | R-F 100 1% .125W  | A5                   | R90 | 9 | 2100-3354       | R-VAR 50K 10%       |
| A5                   | R4  | 8 | 0757-0384       | R-F 20 1% .125W   | A5                   | R91 | 4 | 0698-8827       | R-F 1M 1% .125W     |
| A5                   | R5  | 7 | 2100-3352       | R-VAR 1K .5W      | A5                   | R94 | 7 | 0698-7236       | R-F 1K 1% .05W      |
| A5                   | R6  | 1 | 0757-0428       | RES 1.62K 1% .125 | A5                   | R95 | 9 | 0757-0442       | R-F 10K1% .125W     |
| A5                   | R7  | 1 | 0757-0428       | RES 1.62K 1% .125 | A5                   | R96 | 9 | 1810-0207       | R-F ARRAY 22K       |
| A5                   | R8  | 7 | 2100-3352       | R-VAR 1K .5W      | A5                   | U1  |   | 1826-0955       | TRIANGLE/SLOPE GEN. |
| A5                   | R9  | 2 | 0698-4427       | R-F 1.55K1%       | A5                   | U2  | 7 | 1826-0111       | IC-DUAL OP AMPL     |
| A5                   | R10 | 6 | 2100-3351       | RES TRMR 500 10%  | A5                   | U3  | 7 | 1826-0111       | IC-DUAL OP AMPL     |
| A5                   | R11 | 4 | 0698-3439       | RES 178 1% .125W  | A5                   | U4  | 0 | 1826-0635       | IC LIN OP07C        |
| A5                   | R13 | 2 | 0757-0453       | R-F 30.1K1% .125W | A5                   | U6  | 7 | 1826-0161       | IC 324              |
| A5                   | R14 | 6 | 0757-0449       | R-F 20K1% .125W   | A5                   | U7  | 7 | 1826-0161       | IC 324              |
| A5                   | R15 | 7 | 0757-0200       | R-F 5.62K1%       | A5                   | U8  | 0 | 1820-0471       | IC SN7406 INVERT    |
| A5                   | R16 | 8 | 0698-3558       | R-F 4.02K1%       | A5                   | U9  | 9 | 1826-0501       | IC-CMOS 4053B       |
| A5                   | R20 | 7 | 0698-7236       | R-F 1K 1% .05W    | A5                   | U10 | 9 | 1826-0501       | IC-CMOS 4053B       |
| A5                   | R21 | 1 | 0698-3452       | R-F 147K1% .125W  | A5                   | U11 | 2 | 1820-1546       | IC-4052B            |
| A5                   | R22 | 4 | 0757-0447       | R-F 16.2K 1% .125 | A5                   | U12 | 9 | 1826-0501       | IC-CMOS 4053B       |
| A5                   | R23 | 6 | 0698-3499       | R-F 40.2K1%       | A5                   | U14 | 3 | 1820-1216       | IC-SN74LS138        |
| A5                   | R24 | 2 | 0698-3271       | R-F 115K1% .125W  | A5                   | U16 | 6 | 1820-1201       | IC-SN74LS08N        |
| A5                   | R26 | 5 | 0698-3498       | R-F 8.66K1%       | A5                   | U17 | 6 | 1820-1201       | IC-SN74LS08N        |
| A5                   | R27 | 5 | 0698-3498       | R-F 8.66K1%       | A5                   | VR2 | 7 | 1902-0961       | DIODE-ZENER         |
| A5                   | R28 | 3 | 0698-4501       | R-F 59K1% .125W   |                      |     |   |                 |                     |
| A5                   | R38 | 9 | 0698-7238       | R-F 1.21K 1% .05  | A6                   |     |   | 08111-66506     | BD AY SHAPER        |
| A5                   | R39 | 2 | 0757-0338       | R-F 1K1% .25W F   | A6                   | C1  |   | 0180-3155       | C-F ELCO 100UF      |
| A5                   | R40 | 0 | 0698-3154       | R-F 4.22K 1%      | A6                   | C2  | 5 | 0160-0576       | C-F .1UF 20% CER    |
| A5                   | R41 | 7 | 0757-0458       | R-F 51.1K1%       | A6                   | C3  | 5 | 0160-0576       | C-F .1UF 20% CER    |
| A5                   | R42 | 8 | 0698-3136       | R-F 17.8K1%       | A6                   | C4  | 5 | 0160-0576       | C-F .1UF 20% CER    |
| A5                   | R43 | 4 | 0757-0124       | R-F 39.2K1%       | A6                   | C5  | 5 | 0160-0576       | C-F .1UF 20% CER    |
| A5                   | R44 | 0 | 0698-0077       | R-F 93.1K 1%      | A6                   | C6  | 6 | 0160-3878       | C-F .001UF 100V     |
| A5                   | R45 | 9 | 0698-3484       | R-F 6.65K1%       | A6                   | C7  | 3 | 0160-3875       | C-F 22PF 5% 200V    |
| A5                   | R46 | 1 | 0698-4492       | R-F 32.4K1%       | A6                   | C8  | 9 | 0160-0174       | C-F .47UF 25V CER   |
| A5                   | R47 | 2 | 0698-4493       | R-F 34K1% .125W   | A6                   | C9  | 9 | 0160-0174       | C-F .47UF 25V CER   |
| A5                   | R48 | 9 | 0757-0442       | R-F 10K1% .125W   | A6                   | C10 | 7 | 0180-0229       | C-F 33UF 10V        |
| A5                   | R49 | 6 | 0698-3259       | R-F 7.87K1%       | A6                   | C11 | 9 | 0160-0174       | C-F .47UF 25V CER   |
| A5                   | R50 | 1 | 2100-3273       | R-VAR 2K 10%      | A6                   | C12 | 4 | 0160-4527       | C-F 56PF 5% 200V    |
| A5                   | R51 | 1 | 0757-0428       | RES 1.62K 1% .125 | A6                   | C13 | 5 | 0160-0576       | C-F .1UF 20% CER    |
| A5                   | R52 | 6 | 2100-3351       | RES TRMR 500 10%  | A6                   | C14 | 9 | 0160-0174       | C-F .47UF 25V CER   |
| A5                   | R53 | 4 | 0757-0281       | R-F 2.74K1%       | A6                   | C15 | 9 | 0160-0174       | C-F .47UF 25V CER   |
| A5                   | R54 | 1 | 2100-3273       | R-VAR 2K 10%      | A6                   | C16 | 5 | 0160-0576       | C-F .1UF 20% CER    |
| A5                   | R55 | 3 | 0757-0438       | R-F 5.11K1%       | A6                   | C17 | 3 | 0160-3875       | C-F 22PF 5% 200V    |
| A5                   | R56 | 6 | 0698-4447       | R-F 280 1% .125W  | A6                   | CR1 | 8 | 1901-0047       | DIO SI 20V 10NS     |
| A5                   | R57 | 8 | 0698-4308       | R-F 16.9K 1% 1/8W | A6                   | CR2 | 8 | 1901-0047       | DIO SI 20V 10NS     |
| A5                   | R58 | 1 | 0698-4468       | R-F 1130 1% 1/8W  | A6                   | CR3 | 8 | 1901-0047       | DIO SI 20V 10NS     |
| A5                   | R59 | 1 | 0698-4468       | R-F 1130 1% 1/8W  | A6                   | CR4 | 8 | 1901-0047       | DIO SI 20V 10NS     |
| A5                   | R60 | 9 | 0757-0418       | R-F 619 1% .125W  | A6                   | L1  | 4 | 9100-2247       | COIL-CHOKE .10UH    |
| A5                   | R61 | 2 | 0698-3700       | R-F 715 1% .125W  |                      |     |   |                 |                     |
| A5                   | R62 | 2 | 0698-3700       | R-F 715 1% .125W  |                      |     |   |                 |                     |
| A5                   | R63 | 5 | 0757-0464       | R-F 90.9K1%       |                      |     |   |                 |                     |
| A5                   | R64 | 7 | 0698-7195       | R-F 19.6 1% .05W  |                      |     |   |                 |                     |

Table 6-3. Replaceable Parts (cont'd)

| REFERENCE DESIGNATOR |     | C D | H-P PART NUMBER | DESCRIPTION      | REFERENCE DESIGNATOR |     | C D | H-P PART NUMBER | DESCRIPTION      |
|----------------------|-----|-----|-----------------|------------------|----------------------|-----|-----|-----------------|------------------|
| A6                   | MP1 | 3   | 4040-0748       | EXTR-PC-BD POLYC | A7                   |     |     | 08111-66507     | BD AY-CONTROL    |
| A6                   | MP2 | 1   | 4040-0754       | PC EXTR BD BLU   |                      |     |     |                 |                  |
| A6                   | Q1  | 9   | 1853-0075       | XSTR SI PNP      | A7                   | C1  | 9   | 0160-0174       | C-F .47UF 25VCER |
| A6                   | Q2  | 2   | 1853-0218       | XSTR SI PNP      | A7                   | C2  | 9   | 0160-0174       | C-F .47UF 25VCER |
| A6                   | Q3  | 2   | 1853-0036       | XSTR SI 2N3906   | A7                   | C3  | 4   | 0180-3155       | C-F ELCO 100UF   |
| A6                   | Q4  | 7   | 1854-0477       | XSTR NPN 2N2222A | A7                   | C4  | 4   | 0180-3155       | C-F ELCO 100UF   |
| A6                   | Q5  | 2   | 1854-0795       | XSTR MPS-H10     | A7                   | C5  | 9   | 0160-0174       | C-F .47UF 25VCER |
| A6                   | R1  | 1   | 1810-0275       | R-NETW 9X1KOHM   | A7                   | C6  | 5   | 0160-0576       | C-F .1UF 20% CER |
| A6                   | R2  | 3   | 0757-0280       | R-F 1K 1% .125W  | A7                   | C7  | 5   | 0160-0576       | C-F .1UF 20% CER |
| A6                   | R3  | 9   | 0698-3202       | R-F 1.74K1%      | A7                   | C8  | 5   | 0160-0576       | C-F .1UF 20% CER |
| A6                   | R4  | 9   | 0757-1094       | R-F 1.47K1%      | A7                   | C9  | 9   | 0160-0174       | C-F .47UF 25VCER |
| A6                   | R5  | 0   | 0698-4037       | R-F 46.4 1%      | A7                   | C10 | 9   | 0160-0174       | C-F .47UF 25VCER |
| A6                   | R6  | 7   | 2100-3352       | R-VAR 1K .5W     | A7                   | CR1 | 0   | 1901-0734       | DIO-IN5818       |
| A6                   | R8  | 4   | 0698-3132       | 3-F 261 1% .125W |                      |     |     |                 |                  |
| A6                   | R9  | 1   | 0757-0428       | 3-F 1.62K 1%     | A7                   | MP1 | 3   | 4040-0748       | EXTR-PC-BD POLYC |
| A6                   | R10 | 7   | 2100-3352       | R-VAR 1K .5W     | A7                   | MP2 | 2   | 4040-0755       | PC EXTR BD VIO   |
| A6                   | R11 | 1   | 0757-0428       | R-F 1.62K 1%     | A7                   | R1  | 8   | 1810-0280       | R-NETWORK 9X10K  |
| A6                   | R12 | 4   | 0698-3132       | R-F 261 1% .125W | A7                   | R2  | 5   | 0698-4123       | R-F 499 1% .125W |
| A6                   | R13 | 8   | 0698-3136       | R-F 17.8K1%      | A7                   | R3  | 9   | 0757-0442       | R-F 10K1% .125W  |
| A6                   | R14 | 0   | 2100-3355       | R-VAR 100K       | A7                   | R4  | 9   | 0757-0442       | R-F 10K1% .125W  |
| A6                   | R15 | 0   | 2100-3355       | R-VAR 100K       | A7                   | R7  | 5   | 0698-4123       | R-F 499 1% .125W |
| A6                   | R16 | 0   | 2100-3355       | R-VAR 100K       | A7                   | R9  | 9   | 0757-0442       | R-F 10K1% .125W  |
| A6                   | R17 | 8   | 2100-3353       | R-VAR 20K .5W    |                      |     |     |                 |                  |
| A6                   | R18 | 8   | 2100-3353       | R-VAR 20K .5W    | A7                   | U1  | 5   | 1820-1416       | IC SN74LS14N.    |
| A6                   | R19 | 8   | 0757-0277       | R-F 49.9 1%      | A7                   | U2  | 4   | 1820-1423       | IC SN74LS123N    |
| A6                   | R20 | 8   | 0757-0277       | R-F 49.9 1%      | A7                   | U3  | 1   | 1820-1199       | IC SN74LS04N     |
| A6                   | R21 | 9   | 0698-7238       | R-F 1.21K 1%.05  | A7                   | U4  | 1   | 1820-1199       | IC SN74LS04N     |
| A6                   | R22 | 3   | 0757-0280       | R-F 1K 1% .125W  | A7                   | U6  | 6   | 1820-1144       | IC SN74LS02N     |
| A6                   | R23 | 8   | 2100-3353       | R-VAR 20K .5W    | A7                   | U7  | 6   | 1820-1144       | IC SN74LS02N     |
| A6                   | R24 | 1   | 2100-3273       | R-VAR 2K 10%     |                      |     |     |                 |                  |
| A6                   | R25 | 8   | 0698-3558       | R-F 4.02K1%      | A7                   | U8  | 7   | 1820-1202       | IC SN74LS10N     |
| A6                   | R26 | 8   | 0757-0433       | R-F 3.32K1%      | A7                   | U9  | 7   | 1820-1202       | IC SN74LS10N     |
| A6                   | R27 | 7   | 2100-3352       | R-VAR 1K .5W     | A7                   | U10 | 6   | 1820-1243       | IC SN 74LS15N    |
| A6                   | R28 | 9   | 0698-3434       | R-F 34.8 1%      | A7                   | U11 | 6   | 1820-1243       | IC SN 74LS15N    |
| A6                   | R29 | 0   | 0698-4409       | R-F 127 1% .125W | A7                   | U12 | 6   | 1820-1194       | IC SN74LS193N    |
| A6                   | R30 | 3   | 0757-0280       | R-F 1K 1% .125W  | A7                   | U13 | 6   | 1820-1194       | IC SN74LS193N    |
| A6                   | R31 | 3   | 0757-0280       | R-F 1K 1% .125W  | A7                   | U14 | 1   | 1820-1470       | IC SN74LS157N    |
| A6                   | R32 | 0   | 0698-4409       | R-F 127 1% .125W | A7                   | U15 | 3   | 1820-1216       | IC SN74LS138N    |
| A6                   | R33 | 1   | 2100-3273       | R-VAR 2K 10%     | A7                   | U16 | 8   | 1820-1112       | IC SN74LS74AN    |
| A6                   | R34 | 5   | 0698-3430       | R-F 21.5 1%.125W |                      |     |     |                 |                  |
| A6                   | R35 | 5   | 0698-3430       | R-F 21.5 1%.125W | A8                   |     |     | 08111-66508     | BD AY-OUTPUT     |
| A6                   | R36 | 1   | 2100-3207       | R-VAR 5K 10%     |                      |     |     |                 |                  |
| A6                   | R37 | 1   | 0757-0999       | R-F 47.5 1% .5W  | A8                   | C1  | 3   | 0160-4493       | C-F 27PF 5% 200V |
| A6                   | R38 | 1   | 0757-0999       | R-F 47.5 1% .5W  | A8                   | C2  | 6   | 0180-3157       | C-F ELCO 47UF40V |
| A6                   | R39 | 0   | 0757-0401       | R-F 100 1% .125W | A8                   | C3  | 6   | 0180-3157       | C-F ELCO 47UF40V |
| A6                   | R40 | 0   | 0757-0401       | R-F 100 1% .125W | A8                   | C4  | 0   | 0160-4383       | C-F 6.8PF 200V   |
| A6                   | R41 | 6   | 0698-4421       | R-F 249 1% .125W | A8                   | C5  | 6   | 0160-3878       | C-F .001UF 100V  |
| A6                   | R42 | 1   | 0698-7222       | R-F 261 1% .05W  | A8                   | C6  | 1   | 0160-3097       | C-F .47UF CER    |
| A6                   | R43 | 5   | 0698-4123       | R-F 499 1% .125W |                      |     |     |                 |                  |
| A6                   | R44 | 8   | 0757-0277       | R-F 49.9 1%      | A8                   | C7  | 1   | 0160-3097       | C-F .47UF CER    |
| A6                   | R45 | 0   | 0757-0401       | R-F 100 1% .125W | A8                   | C8  | 3   | 0160-3875       | C-F 22PF 5% 200V |
| A6                   | R46 | 8   | 0757-0277       | R-F 49.9 1%      | A8                   | C9  | 3   | 0160-3875       | C-F 22PF 5% 200V |
| A6                   | R47 | 0   | 0698-4392       | R-F 71.5 1/8W 1% | A8                   | C10 | 7   | 0160-3879       | C-F .01UF 100V   |
| A6                   | R48 | 5   | 0698-7226       | R-F 383 1% .05W  | A8                   | C11 | 8   | 0160-4381       | C-F 1.5PF 200V   |
| A6                   | R49 | 0   | 0757-0443       | R-F 11K1% .125W  |                      |     |     |                 |                  |
| A6                   | R50 | 8   | 2100-3353       | R-VAR 20K .5W    | A8                   | C12 | 5   | 0160-0576       | C-F .1UF 20% CER |
| A6                   | R51 | 7   | 0757-0284       | R-F 150 1% .125W | A8                   | C13 | 5   | 0160-0576       | C-F .1UF 20% CER |
| A6                   | R52 | 9   | 0757-0442       | R-F 10K1% .125W  | A8                   | C14 | 2   | 0121-0525       | C-VAR 1-3PF NPO  |
| A6                   | U1  | 2   | 1820-1546       | ANLG MUXR        | A8                   | C15 | 5   | 0160-0576       | C-F .1UF 20% CER |
| A6                   | U2  | 4   | 5180-2417       | SHAPER SEL TEMP  | A8                   | C16 | 5   | 0160-0576       | C-F .1UF 20% CER |
| A6                   | U3  | 1   | 1820-0802       | IC MC10102P      |                      |     |     |                 |                  |
| A6                   | U4  | 5   | 1820-1052       | IC MC10125L      | A8                   | C17 | 5   | 0160-0576       | C-F .1UF 20% CER |
| A6                   | VR1 | 6   | 1902-3097       | DIO 5.23V 2% .4W | A8                   | C18 | 5   | 0180-0582       | C-F 270UF 40V    |
|                      |     |     |                 |                  | A8                   | C19 | 5   | 0180-0582       | C-F 270UF 40V    |
|                      |     |     |                 |                  | A8                   | C20 | 2   | 0160-4492       | C-F 18PF 200V    |

Table 6-3. Replaceable Parts (cont'd)

| REFERENCE DESIGNATOR | C | D           | H-P PART NUMBER   | DESCRIPTION | REFERENCE DESIGNATOR | C | D           | H-P PART NUMBER  | DESCRIPTION |
|----------------------|---|-------------|-------------------|-------------|----------------------|---|-------------|------------------|-------------|
| A8 C21               | 1 | 0160-3097   | C-F .47UF CER     |             | A8 R24               | 6 | 0757-0407   | R-F 200 1% .125W |             |
| A8 C22               | 4 | 0180-3155   | C-F ELCO 100UF    |             | A8 R25               | 8 | 0698-3558   | R-F 4.02K1%      |             |
| A8 C23               | 5 | 0160-0576   | C-F .1UF 20% CER  |             | A8 R26               | 8 | 0698-3558   | R-F 4.02K1%      |             |
| A8 C24               | 1 | 0160-3097   | C-F .47UF CER     |             |                      |   |             |                  |             |
| A8 C25               | 1 | 0160-3097   | C-F .47UF CER     |             | A8 R27               | 6 | 0757-0407   | R-F 200 1% .125W |             |
|                      |   |             |                   |             | A8 R29               | 1 | 0757-0428   | R-F 1.62K 1%     |             |
| A8 C26               | 0 | 0160-0571   | C-F 470PF20% CER  |             | A8 R30               | 1 | 0757-0428   | R-F 1.62K 1%     |             |
| A8 C27               | 4 | 0160-4387   | C-F 47PF 200V     |             | A8 R31               | 1 | 0698-4442   | R-F 4.42K1%      |             |
| A8 C28               | 8 | 0160-4381   | C-F 1.5PF 200V    |             | A8 R32               | 1 | 0698-4442   | R-F 4.42K1%      |             |
|                      |   |             |                   |             | A8 R33               | 9 | 0757-0830   | R-F 3.92K1% .5W  |             |
| A8 CR1               | 7 | 1901-0179   | DIO SI 15V .75NS  |             |                      |   |             |                  |             |
| A8 CR2               | 7 | 1901-0179   | DIO SI 15V .75NS  |             | A8 R34               | 7 | 0698-7195   | R-F 19.6 1% .05W |             |
| A8 CR3               | 7 | 1901-0179   | DIO SI 15V .75NS  |             | A8 R35               | 8 | 0698-7196   | R-F 21.5 2% .05W |             |
| A8 CR4               | 7 | 1901-0179   | DIO SI 15V .75NS  |             | A8 R36               | 7 | 0698-7236   | R-F 1K 1% .05W   |             |
| A8 CR5               | 7 | 1901-0179   | DIO SI 15V .75NS  |             | A8 R37               | 1 | 0698-7222   | R-F 261 1% .05W  |             |
| A8 CR6               | 7 | 1901-0179   | DIO SI 15V .75NS  |             | A8 R38               | 8 | 0698-7196   | R-F 21.5 2% .05W |             |
|                      |   |             |                   |             |                      |   |             |                  |             |
| A8 K1                | 5 | 0490-1137   | RELAY-REED 5V     |             | A8 R39               | 7 | 0698-7195   | R-F 19.6 1% .05W |             |
| A8 K2                | 5 | 0490-1137   | RELAY-REED 5V     |             | A8 R40               | 8 | 0698-7188   | R-F 10 2% .050W  |             |
| A8 K3                | 5 | 0490-1137   | RELAY-REED 5V     |             | A8 R41               | 8 | 0698-7188   | R-F 10 2% .050W  |             |
|                      |   |             |                   |             | A8 R42               | 1 | 0757-0428   | R-F 1.62K 1%     |             |
| A8 L1                | 0 | 9170-0894   | CORE MAGNETIC     |             | A8 R43               | 1 | 0757-0428   | R-F 1.62K 1%     |             |
| A8 *L2               | 0 | 9170-0894   | CORE MAGNETIC     |             |                      |   |             |                  |             |
|                      |   |             |                   |             | A8 R44               | 2 | 0757-0346   | R-F 10 1% .125W  |             |
| A8 MP1               | 3 | 4040-0748   | EXTR-PC-BD POLYC  |             | A8 R45               | 2 | 0757-0346   | R-F 10 1% .125W  |             |
| A8 MP2               | 2 | 4040-0747   | PC EXTR BD GRA    |             | A8 R46               | 2 | 0757-0346   | R-F 10 1% .125W  |             |
| A8 MP3               | 6 | 08111-02303 | HEATSINK THERMO   |             | A8 R47               | 2 | 0757-0346   | R-F 10 1% .125W  |             |
| A8 MP4               | 7 | 08111-02304 | HEATSINK OUTPUT   |             | A8 R48               | 3 | 0766-0025   | R-F 101 2% 3W MO |             |
| A8 MP5               | 3 | 1205-0329   | HT-SINK SGL       |             |                      |   |             |                  |             |
|                      |   |             |                   |             | A8 R49               | 3 | 0766-0025   | R-F 101 2% 3W MO |             |
| A8 MP6               | 3 | 1205-0329   | HT-SINK SGL       |             | A8 R50               | 3 | 0757-0818   | R-F 825 1% .5W   |             |
| A8 MP7               | 3 | 1205-0329   | HT-SINK SGL       |             | A8 R51               | 2 | 0698-3601   | R-F 10 5% 2W MO  |             |
| A8 MP8               | 3 | 1205-0329   | HT-SINK SGL       |             | A8 R52               | 2 | 0698-3601   | R-F 10 5% 2W MO  |             |
| A8 MP9               | 3 | 1205-0329   | HT-SINK SGL       |             | A8 R53               | 2 | 0698-3601   | R-F 10 5% 2W MO  |             |
| A8 MP10              | 3 | 1205-0329   | HT-SINK SGL       |             |                      |   |             |                  |             |
|                      |   |             |                   |             | A8 R54               | 2 | 0698-3601   | R-F 10 5% 2W MO  |             |
| A8 MP11              | 3 | 1205-0329   | HT-SINK SGL       |             | A8 R55               | 8 | 2100-3353   | R-VAR 20K .5W    |             |
| A8 MP12              | 3 | 1205-0329   | HT-SINK SGL       |             |                      |   |             |                  |             |
|                      |   |             |                   |             | A8 U1                | 0 | 1826-0635   | IC LIN OP07C     |             |
| A8 Q1                | 9 | 1854-0354   | XSTR SI NPN       |             | A8 U2                | 0 | 1826-0635   | IC LIN OP07C     |             |
| A8 Q2                | 2 | 1853-0218   | XSTR SI PNP       |             |                      |   |             |                  |             |
| A8 Q3                | 9 | 1854-0354   | XSTR SI NPN       |             | A8 VR1               | 6 | 1902-0960   | DIO-ZNR 12V 5%   |             |
| A8 Q4                | 2 | 1853-0218   | XSTR SI PNP       |             | A8 VR2               | 6 | 1902-0960   | DIO-ZNR 12V 5%   |             |
| A8 Q5                | 9 | 1853-0314   | XSTR 2N2905A PNP  |             | A8 VR3               | 4 | 1902-0025   | DIO 10V 5% .4W   |             |
|                      |   |             |                   |             |                      |   |             |                  |             |
| A8 Q6                | 9 | 1854-0784   | XSTR NPN 2N3866A  |             |                      |   |             |                  |             |
| A8 Q7                | 7 | 1854-0477   | XSTR NPN 2N2222A  |             | A10                  |   | 08111-66510 | BD AY-DISPLAY    |             |
| A8 Q8                | 1 | 1854-0637   | XSTR SI 2N2219A   |             |                      |   |             |                  |             |
| A8 Q9                | 9 | 1853-0314   | XSTR 2N2905A PNP  |             | A10 C1               | 4 | 0160-4387   | C-F 47PF 200V    |             |
| A8 Q10               | 1 | 1854-0637   | XSTR SI 2N2219A   |             | A10 C2               | 9 | 0160-0174   | C-F .47UF 25VCER |             |
| A8 Q11               | 9 | 1853-0314   | XSTR 2N2905A PNP  |             | A10 C3               | 9 | 0160-0174   | C-F .47UF 25VCER |             |
|                      |   |             |                   |             | A10 C4               | 7 | 0160-5437   | C-F .068UF 160V  |             |
| A8 Q12               | 1 | 1854-0637   | XSTR SI 2N2219A   |             | A10 C5               | 5 | 0160-0576   | C-F .1UF 20% CER |             |
| A8 Q13               | 9 | 1853-0314   | XSTR 2N2905A PNP  |             |                      |   |             |                  |             |
| A8 Q16               | 2 | 1855-0082   | XSTR FET P        |             | A10 C8               | 5 | 0160-0576   | C-F .1UF 20% CER |             |
|                      |   |             |                   |             | A10 C9               | 5 | 0160-0576   | C-F .1UF 20% CER |             |
| A8 R1                | 1 | 0757-0387   | R-F 27.4 1%       |             |                      |   |             |                  |             |
| A8 R2                | 5 | 0757-0282   | R-F 221 1% .125W  |             | A10 DS1              | 2 | 1990-0846   | DISPLAY SOLID ST |             |
| A8 R3                | 0 | 0698-4409   | R-F 127 1% .125W  |             | A10 DS2              | 2 | 1990-0846   | DISPLAY SOLID ST |             |
| A8 R7                | 5 | 0757-0349   | R-F 22.6K1% .125W |             | A10 DS3              | 2 | 1990-0846   | DISPLAY SOLID ST |             |
| A8 R10               | 8 | 0698-3516   | R-F 6.34K1%       |             | A10 DS4              | 2 | 1990-0846   | DISPLAY SOLID ST |             |
|                      |   |             |                   |             | A10 DS5              | 6 | 1990-0486   | LED-VISIBLE RED  |             |
| A8 R11               | 8 | 0698-3516   | R-F 6.34K1%       |             |                      |   |             |                  |             |
| A8 R12               | 4 | 0757-0447   | R-F 16.2K 1% .125 |             | A10 DS6              | 6 | 1990-0486   | LED-VISIBLE RED  |             |
| A8 R13               | 8 | 0698-3178   | R-F 487 1% .125W  |             | A10 DS7              | 6 | 1990-0486   | LED-VISIBLE RED  |             |
| A8 R14               | 5 | 2100-3350   | R-VAR 200 10%     |             | A10 DS8              | 6 | 1990-0486   | LED-VISIBLE RED  |             |
| A8 R15               | 0 | 0757-0443   | R-F 11K1% .125W   |             | A10 DS10             | 6 | 1990-0486   | LED-VISIBLE RED  |             |
|                      |   |             |                   |             | A10 DS11             | 6 | 1990-0486   | LED-VISIBLE RED  |             |
| A8 R16               | 0 | 0757-0443   | R-F 11K1% .125W   |             |                      |   |             |                  |             |
| A8 R18               | 8 | 0757-0277   | R-F 49.9 1%       |             | A10 DS12             | 6 | 1990-0486   | LED-VISIBLE RED  |             |
| A8 R19               | 8 | 0757-0277   | R-F 49.9 1%       |             | A10 DS13             | 6 | 1990-0486   | LED-VISIBLE RED  |             |
| A8 R20               | 3 | 0757-0280   | R-F 1K 1% .125W   |             | A10 DS14             | 6 | 1990-0486   | LED-VISIBLE RED  |             |
| A8 R21               | 3 | 0757-0280   | R-F 1K 1% .125W   |             | A10 DS15             | 6 | 1990-0486   | LED-VISIBLE RED  |             |
|                      |   |             |                   |             | A10 DS16             | 6 | 1990-0486   | LED-VISIBLE RED  |             |
| A8 R22               | 3 | 0757-0280   | R-F 1K 1% .125W   |             |                      |   |             |                  |             |
| A8 R23               | 3 | 0757-0280   | R-F 1K 1% .125W   |             |                      |   |             |                  |             |

Table 6-3. Replaceable Parts (cont'd)

| REFERENCE DESIGNATOR | C D | H-P PART NUMBER | DESCRIPTION       | REFERENCE DESIGNATOR | C D | H-P PART NUMBER | DESCRIPTION      |
|----------------------|-----|-----------------|-------------------|----------------------|-----|-----------------|------------------|
| A10 DS17             | 6   | 1990-0486       | LED-VISIBLE RED   | A12                  |     | 08111-66512     | BD AY-SWITCH LOW |
| A10 DS18             | 6   | 1990-0486       | LED-VISIBLE RED   | A12 DS1              | 5   | 1990-0485       | LED VISIBLE GRN  |
| A10 DS19             | 0   | 1990-0696       | LED-VISIBLE       | A12 MP1              | 7   | 5040-9321       | KEY CAP QUARTER  |
| A10 R1               | 9   | 1810-0330       | R-NETWORK 8X470   | A12 MP2              | 7   | 5040-9321       | KEY CAP QUARTER  |
| A10 R2               | 0   | 0757-0401       | R-F 100 1% .125W  | A12 MP3              | 7   | 5040-9321       | KEY CAP QUARTER  |
| A10 R7               | 1   | 0698-7272       | R-F 31.6K 1% .05  | A12 MP4              | 7   | 5040-9321       | KEY CAP QUARTER  |
| A10 R8               | 5   | 0757-0472       | R-F 200K1% .125W  | A12 MP5              | 7   | 5040-9321       | KEY CAP QUARTER  |
| A10 S1               | 4   | 3101-2530       | SW RKR            | A12 MP6              | 7   | 5040-9321       | KEY CAP QUARTER  |
| A10 U1               | 1   | 1826-0876       | A/D 3-1/2-DGT     | A12 MP7              | 7   | 5040-9321       | KEY CAP QUARTER  |
| A11                  |     | 08111-66511     | BD AY-SWITCH UPR  | A12 R1               | 9   | 0757-0442       | R-F 10K1% .125W  |
| A11 CR11             | 1   | 1901-1098       | DIO-1N4150 50V    | A12 R2               | 6   | 0698-4413       | R-F 154 1% .125W |
| A11 MP1              | 8   | 5040-9322       | KEY-CAP QUARTER   | A12 R3               | 6   | 0757-0407       | R-F 200 1% .125W |
| A11 MP2              | 8   | 5040-9322       | KEY-CAP QUARTER   | A12 R4               | 2   | 0757-0411       | R-F 332 1% .125W |
| A11 MP3              | 8   | 5040-9322       | KEY-CAP QUARTER   | A12 R5               | 9   | 0757-0442       | R-F 10K1% .125W  |
| A11 MP4              | 8   | 5040-9322       | KEY-CAP QUARTER   | A12 R6               | 3   | 0757-0280       | R-F 1K 1% .125W  |
| A11 MP5              | 8   | 5040-9322       | KEY-CAP QUARTER   | A12 R7               | 0   | 0757-0401       | R-F 100 1% .125W |
| A11 MP6              | 8   | 5040-9322       | KEY-CAP QUARTER   | A12 S2               | 3   | 3101-2513       | SW-P-BTN 4STA    |
| A11 MP7              | 8   | 5040-9322       | KEY-CAP QUARTER   | A12 S4               | 2   | 3101-2512       | SW P-BTN LINE    |
| A11 MP8              | 8   | 5040-9322       | KEY-CAP QUARTER   | A12 W2               | 2   | 5180-2407       | CBL AY RBN 60MM  |
| A11 Q1               | 2   | 1853-0036       | XSTR SI 2N3906    | A13                  |     | 08111-66513     | BD AY-SW & FUSE  |
| A11 Q2               | 1   | 1854-0215       | XSTR SI 2N3904    | A13 S1               | 1   | 3101-2511       | SW P-BTN LINE    |
| A11 R11              | 3   | 0698-4436       | R-F 2.8K1% .125W  | A13 S2               | 6   | 3101-2300       | SWITCH-SLIDE     |
| A11 R12              | 5   | 0757-0274       | R-F 1.21K1%       | A13 S3               | 6   | 3101-2300       | SWITCH-SLIDE     |
| A11 R13              | 5   | 0698-4123       | R-F 499 1% .125W  |                      |     |                 |                  |
| A11 R14              | 5   | 0698-4404       | R-F 105 1% .125W  |                      |     |                 |                  |
| A11 R15              | 4   | 0698-4453       | R-F 402 1% .125W  |                      |     |                 |                  |
| A11 R16              | 5   | 0698-3498       | R-F 8.66K1% .125W |                      |     |                 |                  |
| A11 R18              | 6   | 0757-0283       | R-F 2K1% .125W F  |                      |     |                 |                  |
| A11 R20              | 5   | 0757-0290       | R-F 6.19K1% .125W |                      |     |                 |                  |
| A11 R21              | 0   | 0698-3493       | R-F 4.12K1%       |                      |     |                 |                  |
| A11 R26              | 9   | 0757-0442       | R-F 10K1% .125W   |                      |     |                 |                  |
| A11 R27              | 9   | 0757-0442       | R-F 10K1% .125W   |                      |     |                 |                  |
| A11 R28              | 9   | 0757-0442       | R-F 10K1% .125W   |                      |     |                 |                  |
| A11 R29              | 0   | 0698-3154       | R-F 4.22K 1%      |                      |     |                 |                  |
| A11 R30              | 6   | 0757-0465       | R-F 100K1% .125W  |                      |     |                 |                  |
| A11 R31              | 9   | 0757-0442       | R-F 10K1% .125W   |                      |     |                 |                  |
| A11 R32              | 8   | 0757-0441       | R-F 8.25K1%       |                      |     |                 |                  |
| A11 R33              | 6   | 0698-3499       | R-F 40.2K1%       |                      |     |                 |                  |
| A11 R34              | 6   | 0757-0465       | R-F 100K1% .125W  |                      |     |                 |                  |
| A11 R35              | 8   | 0698-4431       | R-F 2.05K1%       |                      |     |                 |                  |
| A11 R41              | 0   | 0698-3279       | R-F 4.99K1%       |                      |     |                 |                  |
| A11 R42              | 8   | 0757-0706       | R-F 51.1 1% .25W  |                      |     |                 |                  |
| A11 R44              | 6   | 0757-0283       | R-F 2K1% .125W F  |                      |     |                 |                  |
| A11 R45              | 6   | 0698-3449       | R-F 28.7K1%       |                      |     |                 |                  |
| A11 R46              | 4   | 0757-0447       | R-F 16.2K 1% .125 |                      |     |                 |                  |
| A11 S1               | 2   | 3101-1762       | SW-P-BRN MOM.45A  |                      |     |                 |                  |
| A11 S3               | 5   | 3101-2515       | SW-P-BTN 4STA     |                      |     |                 |                  |
| A11 S5               | 4   | 3101-2514       | SW-P-BTN 3STA     |                      |     |                 |                  |
| A11 U11              | 3   | 1820-1745       | IC MC14001BCP     |                      |     |                 |                  |
| A11 U12              | 2   | 1820-1546       | ANLG MUXR         |                      |     |                 |                  |
| A11 W1               | 3   | 08111-61603     | CBL AY AMPL OUT   |                      |     |                 |                  |

## OPTION 001

Table 6-3. Replaceable Parts (cont'd)

| REFERENCE DESIGNATOR                     | C        | D | H-P PART NUMBER | DESCRIPTION       | REFERENCE DESIGNATOR | C   | D | H-P PART NUMBER | DESCRIPTION       |
|------------------------------------------|----------|---|-----------------|-------------------|----------------------|-----|---|-----------------|-------------------|
| <b>FRAME</b>                             |          |   |                 |                   | A3                   | U7  | 6 | 1820-1144       | IC SN74LS02N      |
| A3                                       |          |   | 08111-66503     | BD AY-BURST       | A3                   | U8  | 6 | 1820-1970       | IC DIG 14071B     |
| A9                                       |          |   | 08111-66509     | BD AY BRSTNO CTL  | A3                   | U9  | 6 | 1820-1970       | IC DIG 14071B     |
| A21                                      |          |   | 08111-66521     | BD AY- MOTHER     | A3                   | U10 | 9 | 1820-1486       | IC MC14081BCP     |
| A30                                      | SEE NOTE |   | 08111-66530     | BD AY DISPLAY     | A3                   | U11 | 9 | 1820-1486       | IC MC14081BCP     |
| A31                                      |          |   | 08111-66531     | BD AY-SWITCH UP   | A3                   | U12 | 3 | 1820-1208       | IC SN74LS32N      |
|                                          |          |   |                 |                   | A3                   | U13 | 7 | 1820-0931       | IC CD4029BE       |
|                                          |          |   |                 |                   | A3                   | U14 | 7 | 1820-0931       | IC CD4029BE       |
|                                          |          |   |                 |                   | A3                   | U15 | 7 | 1820-0931       | IC CD4029BE       |
| S2                                       |          |   | 3101-1701       | SW TOGGLE SPDT    | A3                   | U16 |   | 1820-1964       | IC MC14027BCP     |
| NOTE: A30 & A31 ARE SUB-ASSEMBLIES OF    |          |   |                 |                   | A3                   | U17 | 1 | 1820-1454       | IC SN745168N      |
| A41 (08111-66541) AND ARE NOT SEPARATELY |          |   |                 |                   | A3                   | U18 | 6 | 1820-1277       | IC SN74LS 192 N   |
| AVAILABLE.                               |          |   |                 |                   | A3                   | U19 | 6 | 1820-1277       | IC SN74LS 192 N   |
| A3                                       |          |   | 08111-66503     | BD AY-BURST       | A3                   | U20 | 8 | 1820-0693       | IC SN74S74N TTL   |
| A3                                       | C1       | 5 | 0160-0576       | C-F .1UF 20% CER  | A3                   | U21 | 4 | 1820-1423       | IC SN74LS123N     |
| A3                                       | C2       | 3 | 0180-0291       | C-F 1UF 35V       | A3                   | U22 | 4 | 1820-1449       | IC 74S32          |
| A3                                       | C3       | 5 | 0160-0576       | C-F .1UF 20% CER  | A3                   | W2  |   | 5180-2408       | CBL AY RBN 280MM  |
| A3                                       | C4       | 5 | 0160-0576       | C-F .1UF 20% CER  | <b>A9</b>            |     |   |                 |                   |
| A3                                       | C5       | 1 | 0160-0572       | C-F 2200PF CER    | A9                   | C1  | 9 | 0160-0174       | C-F .47UF 25VCER  |
| A3                                       | C6       | 6 | 0160-4040       | C-F 1000PF 100V   | A9                   | J5  | 5 | 1251-3708       | CONN-POST 10F     |
| A3                                       | C7       | 6 | 0160-4371       | C-F 680 PF        | A9                   | J6  | 5 | 1251-3708       | CONN-POST 10F     |
| A3                                       | C8       | 6 | 0160-4371       | C-F 680 PF        | A9                   | J7  | 2 | 1251-3119       | CONN 20PIN RIBN   |
| A3                                       | C9       | 5 | 0160-0576       | C-F .1UF 20% CER  | A9                   | Q1  | 1 | 1854-0215       | XSTR SI 2N3904    |
| A3                                       | C10      | 5 | 0160-0576       | C-F .1UF 20% CER  | A9                   | R1  | 9 | 0757-0442       | R-F 10K1% .125W   |
| A3                                       | C11      | 5 | 0160-0576       | C-F .1UF 20% CER  | A9                   | R2  | 7 | 0757-0200       | R-F 5.6K1% .125W  |
| A3                                       | C12      | 5 | 0160-0576       | C-F .1UF 20% CER  | A9                   | R3  | 6 | 0698-3499       | R-F 40.2K1% .125W |
| A3                                       | C13      | 5 | 0160-0576       | C-F .1UF 20% CER  | A9                   | R4  | 8 | 0757-0467       | R-F 121K 1% .125W |
| A3                                       | C14      | 5 | 0180-2207       | C-F 100UF 10V     | A9                   | R5  | 0 | 0698-3279       | R-F 4.99K1% .125W |
| A3                                       | C15      | 2 | 0160-3874       | C-F 10PF 200V     | A9                   | R6  | 8 | 0698-4431       | R-F 2.05K1% .125W |
| A3                                       | C16      | 6 | 0160-4040       | C-F 1000PF 100V   | A9                   | R7  | 0 | 0698-3162       | R-F 46.4K1% .125W |
| A3                                       | CR1      | 1 | 1901-1098       | DIO-SWIT .1N4150  | A9                   | R8  | 2 | 0757-0453       | R-F 30.1K1% .125W |
| A3                                       | CR2      | 1 | 1901-1098       | DIO-SWIT .1N4150  | A9                   | R9  | 2 | 0698-4435       | R-F 2.49K1% .125W |
| A3                                       | CR3      | 1 | 1901-1098       | DIO-SWIT .1N4150  | A9                   | R10 | 6 | 0757-0449       | R-F 20K1% .125W   |
| A3                                       | CR4      | 1 | 1901-1098       | DIO-SWIT .1N4150  | A9                   | U1  | 3 | 1820-1745       | IC MC14001BCP     |
| A3                                       | MP1      | 3 | 4040-0748       | PC EXTR BD BLK    | A9                   | U2  | 8 | 1820-1112       | IC DGTL SN74LS74  |
| A3                                       | MP2      | 8 | 4040-0751       | PC EXTR BD ORN    | A9                   | U3  | 6 | 1820-1277       | IC SN74LS 192 N   |
| A3                                       | R1       | 5 | 0757-0472       | R-F 200K1% .125W  | A9                   | U4  | 6 | 1820-1277       | IC SN74LS 192 N   |
| A3                                       | R2       | 4 | 0698-4479       | R-F 14K1% .125W   | A9                   | U5  | 6 | 1820-1277       | IC SN74LS 192 N   |
| A3                                       | R3       | 4 | 0698-8827       | R-F 1M 1% .125W   | A9                   | U6  | 6 | 1820-1277       | IC SN74LS 192 N   |
| A3                                       | R4       | 1 | 0698-8345       | R-F 634K 1% .125W | A9                   | U7  | 3 | 1826-0175       | IC DUAL 14-DIP    |
| A3                                       | R5       | 5 | 0757-0472       | R-F 200K1% .125W  | <b>A21</b>           |     |   |                 |                   |
| A3                                       | R6       | 7 | 0698-4125       | R-F 953 1% .125W  | A21                  | C1  |   | 0180-3158       | C-F ELCO 6800UF   |
| A3                                       | R7       | 8 | 1810-0206       | R-NETWORK 7X10K   | A21                  | C2  |   | 0180-3162       | C-F ELCO 4700UF   |
| A3                                       | R8       | 8 | 1810-0280       | R-NETWORK 9X10K   | A21                  | C3  |   | 0180-3161       | C-F ELCO 3300VF   |
| A3                                       | R9       |   | 0698-4421       | R-F 249 1% .125W  | A21                  | C4  |   | 0180-3161       | C-F ELCO 3300VF   |
| A3                                       | R10      |   | 0698-4421       | R-F 249 1% .125W  | A21                  | CR1 | 3 | 1901-0638       | DIO AY-SI 100V    |
| A3                                       | R11      | 6 | 0757-0465       | R-F 100K1% .125W  | A21                  | CR2 | 7 | 1906-0096       | DIO-FULL WAVE BR  |
| A3                                       | R12      | 9 | 0757-0442       | R-F 10K1% .125W   | A21                  | J1  | 7 | 1251-3825       | CONNECTOR 5 PIN   |
| A3                                       | R13      | 9 | 0757-0442       | R-F 10K1% .125W   | A21                  | J2  | 8 | 1251-2026       | CONN PC 36CONT R  |
| A3                                       | R14      | 5 | 0698-3498       | R-F 8.66K1% .125W | A21                  | J3  | 8 | 1251-2026       | CONN PC 36CONT R  |
| A3                                       | R15      | 5 | 0698-4412       | R-F 143 1% .125W  | A21                  | J4  | 8 | 1251-2026       | CONN PC 36CONT R  |
| A3                                       | R16      | 6 | 0757-0449       | R-F 20K1% .125W   | A21                  | J5  | 8 | 1251-2026       | CONN PC 36CONT R  |
| A3                                       | U1       | 3 | 1820-1208       | IC-SN74LS32       | A21                  | J6  | 8 | 1251-2026       | CONN PC 36CONT R  |
| A3                                       | U2       | 5 | 1820-1200       | IC SN74LS05       | A21                  | J7  | 8 | 1251-2026       | CONN PC 36CONT R  |
| A3                                       | U3       | 1 | 1820-2014       | IC DGT MC14069BC  | A21                  | J8  | 8 | 1251-2026       | CONN PC 36CONT R  |
| A3                                       | U4       | 6 | 1820-1201       | IC-SN74LS08N      | A21                  | J12 |   | 1251-7456       | CONN 25 CONT      |
| A3                                       | U5       | 5 | 1820-1961       | IC MC14023BCP     |                      |     |   |                 |                   |
| A3                                       | U6       | 9 | 1820-1486       | IC MC14081BCP     |                      |     |   |                 |                   |

Table 6-3. Replaceable Parts (cont'd)

| REFERENCE DESIGNATOR | C | D | H-P PART NUMBER | DESCRIPTION      | REFERENCE DESIGNATOR | C | D | H-P PART NUMBER | DESCRIPTION       |
|----------------------|---|---|-----------------|------------------|----------------------|---|---|-----------------|-------------------|
| A21 Q3               | 6 |   | 1853-0212       | XSTR 2N5194 SI   | A31                  |   |   | 08111-66531     | BD AY-SWITCH UP   |
| A21 Q4               | 5 |   | 1854-0368       | XSTR 2N5191      | A31 CR11             | 1 |   | 1901-1098       | DIO-SWIT.1N4150   |
| A21 Q7               | 6 |   | 1853-0212       | XSTR 2N5194 SI   | A31 J5               | 2 |   | 1251-4084       | CONN POST 10MALE  |
| A21 Q8               | 5 |   | 1854-0368       | XSTR 2N5191      | A31 J6               | 2 |   | 1251-4084       | CONN POST 10MALE  |
| A21 R12              | 1 |   | 0757-0197       | R-F 1.5K1% .5W   | A31 MP1-8            | 8 |   | 5040-9322       | KEY CAP QUARTER   |
| A21 R13              | 1 |   | 0757-0197       | R-F 1.5K1% .5W   | A31 Q1               | 2 |   | 1853-0036       | XSTR SI 2N3906    |
| A21 R20              | 6 |   | 0812-0045       | R-F .15 5% 3W    | A31 Q2               | 1 |   | 1854-0215       | XSTR SI 2N3904    |
| A21 R21              | 6 |   | 0812-0045       | R-F .15 5% 3W    | A31 R11              | 3 |   | 0698-4436       | R-F 2.8K1% .125W  |
| A21 R25              | 9 |   | 0757-0731       | R-F 825 1% .25W  | A31 R12              | 5 |   | 0757-0274       | R-F 1.21K1%       |
| A21 R28              | 9 |   | 0757-0731       | R-F 825 1% .25W  | A31 R13              | 5 |   | 0698-4123       | R-F 499 1% .125W  |
| A21 R31              | 4 |   | 0811-2455       | R-F 2 1% 3W      | A31 R14              | 5 |   | 0698-4404       | R-F 105 1% .125W  |
| A21 R32              | 4 |   | 0811-2455       | R-F 2 1% 3W      | A31 R15              | 4 |   | 0698-4453       | R-F 402 1% .125W  |
| A21 R39              | 3 |   | 0757-0280       | R-F 1K1% .125W F | A31 R16              | 5 |   | 0698-3498       | R-F 8.66K1%       |
| A21 R40              | 3 |   | 0757-0280       | R-F 1K1% .125W F | A31 R18              | 6 |   | 0757-0283       | R-F 2K1% .125W F  |
| A21 R41              | 3 |   | 0757-0280       | R-F 1K1% .125W F | A31 R20              | 5 |   | 0757-0290       | R-F 6.19K1%       |
| A21 R42              | 3 |   | 0757-0280       | R-F 1K1% .125W F | A31 R21              | 0 |   | 0698-3493       | R-F 4.12K1%       |
| A30                  |   |   | 08111-66530     | BD AY DISPLAY    | A31 R26              | 9 |   | 0757-0442       | R-F 10K1% .125W   |
| A30 C1               | 4 |   | 0160-4494       | C-F 39PF 200V    | A31 R27              | 9 |   | 0757-0442       | R-F 10K1% .125W   |
| A30 C2               | 9 |   | 0160-0174       | C-F .47UF 25VCER | A31 R28              | 9 |   | 0757-0442       | R-F 10K1% .125W   |
| A30 C3               | 9 |   | 0160-0174       | C-F .47UF 25VCER | A31 R29              | 0 |   | 0698-3154       | R-F 4.22K 1%      |
| A30 C4               |   |   | 0160-5437       | C-F .068UF 160V  | A31 R30              | 6 |   | 0757-0465       | R-F 100K1% .125W  |
| A30 C5               | 5 |   | 0160-0576       | C-F .1UF 20% CER | A31 R31              | 9 |   | 0757-0442       | R-F 10K1% .125W   |
| A30 C8               | 5 |   | 0160-0576       | C-F .1UF 20% CER | A31 R32              | 8 |   | 0757-0441       | R-F 8.25K1%       |
| A30 C9               | 5 |   | 0160-0576       | C-F .1UF 20% CER | A31 R33              | 6 |   | 0698-3499       | R-F 40.2K1%       |
| A30 DS1              |   |   | 1990-0846       | DISPLAY SOLID ST | A31 R34              | 6 |   | 0757-0465       | R-F 100K1% .125W  |
| A30 DS2              |   |   | 1990-0846       | DISPLAY SOLID ST | A31 R35              | 8 |   | 0698-4431       | R-F 2.05K1%       |
| A30 DS3              |   |   | 1990-0846       | DISPLAY SOLID ST | A31 R41              | 0 |   | 0698-3279       | R-F 4.99K1%       |
| A30 DS4              |   |   | 1990-0846       | DISPLAY SOLID ST | A31 R42              | 8 |   | 0757-0706       | R-F 51.1 1% .25W  |
| A30 DS5              | 6 |   | 1990-0486       | LED-VISIBLE RED  | A31 R44              | 6 |   | 0757-0283       | R-F 2K1% .125W F  |
| A30 DS6              | 6 |   | 1990-0486       | LED-VISIBLE RED  | A31 R45              | 6 |   | 0698-3449       | R-F 28.7K1%       |
| A30 DS7              | 6 |   | 1990-0486       | LED-VISIBLE RED  | A31 R46              | 4 |   | 0757-0447       | R-F 16.2K 1% .125 |
| A30 DS8              | 6 |   | 1990-0486       | LED-VISIBLE RED  | A31 S1               | 2 |   | 3101-1762       | SW-P-BRN MOM.45A  |
| A30 DS9              | 6 |   | 1990-0486       | LED-VISIBLE RED  | A31 S3               |   |   | 3101-2515       | SW-P-BTN 4STA     |
| A30 DS10             | 6 |   | 1990-0486       | LED-VISIBLE RED  | A31 S5               |   |   | 3101-2514       | SW-P-BTN 3STA     |
| A30 DS11             | 6 |   | 1990-0486       | LED-VISIBLE RED  | A31 U11              | 3 |   | 1820-1745       | IC MC14001BCP     |
| A30 DS12             | 6 |   | 1990-0486       | LED-VISIBLE RED  | A31 U12              | 2 |   | 1820-1546       | IC-4052B          |
| A30 DS13             | 6 |   | 1990-0486       | LED-VISIBLE RED  |                      |   |   |                 |                   |
| A30 DS14             | 6 |   | 1990-0486       | LED-VISIBLE RED  |                      |   |   |                 |                   |
| A30 DS15             | 6 |   | 1990-0486       | LED-VISIBLE RED  |                      |   |   |                 |                   |
| A30 DS16             | 6 |   | 1990-0486       | LED-VISIBLE RED  |                      |   |   |                 |                   |
| A30 DS17             | 6 |   | 1990-0486       | LED-VISIBLE RED  |                      |   |   |                 |                   |
| A30 DS18             | 6 |   | 1990-0486       | LED-VISIBLE RED  |                      |   |   |                 |                   |
| A30 DS19             | 0 |   | 1990-0696       | LED-VISIBLE      |                      |   |   |                 |                   |
| A30 R1               | 9 |   | 1810-0330       | R-NETWORK 8X470  |                      |   |   |                 |                   |
| A30 R2               | 0 |   | 0757-0401       | R-F 100 1% .125W |                      |   |   |                 |                   |
| A30 R7               | 1 |   | 0698-7272       | R-F 31.6K 1% .05 |                      |   |   |                 |                   |
| A30 R8               | 5 |   | 0757-0472       | R-F 200K1% .125W |                      |   |   |                 |                   |
| A30 S1               |   |   | 3101-2530       | SW RKR           |                      |   |   |                 |                   |
| A30 S2               |   |   | 3101-2530       | SW RKR           |                      |   |   |                 |                   |
| A30 S3               |   |   | 3101-2530       | SW RKR           |                      |   |   |                 |                   |
| A30 S4               |   |   | 3101-2530       | SW RKR           |                      |   |   |                 |                   |
| A30 U1               |   |   | 1826-0876       | AD-CONV ICL7107  |                      |   |   |                 |                   |

## SECTION VII BACKDATING

### 7-1 INTRODUCTION

7-2 This section contains backdating information which adapts this manual to instrument with serial numbers lower than that shown on the title page.

### 7-3 CHANGE SEQUENCE

7-4 Changes are listed in the serial number order that they occurred in the manufacture of the instrument. However, in adapting this manual to an instrument with a particular serial number, apply the changes in reverse order. That is, begin with the latest change and progress to the earliest change that applies to the serial number in question. Table 7-1 lists the serial numbers to which each change applies.

Table 7-1. Manual Backdating Changes

| Instrument<br>Serial Number | Make Manual<br>Changes |
|-----------------------------|------------------------|
| 2123G00100 and lower        | 1 to 14                |
| 2123G00150 and lower        | 2 to 14                |
| 2123G00165 and lower        | 3 to 14                |
| 2123G00235 and lower        | 4 to 14                |
| 2123G00285 and lower        | 5 to 14                |
| 2123G00435 and lower        | 6 to 14                |
| 2215G00485 and lower        | 7 to 14                |
| 2215G00535 and lower        | 8 to 14                |
| 2215G00715 and lower        | 9 to 14                |
| 2215G00835 and lower        | 10 to 14               |
| 2215G01075 and lower        | 11 to 14               |
| 2215G01540 and lower        | 12 to 14               |
| 2215G01590 and lower        | 13 to 14               |
| 2215G01840 and lower        | 14                     |

#### CHANGE 1 For serial numbers 2123G00100 and lower.

In Table 6-3. Replaceable Parts, make the following changes to the parts lists stated:

Frame list: Delete MP34

A12 list: Delete A12R7

Change associated schematic and component layout diagrams as necessary.

#### CHANGE 2 For serial numbers 2123G00150 and lower.

In Table 6-3. Replaceable Parts, make the following changes to the parts lists stated:

Frame list: Delete MP5, MP6 and MP7

A3 list: Delete A3C16

Change associated schematic and component layout diagrams as necessary.

#### CHANGE 3 For serial numbers 2123G00165 and lower.

In Table 6-3. Replaceable Parts, make the following changes to the parts lists stated:

A 5 list: Add: A5C9                      0160-3725 C-F 0.68  $\mu$ F 100 V

Change A5C8 to:                      0160-3376 C-F 3.3  $\mu$ F 63 V

Change associated schematic and component layout diagrams as necessary.

C9 is connected in parallel to C8.

**CHANGE 4** For serial numbers 2123G00235 and lower.

In Table 6-3, Replaceable Parts, make the following changes to the parts lists stated:  
Frame list: Change MP42 to MP42 (X4) 0340-0451 INS WASHER

**CHANGE 5** For serial numbers 2123G00285 and lower.

In Table 6-3, Replaceable Parts, make the following changes to the parts lists stated:  
A3 list: Change A3R15 to: 0698-4411 R-F 140 1 % .125 W  
Frame list: Delete R1

Change the associated schematic and component layout diagrams as necessary.

**CHANGE 6** For serial numbers 2123G00435 and lower

Delete the following from Table 6-3, Replaceable Parts, and from the A6 component layout:

A6R49, A6R50, A6R51, A6R52 and A6Q3

Add the following to Table 6-3, Replaceable Parts, and to the A6 component layout:

A6R7 0698-7260 R-F 10K

On the A6 component layout, A7 is located directly below R5.

Change the associated schematic as shown in the Figure 7-1.

Delete any reference to A6R50 in the Adjustment Procedure (page 5-1, para 5-2, step 3; page 5-4, para 5-4, step 5; page 5-5, step 30)

**CHANGE 7** For serial numbers 2215G00485 and lower

Delete A8L2 from parts list, component layout and schematic.

**CHANGE 8** For serial numbers 2215G00535 and lower

Change Table 6-3, Replaceable Parts to read:

|         |           |                 |
|---------|-----------|-----------------|
| A8C8,C9 | 0160-3878 | C-F .001UF 100V |
| A8L1    | 9170-0894 | CORE MAGNETIC   |

**CHANGE 9** For serial numbers 2215G00715 and lower

Change Table 6-3, Replaceable Parts to read:

|      |           |               |
|------|-----------|---------------|
| A8Q6 | 1854-0637 | XSTR SI 2219A |
|------|-----------|---------------|

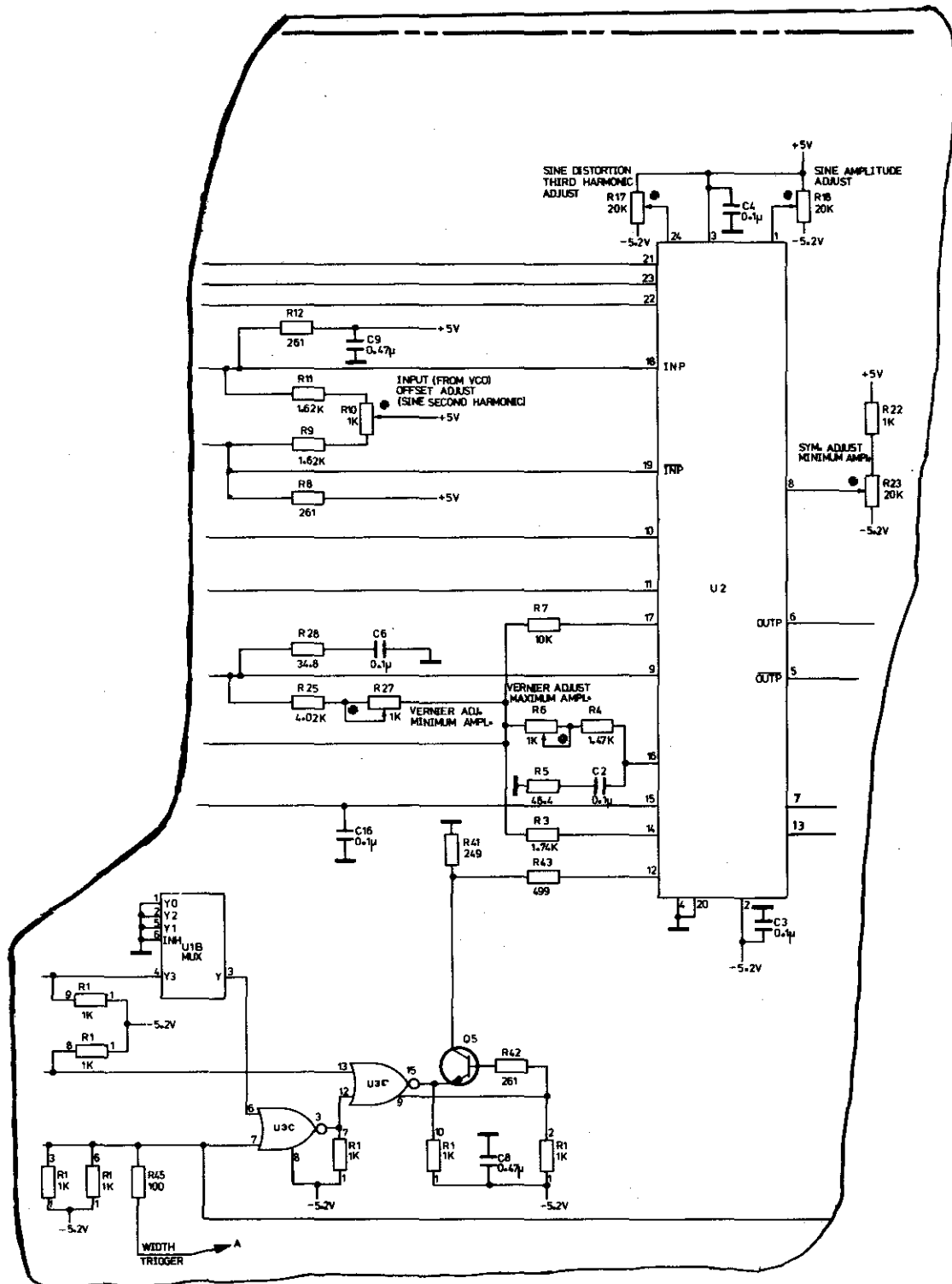


Figure 7-1

**CHANGE 10** For serial numbers 2215G00835 and lower

Change Table 6-3, Replaceable Parts to read:

A6Q1 5180-2409 XSTR SEL PAIR

Delete the following components from the parts list, component layout and schematic:

A6R53\*, A6RT1\*

**CHANGE 11** For serial numbers 2215G01075 and lower

Delete the following components from the parts list, component layout and schematic:

A7C9, A7C10, A7R3, A7R4 and A7U2

On Service Sheet 4, U1E pin1 is connected to U8C/U9C pin 10, and U1D pin 8 is connected to U8A/U9A pin 13

**CHANGE 12** For serial numbers 2215G01540 and lower

Change Table 6-3, Replaceable Parts to read:

A6C10 0160-0174 C-F 0.47UF 25VCER

**CHANGE 13** For serial numbers 2215G01590 and lower

Change Table 6-3, Replaceable Parts to read:

A5R9 0757-0278 R-F 1.78K

**CHANGE 14** For serial numbers 2215G01840 and lower

Change Table 6-3, Replaceable Parts to read:

A7CR1 1901-0731 DIO-PWR 400V 1A

## SECTION VIII SERVICE

### 8-1 INTRODUCTION

8-2 This section contains the information to service the HP Model 8111A. The information includes theory of operation, troubleshooting, schematics, component layouts and block diagram.

8-3 The schematics and component layouts are organized as 'Service Sheets' which are identified by a large number within a square in the lower corners. A table relating these Service Sheets to board assemblies is given in Table 8-1. Schematic diagram symbols are given in Table 8-3.

Table 8-1. Index of Assemblies

| Assembly                                 | Service Sheet |
|------------------------------------------|---------------|
| A1 (A21) Mother Board                    | 1             |
| A2 Regulator Board                       | 2             |
| A3 Burst Board (Opt. 001)                | 6             |
| A4 Width Generator Board                 | 9             |
| A5 VCO Board                             | 8             |
| A6 Shaper Board                          | 10            |
| A7 Control Board                         | 4             |
| A8 Output Board                          | 11            |
| A9 Burst No. Control Board<br>(Opt. 001) | 7             |
| A10 (A30) Display Board                  | 5             |
| A11 (A31) Upper Switch Board             | 3             |
| A12 Lower Switch Board                   | 3             |
| A13 Switch and Fuse Board                | 2             |

**NOTE:** The numbers given in brackets e.g. (A21) refer to the boards as used in Option 001 (Burst) instruments where they differ from the standard type.

### 8-4 SAFETY CONSIDERATIONS

8-5 This section contains warnings and cautions that must be followed for your protection and to avoid damage to the equipment:

#### **WARNING**

*Maintenance described herein is performed with power supplied to the instrument, and protective covers removed. Such maintenance should be performed only by service-trained personnel who are aware of the*

*hazards involved (for example, fire and electrical shock). Where maintenance can be performed without power applied, the power should be removed.*

*When servicing is complete, the After Service Safety Check must be performed.*

### 8-6 AFTER SERVICE SAFETY CHECK

8-7 Execute the following checks when servicing is completed.

8-8 Disconnect power cord from line. Visually inspect interior of instrument for any sign of abnormal internally generated heat, such as discolored printed circuit boards or components, damaged insulation, or evidence of arcing. Determine cause and remedy.

8-9 Check cabinet/ground pin continuity in accordance with IEC/VDE. Flex the power cord while making the measurement to detect any intermittent discontinuity. Check internal ground connections on boards and frame. Also check resistance of any front or rear panel ground terminals marked  $\frac{1}{1}$ .

8-10 Check cabinet/line isolation in accordance with IEC/VDE. Replace any component which results in a failure or refer to production Memo or Service Note issued by product division for alternate action.

8-11 Check line fuse to verify that the proper value is installed.

8-12 Check that safety covers are installed.

8-13 Check that the coaxial and flat cables are properly connected. Check that all boards are properly fitted and the heatsink connections between the Output board A8 and front frame member are secure.

8-14 Inform Hewlett-Packard (internally, the responsible product division) of any repeated failures in the above tests or any other safety features.

### 8-15 SERVICE BLOCKS (THEORY/TROUBLESHOOTING)

8-16 The theory of operation and troubleshooting

Table 8-3. Schematic Diagram Notes (1 of 2)

The following symbols conform, as far as possible, with ANSI Y 32.2, IEEE No. 315 and ANSI Y32.14 (for the logic symbols). These standards should be consulted when further information is required.

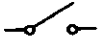
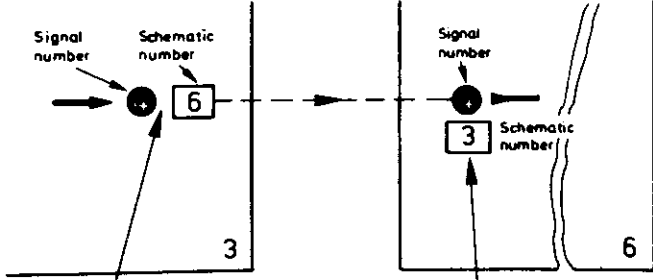
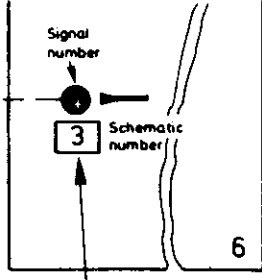
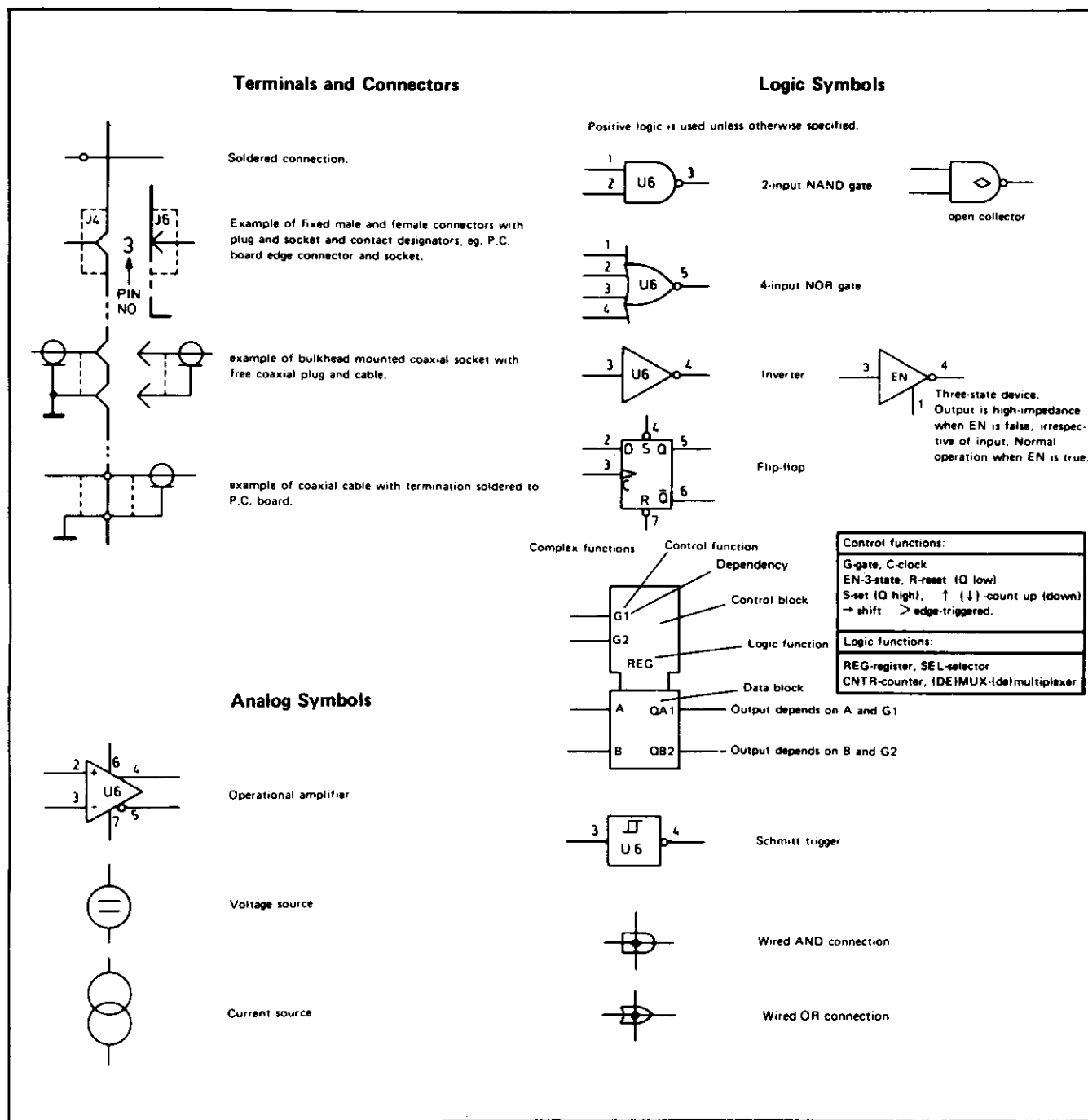
| General                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                                                                                  | Components                                                                           |                                                                                                                          |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------|
| <b>Units</b>                                                                                                                                                                                                                                                                                                | Resistance values are in ohms, capacitance values in microfarads and inductance values in microhenries unless otherwise noted !                                                                                                                  |    | Normally open toggle switch. Circles (O) are used for the contacts to indicate a locking type switch.                    |
| <b>P/O</b>                                                                                                                                                                                                                                                                                                  | Part of                                                                                                                                                                                                                                          |    | Spring return, 2-position transfer switch. Triangle (▲) are used for the contacts to indicate a non-locking type switch. |
|                                                                                                                                                                                                                            | Asterisk denotes a factory selected value. The value shown is the nominal value.                                                                                                                                                                 |    | 2-position, 2-pole slide switch.                                                                                         |
|                                                                                                                                                                                                                            | Encloses front panel nomenclature.                                                                                                                                                                                                               |     | Air cored inductor.                                                                                                      |
|                                                                                                                                                                                                                            | Encloses rear panel nomenclature.                                                                                                                                                                                                                |    | Air cored transformer. The dot (●) is used, when necessary, to indicate instantaneous polarity.                          |
|                                                                                                                                                                                                                            | Heavy line indicates signal path.                                                                                                                                                                                                                |     | Iron core                                                                                                                |
|                                                                                                                                                                                                                            | Heavy dashed line indicates primary feedback path.                                                                                                                                                                                               |    | Ferrite core                                                                                                             |
|                                                                                                                                                                                                                            | Wire colour code. Same as resistor colour code. First number is wire body colour.                                                                                                                                                                |   | Ferrite bead                                                                                                             |
|                                                                                                                                                                                                                            | Wire or plug used as link.                                                                                                                                                                                                                       |  | Varactor diode                                                                                                           |
|                                                                                                                                                                                                                           | Test point in a circuit. Point may/may not be identified on P.C. board.                                                                                                                                                                          |  | Multi-junction diode                                                                                                     |
|                                                                                                                                                                                                                          | Used with trimmer potentiometers or capacitors to indicate screwdriver adjustment.                                                                                                                                                               |   | Diode                                                                                                                    |
|                                                                                                                                                                                                                          | Direct connection to earth.                                                                                                                                                                                                                      |   | Zener diode                                                                                                              |
|                                                                                                                                                                                                                          | Ground connection to instrument chassis or frame.                                                                                                                                                                                                |   | Schottky diode                                                                                                           |
|                                                                                                                                                                                                                          | Used when a number of common-return connections are at the same potential. If there is more than one such system in the same circuit, numbers are written in the triangles so that all connections with the same potential have the same number. |   | Light Emitting Diode (LED)                                                                                               |
|                                                                                                                                                                                                                          | Specific potential difference with respect to a potential reference level, eg. +10 V                                                                                                                                                             |   | Photodiode                                                                                                               |
| <b>Schematic Referencing</b>                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                  |   | Fuse                                                                                                                     |
|  <p>These references on a signal leaving a schematic diagram indicate the signal destination. The circle contains the signal number and the square contains the number of the schematic to which that signal goes.</p>   |                                                                                                                                                                                                                                                  |   | Neon                                                                                                                     |
|  <p>These references on a signal entering a schematic diagram indicate the signal origin. The circle contains the signal number and the square contains the number of the schematic to which that signal originates.</p> |                                                                                                                                                                                                                                                  |   | Filament lamp                                                                                                            |

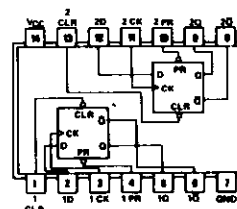
Table 8-3. Schematic Diagram Notes (2 of 2)



1820-0693

# DUAL D-TYPE POSITIVE-EDGE-TRIGGERED FLIP-FLOPS WITH PRESET AND CLEAR (S74)

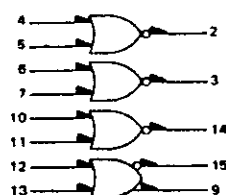
| FUNCTION TABLE |       |       |   |         |             |
|----------------|-------|-------|---|---------|-------------|
| INPUTS         |       |       |   | OUTPUTS |             |
| PRESET         | CLEAR | CLOCK | D | Q       | $\bar{Q}$   |
| L              | H     | X     | X | H       | L           |
| H              | L     | X     | X | L       | H           |
| L              | L     | X     | X | H*      | H*          |
| H              | H     | 1     | H | H       | L           |
| H              | H     | 1     | L | L       | H           |
| H              | H     | L     | X | $Q_0$   | $\bar{Q}_0$ |



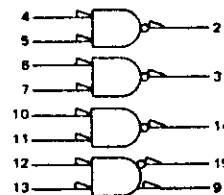
1820-0802

# QUAD 2-INPUT NOR GATE (ECL)

POSITIVE LOGIC



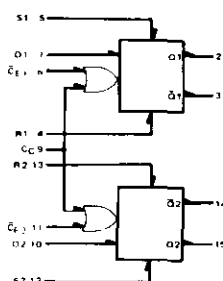
NEGATIVE LOGIC



VCC1 = Pin 1  
VCC2 = Pin 16  
VEE = Pin 8

1820-0817

# DUAL TYPE D MASTER-SLAVE FLIP-FLOP (ECL)



CLOCKED TRUTH TABLE

| C | D | $Q_{n+1}$ |
|---|---|-----------|
| L | X | $Q_n$     |
| H | L | L         |
| H | H | H         |

X = Don't Care  
C =  $C_E = C_C$   
A clock H is a clock transition from a low to a high state

VCC1 = Pin 1  
VCC2 = Pin 16  
VEE = Pin 8

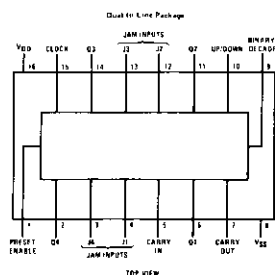
R-S TRUTH TABLE

| R | S | $Q_{n+1}$ |
|---|---|-----------|
| L | L | $Q_n$     |
| L | H | L         |
| H | L | L         |
| H | H | N/D       |

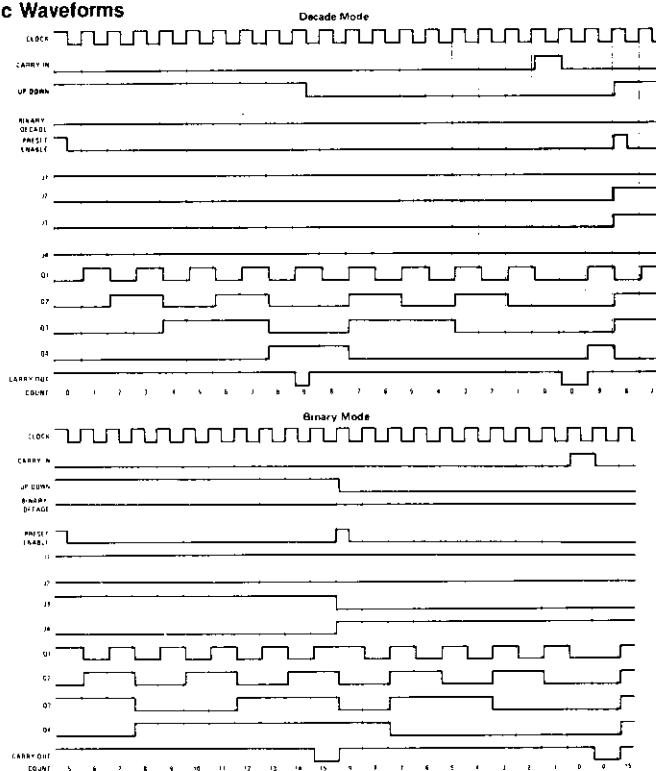
N/D = Not Defined

1820-0931

## PRESETTABLE BINARY/DECADE UP/DOWN COUNTER

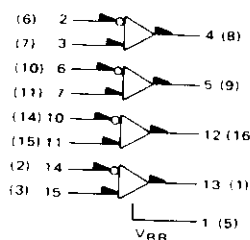


## Logic Waveforms



1820-1052

## QUAD ECL TO TTL CONVERTER

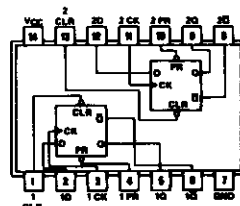


Gnd = Pin 16 (4)  
 $V_{CC}$  (+5.0 Vdc) = Pin 9 (13)  
 $V_{EE}$  (-5.2 Vdc) = Pin 8 (12)

1820-1112

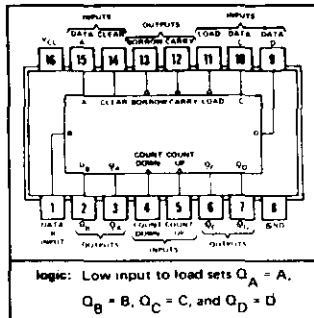
DUAL D-TYPE POSITIVE-EDGE-TRIGGERED  
FLIP-FLOPS WITH PRESET AND CLEAR (LS74)

| FUNCTION TABLE |       |       |   |         |             |
|----------------|-------|-------|---|---------|-------------|
| INPUTS         |       |       |   | OUTPUTS |             |
| PRESET         | CLEAR | CLOCK | D | Q       | $\bar{Q}$   |
| L              | H     | X     | X | H       | L           |
| H              | L     | X     | X | L       | H           |
| L              | L     | X     | X | H*      | H*          |
| H              | H     | 1     | H | H       | L           |
| H              | H     | 1     | L | L       | H           |
| H              | H     | L     | X | $Q_0$   | $\bar{Q}_0$ |



1820-1194

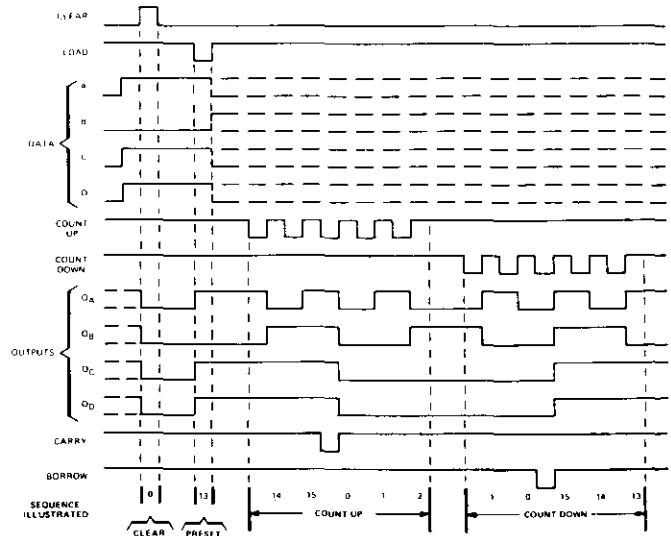
# SYNCHRONOUS 4 BIT UP/DOWN COUNTER (DUAL CLOCK WITH CLEAR)



typical clear, load, and count sequences

Illustrated below is the following sequence:

1. Clear outputs to zero.
2. Load (preset) to binary thirteen.
3. Count up to fourteen, fifteen, carry, zero, one, and two.
4. Count down to one, zero, borrow, fifteen, fourteen, and thirteen.

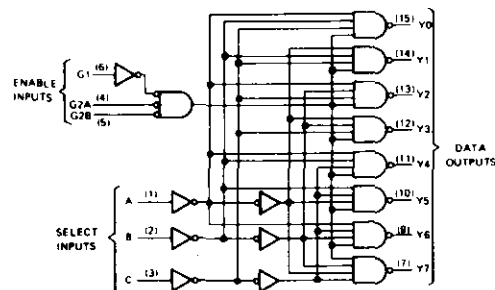


NOTES: A. Clear overrides load, data, and count inputs.

B. When counting up, count-down input must be high; when counting down, count-up input must be high.

1820-1216

## 3-BIT BINARY DECODER/DEMULTIPLEXER



FUNCTION TABLE

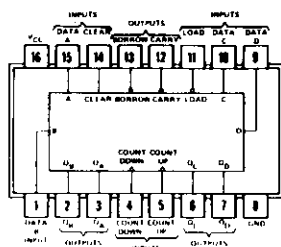
| ENABLE |     | SELECT |   |   | OUTPUTS |    |    |    |    |    |    |    |
|--------|-----|--------|---|---|---------|----|----|----|----|----|----|----|
| G1     | G2* | C      | B | A | Y0      | Y1 | Y2 | Y3 | Y4 | Y5 | Y6 | Y7 |
| X      | H   | X      | X | X | H       | H  | H  | H  | H  | H  | H  | H  |
| L      | X   | X      | X | X | H       | H  | H  | H  | H  | H  | H  | H  |
| H      | L   | L      | L | L | L       | H  | H  | H  | H  | H  | H  | H  |
| H      | L   | L      | L | H | H       | L  | H  | H  | H  | H  | H  | H  |
| H      | L   | L      | L | L | H       | H  | L  | H  | H  | H  | H  | H  |
| H      | L   | L      | L | H | H       | H  | L  | H  | H  | H  | H  | H  |
| H      | L   | L      | L | L | H       | H  | H  | L  | H  | H  | H  | H  |
| H      | L   | L      | L | H | H       | H  | H  | L  | H  | H  | H  | H  |
| H      | L   | L      | L | L | H       | H  | H  | H  | L  | H  | H  | H  |
| H      | L   | L      | L | H | H       | H  | H  | H  | L  | H  | H  | H  |
| H      | L   | L      | L | L | H       | H  | H  | H  | H  | L  | H  | H  |
| H      | L   | L      | L | H | H       | H  | H  | H  | H  | H  | L  | H  |

\*G2 = G2A + G2B

H = high level, L = low level, X = irrelevant

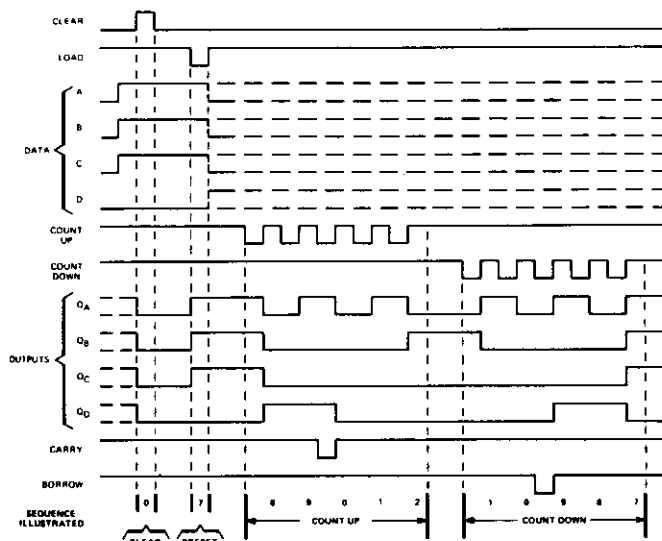
1820-1277

# SYNCHRONOUS 4-BIT DECADE UP/DOWN COUNTERS (DUAL CLOCK WITH CLEAR)



Illustrated below is the following sequence:

1. Clear outputs to zero.
2. Load (preset) to BCD seven.
3. Count up to eight, nine, carry, zero, one, and two.
4. Count down to one, zero, borrow, nine, eight, and seven.



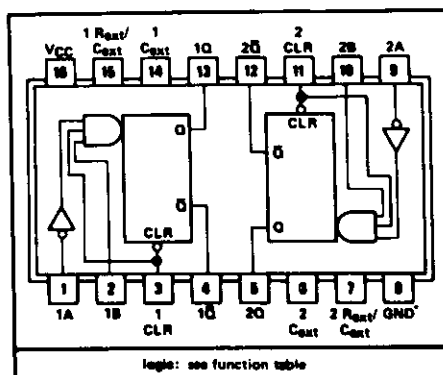
NOTES: A. Clear overrides load, data, and count inputs.  
B. When counting up, count-down input must be high; when counting down, count-up input must be high.

1820-1423

# DUAL RETRIGGERABLE MONOSTABLE MULTIVIBRATORS WITH CLEAR

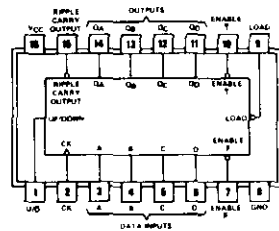
FUNCTION TABLE

| INPUTS |   | OUTPUTS |           |
|--------|---|---------|-----------|
| CLEAR  | A | Q       | $\bar{Q}$ |
| L      | X | X       | L         |
| X      | H | X       | L         |
| X      | X | L       | H         |
| H      | L | ↑       | ↓         |
| H      | X | ↓       | ↑         |
| ↑      | L | H       | ↓         |



## 1820-1454

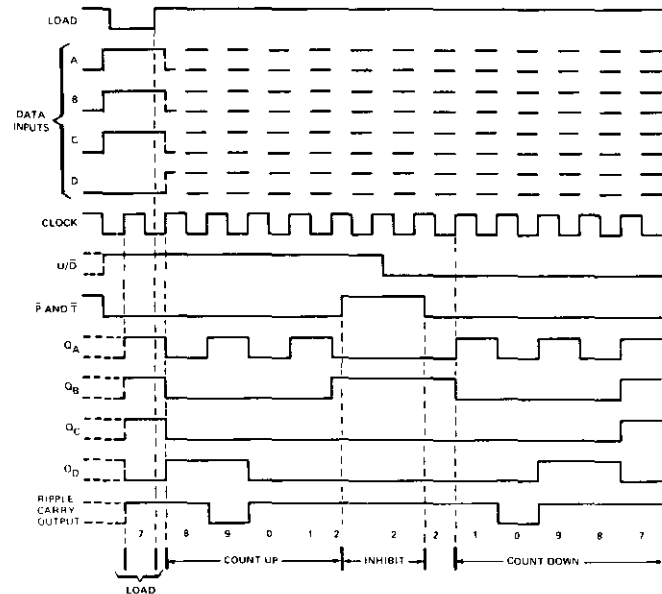
## SYNCHRONOUS DECADE UP/DOWN COUNTER



## typical load, count, and inhibit sequences

Illustrated below is the following sequence:

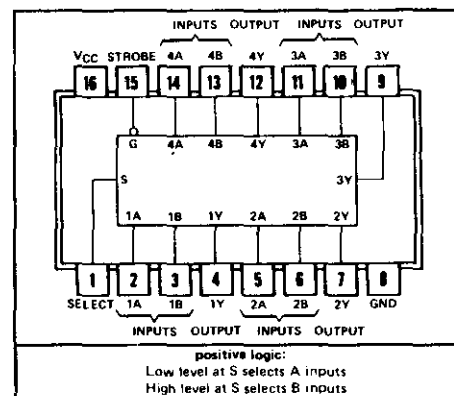
1. Load (preset) to BCD seven
2. Count up to eight, nine (maximum), zero, one, and two
3. Inhibit
4. Count down to one, zero (minimum), nine, eight, and seven



## 1820-1470

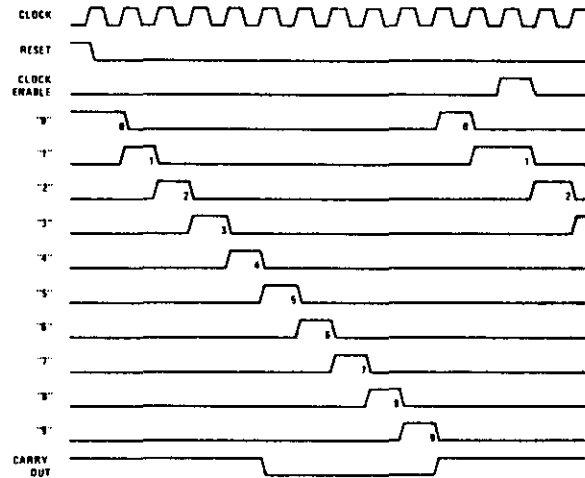
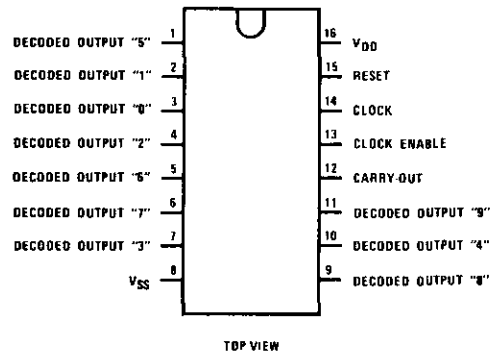
## QUAD 2 TO 1-LINE DATA SELECTORS/MULTIPLEXERS

| Inputs |        |     | Output |
|--------|--------|-----|--------|
| Strobe | Select | A B | Y      |
| H      | X      | X X | L      |
| L      | L      | L X | L      |
| L      | L      | H X | H      |
| L      | H      | X L | L      |
| L      | H      | X H | H      |



1820-1508

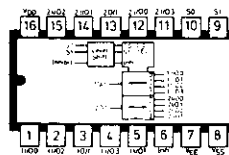
## DECADE COUNTER/DIVIDER WITH 10 DECODED OUTPUTS



1820-1546

## DUAL 4 TO 1-LINE ANALOG MULTIPLEXERS

| Inputs |    |    | Channel turned on |
|--------|----|----|-------------------|
| INH    | S1 | S0 |                   |
| H      | X  | X  | None              |
| L      | L  | L  | 0                 |
| L      | L  | H  | 1                 |
| L      | H  | L  | 2                 |
| L      | H  | H  | 3                 |



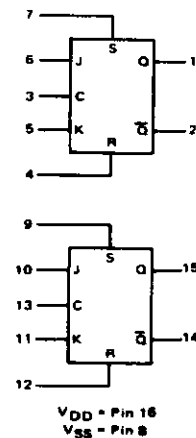
1820-1964

## DUAL JK FLIP-FLOP

| TRUTH TABLE |        |   |   |   |                  |                  |                  |
|-------------|--------|---|---|---|------------------|------------------|------------------|
| C†          | INPUTS |   |   |   | OUTPUTS*         |                  |                  |
|             | J      | K | S | R | Q <sub>n</sub> ‡ | Q <sub>n+1</sub> | Q <sub>n+1</sub> |
| 1           | 1      | X | 0 | 0 | 0                | 1                | 0                |
| 1           | X      | 0 | 0 | 0 | 1                | 1                | 0                |
| 1           | 0      | X | 0 | 0 | 0                | 0                | 1                |
| 1           | X      | 1 | 0 | 0 | 1                | 0                | 1                |
| 1           | X      | X | 0 | 0 | X                | Q <sub>n</sub>   | Q <sub>n</sub>   |
| 1           | X      | X | 1 | 0 | X                | 1                | 0                |
| 1           | X      | X | 0 | 1 | X                | 0                | 1                |
| 1           | X      | X | 1 | 1 | X                | 1                | 1                |

X = Don't Care  
 † = Level Change  
 ‡ = Present State  
 \* = Next State

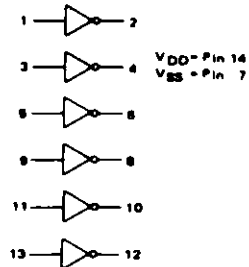
No Change



1820-2014

## HEX INVERTER

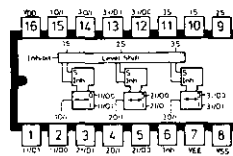
## LOGIC DIAGRAM



1826-0501

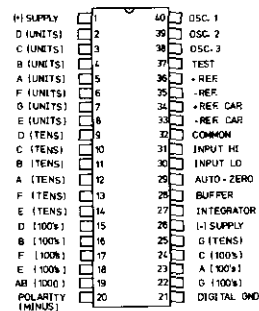
## TRIPLE 2 TO 1-LINE ANALOG MULTIPLEXER

| Inputs |   | Channel<br>turned on |
|--------|---|----------------------|
| INH    | S |                      |
| H      | X | None                 |
| L      | L | 0                    |
| L      | H | 1                    |



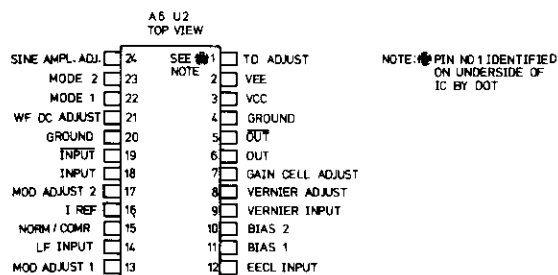
1826-0876

## 3 1/2DIGIT A/D CONVERTER



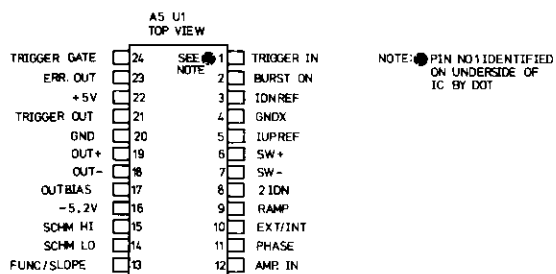
1826-0923

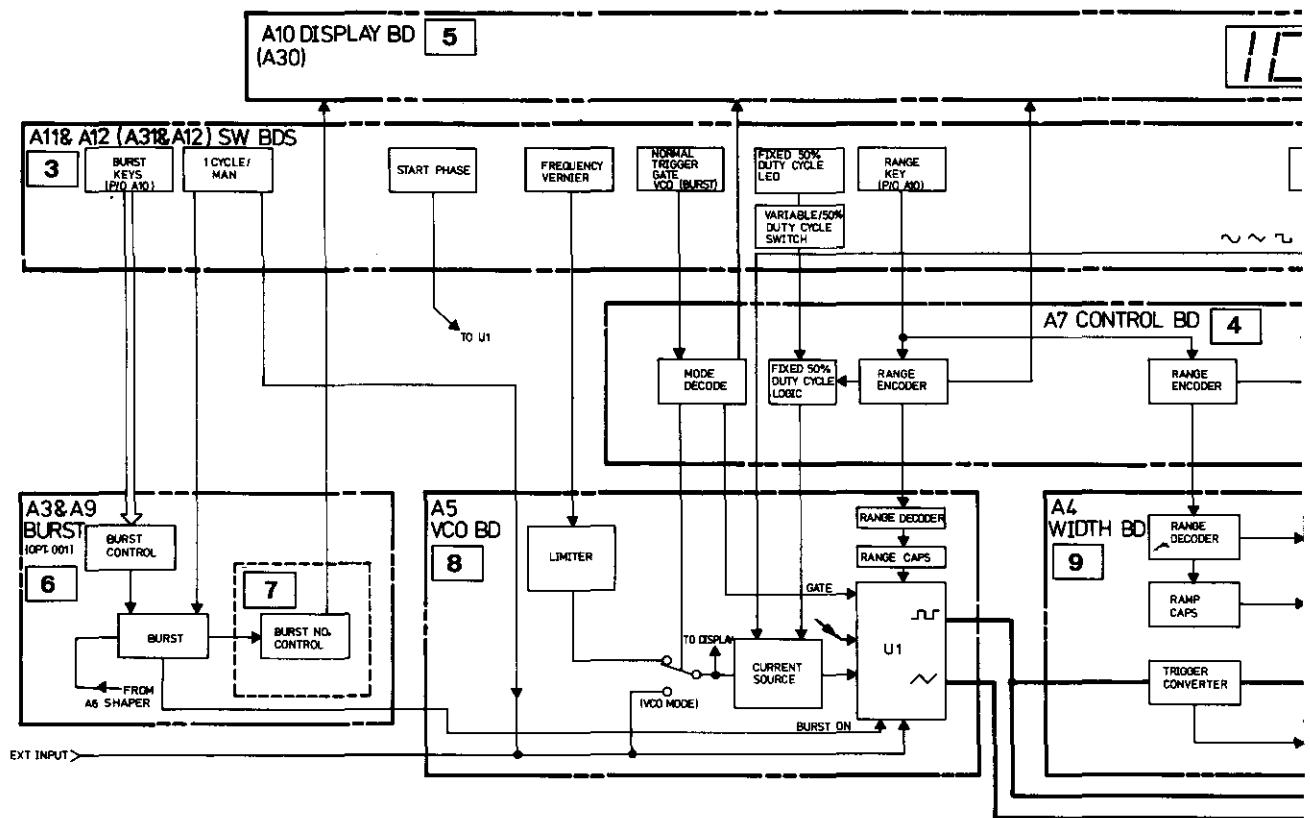
## SHAPER/VERNIER IC



1826-0955

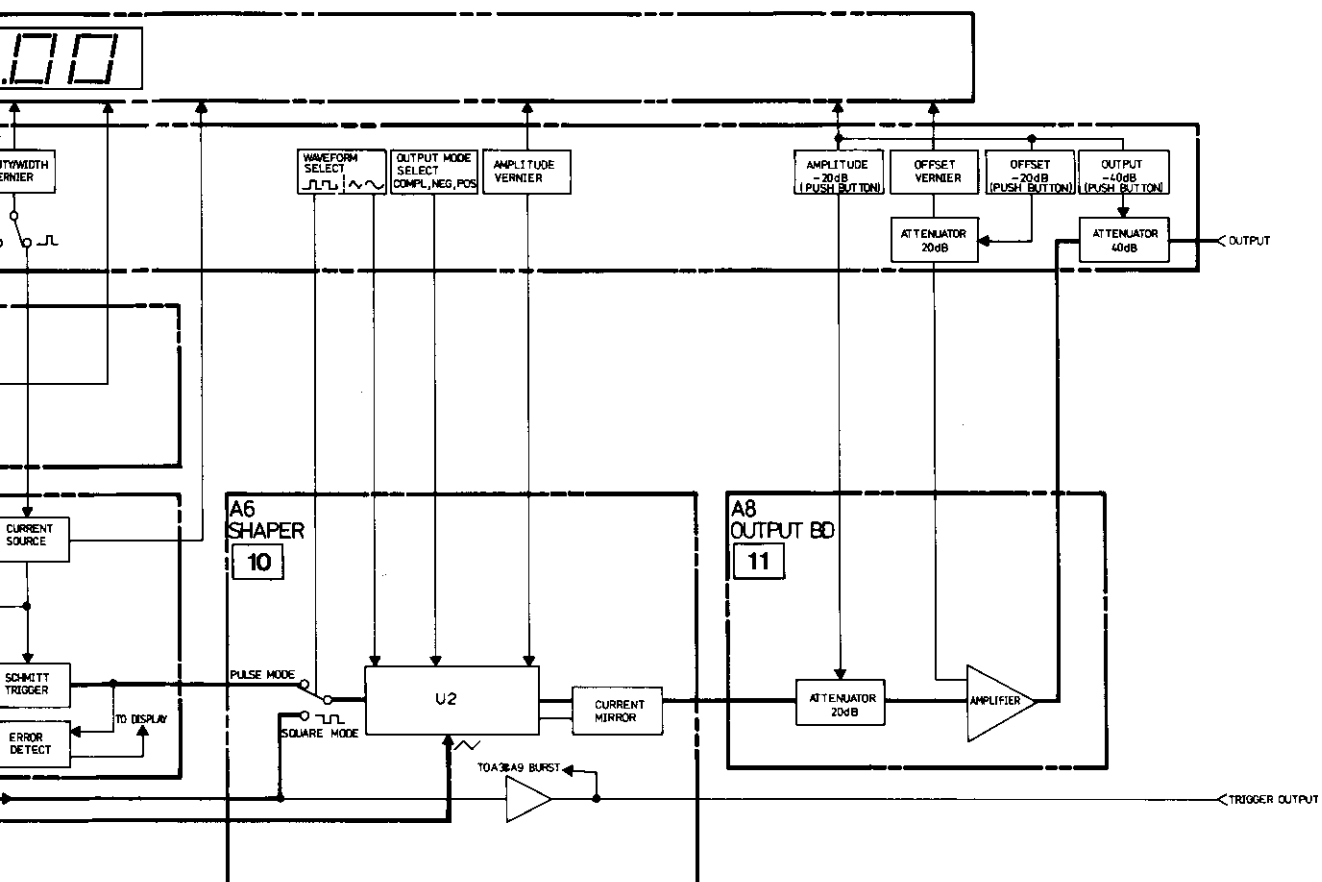
## TRIANGLE/SLOPE GENERATOR IC





NOTE: BOARD NUMBERS IN BRACKETS  
eg: A30) INDICATE DIFFERENCES  
FOR OPTION 001 (BURST) INSTRUMENTS.  
NUMBERS WITHIN RECTANGLES eg: [6]  
ARE SCHEMATIC IDENTIFIERS

Figure 8-1-1. 8111A Block Diagram, Option 001 (Burst) Details Included



## SERVICE BLOCK 1 PROBLEM AREA IDENTIFICATION

### General

The purpose of this Service Block is to present a brief overview of the instrument circuits operation which, when combined with the Troubleshooting Tree (Figure 8-1-3), will assist in quickly identifying which Service Block(s) should be referred to. Once the actual board or circuit at fault has been identified, reference to the appropriate Service Block will provide detailed circuit operational theory and comprehensive troubleshooting data. Details of the overall 811A circuits operation and the function of individual boards follows, reference should also be made as necessary to Figure 8-1-1 and the condensed block diagram - Figure 8-1-2. Where possible, the board descriptions are given in the same order as they appear in the two block diagrams i.e. in their logical priority.

### Board/Signal Flow Description (Standard 8111A)

In all operating and waveform modes except External Trigger/Pulse, board A5 (VCO) functions as a rate generator with the rate (or frequency) being determined either by front panel settings or by an externally applied control voltage. For the one exception stated, A5 serves only as a Schmitt trigger to ensure that the incoming trigger signal is compatible with level shifter of A6 (Shaper) and the trigger converter circuit of A4 (Width).

Two output signals are produced by A5 U1 - triangular and square waveforms, the triangular waveform is input to A6 (Shaper) where it is further processed by A6 U2 to form a sinusoidal function if necessary and also given the required ("front panel") output mode and amplitude settings. If a squarewave is required then the "square output" from A5 U1 is utilized and processed by A6 U2. In pulse mode, the "square output" from A5 U1 is input to A4, given the required width characteristics (determined by front panel settings) and then output to A6 where it is processed as necessary. In all cases, the output from A6 is input to A8 (Output) for offset control and amplitude, output and offset attenuation.

A7 (Control) serves basically as an interface between A11, A12, A5 and A4. A3, A9, A6 and A8 interface directly with the front panel controls and A11, A12.

Parameter and error display is by board A10 with parameter display being via an A-D converter (analogue voltages derived from vernier control settings) and application of appropriate scaling factors via A12U12 depending on the chosen parameter.

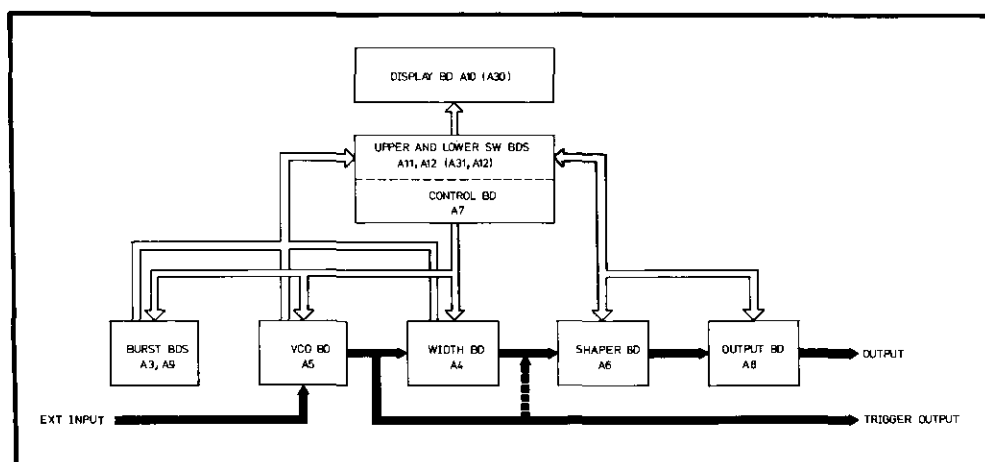


Figure 8-1-2. 8111A Condensed Block Diagram

### Differences for Option 001 - Burst instruments

In Option 001 (Burst) instruments a trigger signal, either externally generated or via the Manual/1 Cycle switch, is required to initially activate A5U1. It is then maintained active by a signal (BURST ON) from A3.

The operating frequency and all other settings are made as for the standard 8111A, (via front panel settings and A11, A12 and A7 Control). The output is disabled by the BURST ON signal going low. The burst number, set by the Burst rocker switches, keeps the signal active high until the required output count is reached, it is also used by A9 to control the display value of A10.

### TROUBLESHOOTING

The Troubleshooting Tree, Figure 8-1-3, should be referred to when necessary since it shows the connection between possible faults and related boards. While it will be found to be correct for all the basic fault conditions or symptoms, it cannot cover all possible situations.

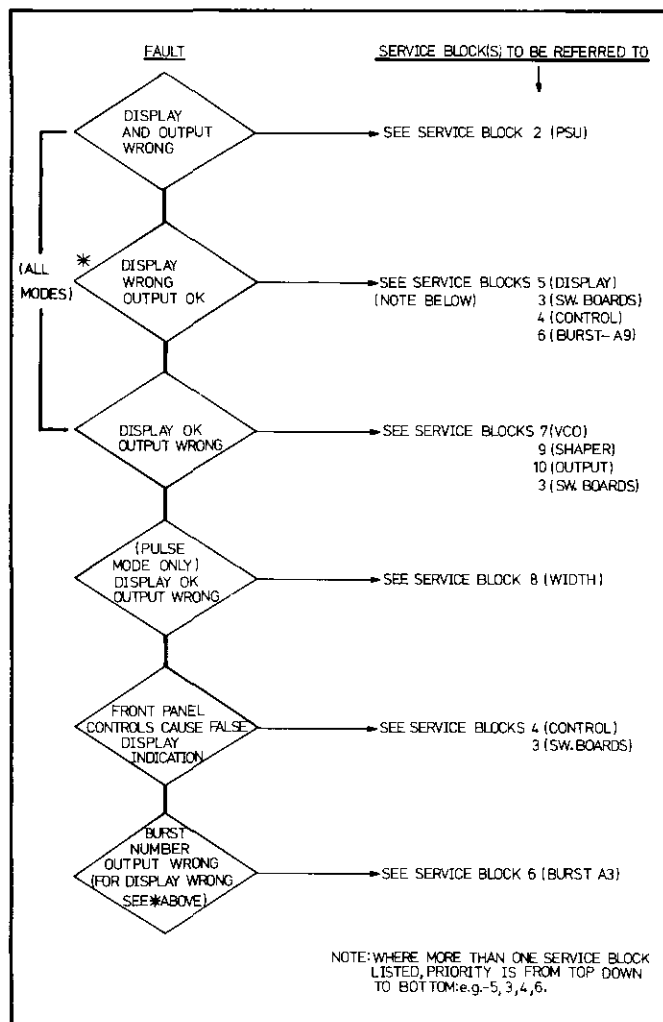
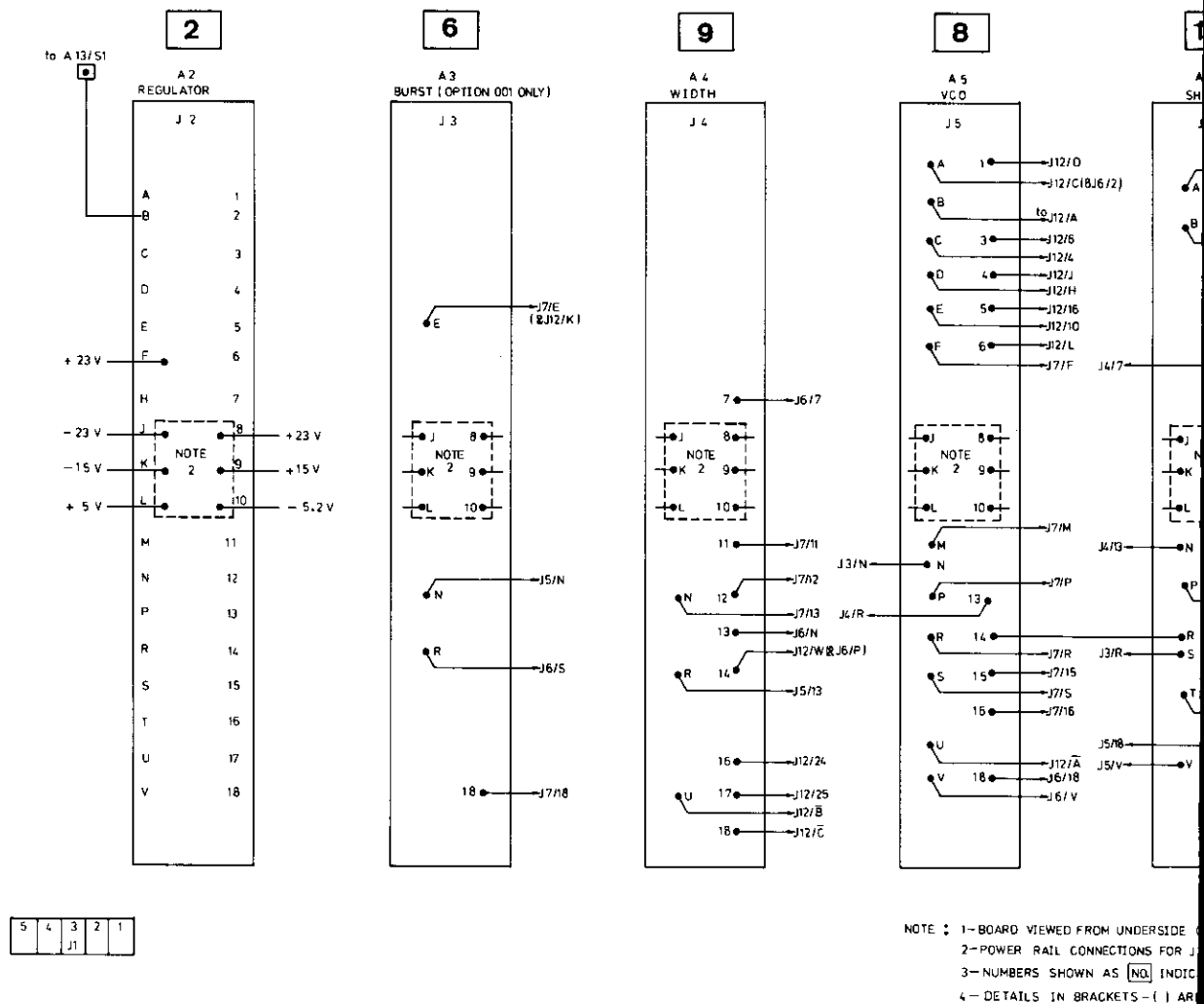


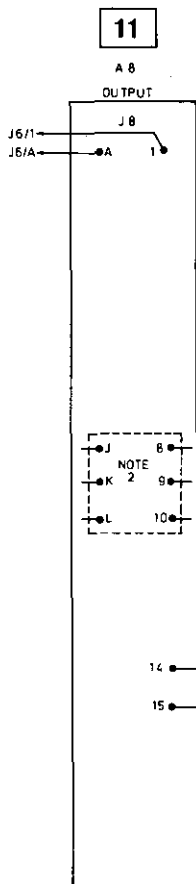
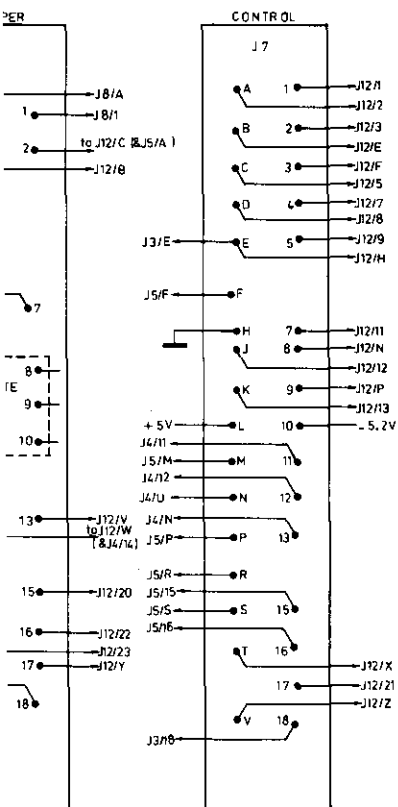
Figure 8-1-3. Troubleshooting Tree

A1 BD AY MOTHERBOARD 08111-66501 STANDARD  
 A21 ■ ■ ■ 08111-66521 OPTION 001

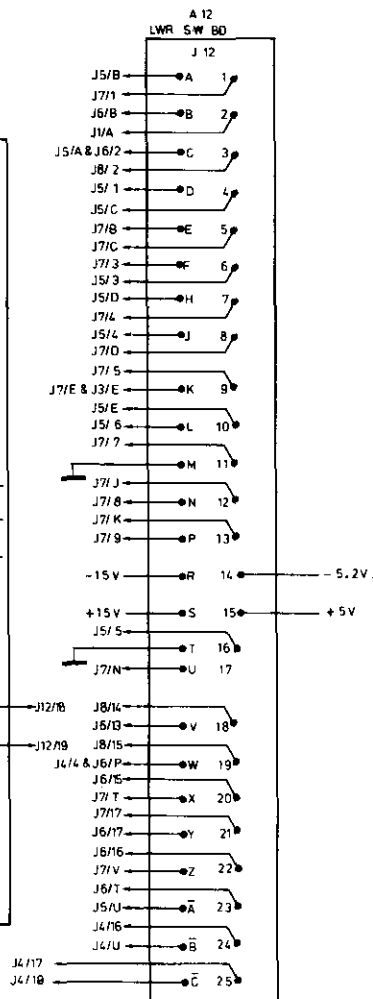


—FRONT—

0



**3**



INSTRUMENT  
AND J 8 IDENTICAL WITH J 2.  
E CORRESPONDING SERVICE SHEET NUMBER.  
ADDITIONAL CONNECTION POINTS

—FRONT—

## SERVICE BLOCK 2 POWER SUPPLY A1, A2, A13 2

### THEORY OF OPERATION

#### General

The 8111A power supply comprises basically a step down transformer, bridge rectifiers, smoothing capacitors and various regulators. The components are distributed over boards — A1, A2 and A13.

The instrument may be operated from 100/120/220 or 240 Vrms single phase supplies. Two line voltage selector switches, A2, S2 and S3, are provided to enable the appropriate local voltage to be used. Operation of these switches causes the correct combination of transformer T1 primary windings to be selected so that the required secondary voltages are produced. These voltages are then rectified, smoothed and regulated to produce the following regulated supplies:

$$\pm 23 \text{ V}, \pm 15 \text{ V}, +5 \text{ V}, -5.2 \text{ V}$$

The unregulated  $\pm 23 \text{ V}$  rails are used to generate auxiliary  $\pm 15 \text{ V}$  supplies and regulated  $\pm 23 \text{ V}$  and  $\pm 15 \text{ V}$ . The auxiliary supplies ( $\pm 15 \text{ VR}$ ) are derived via zener diodes

and are the power source for PSU (Power Supply Unit) regulators and protection circuits. In the event of a PSU shut-down, due to a short circuit for example, the auxiliary supplies ensure that the protection circuits maintain their integrity.

**NOTE:** References to components in the following paragraphs are always for board A2 unless otherwise indicated.

#### Reference Voltage

All voltage regulators in this PSU use the same reference voltage ( $-5.2 \text{ V}$ ) which is generated by zener diode VR1 and a potential divider.

At instrument switch on the zener diode supply current for the  $-5.2 \text{ V}$  supply comes from the rectified transformer output via CR10, R3, Q2. During normal operation the zener current comes from the regulated  $-15 \text{ V}$  supply via CR9, CR10 is then nonconducting. R2/C5 provides a slow ramp-like rise of the reference voltage and therefore also of the regulated supplies.

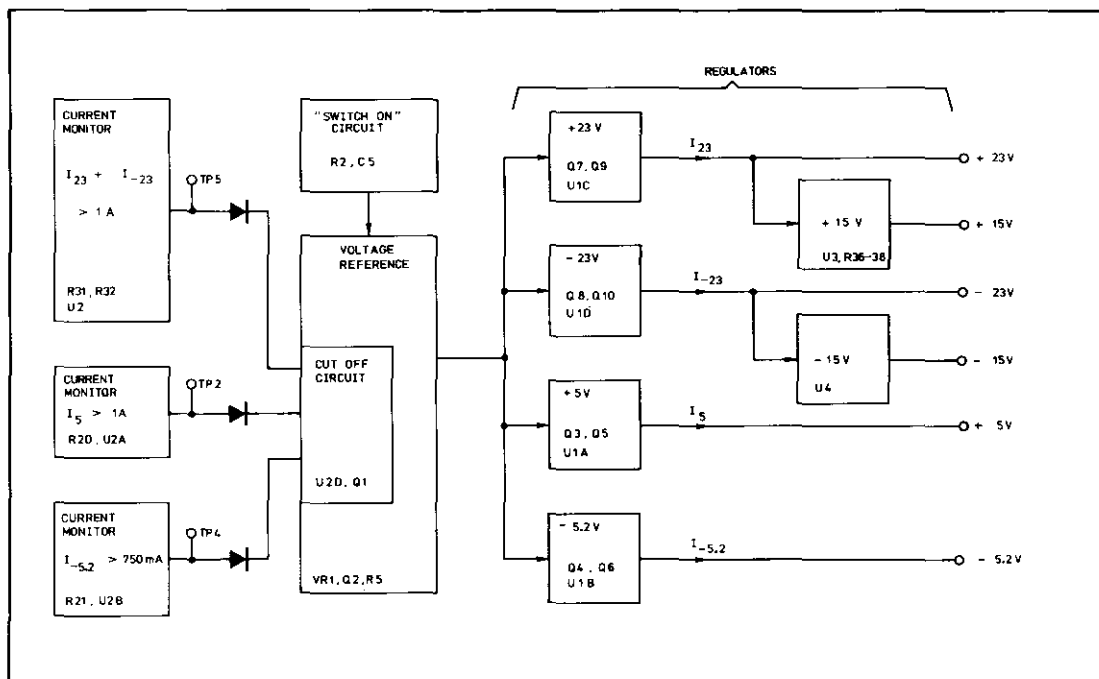


Figure 8-2-1. Simplified Voltage/Current Regulating/Limiting Circuits

### ± 23 V Supplies

A simplified functional diagram illustrating the operating principle of a positive voltage regulator is shown in Figure 8-2-2. The circuit functions as an inverting amplifier with a high current output. The operating principle of the negative voltage regulator is shown in Figure 8-2-3. The error amplifier compares  $V_{reg}$  with  $V_{ref}$  and drives the regulator transistor to zero difference. Excessive output current is detected by R31 and R32 as shown in Figure 8-2-5. The output of the overload amplifier U2C goes high if the voltage drops over R31 and R32 exceed a set level.

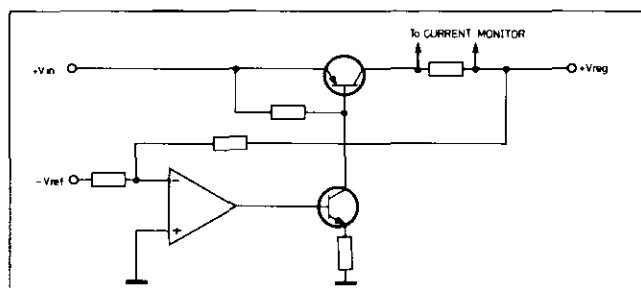


Figure 8-2-2. Principle of Fixed Positive Voltage Regulator

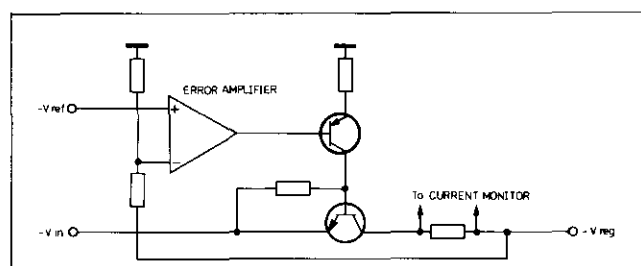


Figure 8-2-3. Principle of Fixed Negative Voltage Regulator

### ± 15 V Supplies

The ± 15 V supplies are derived from the regulated ± 23 V supplies by using "standard 3 pin" voltage regulators. Excessive current is detected by R31 and R32.

### ± 5 V/-5.2 V Supplies

The voltage regulator operating principles are the same as those which have been described in the previous paragraphs. Principles of excessive current detection of the +5 V regulator is shown in Figure 8-2-4. For the -5.2 V regulator the same principle applies with changed polarities.

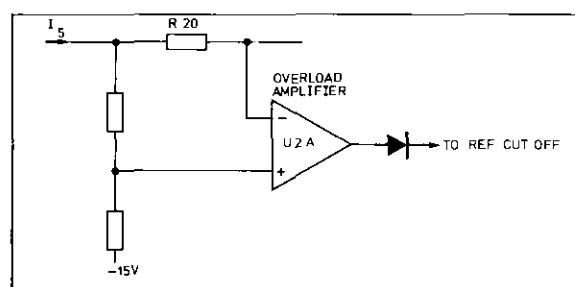


Figure 8-2-4. Current Monitor

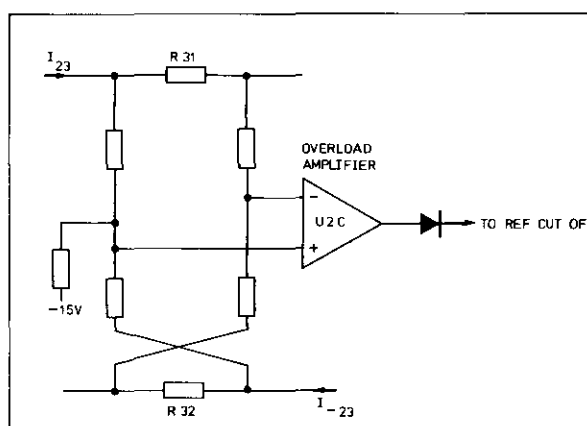


Figure 8-2-5. Summing Current Monitor

Switch-off Circuit

An overload signal from one of the current monitoring amplifiers will cause C6 to charge up via R8. When the threshold level of the Schmitt trigger U2D, R9, R10 is reached, its negative going output turns Q1 on, the current for Vref is turned off, so Vref goes to zero causing all regulated voltages to be reduced to zero. After a time (determined by the time constant of R7 and C6) the threshold level of the Schmitt trigger (now negative) is reached, Q1 turns off, C5 begins to charge up, thus ensuring a slow ramp-like rise of the reference voltage at R5. If the overload still exists, then the whole procedure is repeated continuously.

TROUBLESHOOTING

Two basic faults can occur in the PSU:

- a. no voltage or over-voltage caused by a faulty supply.
- b. excessive current consumption (due to a short circuit or faulty component) on one of the boards which is recognizable by all supplies being repeatedly switched on and off.

Faulty Supply

If one supply is at fault, troubleshoot it as necessary to locate the faulty or failed components.

Excessive Current

Note that an excessive current taken from only one supply will cause all supplies to be switched on and off repeatedly. A short circuit across one of the supplies will cause all voltage rails to be narrow pulsed, thus the 8111A display will remain dark (LEDs under-energized). Excessive current, but no short circuit causes wider pulses and the display may flash.

To determine which is the overloaded supply, measure at TP2, TP4 and TP5 and note which current monitor is active, (see Figure 8-2-6).

Having determined the overloaded supply, locate the faulty board by pulling out each in turn starting with the output amplifier and finishing with the complete front panel assembly.

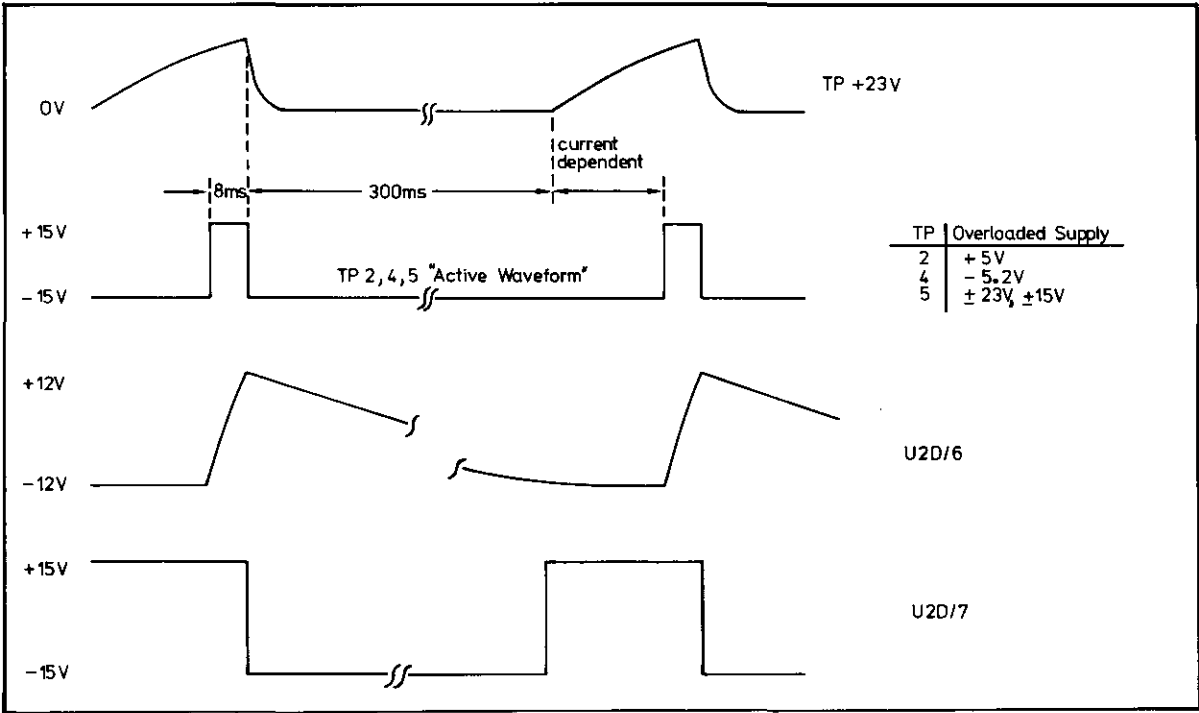
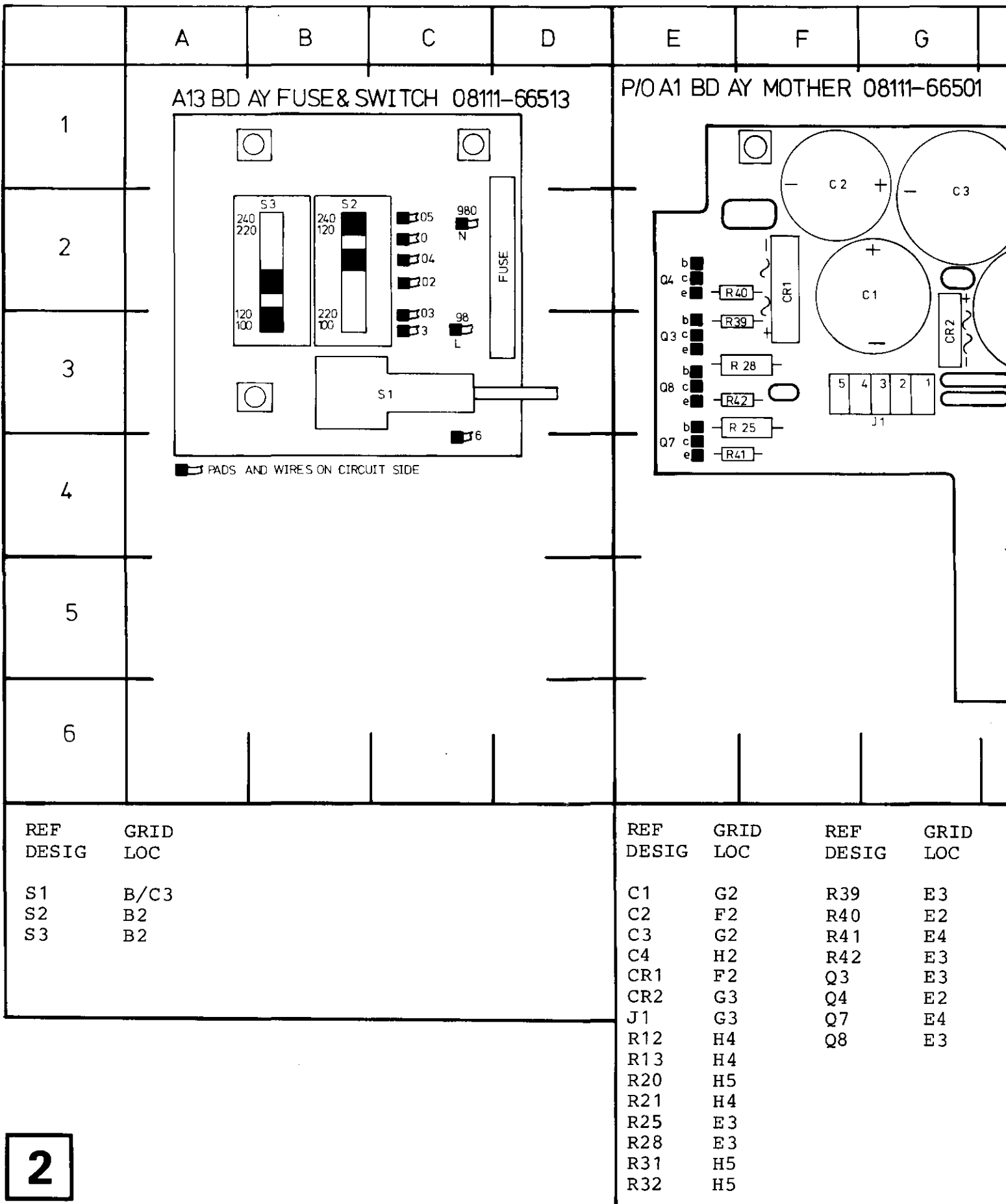
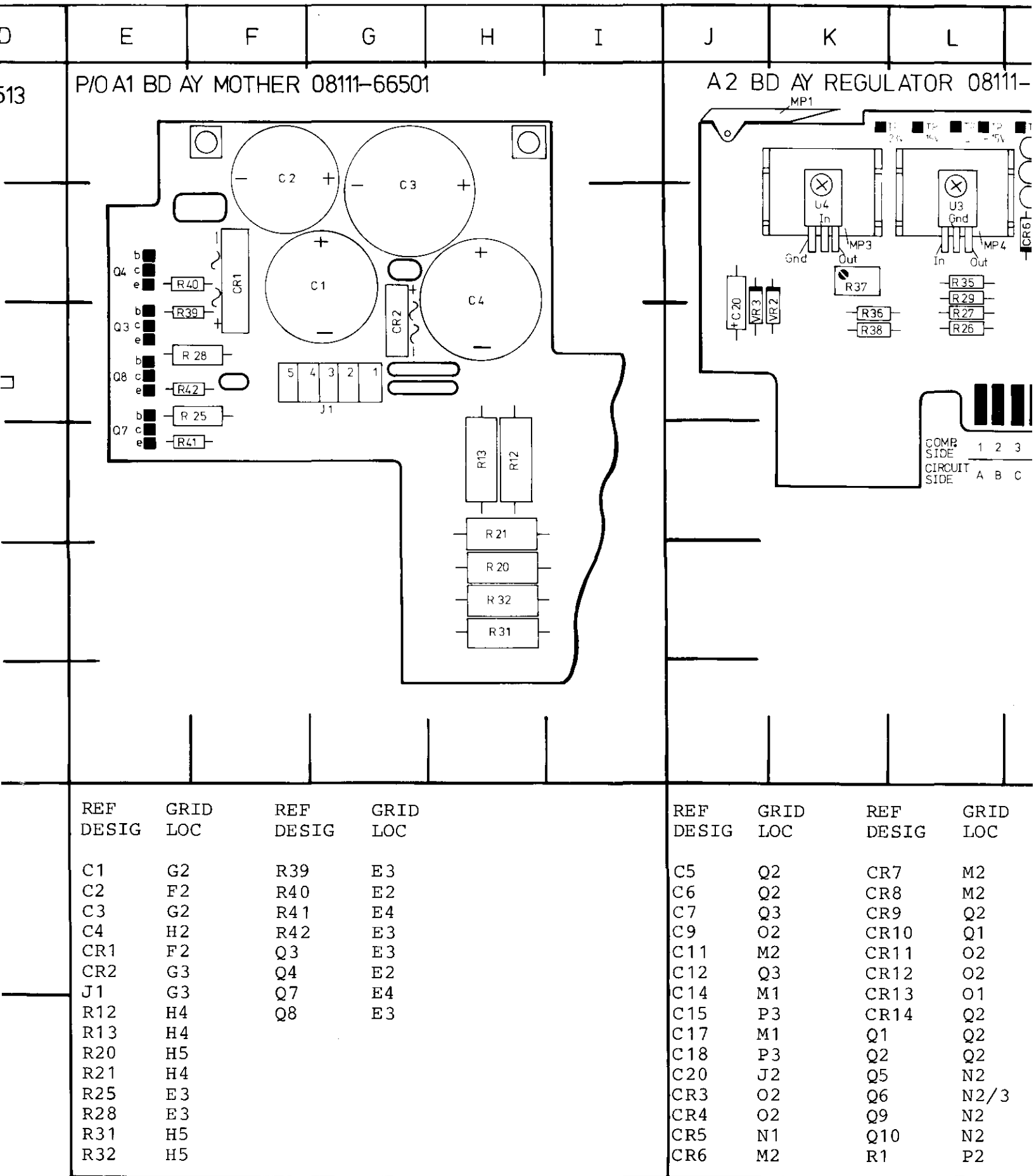
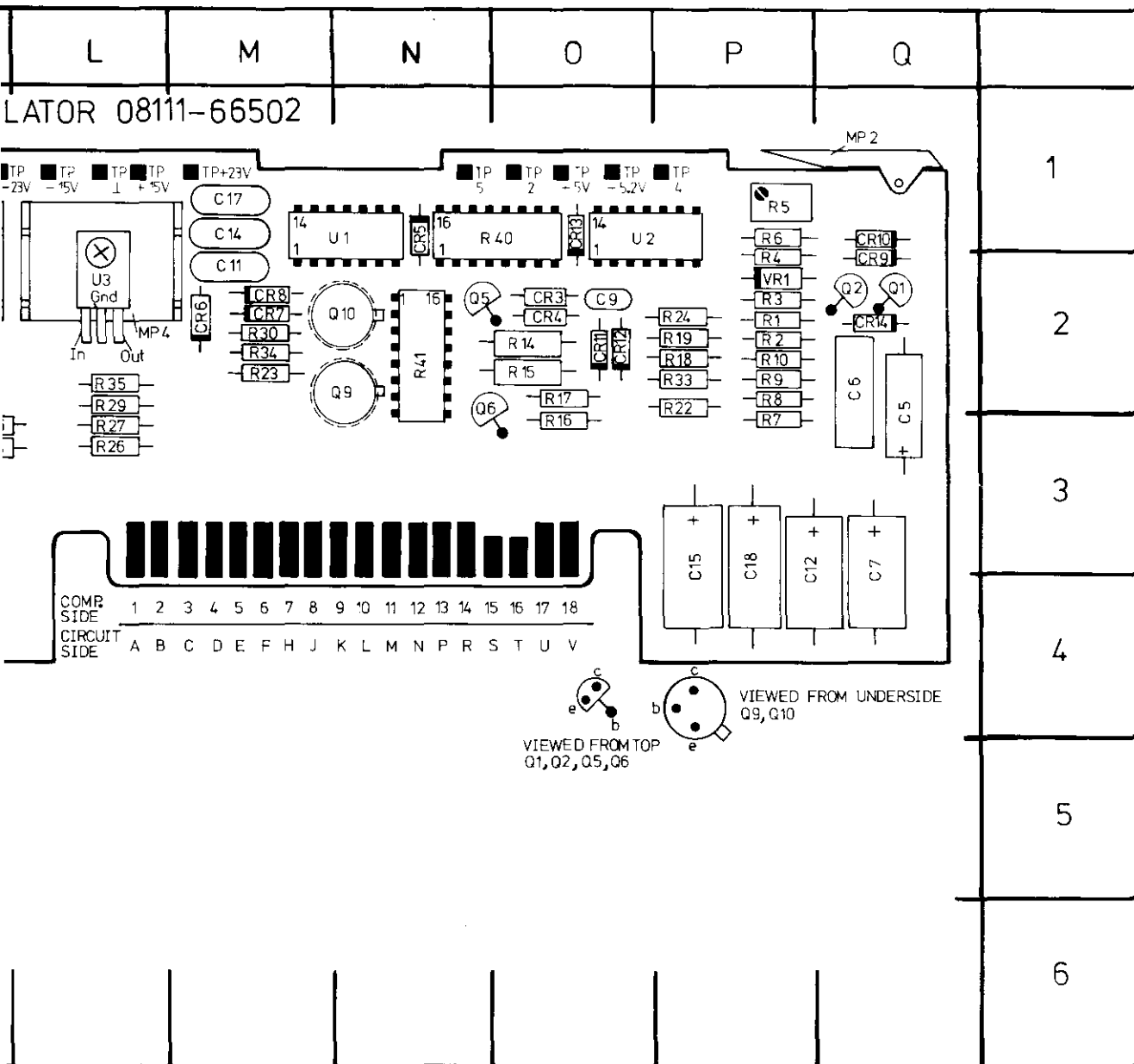


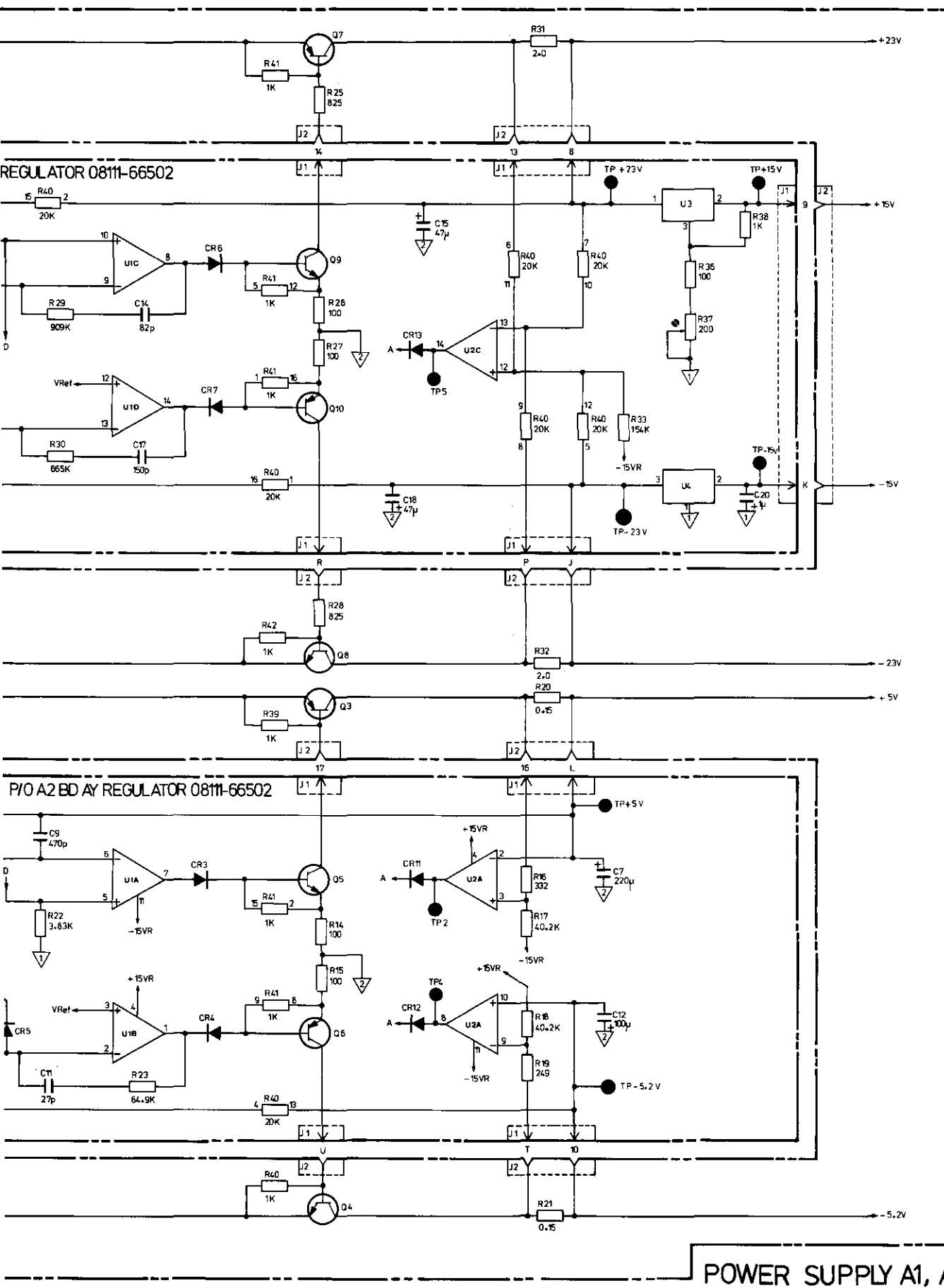
Figure 8-2-6. Fault Condition Output Waveforms



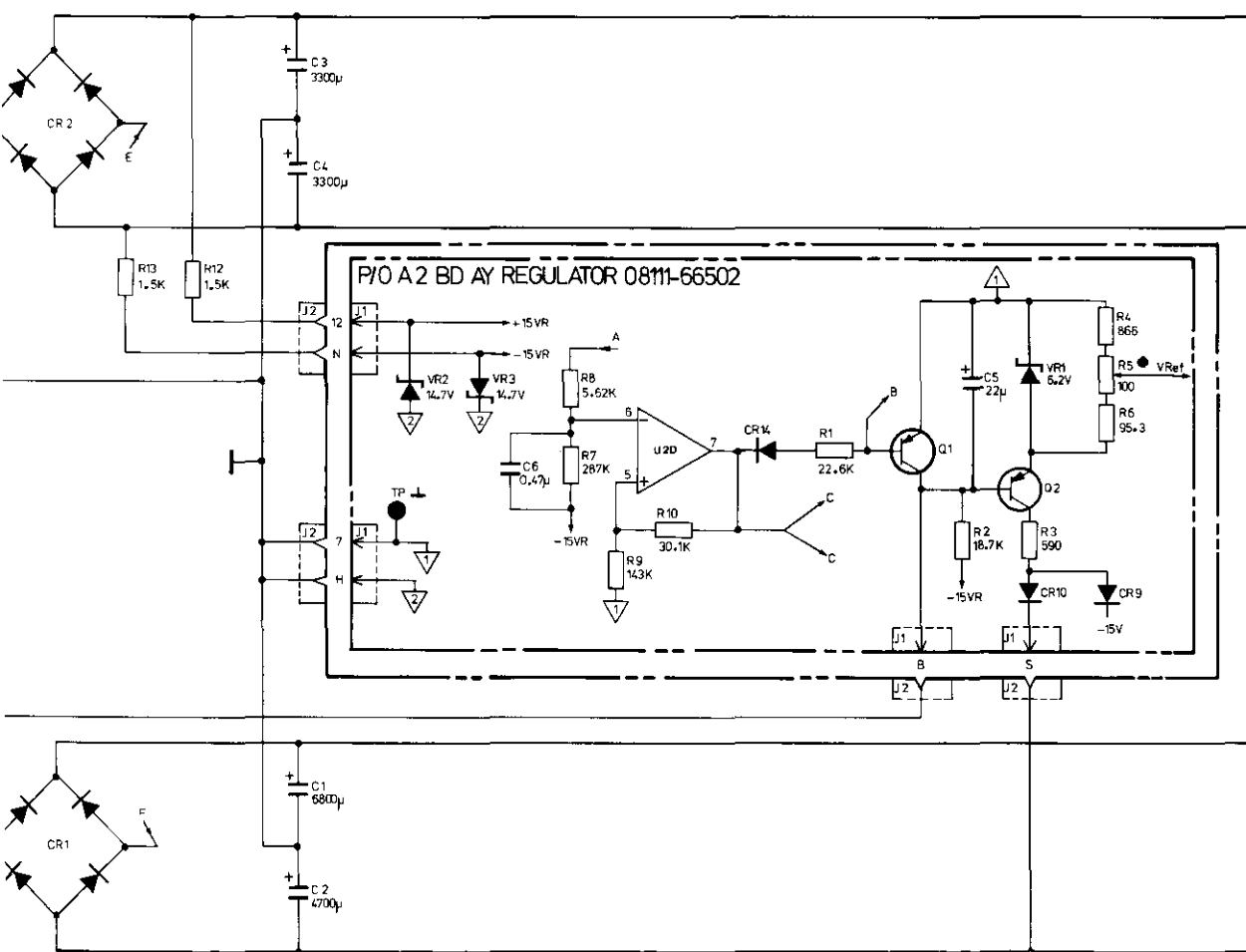




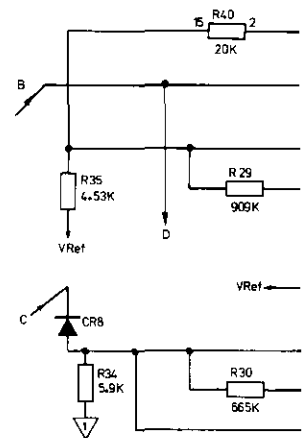




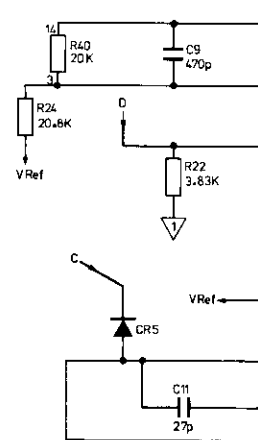
Y MOTHERBOARD 08111-66501 (STANDARD)  
Y MOTHERBOARD 08111-66521 (OPTION 001)



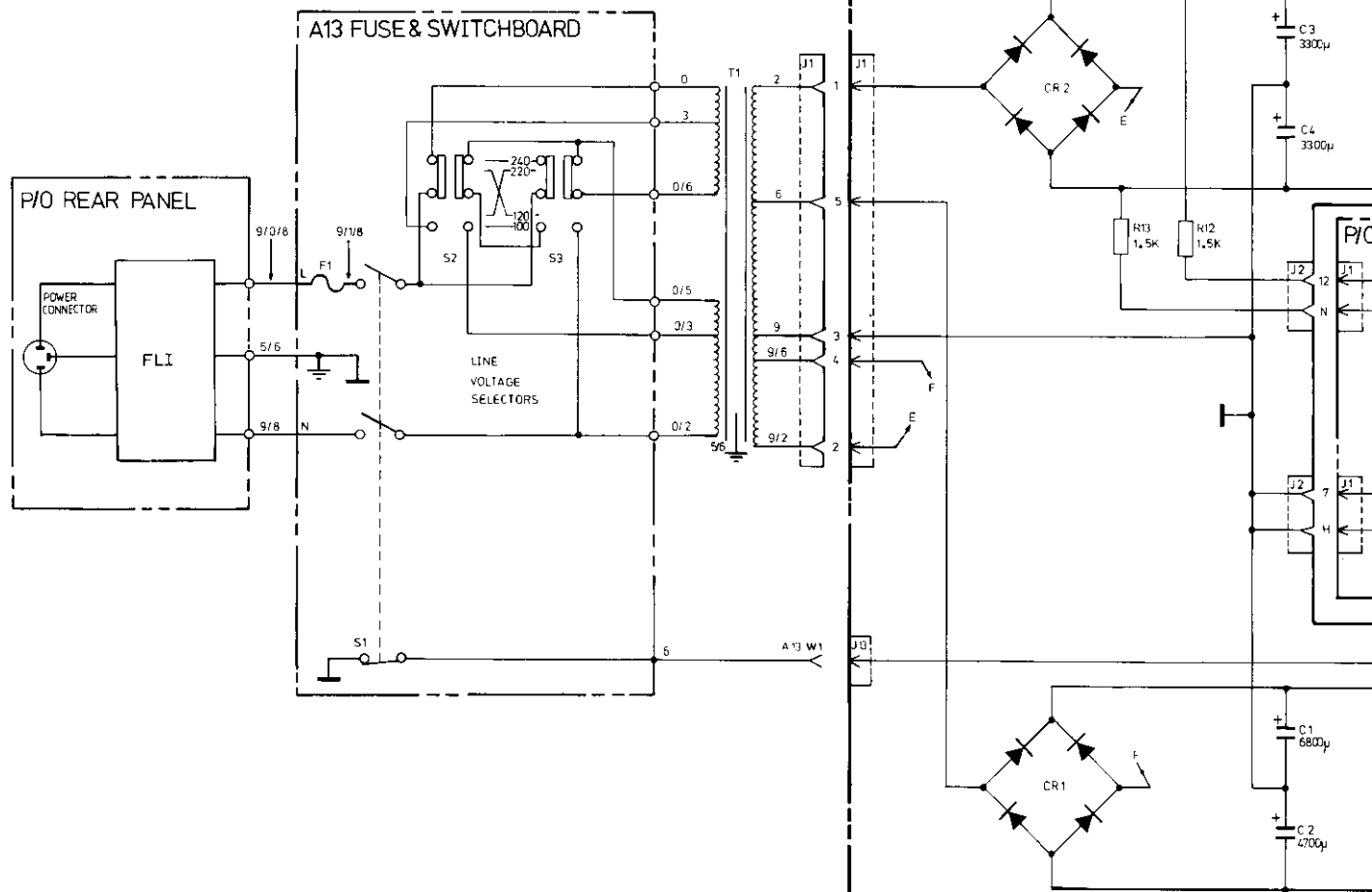
P/O A2 BD AY REGULATOR 0



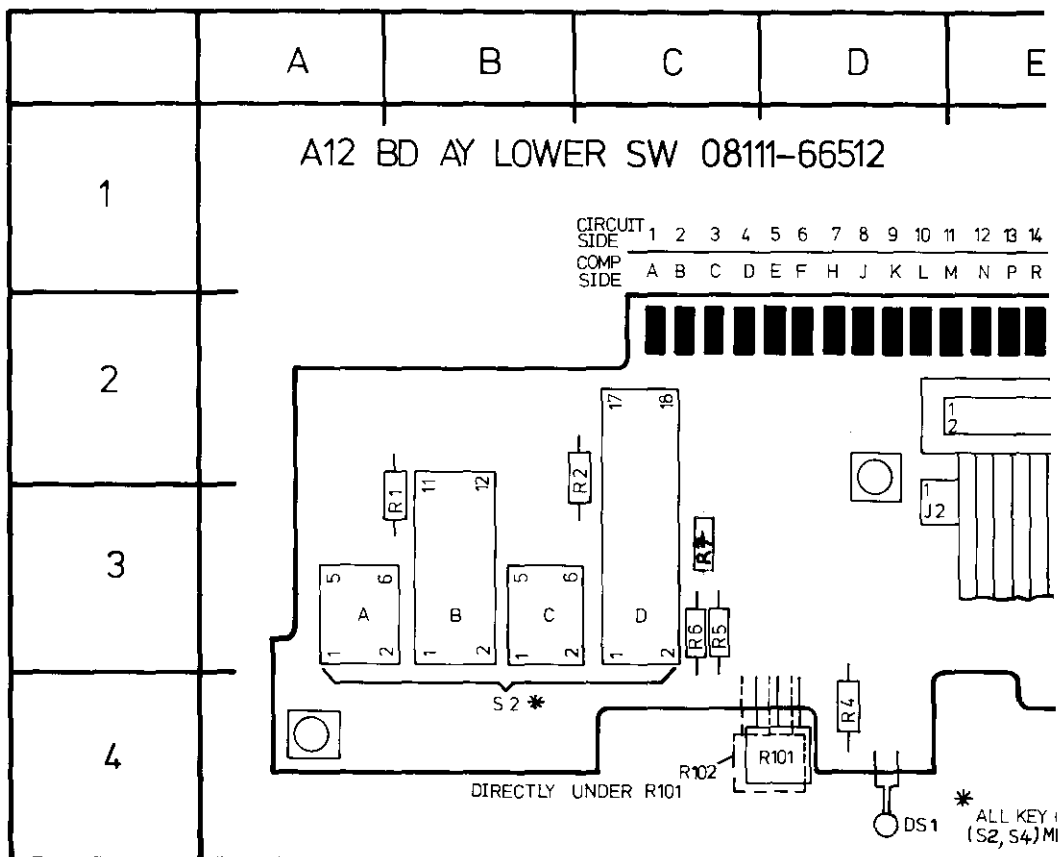
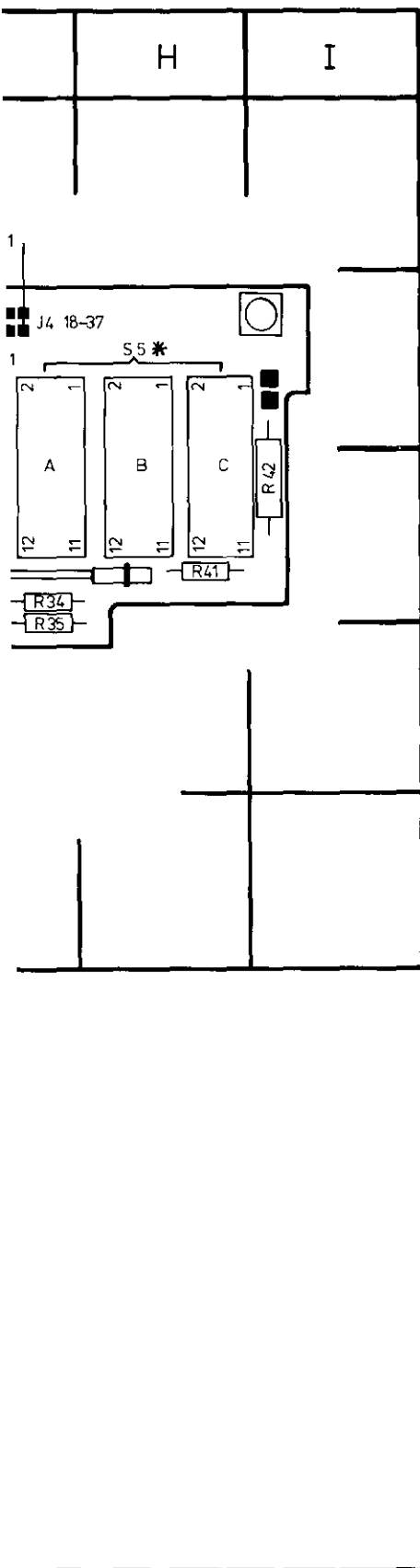
P/O A2 BD AY



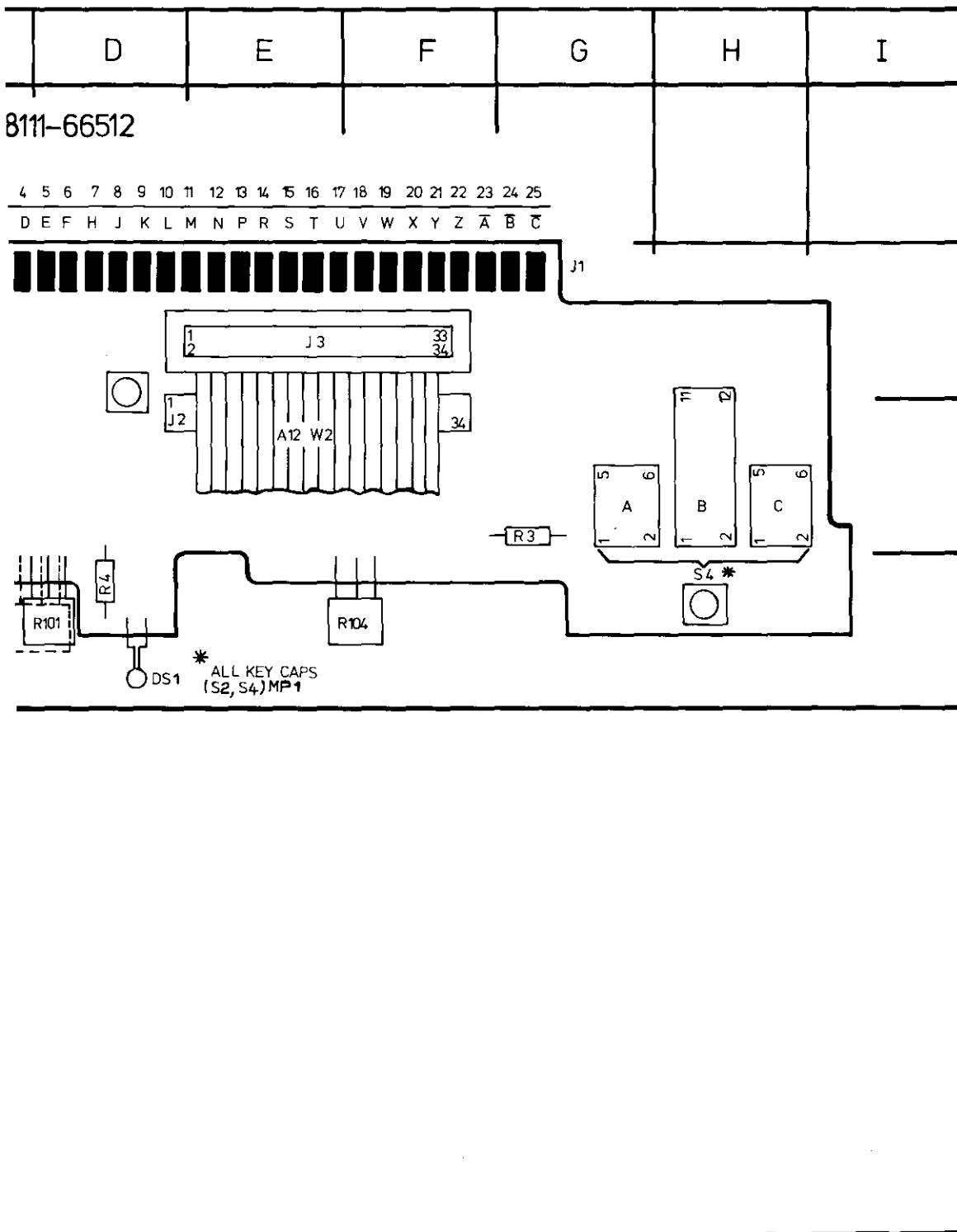
P/O A1 BD AY MOTHERBOARD 08111-66501 (STA  
 A21BD AY MOTHERBOARD 08111-66521 (OP



| REF<br>DESIG | GRID<br>LOC | REF<br>DESIG | GRID<br>LOC |
|--------------|-------------|--------------|-------------|
| CR11         | B3          | R30          | F3          |
| Q1           | E2          | R31          | F3          |
| Q2           | B3          | R32          | G4          |
| R11          | C2          | R33          | G3          |
| R12          | C2          | R34          | G3          |
| R13          | C2          | R35          | G4          |
| R14          | C3          | R41          | H3          |
| R15          | C3          | R42          | F3          |
| R16          | D2          | R44          | B2          |
| R18          | B3          | R45          | B2          |
| R20          | C3          | R46          | B2          |
| R21          | C3          | S1           | A2          |
| R26          | D3          | S3           | C/G3        |
| R27          | D3          | S5           | D/G3        |
| R28          | D3          | U11          | C3          |
| R29          | F3          | U12          | C3          |



| REF<br>DESIG | GRID<br>LOC |
|--------------|-------------|
| DS1          | D4          |
| J2           | D/F2        |
| R1           | B3          |
| R2           | B3          |
| R3           | G3          |
| R4           | D4          |
| R5           | C3          |
| R6           | C3          |
| R101         | D4          |
| R102         | D4          |
| R104         | F4          |
| S2           | A/C3        |
| S4           | G/H3        |
| R7           | C3          |



## SERVICE BLOCK 3 SWITCH BOARDS A11 (A31), A12 3

### THEORY OF OPERATION

The Switch boards contain the switches and interconnections required for selection of the appropriate circuit elements involved in the various 8111A operating modes and functions. An additional feature of A11 (A31) is that it includes the voltage reference, and parameter signal control circuitry for the Display board A-D converter. The reference selection and signal switching is achieved by multiplexer A11 U12 under the control of A11 U11.

### TROUBLESHOOTING

#### NOTE: FRONT PANEL ASSEMBLY REMOVAL:

To troubleshoot either of the switch boards (or Display or Burst Number Control board) it is usually necessary to separate the complete Front Panel Assembly from the instrument frame and motherboard connector (J12) and reconnect it via an extender board. To remove the front Panel Assembly refer to Figure 3-1 to identify the securing screws to be removed. Access to the two upper screws is by removing MP24 — the plastic trim strip which can be levered out with the aid of a screwdriver.

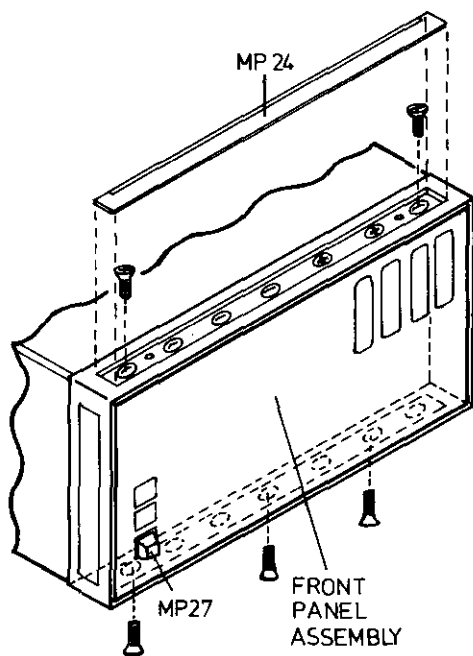


Figure 3-1.

After removal of the five screws the complete Front Panel assembly can be gently pushed forward out of the instrument frame away from the motherboard connector and over MP27.

**NOTE:** There are two interconnecting co-axial cables between the Front Panel assembly and boards A6 and A8, complete removal of the assembly from the instrument requires that they are disconnected at the two boards. The same applies (Option 001 instruments only) to the ribbon cable between A3 and A9, this should be disconnected at board A9.

**REMEMBER** to reconnect all of these cables when re-fitting the Front Panel Assembly in the instrument.

When refitting the assembly, MP27 should be guided through the appropriate front panel hole otherwise it can jam.

Since the switch boards comprise mostly passive components, no troubleshooting information is included for these. The only data is the following: If the displayed value is incorrect, then, as mentioned in Service Block 5 (Display), A11 U11 and A11 U12 may be faulty. The following truth table conditions should be checked and it should be noted that U11 pin 9 is high only when the Duty/Width and Frequency pushbuttons are both pressed.

Table 8-3-1. U11 Truth Table

| Selected Waveform                                                                     | U11 pin 8 |
|---------------------------------------------------------------------------------------|-----------|
|    | L         |
|  | H         |
|  |           |

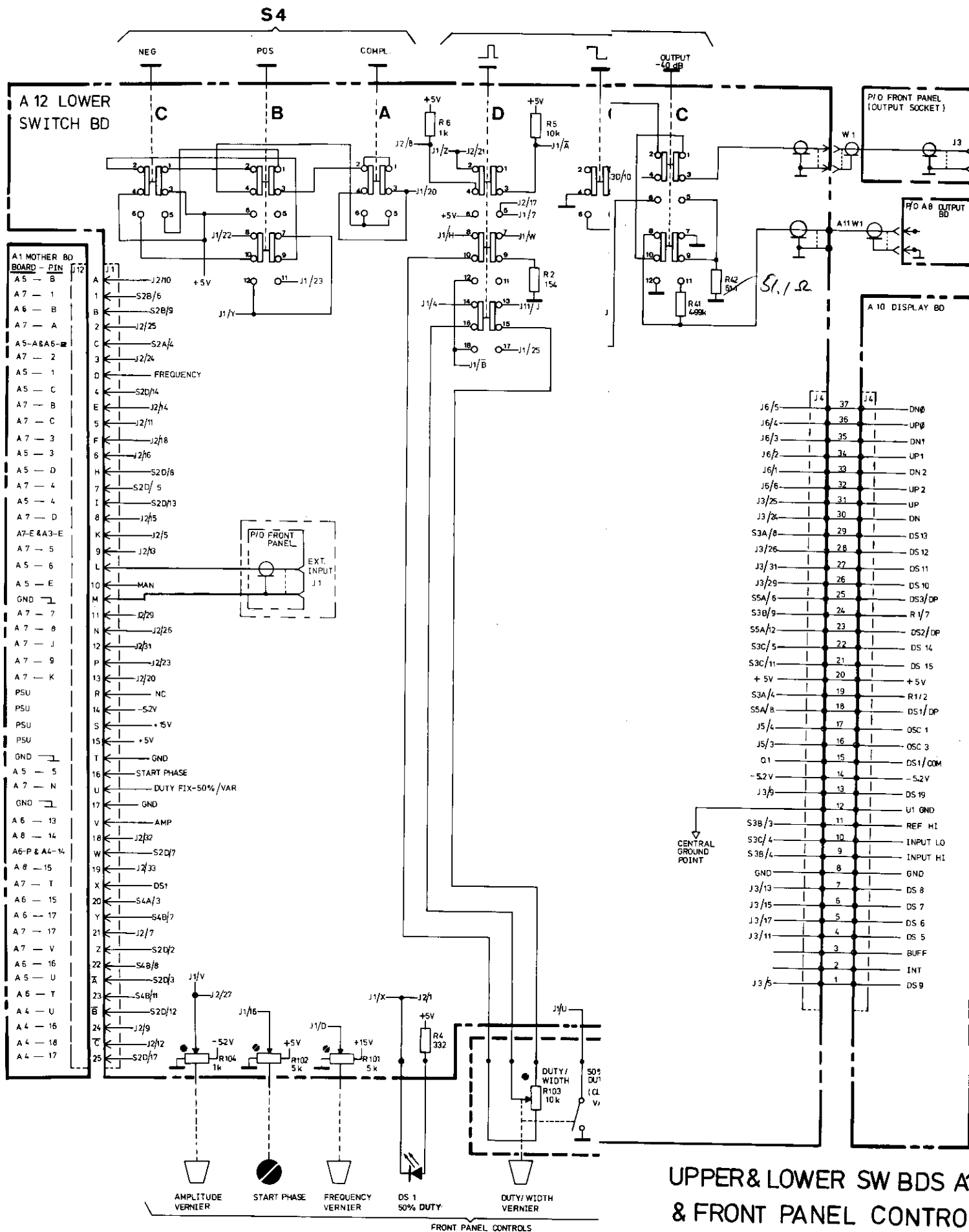
Table 8-3-2. U11 Truth Table

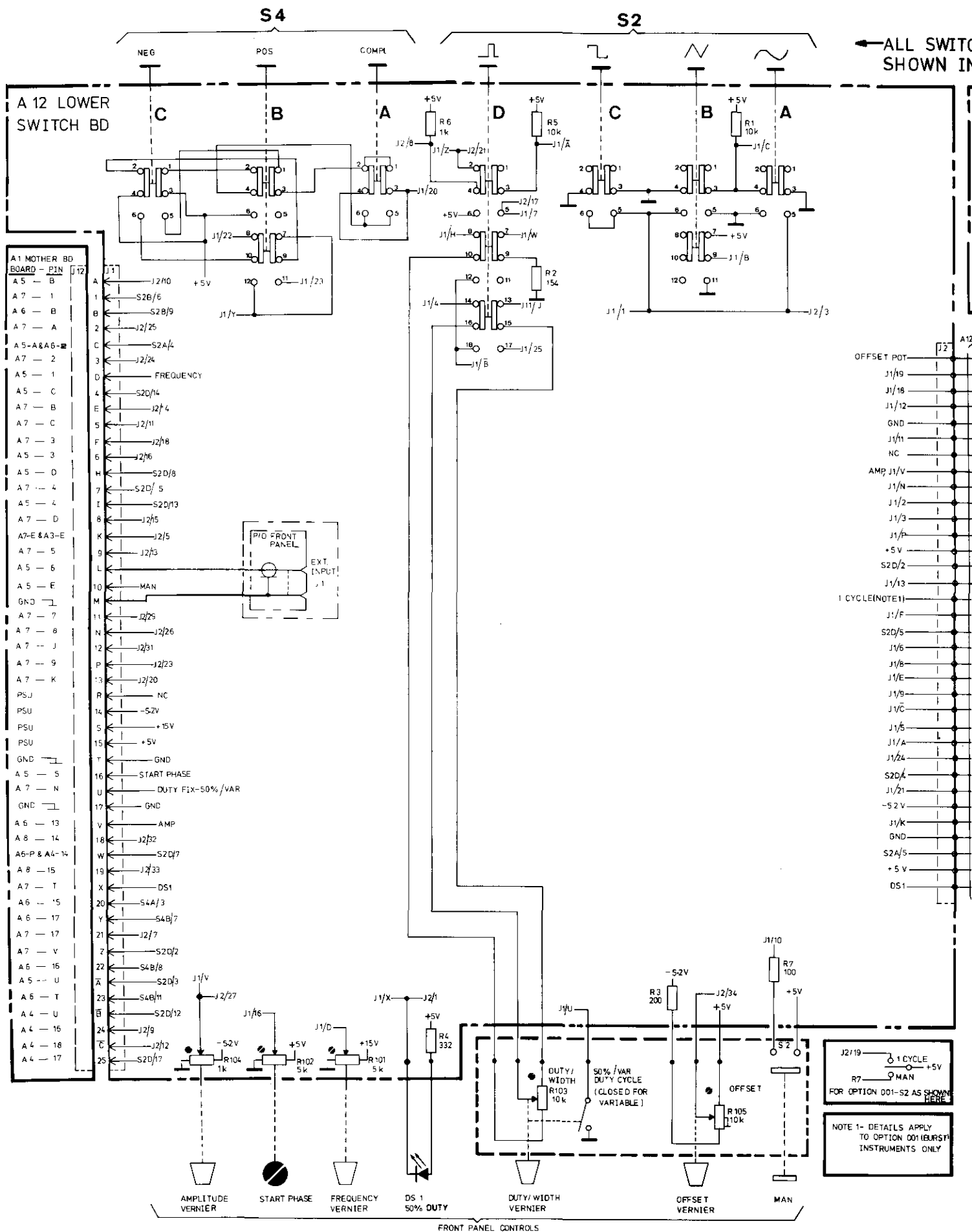
| Duty/Width Mode                                                                      | U11 pin 5/6 |
|--------------------------------------------------------------------------------------|-------------|
| variable                                                                             | H           |
| fixed 50 %                                                                           | L           |
|  | H           |

To check that the correct voltages are output from A11, refer to Service Block 5, Table 8-5-1 and A11 J4 pins 9, 10 and 11 (instead of A10 U1 pins 31, 30 and 36 respectively).

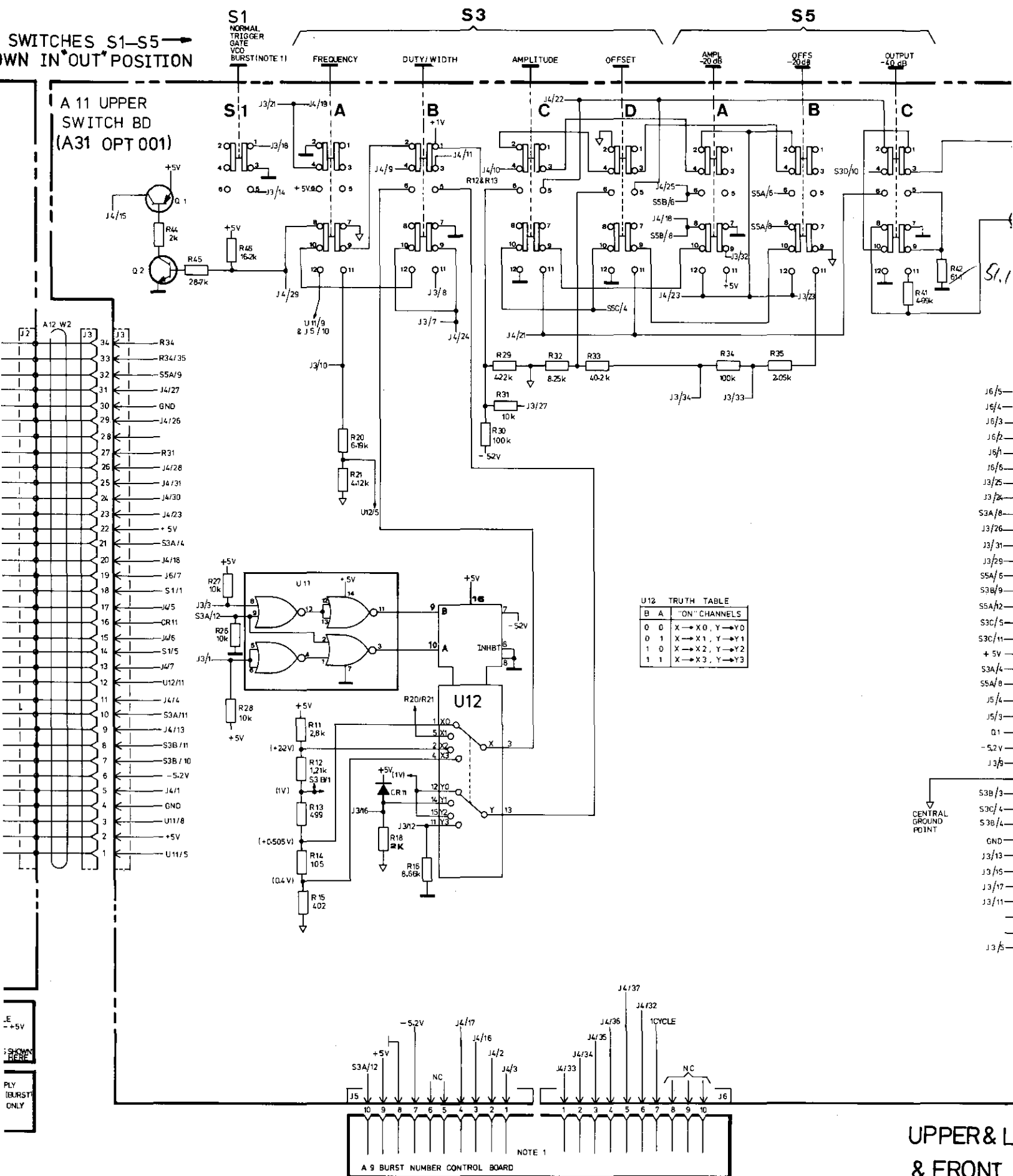
Table 8-3-3 U11, U12 Truth Table for various 8111A settings

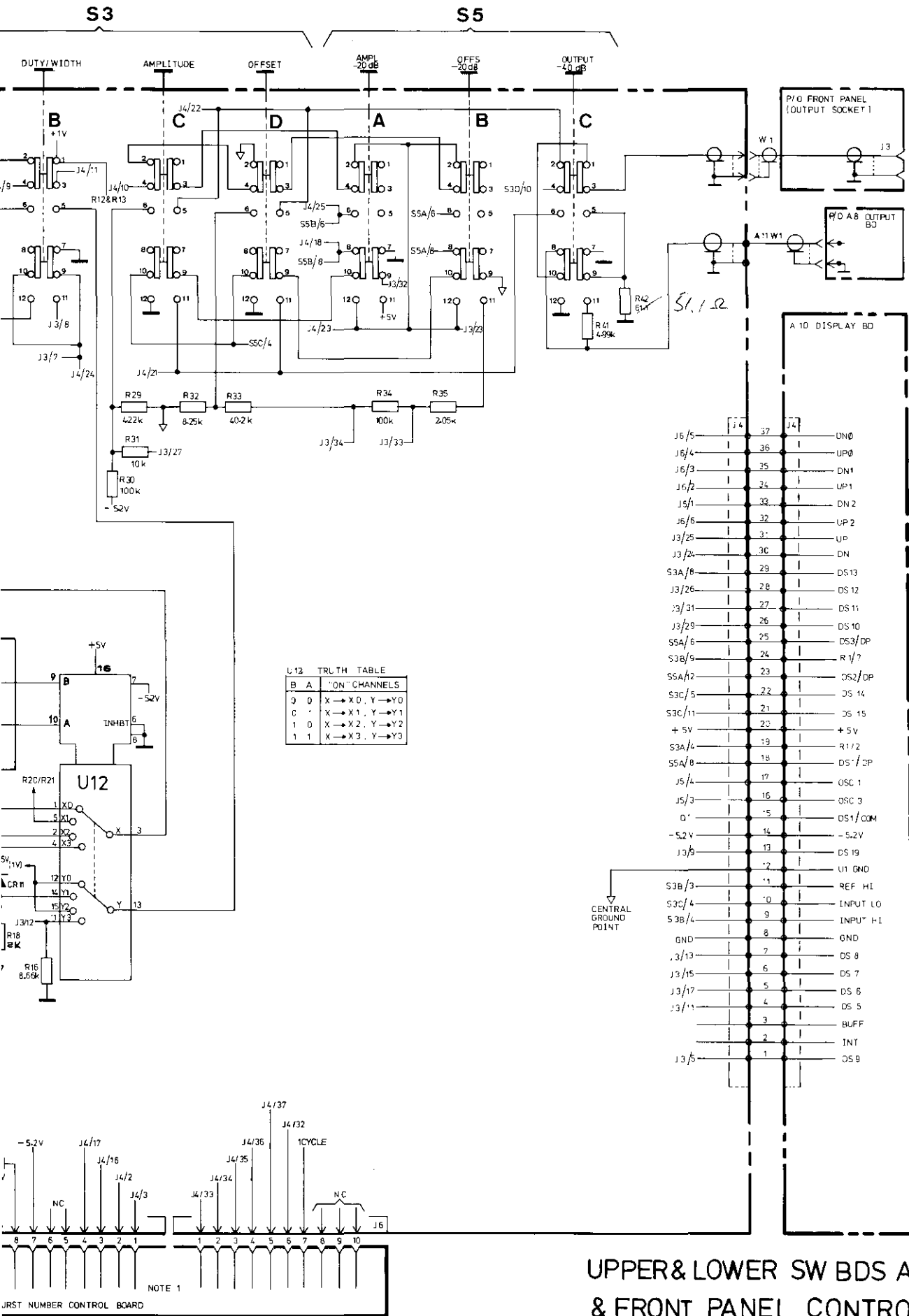
| 8111A Setting                                                                                                                                                                                                                                               |                                                        |                 |     |          |   |     |          |    |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------|-----------------|-----|----------|---|-----|----------|----|
| Selected Waveform                                                                                                                                                                                                                                           | Freq & Duty/Width<br>pressed for Burst<br>No Display ? | Duty Cycle Mode | pin | U11<br>8 | 9 | 5/6 | U12<br>9 | 10 |
|  or  or  | no                                                     | fixed 50 %      |     | L        | L | L   | L        | L  |
|  or  or  | no                                                     | variable        |     | L        | L | H   | L        | H  |
|  or  or  | yes                                                    | fixed 50 %      |     | L        | H | L   | H        | L  |
|  or  or  | yes                                                    | variable        |     | L        | H | H   | H        | L  |
|                                                                                                                                                                            | yes                                                    | X               |     | H        | H | H   | H        | L  |
|                                                                                                                                                                            | no                                                     | X               |     | H        | L | H   | H        | H  |





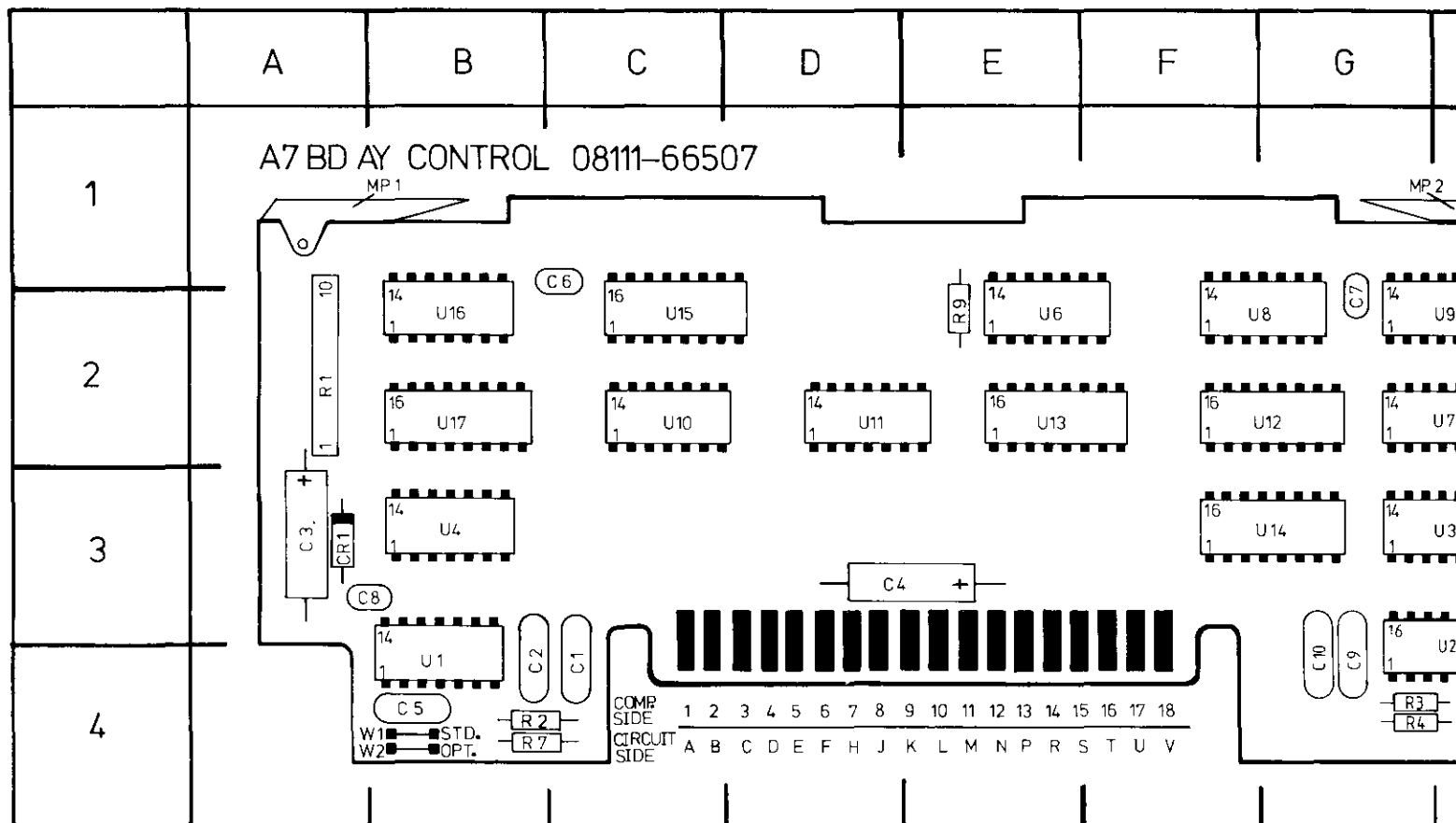
SWITCHES S1-S5 →  
DOWN IN OUT POSITION



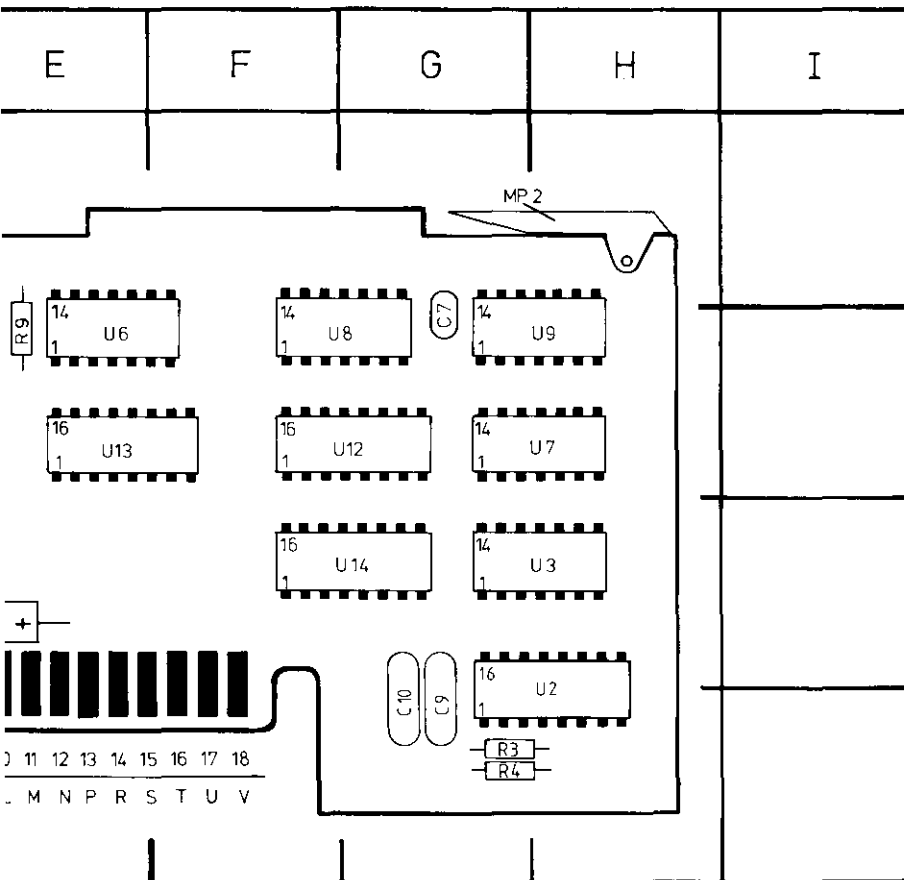


UPPER & LOWER SW BDS A11 & A12  
& FRONT PANEL CONTROLS

3



| REF<br>DESIG | GRID<br>LOC | REF<br>DESIG | GRID<br>LOC |
|--------------|-------------|--------------|-------------|
|              |             | U1           | B4          |
| C1           | B4          | U2           | G/H3        |
| C2           | B4          | U3           | G3          |
| C3           | A3          | U4           | B3          |
| C4           | E3          | U6           | E2          |
| C5           | B4          | U7           | G2          |
| C6           | C1          | U8           | F2          |
| C7           | G2          | U9           | G2          |
| C8           | A3          | U10          | C2          |
| C9           | G3/4        | U11          | D2          |
| C10          | G3/4        | U12          | F2          |
| CR1          | A3          | U13          | G3          |
| R1           | A2          | U14          | F3          |
| R2           | B4          | U15          | C2          |
| R3           | G/H4        | U16          | B2          |
| R4           | G/H4        | U17          | B2          |
| R7           | B4          | W1           | B4          |
| R9           | E2          | W2           | B4          |



## SERVICE BLOCK 4 CONTROL BOARD A7 4

### THEORY OF OPERATION

#### General

The Control Board is the interface between the Switch boards A11, A12 and VCO and Width boards. It also directly controls the following Display board LEDs: operating mode, numeric display decimal point position, and the width and frequency unit indicators. An additional feature of A7 is to provide 8111A "power on" initial condition settings via the preset circuitry.

#### OPERATION

Referring to the block diagram Figure 8-4-1, the board operation is as follows: The two up/down counters U12 and U13 are clocked by the range rocker switch and output their data to either the VCO or Width boards. They also output, via U14/U15, the appropriate range unit and decimal point data to the Display board A10. The range rocker switch data is input to either U12 or

U13 via multiplexers U8A, C and U9A, C depending on whether the FREQUENCY or DUTY/WIDTH front panel pushbuttons are depressed.

The mode select pushbutton signal clocks a counter U17 whose outputs are fed to the VCO board A5 and sets the operating mode of the Triangle/Slope Generator IC A5U1. A7U17 outputs are also fed to the Display board and control the operating mode LEDs. In Option 001 (Burst) instruments A7U17 outputs enable the Burst function and associated mode LED.

On 8111A switch on the preset circuit sets the instrument to NORMAL mode, 1-10kHz frequency range and 1-10  $\mu$ s pulse width range. In option 001 models the burst counter is preset to one.

Depending on whether a waveform function (instead of PULSE) is selected, the operative frequency range and/or the position of the DUTY CYCLE vernier/switch, the "50 % LED" will be energised and the VCO board current source suitably controlled via the circuit elements shown.

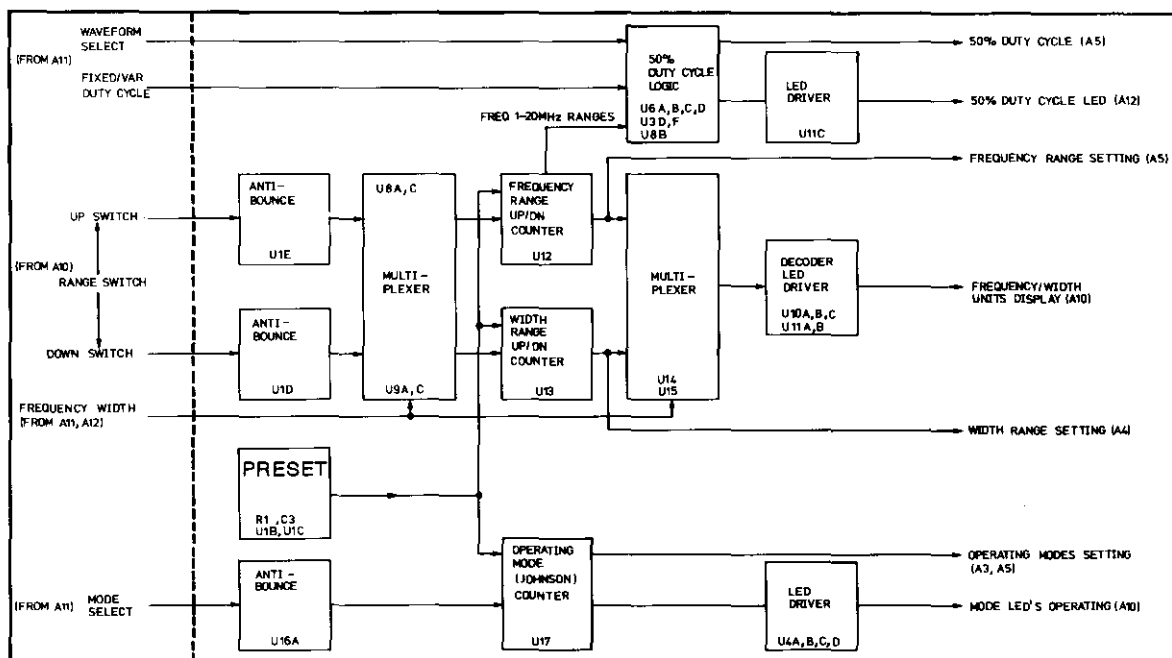


Figure 8-4-1. Simplified Control Board Block Diagram

## TROUBLESHOOTING

The board can be considered as three separate functions for troubleshooting purposes. These are:

- Fixed 50 % Duty Cycle Logic
- Frequency/Width Up and Down Ranging
- Operating Mode Selection.

Since the three functions are all very different it is quite easy to link a failure or fault to the appropriate one.

All logic levels are TTL and can be measured with a suitable logic probe, it can be either externally energised or the 8111A +15 V supply may be used.

To isolate a fault check the circuit operation with the aid of the following truth tables.

Table 8-4-1. U6, U11 Truth Table

| 8111A Setting                     | U6<br>pin 13 | U11<br>pin 8 |
|-----------------------------------|--------------|--------------|
| -Mode                             | H            | H            |
| Mode, fixed 50 % DTY              | H            | L            |
| Mode, variable DTY, 1 MHz-20 MHz  | H            | L            |
| Mode, variable DTY, 1 Hz-1000 kHz | L            | H            |

Table 8-4-2. U8 Truth Table

| 8111A Setting                    | down ranging |   |   |    |    | up ranging |   |    |   |
|----------------------------------|--------------|---|---|----|----|------------|---|----|---|
|                                  | U8<br>pin    | 1 | 2 | 13 | 12 | 11         | 9 | 10 | 8 |
| Frequency pushbutton<br>pressed  |              |   |   |    |    |            |   |    |   |
| 10 – 20 MHz                      |              | H | H |    |    | H          | L |    | H |
| 1 – 10 MHz                       |              | H | H |    |    | H          | H |    |   |
| 100 – 1000 kHz                   |              | H | H |    |    | H          | H |    |   |
| 10 – 100 kHz                     |              | H | H |    |    | H          | H |    |   |
| 1 – 10 kHz                       |              | H | H |    |    | H          | H |    |   |
| 100 – 1000 Hz                    |              | H | H |    |    | H          | H |    |   |
| 10 – 100 Hz                      |              | H | H |    |    | H          | H |    |   |
| 1 – 10 Hz                        |              | H | L |    | H  | H          | H |    |   |
| Frequency pushbutton<br>released |              | L | X |    | H  | L          | X |    | H |

Table 8-4-3. U9 Truth Table

| 8111A Setting                                     | down ranging |   |   |            |            | up-ranging |   |            |            |
|---------------------------------------------------|--------------|---|---|------------|------------|------------|---|------------|------------|
|                                                   | U9<br>pin    | 1 | 2 | 13         | 12         | 11         | 9 | 10         | 8          |
| Width and $\text{L}$ -Mode<br>pushbuttons pressed |              |   |   |            |            |            |   |            |            |
| 10 – 100 ms                                       |              | H | H | $\text{L}$ | $\text{H}$ | H          | L | $\text{L}$ | H          |
| 1 – 10 ms                                         |              | H | H | $\text{L}$ | $\text{H}$ | H          | H | $\text{L}$ | $\text{H}$ |
| 100 – 1000 $\mu\text{s}$                          |              | H | H | $\text{L}$ | $\text{H}$ | H          | H | $\text{L}$ | $\text{H}$ |
| 10 – 100 $\mu\text{s}$                            |              | H | H | $\text{L}$ | $\text{H}$ | H          | H | $\text{L}$ | $\text{H}$ |
| 1 – 10 $\mu\text{s}$                              |              | H | H | $\text{L}$ | $\text{H}$ | H          | H | $\text{L}$ | $\text{H}$ |
| 100 – 1000 ns                                     |              | H | H | $\text{L}$ | $\text{H}$ | H          | H | $\text{L}$ | $\text{H}$ |
| 25 – 100 ns                                       |              | H | L | $\text{L}$ | H          | H          | H | $\text{L}$ | $\text{H}$ |
| Width or $\text{L}$ -Mode<br>pushbutton released  |              | L | X | $\text{L}$ | H          | L          | X | $\text{L}$ | H          |

## Fixed 50 % Duty Cycle Logic

Table 8-4-4. U12 Truth Table

| 8111A Frequency Range Setting | Range Data<br>U12 pin                        | C<br>6 | B<br>2 | A<br>3 |
|-------------------------------|----------------------------------------------|--------|--------|--------|
| 10 – 20 MHz                   |                                              | L      | L      | L      |
| 1 – 10 MHz                    |                                              | L      | L      | H      |
| 100 – 1000 KHz                |                                              | L      | H      | L      |
| 10 – 100 KHz                  |                                              | L      | H      | H      |
| 1 – 10 KHz                    | (Status at 8111A<br>Switch on) $\rightarrow$ | H      | L      | L      |
| 100 – 1000 Hz                 |                                              | H      | L      | H      |
| 10 – 100 Hz                   |                                              | H      | H      | L      |
| 1 – 10 Hz                     |                                              | H      | H      | H      |

## Frequency/Width Up/Down Ranging

Table 8-4-5. U13 Truth Table

| 8111A Width Range Setting | Range Data<br>U13 pin            | C<br>6 | B<br>2 | A<br>3 |
|---------------------------|----------------------------------|--------|--------|--------|
| 10 – 100 ms               |                                  | L      | L      | L      |
| 1 – 10 ms                 |                                  | L      | L      | H      |
| 100 – 1000 $\mu\text{s}$  |                                  | L      | H      | L      |
| 10 – 100 $\mu\text{s}$    |                                  | L      | H      | H      |
| 1 – 10 $\mu\text{s}$      | (Switch on Status) $\rightarrow$ | H      | L      | L      |
| 100 – 1000 ns             |                                  | H      | L      | H      |
| 25 – 100 ns               |                                  | H      | H      | L      |

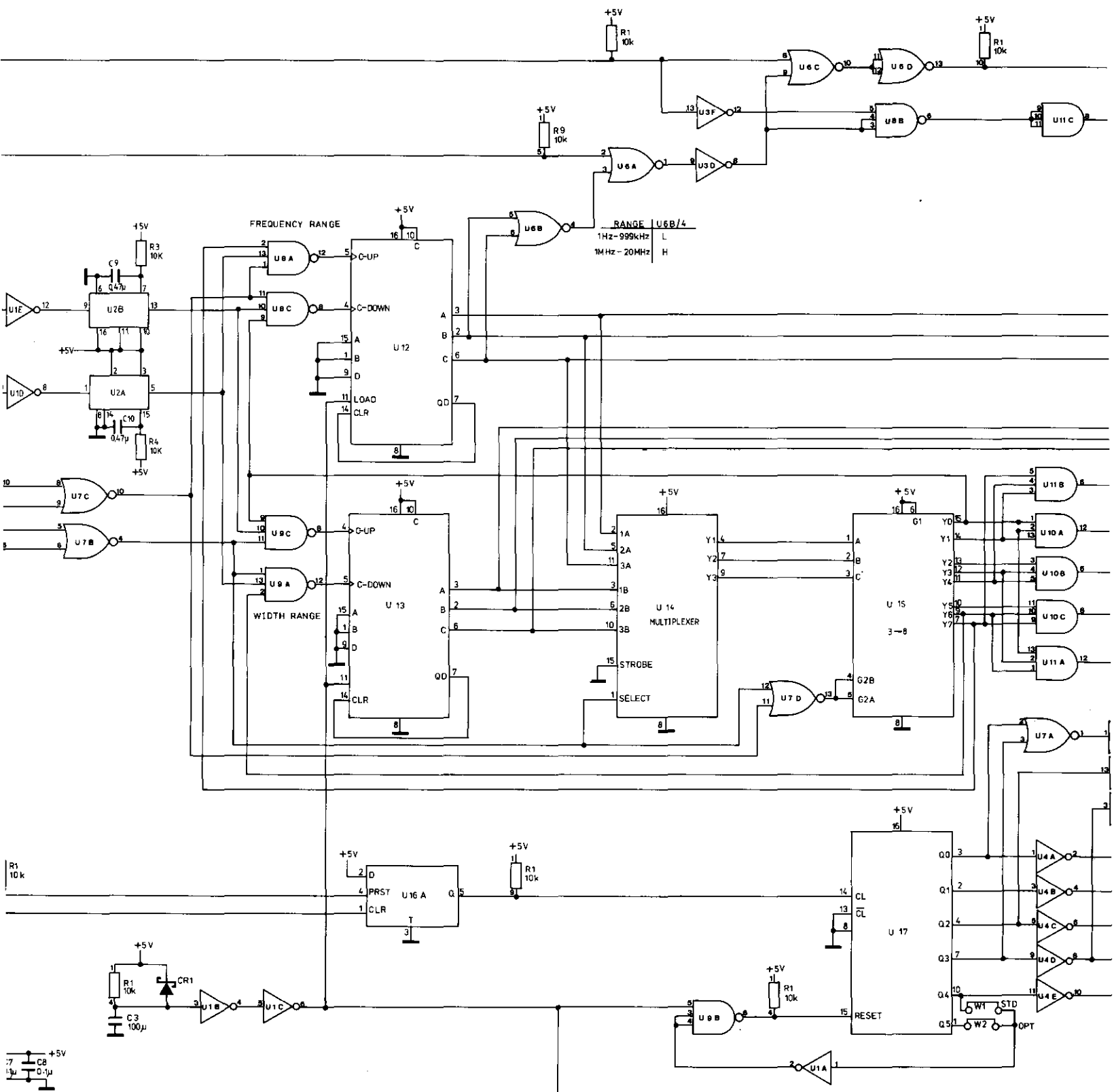
**Operating Mode Selection**

Table 8-4-6. U17 Truth Table

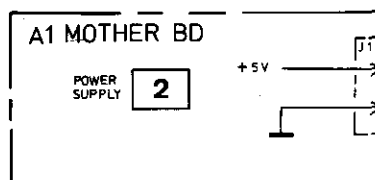
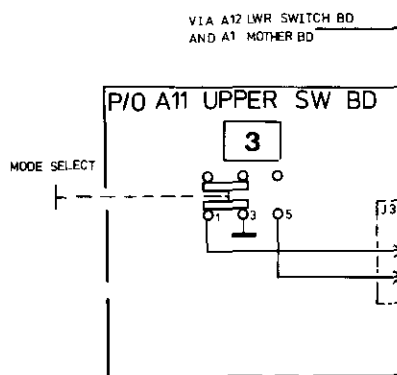
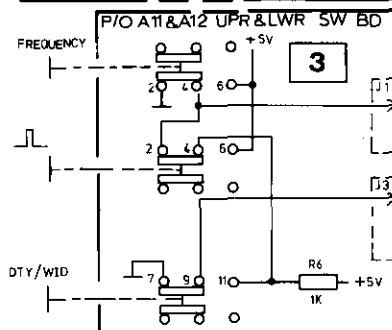
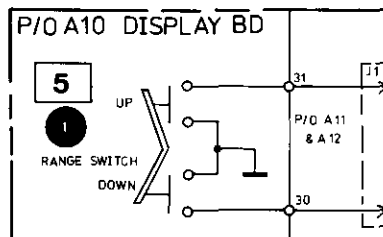
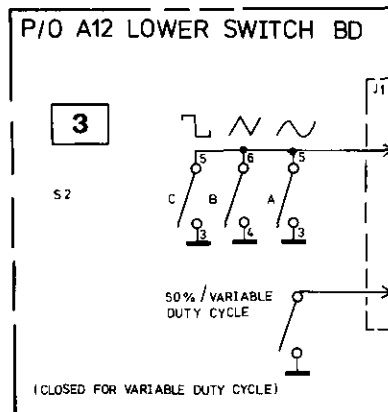
| 8111A Setting<br>U17 pin   | Q <sub>0</sub><br>3 | Q <sub>1</sub><br>2 | Q <sub>2</sub><br>4 | Q <sub>3</sub><br>7 | Q <sub>4</sub><br>10 |
|----------------------------|---------------------|---------------------|---------------------|---------------------|----------------------|
| NORMAL                     | H                   | L                   | L                   | L                   | L                    |
| TRIGGER                    | L                   | H                   | L                   | L                   | L                    |
| GATE                       | L                   | L                   | H                   | L                   | L                    |
| VCO                        | L                   | L                   | L                   | H                   | L                    |
| BURST<br>(Option 001 only) | L                   | L                   | L                   | L                   | H                    |

The counter is reset when Q<sub>4</sub> (Q<sub>5</sub> in Option 001) goes to high level.

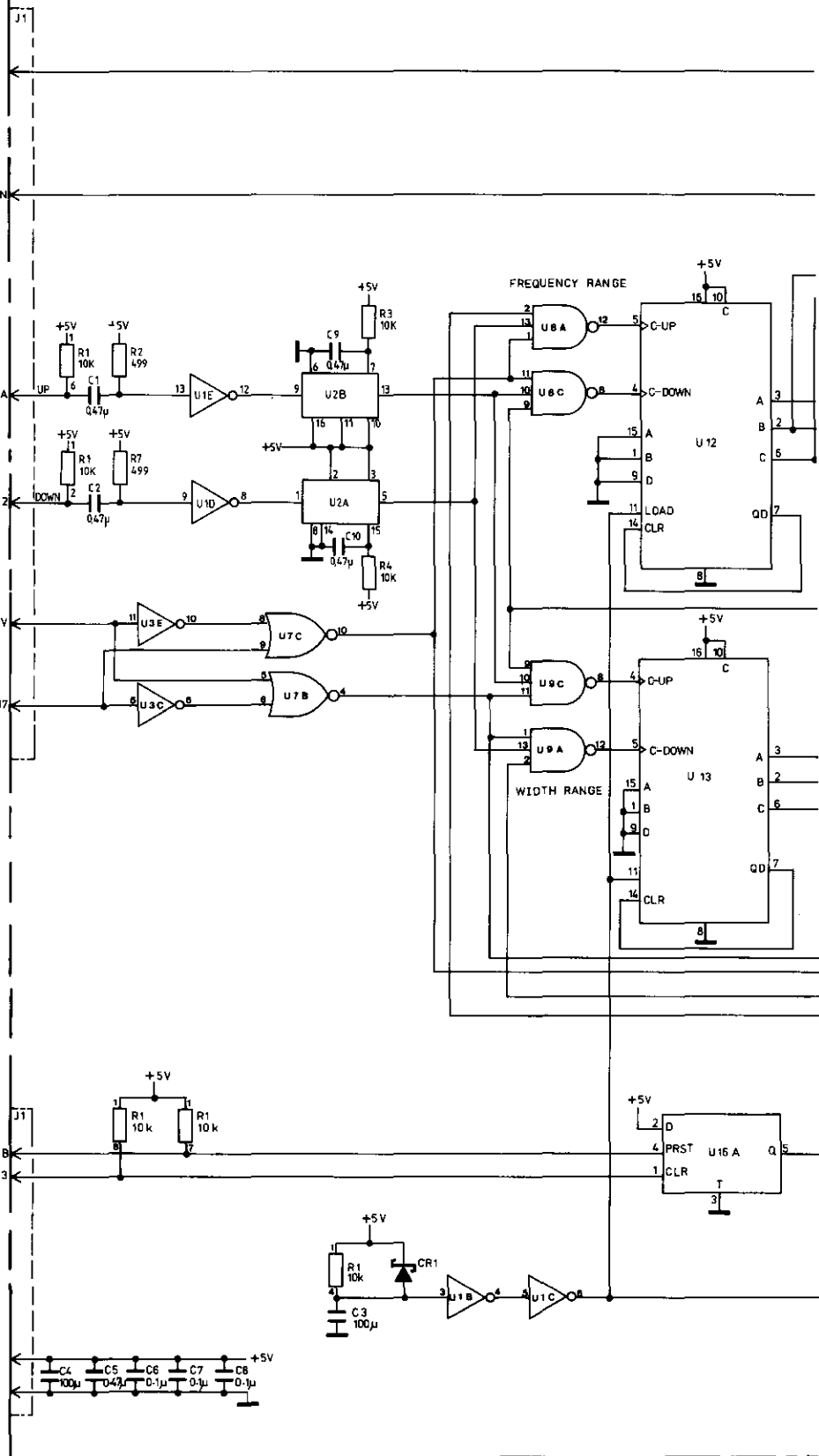




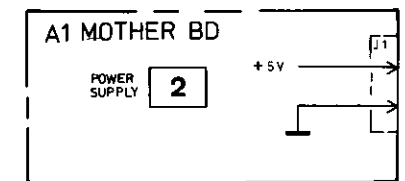
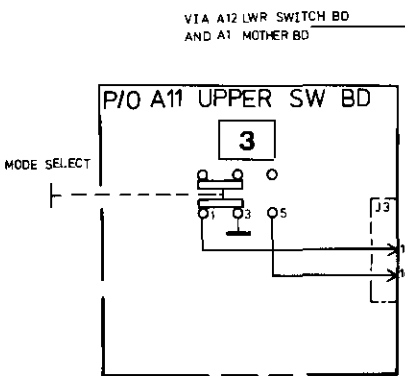
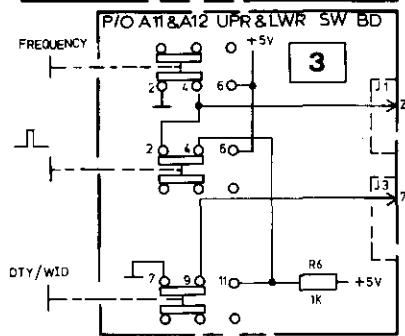
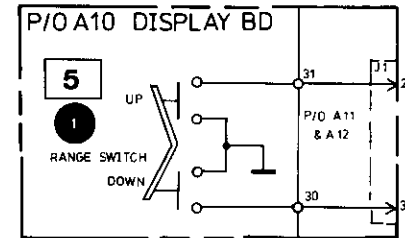
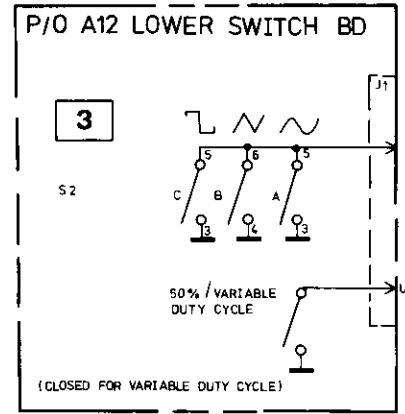
BETWEEN BOARDS  
UNLESS OTHERWISE INDICATED

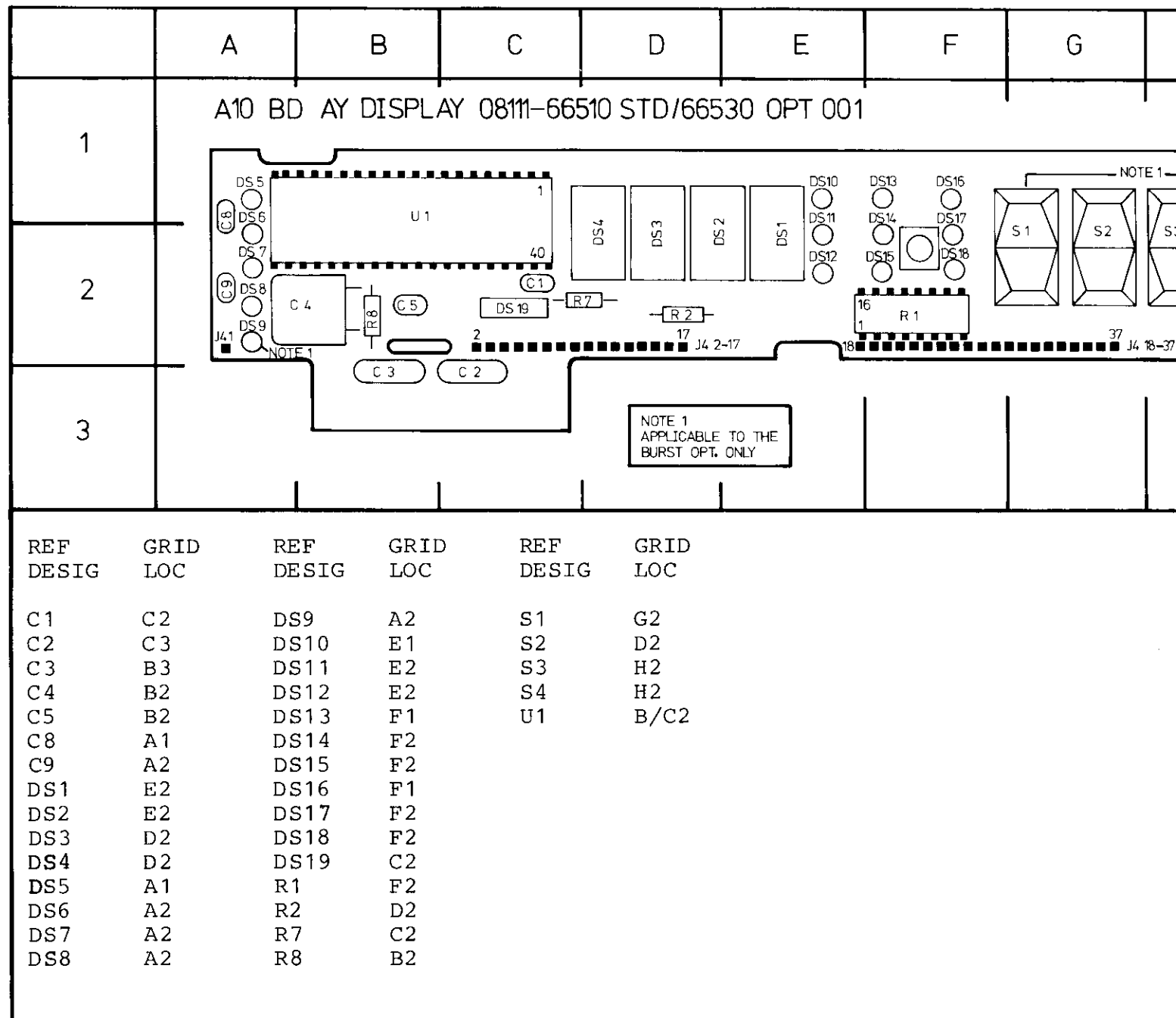


# A 7 BD AY CONTROL 08111-66507



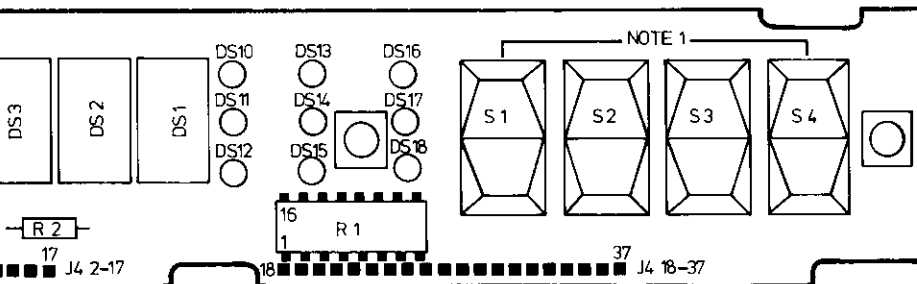
NOTE: ALL INTERCONNECTIONS BETWEEN BOARDS  
VIA A1 MOTHERBOARD UNLESS OTHERWISE INDICATED





|   |   |   |   |   |   |
|---|---|---|---|---|---|
| D | E | F | G | H | I |
|---|---|---|---|---|---|

TD/66530 OPT 001



NOTE 1  
APPLICABLE TO THE  
BURST OPT. ONLY

GRID  
LOC

2  
2  
2  
2  
/C2

## SERVICE BLOCK 5 DISPLAY BOARD A10 (A30) 5

### THEORY OF OPERATION

All parameters of the 8111A except the burst number are voltage controlled via the front panel settings. The resulting control voltages are measured by a DVM based on an A-D converter IC—U1. This "DVM" uses the dual slope integration method of A-D conversion and the operating principle is shown in Figure 8-5-1.

The operation is as follows: The signal input voltage is connected to the integrator for a time period of 1000 oscillator cycles, this is therefore the integration time  $T_I$ . During this time,  $C_{int}$  is charged up linearly starting from 0 volts. At the end of  $T_I$   $C_{int}$  will have been charged to a value proportional to the input voltage. The second phase of the dual slope integration involves connecting a fixed reference voltage  $V_{ref}$  to the integrator input, this voltage is of opposite polarity to the signal input and results in  $C_{int}$  being linearly discharged. At the beginning of this discharge the output from the oscillator is gated into a counter, the gate is disabled when  $C_{int}$  has discharged to zero.

Referring to Figure 8-5-2, when the input voltage is equal to the reference the time to discharge  $C_{int}$  will be the period for 1000 oscillator cycles and the displayed value will be 1000. When the input voltage =  $2 \times V_{ref}$  then the discharge time will be 2000 cycles and the corresponding display will be 2000 etc.

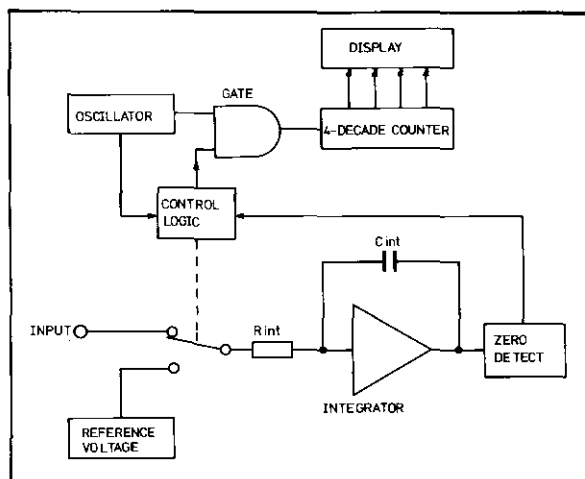


Figure 8-5-1. Simplified Dual Slope Integrating DVM

The DVM IC has differential inputs for both the input and the reference voltages. The Ref. low input is always connected to ground and therefore the displayed value is expressed by:

$$\text{Displayed Value} = \frac{V_{in \text{ Hi}} - V_{in \text{ Lo}}}{V_{ref \text{ Hi}}} \cdot 1000$$

Since various parameters have to be displayed it is necessary to vary the value of  $V_{ref}$  and/or interchange it with the  $V_{in}$ . The following paragraphs detail how this is done for all parameter display requirements.

#### Amplitude, Offset and Frequency

To display these parameters the DVM IC is used in its normal application i.e.  $V_{ref} = 1 \text{ V}$ , the parameter control voltages are fed to the differential inputs of IC and are displayed in their "Oscillator cycle count" equivalent. The decimal point position is controlled by the Control board A7.

#### Width

The width control voltage is inversely proportional to the width value, therefore, to achieve the correct display value the input signal (control voltage) and the reference voltage for the DVM IC U1 are interchanged.

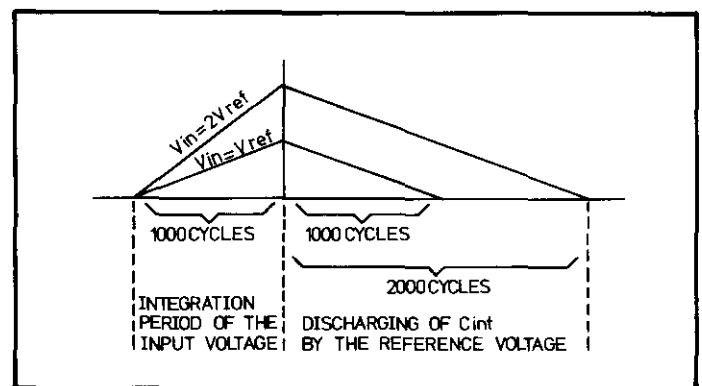


Figure 8-5-2. Dual Slope Integration Measurement Sequence

### Duty Cycle

The Duty Cycle is determined by the ratio between the control voltage for the frequency and the voltage  $V_{up}$  which controls the  $I_{up}$  current source on the VCO board. To display this ratio,  $V_{up}$  is used as a variable reference voltage and the frequency control voltage is connected to the input pins of U1.

In fixed duty cycle (50 %) mode a constant 0.505 V voltage is connected to the DVM IC input with a reference voltage of 1 V, this therefore results in 50 being displayed (the last digit is blanked). See Table 8–5–1 for clarification.

### Burst (Option 001 only)

The display method for the burst number is a totally digital procedure unlike that for all other parameters and is controlled from the Burst No Control board A9. The theory of operation including the display technique is described in Service Block 6. Table 8–5–1 shows the input conditions at the DVM IC U1 for all parameter displays.

### DVM IC U1

If the fault is that the display readout remains fixed when any vernier control is varied but the decimal point position and unit indicators may be varied then A10 U1 oscillator is suspect. The correct oscillator output should be as shown below with a frequency of approximately 190 kHz. If there is no output verify that U1 pin 40 is not shorted to ground since this disables the oscillator.



### Numeric Display

The display can be checked for correct operation — all segments operatable — by connecting U1 pin 37 to +5 V, all numeric displays should then be illuminated to give a readout of –1888.

## TROUBLESHOOTING

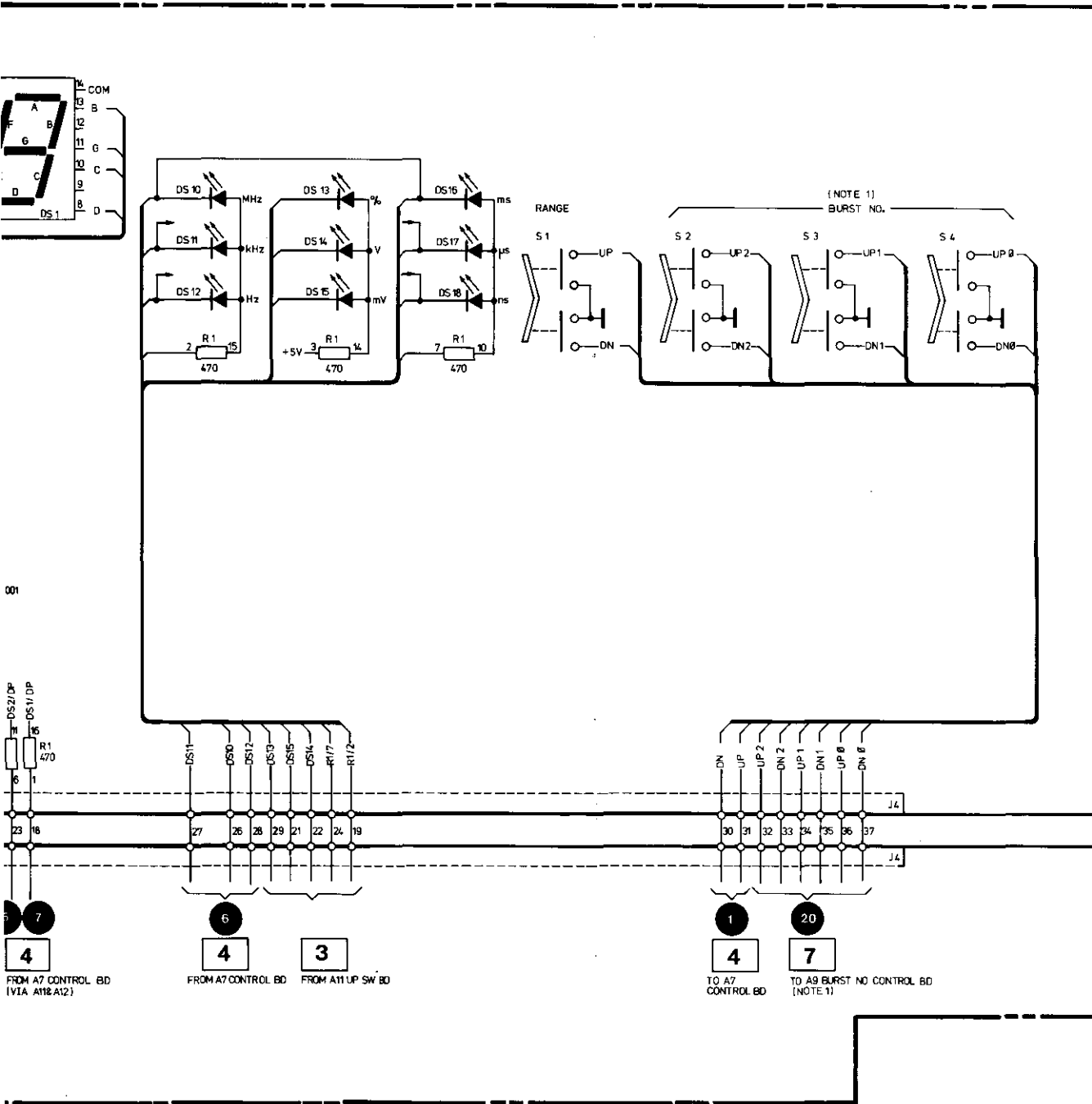
### General

Since all switching and changing of the reference and input signals for the DVM is done on switch board A11 by A11U12, most cases of incorrect display value are likely to be related to the A11, A12 assembly. A12 is mentioned since the vernier control outputs go via A12 to A11. If the fault concerns the operating mode, decimal point, width or frequency unit indicating LEDs and not the numeric displays then the Control Board A7 should be suspected.

Table 8–5–1. Display Required/DVM Input Voltages

| Displayed Parameter      | DVM Input Voltages          |                                  |                              | Values shown on the<br>Display = $\frac{V_{HI}-V_{LO}}{V_{REF}} \cdot 1000$ |
|--------------------------|-----------------------------|----------------------------------|------------------------------|-----------------------------------------------------------------------------|
|                          | INPUT HI<br>pin 31          | INPUT LO<br>pin 30               | REF HI<br>pin 36             |                                                                             |
| FREQUENCY                | $V_{Freq}$<br>0.1 V ... 1 V | gnd                              | +1 V                         | 10.0 ... 100.0                                                              |
| FIXED 50 % DUTY<br>CYCLE | 0.505 V                     | gnd                              | +1 V                         | 50                                                                          |
| VARIABLE DUTY<br>CYCLE   | $V_{Freq}$<br>40 mV...0.4 V | gnd                              | $V_{up}$<br>40 mV...0.4 V    | 10 ... 90 } last<br>digit<br>switched off                                   |
| WIDTH                    | +0.4 V                      | gnd                              | $V_{Width}$<br>4 V ... 0.4 V | 10.0 ... 100.0                                                              |
| AMPLITUDE                | gnd                         | $V_{Ampl}$<br>–0.16 V ... –1.6 V | +1 V                         | 1.60 ... 16.00                                                              |
| OFFSET                   | gnd                         | $V_{offs}$<br>+0.8 V ... –0.8 V  | +1 V                         | –8.00 ... 8.00                                                              |
| BURST                    | 2.2 V                       | gnd                              | +1 V                         | 1...1999                                                                    |

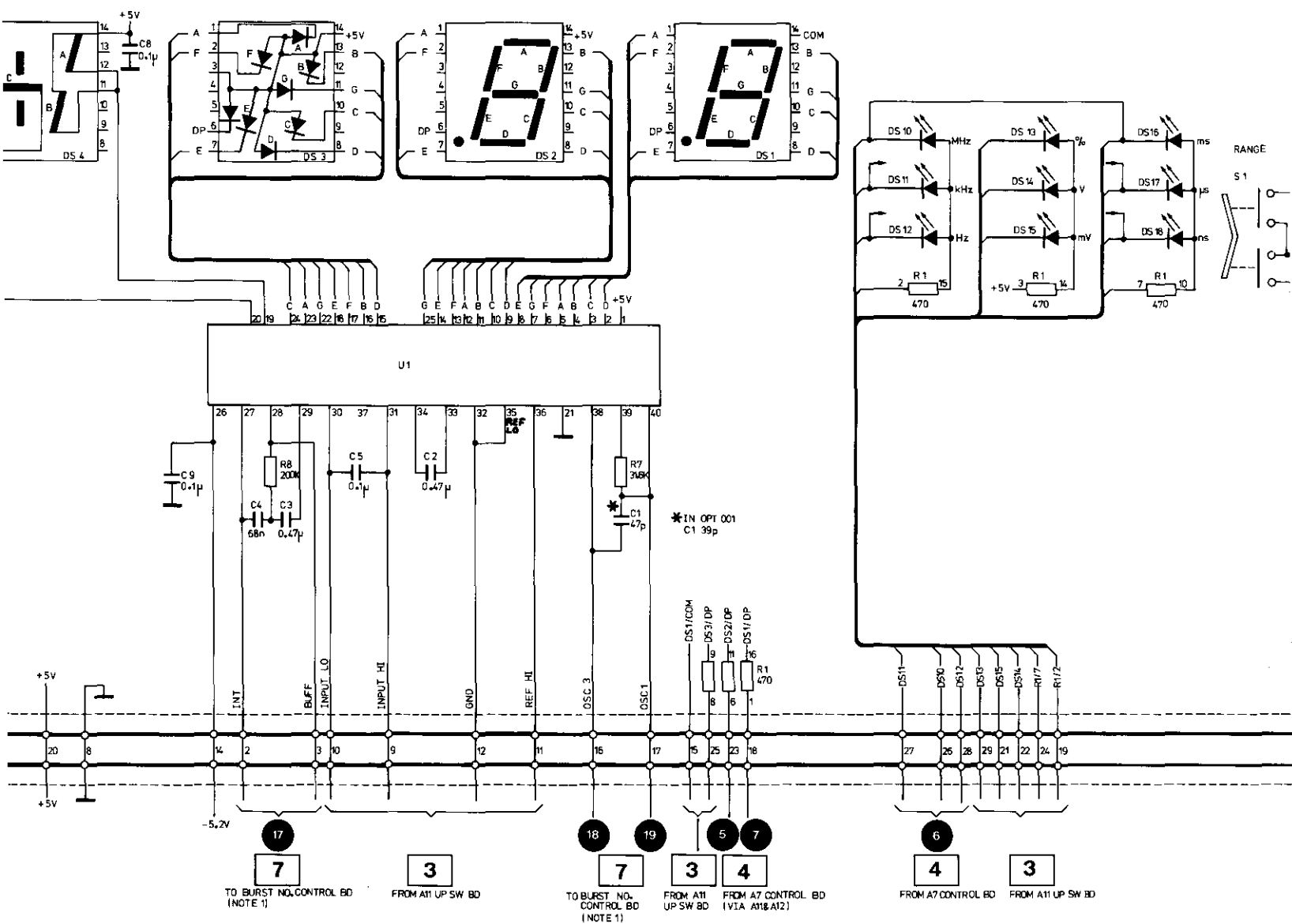




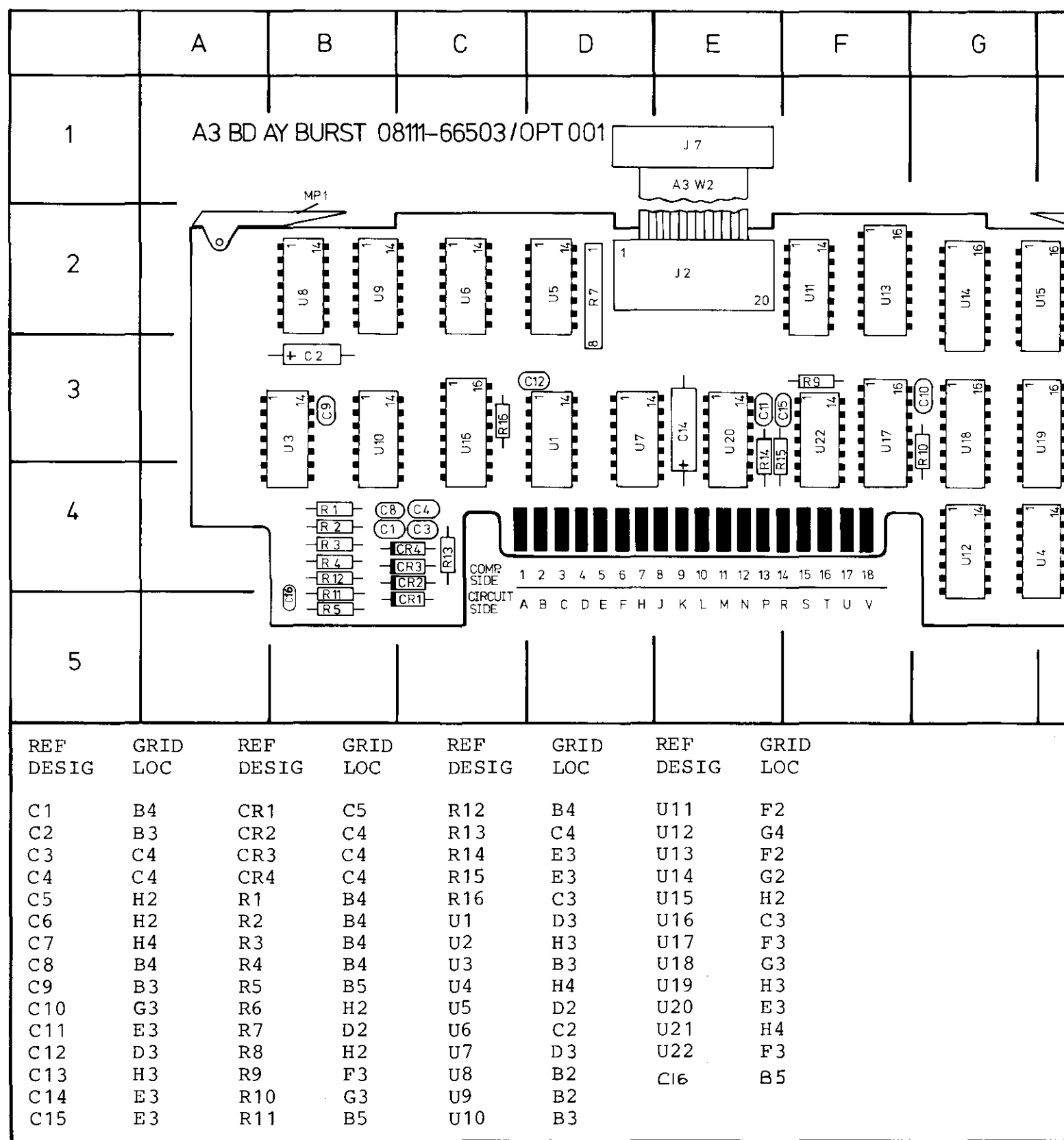
DISPLAY BD A10 (OPT 001 A30)

5

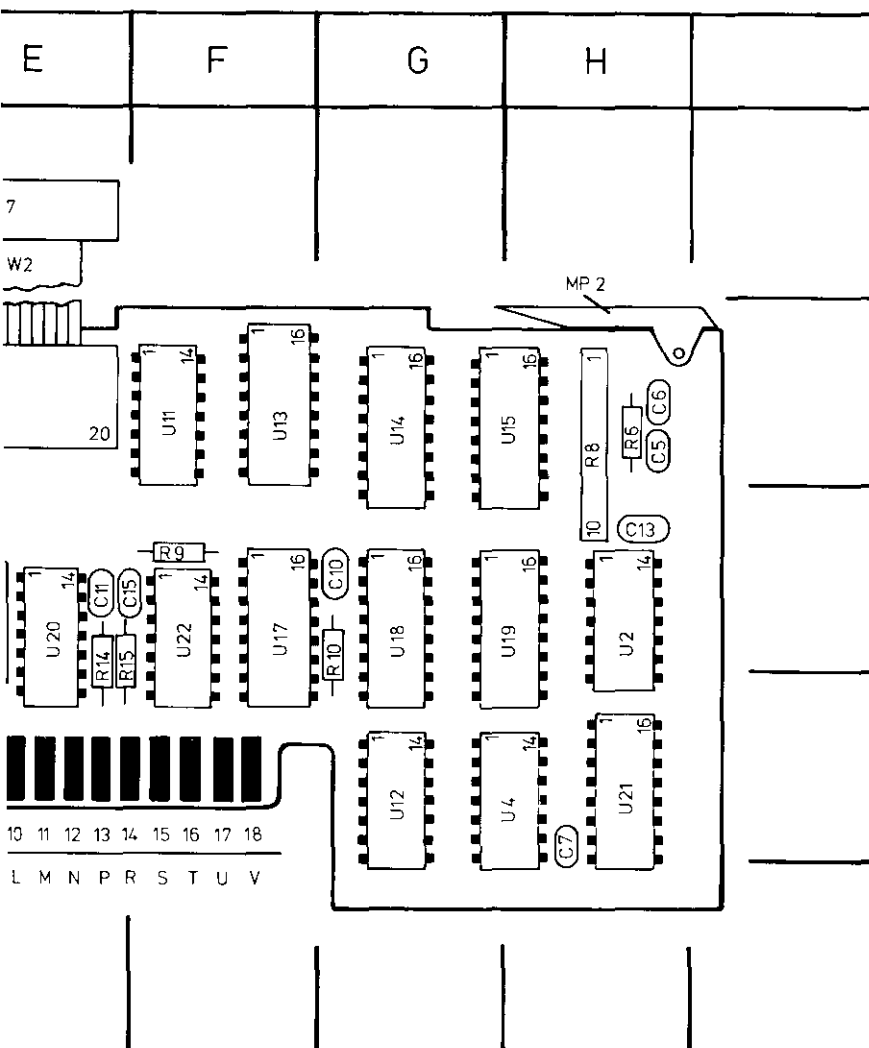
01)



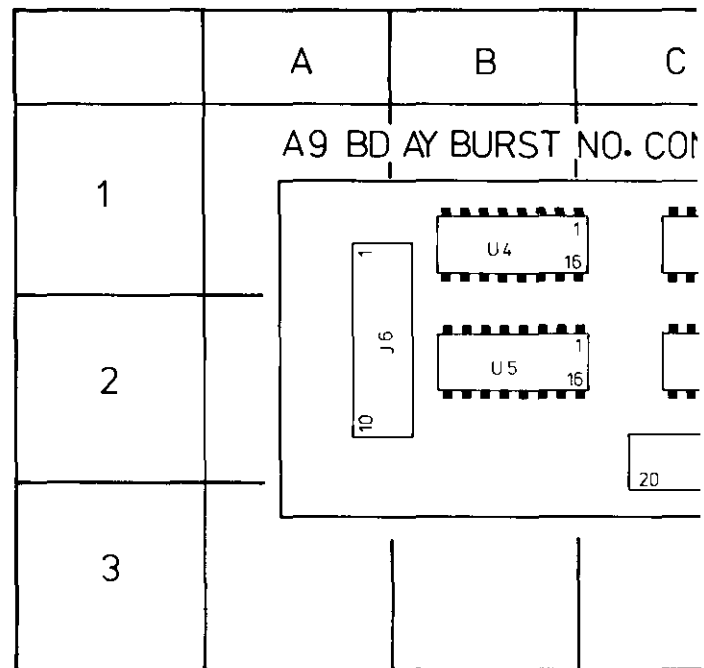




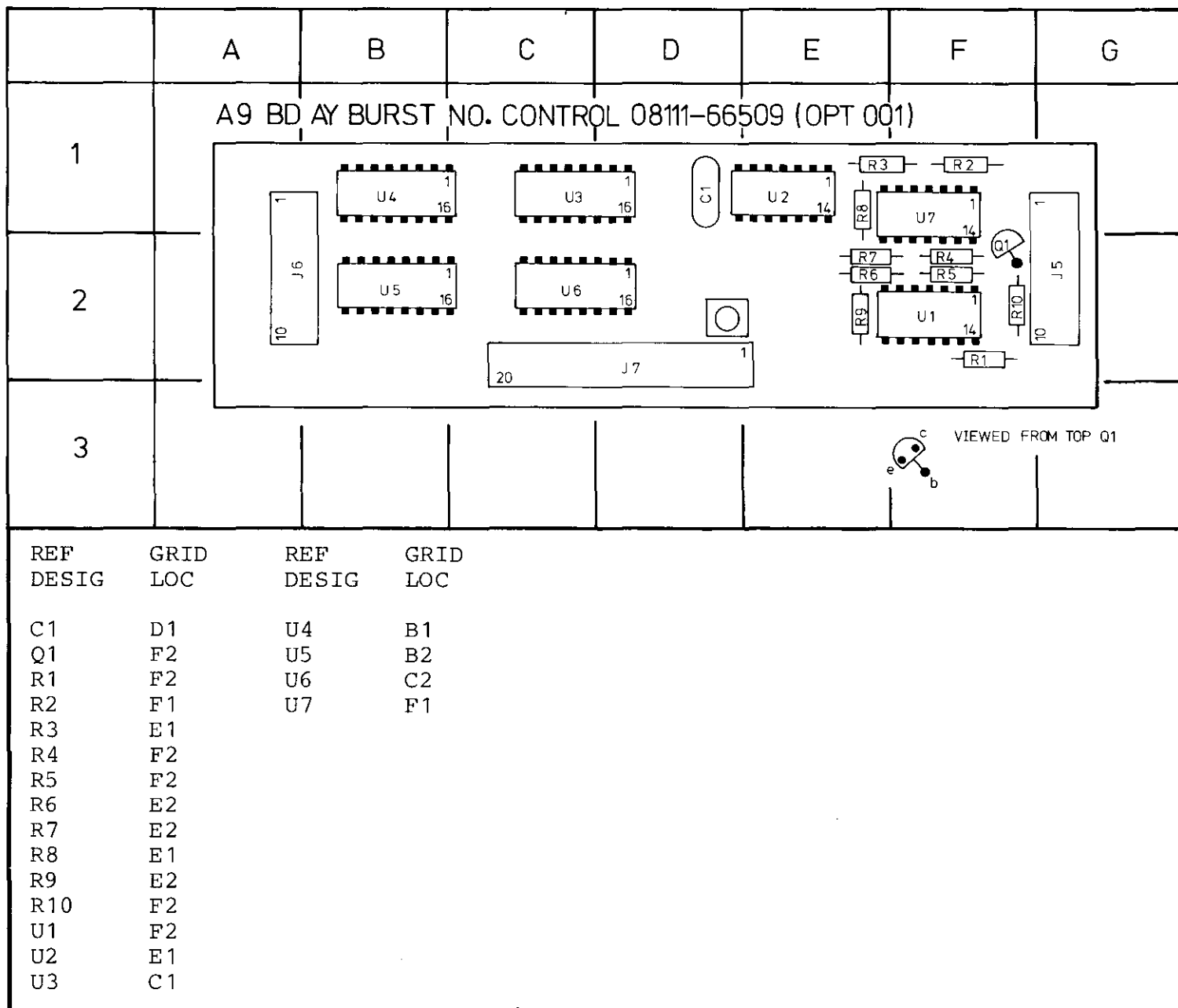
6



| IG | GRID<br>LOC |
|----|-------------|
|    | F2          |
|    | G4          |
|    | F2          |
|    | G2          |
|    | H2          |
|    | C3          |
|    | F3          |
|    | G3          |
|    | H3          |
|    | E3          |
|    | H4          |
|    | F3          |
|    | B5          |



| REF<br>DESIG | GRID<br>LOC | REF<br>DESIG | GRID<br>LOC |
|--------------|-------------|--------------|-------------|
| C1           | D1          | U4           | B1          |
| Q1           | F2          | U5           | B2          |
| R1           | F2          | U6           | C2          |
| R2           | F1          | U7           | F1          |
| R3           | E1          |              |             |
| R4           | F2          |              |             |
| R5           | F2          |              |             |
| R6           | E2          |              |             |
| R7           | E2          |              |             |
| R8           | E1          |              |             |
| R9           | E2          |              |             |
| R10          | F2          |              |             |
| U1           | F2          |              |             |
| U2           | E1          |              |             |
| U3           | C1          |              |             |



## SERVICE BLOCK 6 BURST BOARD A3 6 BURST NO. CONTROL A9 7

### THEORY OF OPERATION

#### General

Refer to Figure 8-6-1, in BURST mode, a preset number of cycles is output by the 8111A, this requires a store or CONTROL COUNTER for the set "BURST NO" and a BURST COUNTER which is loaded with the same number and then counted down (or decremented) by pulses from the VCO (A5) after commencement of the burst.

At the start of a burst sequence, following a trigger signal, the VCO is enabled and outputs cycles as in other modes, pulses (BURST CLOCK) are also fed back to the burst counter to decrement the count to one. A "BURST OFF" signal is produced after this condition is detected and this disables the VCO after completion of the final cycle. During this final cycle the burst counter is re-loaded with the burst number from the control counter.

Board A9, the Burst Number Control, has no significance in the actual burst sequence, it serves to interface the burst number data with the Display board and the rocker switches to A3, it will be described later.

#### OPERATION

The following operational description of the BURST BOARD A3 is in four sections:

1. The Control Counter
2. Loading the Burst Counter
3. Burst on
4. End of count down — Burst off

Figure 8-6-2 should be referred to as necessary to aid understanding of the descriptions.

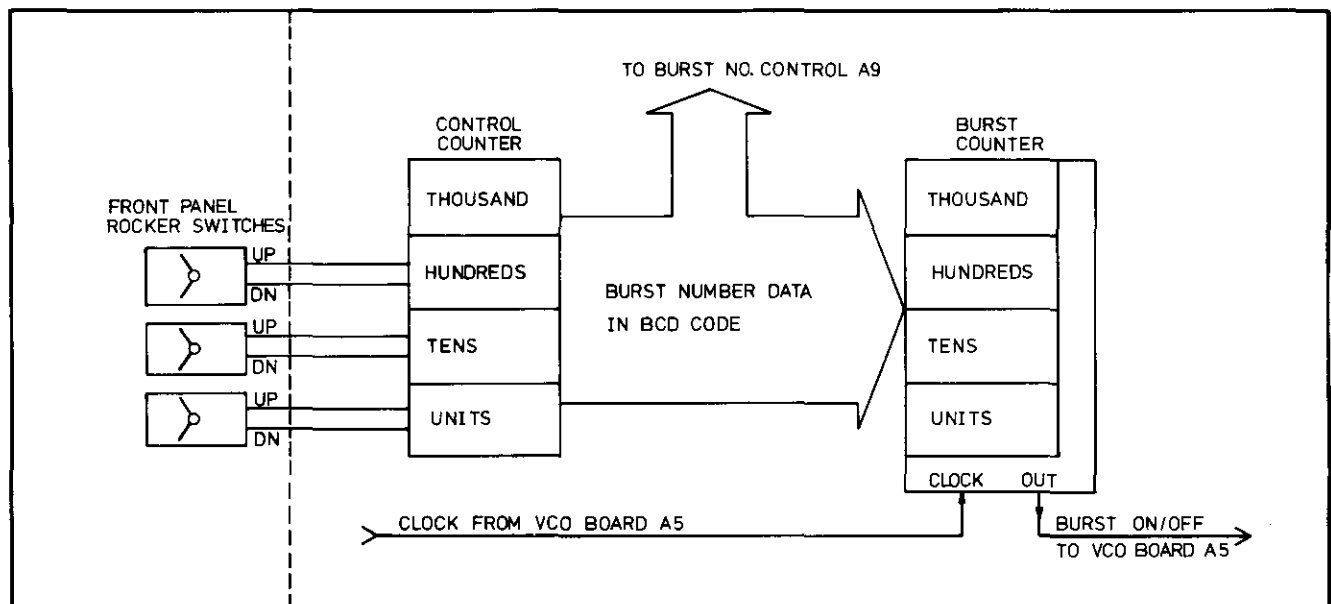


Figure 8-6-1, Burst Block Diagram

## 1. The Control Counter

This consists of a four stage counter — three cascaded BCD counters U13, U14 and 15 for the "units, tens and hundreds" and a flip-flop U16A for the thousand. At instrument switch on the counter is preset to one (001 displayed when BURST NO buttons pressed) via a signal "PRESET" from the Control board. Operation of the BURST NO rocker switches causes the output of U9C to go high for each "push", the signal is debounced via U10D etc and input, via U6C, to the enabled control counter device. This is done by using the operated rocker switch output (via U6A, B or D) and/or a CARRY output signal to enable, via U4C (units), U10A (tens) or U11D (hundreds), the required counter stage. The output from U6C (control counter clock) will be disabled from clocking the stages (via U11C, B and A) if an unallowed count would result e.g. — if present displayed count is 1985 and the hundreds rocker switch is operated in the 'UP' mode, then only one increment — to 1995 — is possible since the next would be 2005 which is not allowed. The circuit comprising U8D, U9A and B and U10B etc. performs the counter status monitoring and prevents unallowed carry up or down action.

The normal carry up or down function is enabled by U10A, U11D and U4C, C7 and R8 ensure that the counter is set to 001 and not 000 when the "tens" or hundreds count is decremented from 010 or 100 respectively. U8C prevents a 000 setting of the counter by enabling a preset signal for the whole counter to be produced whenever the units switch is pressed to the down position at the 001 counter setting.

The output of U5B enables either an up or down count sequence, in a rocker switch "down" position U5B output is low for DN enable and an "up" position enables UP.

The oscillator is enabled and outputs a pulse train when a rocker switch is pressed either "up or down" for longer than the time constant determined by R3 and C2.

## 2. Loading the Burst Counter

This is done whenever the existing burst number is changed or a burst has been completed and the number needs to be reloaded for a further one. The Burst Counter contents are automatically decremented to zero during the cycle. Since there are two different loading/reloading situations they will be separately described as:

### 2-1 Loading a new Burst Number

### 2-2 Reloading after burst completion

### 2-1 Loading a new Burst Number

The negative going edge of the Control Counter clock pulse triggers U21B (pin 9) and its Q output enables the load function of U17 (active low). Delay — R6, C5 and U2D, U22 generate the required clock pulse for U17 which then loads the "units data" into U17. The load enable signal for the "tens", "hundreds" and "thousands" data is U21B  $\bar{Q}$ .

### 2-2 Reloading after burst completion

At the end of a burst cycle, when the count has reached 001, the ONE DETECT circuit output (U22C pin 8) goes low and enables the LOAD of U17. On receipt of next positive going clock transition U17 will be reloaded with the units data.

The other counters are reloaded by a pulse via U21A after U20BQ changes from high to low at burst completion.

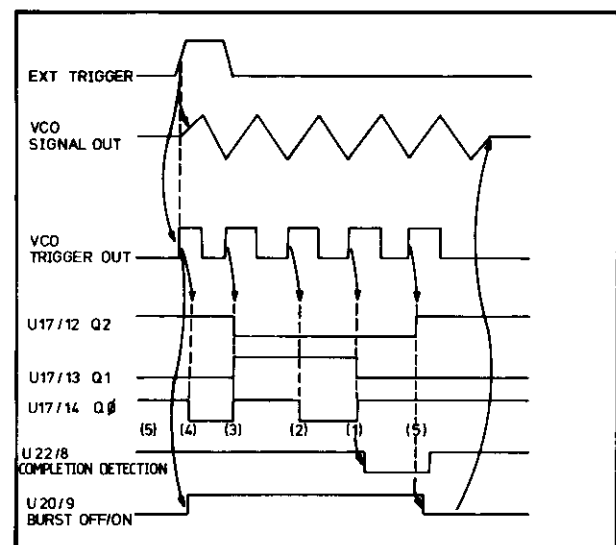


Figure 8-6-2. Burst Timing Diagram (Burst Number = 5)

## 3. Burst on

On receipt of an trigger signal the VCO (board A5) outputs a signal, this is fed to A6 for ECL to TTL conversion and then input as "BURST CLOCK" to A3U20 and U22C. If the Burst Counter is not set to 001 and no rocker switch is being operated, then U20B D-input is high and the first clock pulse will cause the Q output to go high. The signal BURST ON/OFF is fed back to the VCO and enables the free running mode of A5U1. Also, the burst clock signal now starts to decrement the counter via U22C.

#### 4. End of count down – Burst off

The One Detector circuit output, U22C pin 8, is changed from its normal high to a low level when the stored burst count reaches one (001). Until this point, U22C pin 8 at high has maintain the BURST ON/OFF signal at high (Burst on). At the receipt of the next clock pulse, which initiales the last burst cycle, the level at U22C 'D' is transferred to the Q output so disabling burst via the VCO BURST ON input. This is illustrated by Figure 8–6–2.

### BURST NUMBER CONTROL BOARD A9

#### OPERATION

The function of this board is to control the display of the burst number as set in the control counter of A3. It does this basically by counting the number of cycles output by the Display board DVM oscillator and disabling it when the number equals the set burst number. To help understand how this is achieved it is necessary to understand the basic theory of dual slope integration, and its application in the Display board operation, this is given in Service Block 5.

The timing diagram, Figure 8–6–3 should be referred to when reading the following explanation. The principle of operation is that the DVM IC integrator is first supplied with a fixed input (2.2 V) voltage to enable it to ramp up in the normal manner for 1000 cycles time period. The discharge phase is now started and the oscillator disabled via Q1 when the number of cycles output equals the burst count number.

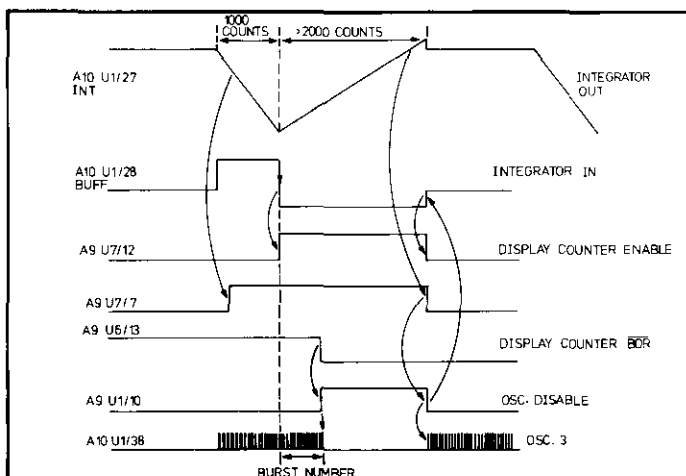


Figure 8–6–3. Burst No. Display Timing Diagram

Since the oscillator has been disabled the normal "end of ramp down" detector circuit within the IC cannot be used (the digital control logic is effectively at standstill without a control clock) and an external circuit, U7B etc., is used instead. U7B functions as a Schmitt trigger and causes Q1 to be switched off, so renabling the oscillator, when the DVM IC integrator output (signal "INT") equals the threshold level of about 0.1 V. The burst number is now displayed and the count and display sequence repeated as illustrated by Figure 8–6–3.

Devices U2A and B provide a divide by 4 function which is necessary since the DVM IC clock signal is normally divided by 4 internally and the burst number display counter must therefore be supplied with the same frequency.

#### TROUBLESHOOTING (A3 and A9)

For the purpose of troubleshooting, the complete burst circuitry can be considered as three functional sections:

1. Burst number setting circuitry (rocker switches, oscillator, control counter, carry/borrow logic).
2. Burst Counter, burst completion detection.
3. Burst number control (A9).

To isolate the faulty components the following general troubleshooting information links various possible fault conditions to the most likely cause:

If it is not possible to set the required burst number on the display and at the 8111A output by operating the appropriate rocker switches, then, a fault in the burst number setting circuitry of A3 is the most likely cause. If however, either the display or the output is wrong but not both, then a check on the operation of A3 Control Counter will assist in identifying the likely fault area. This is done by checking whether the outputs of U13 to U16 have the same decimal value as the display readout. If the values differ and the 8111A burst output is correct then suspect board A9, if they are identical but the output burst number is incorrect then the Burst Counter or completion detector are suspect.

### Burst Counter

The correct operation of the Burst Counter can be verified with the following test procedure, refer to Figure 8-6-4 for the waveform and timing data.

1. Disconnect A3R10.
2. Set 8111A:

OPERATING MODE .....NORMAL  
 WAVEFORM .....Square  
 FREQUENCY RANGE .....100–1000 kHz  
 FREQUENCY (VERNIER) .....1000 kHz

3. Confirm that the waveforms and timing data as given in Figure 8-6-4 are correct. Use oscilloscope internal trigger on positive slope setting.

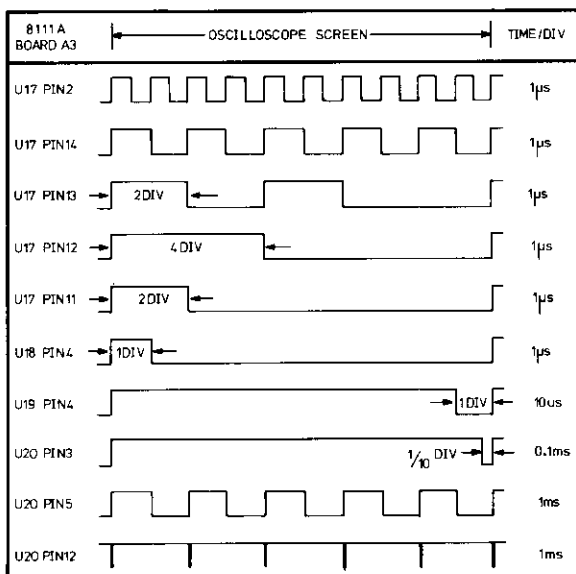


Figure 8-6-4. A3 Troubleshooting Data

### Burst No. Control A9

The special "short" extender board should be used when troubleshooting A9, and A9R10 must be disconnected to leave A9Q1 open base. This enables "free run" operation of the Burst No. Control Counter. Frequency and Duty/Width pushbuttons pressed.

The Schmitt triggers U7A and U7B can be checked for correct operation with the aid of Figure 8-6-5 waveforms.

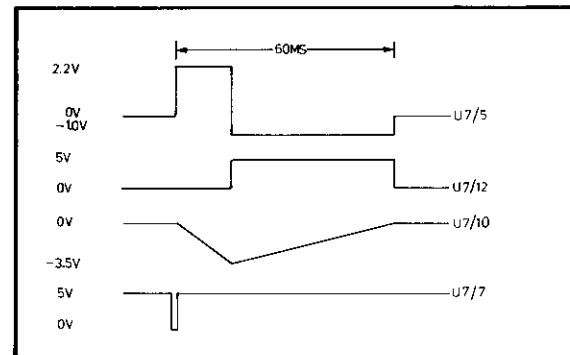


Figure 8-6-5. Burst No. Control A9  
 Troubleshooting Waveforms

The Burst Number Display Counter operation can be checked with the following test procedure.

1. Connect U7 pin 4 to +5 V. Confirm that U7 pin 12 goes to +5 V.
2. Connect U7 pin 9 to +5 V. Confirm that U7 pin 7 goes to +5 V.
3. Check that the waveform and timing data as given in Figure 8-6-6 is correct. Use oscilloscope internal trigger on positive slope setting.

**NOTE:** The "spikes" (U6 pin 4 etc.) might need to be verified with the aid of a TTL probe if difficult to see on the oscilloscope screen.

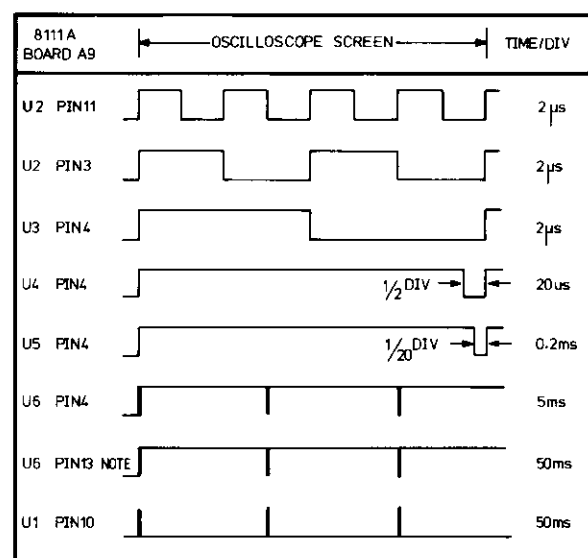
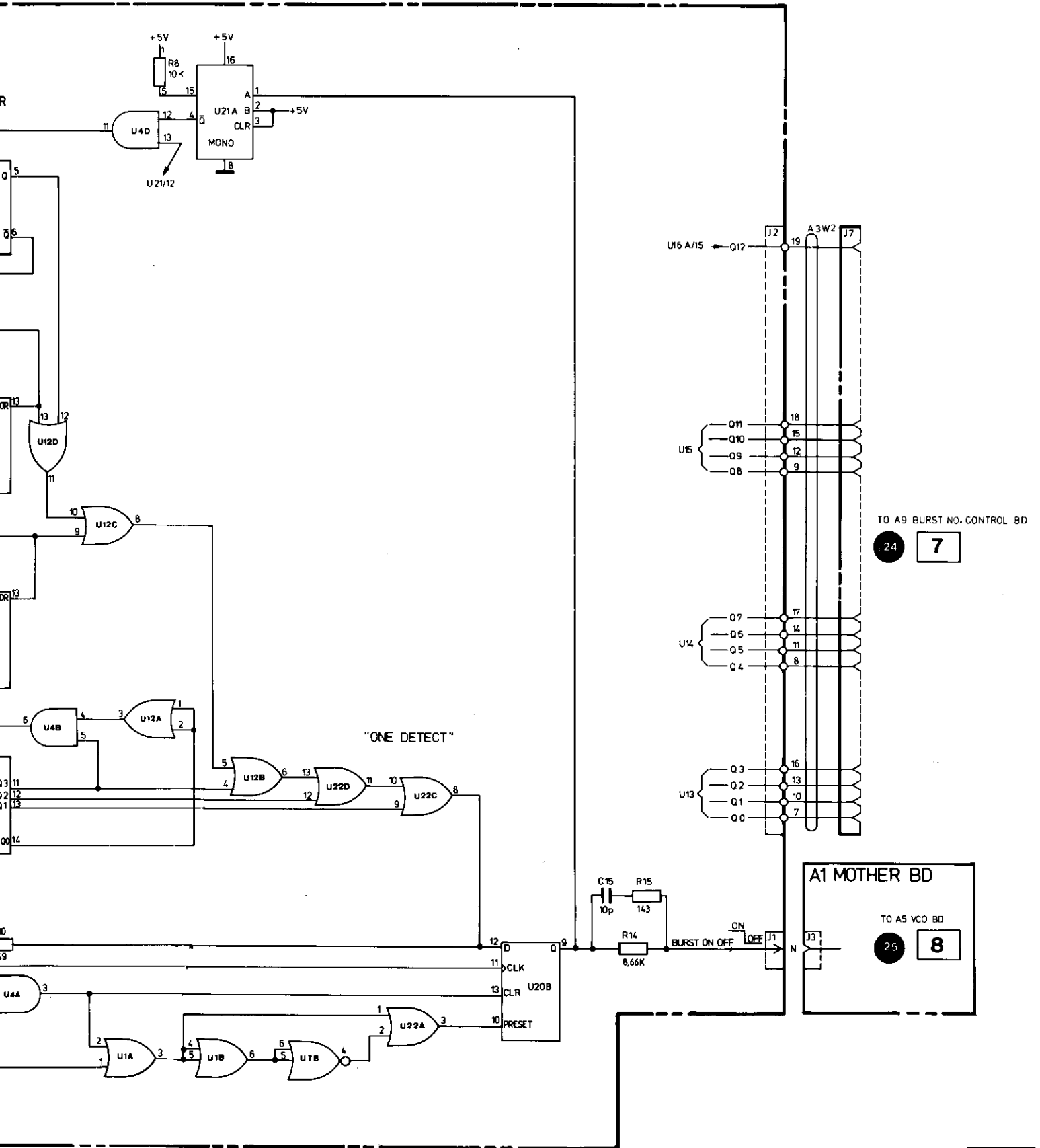
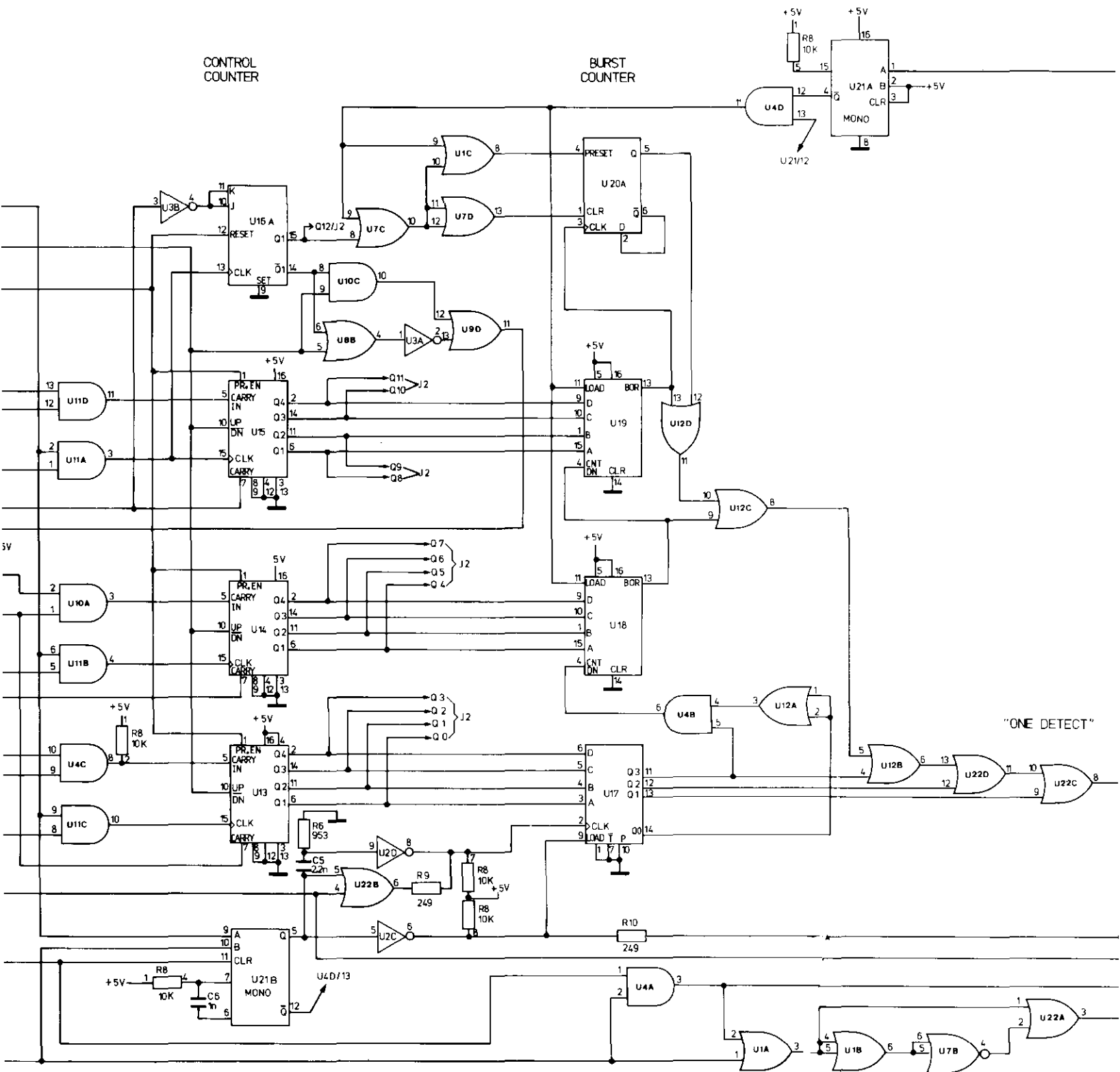


Figure 8-6-6. Burst No. Display Counter  
 Troubleshooting Data



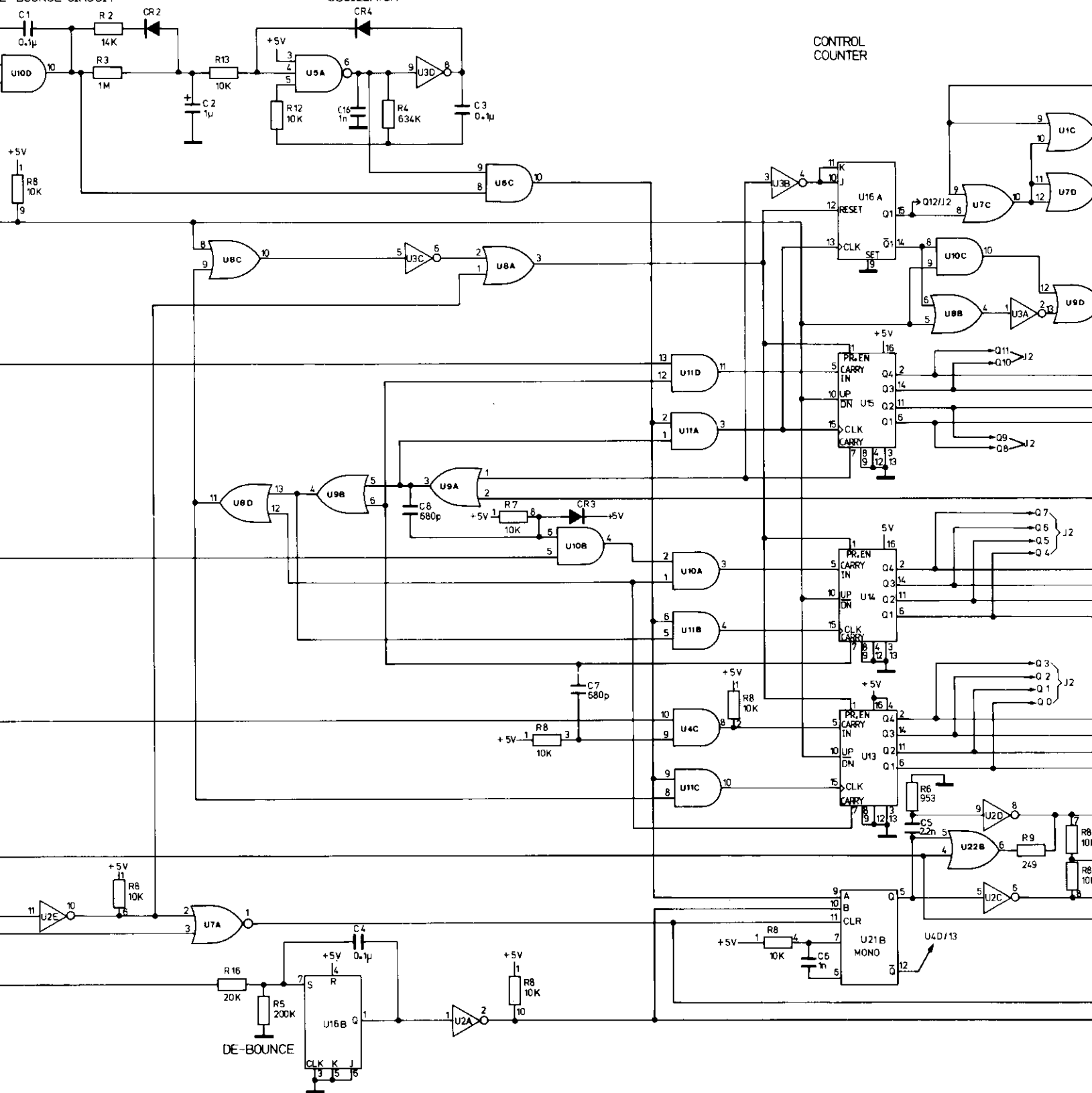
BURST BOARD A3

6

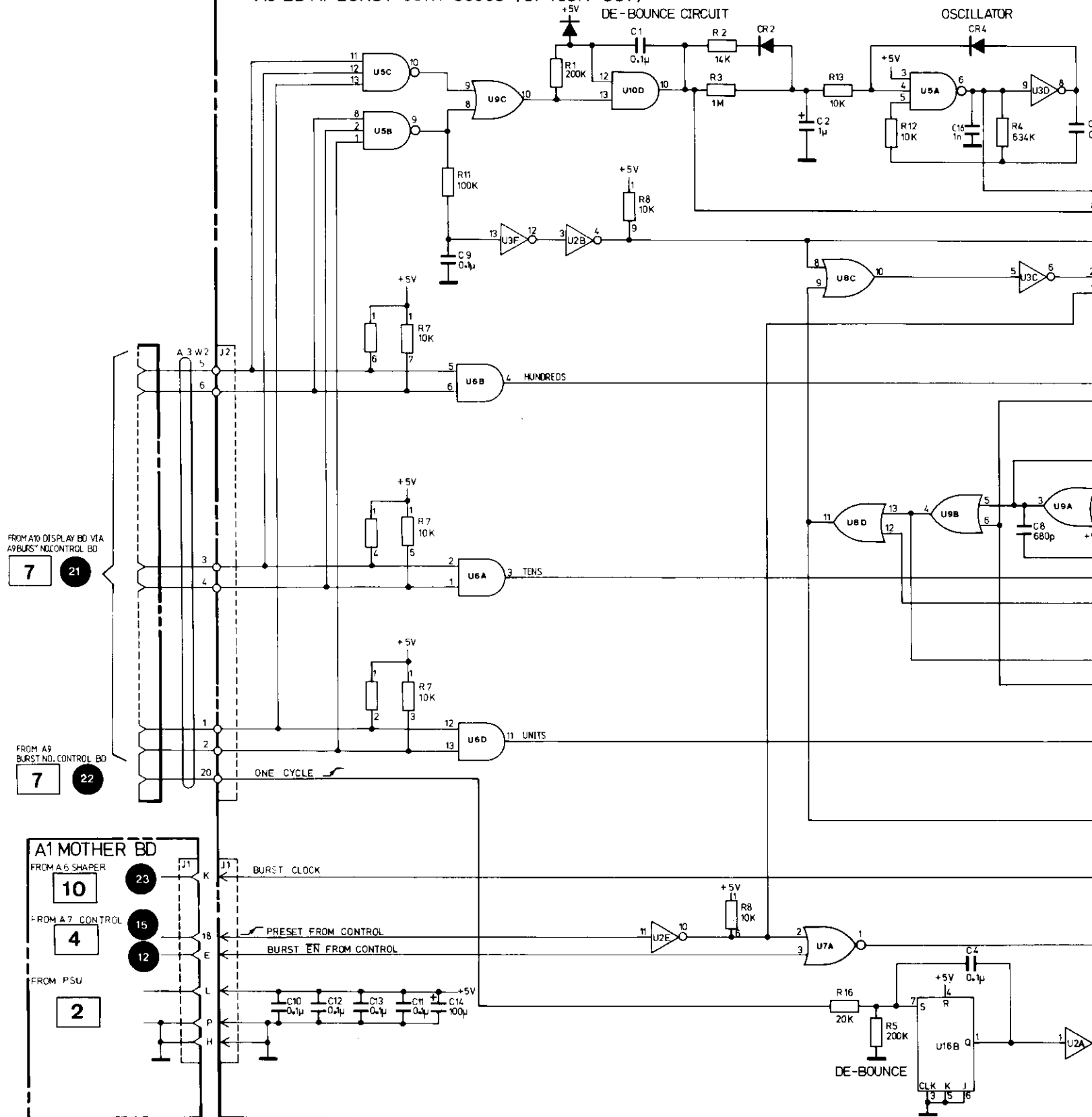


001)

E-BOUNCE CIRCUIT

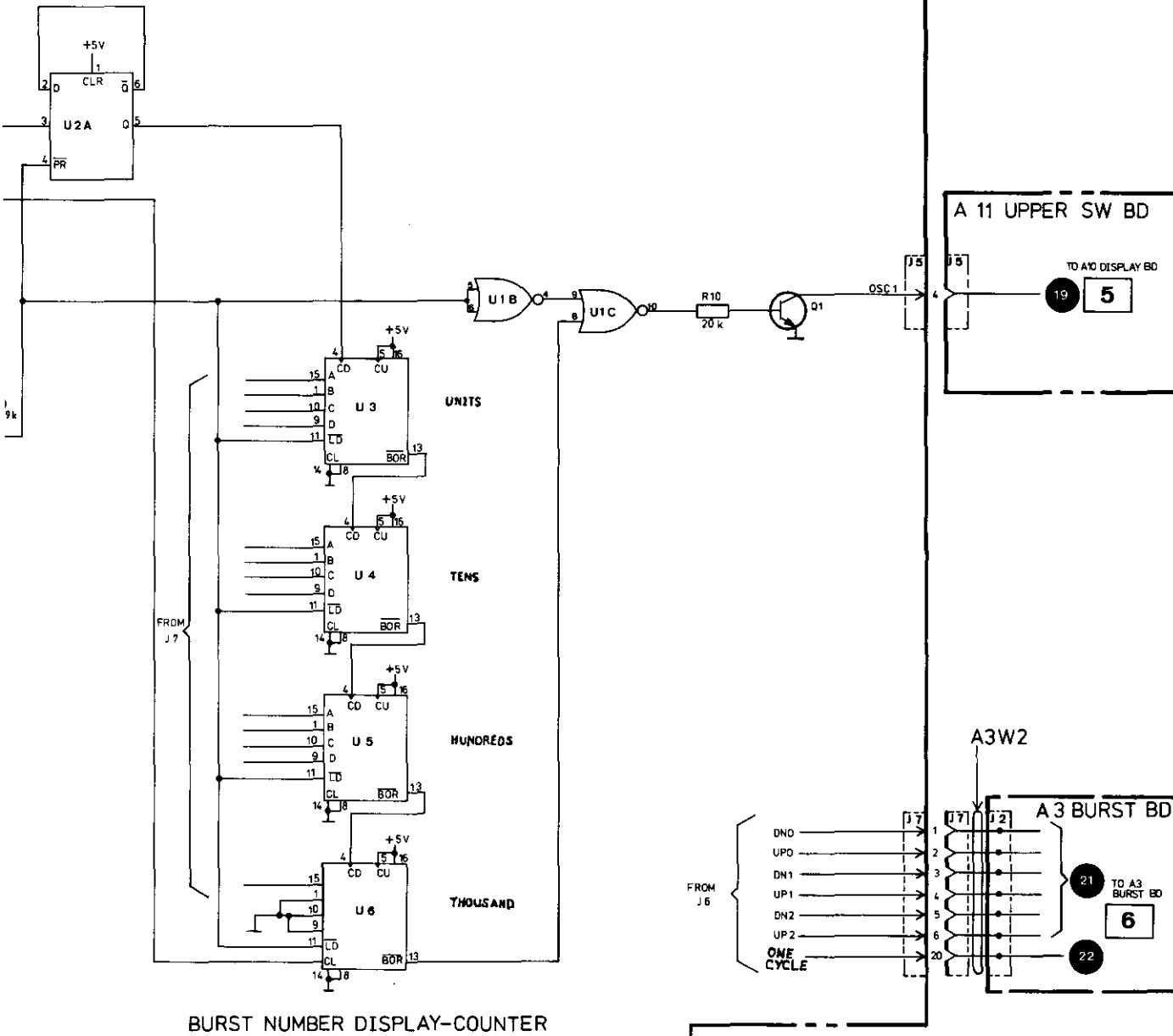


# A3 BD AY BURST 08111-66503 (OPTION 001)



01)

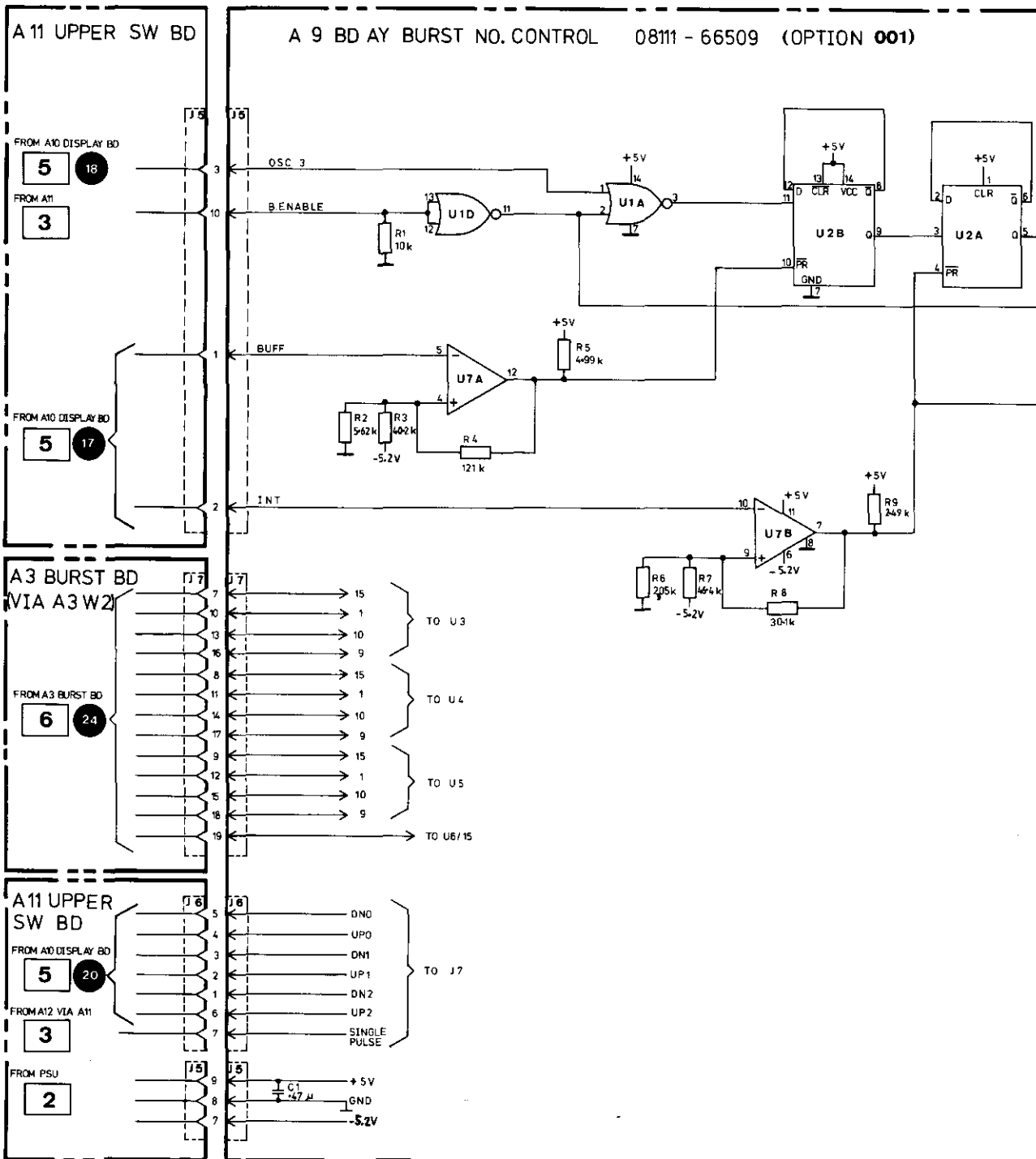
NOTE: FOR TROUBLESHOOTING  
DISCONNECT R10

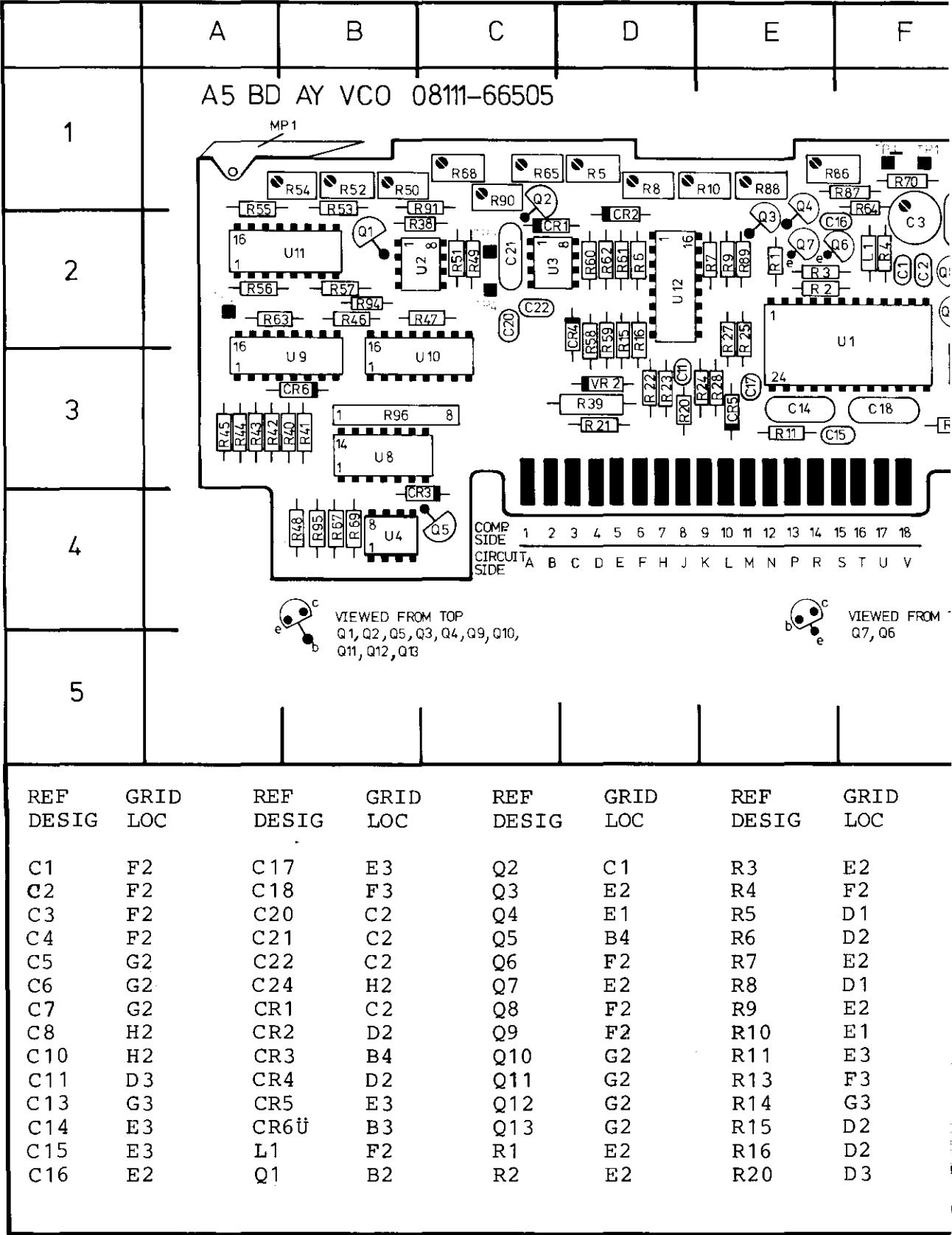


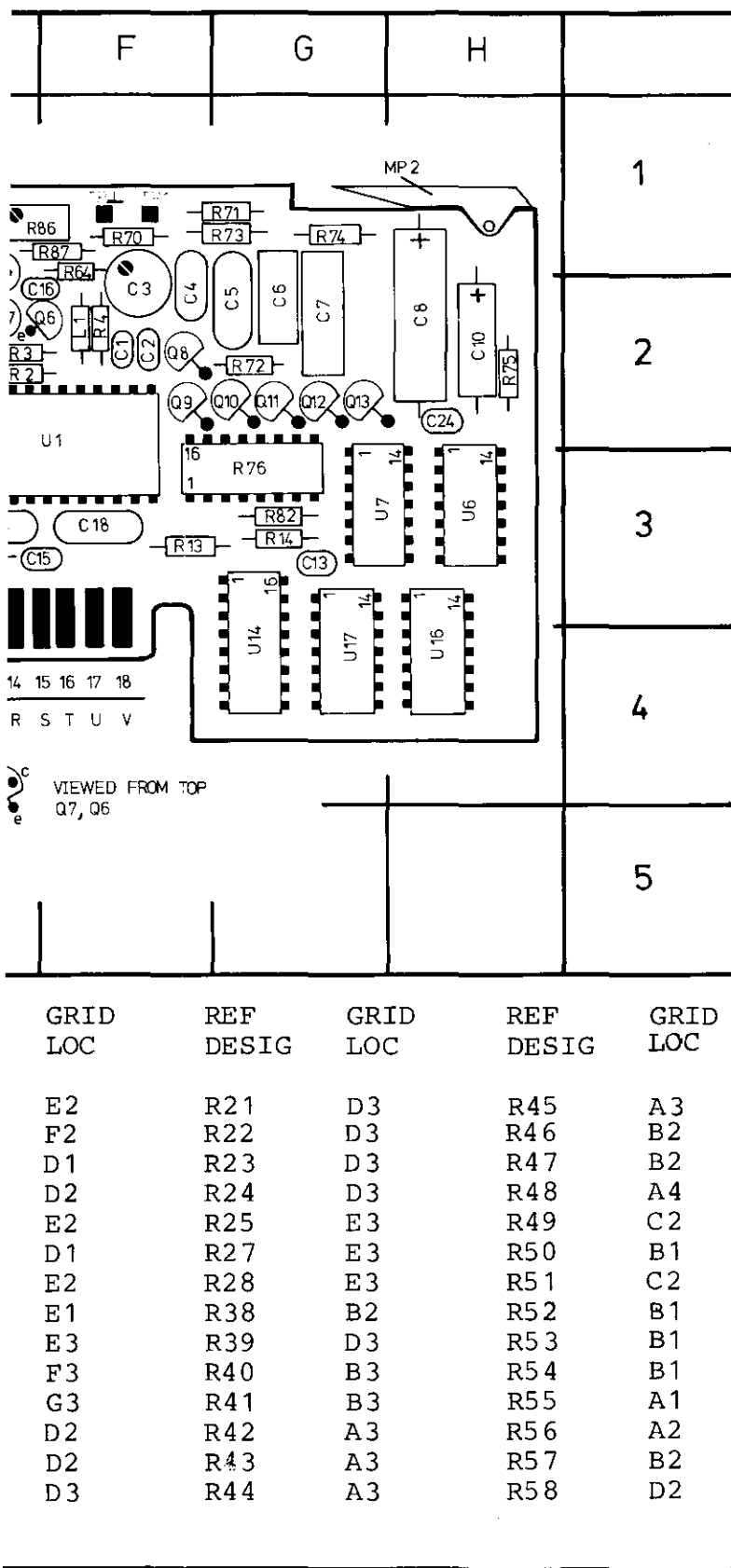
BURST NUMBER DISPLAY-COUNTER

BURST NO. CONTROL A9

7







| REF<br>DESIG | GRID<br>LOC |
|--------------|-------------|
| R59          | D2          |
| R60          | D2          |
| R61          | D2          |
| R62          | D2          |
| R63          | A2          |
| R64          | F2          |
| R65          | C1          |
| R67          | B4          |
| R68          | C1          |
| R69          | B4          |
| R70          | F1          |
| R71          | G1          |
| R72          | G2          |
| R73          | G1          |
| R74          | G1          |
| R75          | H2          |
| R76          | G3          |
| R82          | G3          |
| R86          | E1          |
| R87          | F1          |
| R88          | E1          |
| R89          | E2          |
| R90          | C1          |
| R91          | C1          |
| R94          | B2          |
| R95          | B4          |
| R96          | B3          |
| TP1          | F1          |
| TP2          | A2          |
| TP3          | C2          |
| TP4          | C2          |
| TPGND        | F1          |
| U1           | F2          |
| U2           | B2          |
| U3           | C2          |
| U4           | B4          |
| U6           | H3          |
| U7           | G3          |
| U8           | B3          |
| U9           | A3          |
| U10          | B3          |
| U11          | A2          |
| U12          | D2          |
| U14          | G4          |
| U16          | H4          |
| U17          | G4          |
| VR2          | D3          |

## SERVICE BLOCK 7 VCO BOARD A5 7

### THEORY OF OPERATION

#### General

The function of the VCO board is to generate the required signal frequency in accordance with either the 8111A front panel settings or an external control voltage. When TRIGGER mode is selected, the output signal repetition rate is controlled by the applied external frequency but the VCO board's operation is different depending on whether the 8111A is in waveform (sine, triangle or square) or pulse mode.

In TRIGGER/waveform function mode the VCO produces the waveform frequency, in accordance with the front panel settings but in TRIGGER/PULSE mode the board serves only as a Schmitt trigger/level shifter to shift the incoming trigger signal for compatibility with the trigger converter circuit of the Width board (A4).

The VCO frequency range is from 1 Hz to 20 MHz (with the capability to reduce to 0.1 Hz in VCO mode — see Table 3-2). The frequency is distributed over 7 decades

(from 1 Hz to 10 MHz) and a top 10 – 20 MHz range.

An error detection circuit provides an output signal (in TRIGGER/waveform function mode) whenever an external trigger signal arrives before completion of the current cycle. Reference to Figure 8-7-1 shows that the VCO board comprises a main control IC—U1 and associated external signal and current sources. A range decoder enables selection of a suitable ramp capacitor and also influences, via reference voltages, the current source. A more detailed description of the board's operation will now be given, schematic 8 should be referred to together with the appropriate figures as required.

### OPERATION

There are two operating modes for the VCO board — Free Running Mode which includes NORMAL and VCO operation and Triggered Mode which includes TRIGGER, GATE and BURST modes. Although the circuit operation is similar for both modes there are some slight differences which will be described after the general operational description.

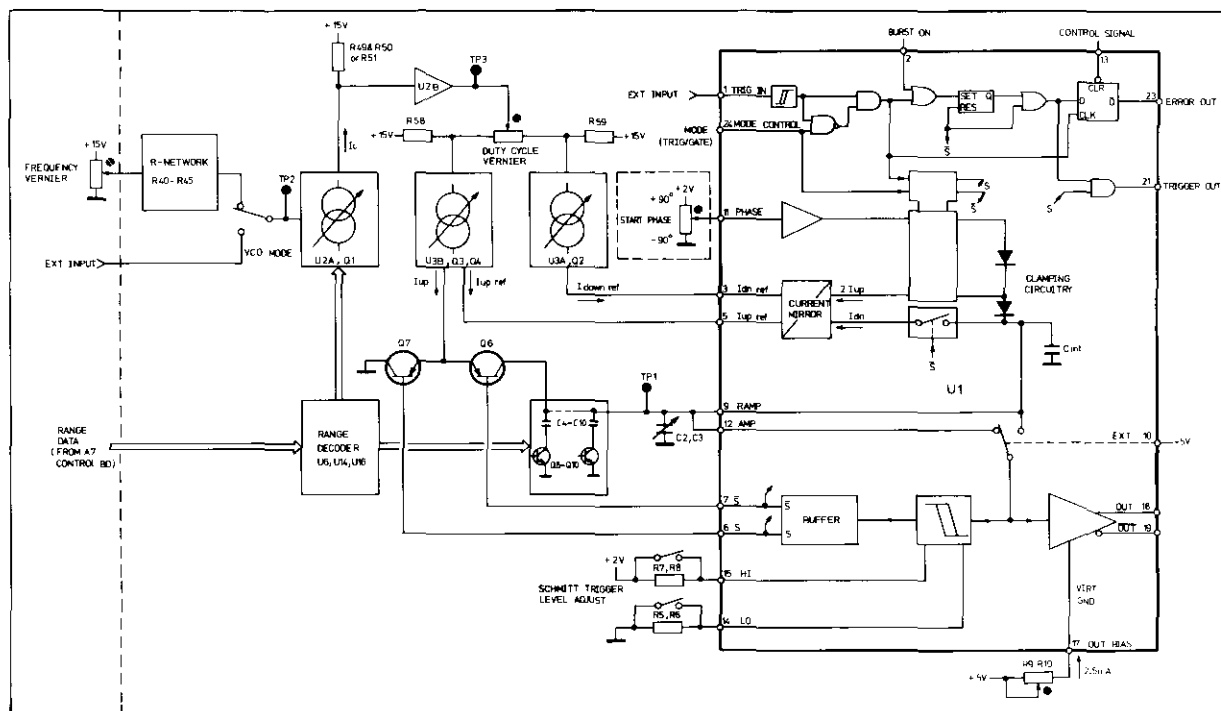
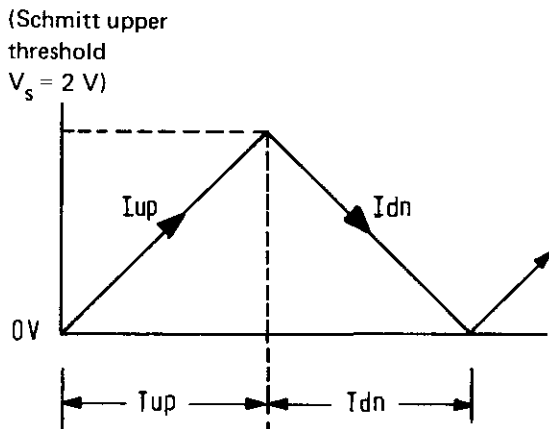


Figure 8-7-1. Simplified VCO Board Block Diagram

In both modes the principle of operation is that a ramp capacitance (one or more of C4–C10) is charged up by  $I_{up}$  to the fixed upper threshold level of a Schmitt trigger (within U1) by switching Q6 on. At this point, Q6 is switched off and Q7 on so discharging the capacitance towards ground and also diverting  $I_{up}$  to ground until the lower Schmitt threshold is reached, the cycle is then repeated. The charge and discharge sequences are illustrated below:



The frequency depends on the two currents and the ramp capacitance. Duty cycle of the waveform is determined by the ratio of  $T_{up}/(T_{up} + T_{dn})$  where  $T_{up}$  is the time taken to charge up to  $V_s$  and  $T_{dn}$  is the time taken to discharge to 0 V.

The difference between the two modes is that in Triggered mode an external trigger signal is required at U1 pin 1 to initiate a charge cycle. Also, the ramp capacitors are preset or changed to a voltage determined by the Start Phase potentiometer setting and therefore the charge or "ramp up" process commences from this level. The clamping is achieved via  $I_{upref}$  and the current mirror internal to U1 which produces  $2 \times I_{upref}$  and the required clamp voltage. A more detailed operational description of the main circuit blocks comprising the VCO board will now be given. Unless otherwise mentioned references are to Figure 8–7–1.

#### R-Network (R40–R45)

The reference voltage from the front panel FREQUENCY vernier is converted by the network to one of two possible values depending on the operative frequency range i.e. – 1 Hz – 9.99 MHz (decades) or 10–20 MHz (non-decades). The resulting voltage is then used to control U2A, Q1 current source.

#### Control Current Source (U2A, Q1)

This current source output  $I_c$  converts the output voltage from the R-Network to a +15 V reference voltage (instead of ground referenced). U11 (see schematic 8) enables one of three resistive networks to be selected depending on which of the three indicated frequency range bands is operative. This will be explained in the Range Decoder and Ramp Capacitor section. The selected network limits  $I_c$  and therefore the voltage produced across R49/50 or R51 within one of three different ranges.

#### Duty Cycle Vernier

The output voltage from U2B is fed either via the Duty Cycle vernier potentiometer (used in an inverse mode) to the two constant current sources shown or, directly connected when fixed 50 % duty cycle or pulse mode is selected. Note: in pulse mode the duty cycle potentiometer is used to control pulse width and the trigger output signal from U1 has a fixed 50 % duty cycle.

#### Current Sources ( $I_{up}$ , $I_{upref}$ , $I_{dnref}$ )

Current source U3B, Q3, Q4 etc. supplies the range capacitance charging current ( $I_{up}$ ) via Q6 which is controlled by U1 SW-output.  $I_{upref}$  is used as a reference by the current mirror of U1 to provide the start phase clamp voltage  $I_{downref}$  is used as a reference by U1 current mirror to enable the correct discharge or ramp down rate of the previously charged capacitance.

#### Transistors Q6 and Q7

Q6 is operated as a switch under the control of U1 to supply charging current to the ramp capacitors. Q7, whose operation is always complementary to Q6, serves to bypass current  $I_{up}$  to ground at the end of the ramp up period ( $I_{up}$  flows constantly).

#### Range Decoder and Range Capacitors (refer to schematic 8 and Figure 8–7–1)

The range data from A7 Control board is decoded by U14/U16 and used to enable the appropriate range capacitors. Also, depending on which of the three frequency bands (1 Hz – 1 MHz, 1 – 10 MHz or 10 – 20 MHz) is operative pre-limiting of control current  $I_c$  within one of three-ranges is done via U11, e.g. a frequency setting of 50 KHz is in band 1 of 1 Hz –

1 MHz, U11 will therefore select the frequency pre-ranging resistive network R55/R54.

The range capacitors are enabled by transistor switches Q8–Q13. C2 and C3 are always enabled and C4–C10 are sequentially enabled in an additive or summing sequence. For the two fastest frequency ranges only C2 and C3 are operative, the 10–20 MHz value being achieved by increasing the available ramp current. This is done by selecting the R56 network which results in maximum  $I_c$  and therefore maximum control voltage being available. For the 1–10 MHz range the  $I_c$  is reduced via R52/R53 network and therefore the ramp current is reduced. All other ranges use R54/R55 and have the same ramp current control voltage and ramp current limits. For the 0.1 – 1 MHz range C2, C3 and C4 are enabled, for 10–100 KHz C2, C3, C4 and C5 are enabled etc. The complete range capacitor selection data is given in Table 8–7–4. in the Troubleshooting section.

#### Schmitt Trigger Level Adjust

The two trigger levels are fixed at 0 V and +2 V for all frequency ranges except the two fastest when they are changed by switching in external resistors.

## TROUBLESHOOTING

1. General Troubleshooting Information
2. Analogue Data
3. Digital Data

#### 1. General Troubleshooting Information:

It is suggested that troubleshooting the VCO board is started at TP 1 since it is possible to confirm, by the presence of either a triangular waveform or a constant dc level as shown, that particular circuit components are operating correctly. For all operating modes of the 8111A except TRIGGER/PULSE the following details apply:

#### Modes

A. (free running)  
NORMAL, VCO  
(50 % DUTY  
CYCLE)



#### Waveshape at TP 2.

0 V and +2 V apply for frequencies between 1 Hz – 1000 KHz for frequencies 1 MHz – 20 MHz values are slightly changed,

b. (Triggered)  
TRIGGER,  
GATE, BURST

When there is no external trigger signal present the voltage at TP 1 should be fixed at between 0 and 2 V depending on the position of the START PHASE potentiometer.

–90° start phase 0 V approx.

0° start phase 1 V approx.

+90° start phase 2 V approx.

In TRIGGER/PULSE mode the VCO board works only as a Schmitt trigger/level shifter with the external trigger signal passing through U1 and being made compatible with circuitry on board A4. If the fault appears to originate from the VCO board then check that U1 pin 13 is clamped at TTL low since, if not, then the input trigger signal will not be transferred to U1 pin 21 (Trigger Out).

If the test condition for the triggered modes (B) is wrong then check whether current source U33, Q3, Q4 is operating correctly, if so and waveshape for mode A is correct then U1 is suspect. Ensure that problem is not with Q3 and that Q6, Q7 are not faulty before replacing U1.

If checks show that the correct test results at TP1 do not occur then the following faultfinding information should help to isolate the faulty component. The voltages given are referenced to ground unless otherwise stated.

## 2. Analogue Data:

★ Referring to Figure 8-7-2. and Schematic 8, it can be seen that the voltage at TP2 comes from either the FREQUENCY potentiometer or, when in VCO mode, the EXT INPUT connector. When not in VCO mode, adjustment of the FREQUENCY vernier should produce the following values:

|                   |       |                             |
|-------------------|-------|-----------------------------|
| Vernier position: | CCW   | CW                          |
| TP2 voltage:      | < 1 V | > 10 V                      |
| or:               | < 1 V | > 2 V (for 10-20 MHz range) |

★ The voltage at TP 3 is referenced to +15 V (TP4) and controls the current sources  $I_{up}$ ,  $I_{upref}$  and  $I_{down}$ . Adjustment of the FREQUENCY/vernier should produce the values shown in Table 8-7-1.

## IC Current Source

★ The current source converts the input voltage from either the FREQUENCY vernier or the EXT INPUT (in VCO mode). The voltage, which is referenced to ground, is converted to a new value referenced to +15 V. A check on the correct operation of the complete current source circuit of U2, Q1 etc. can be done by confirming the values given in Table 8-7-2.

Table 8-7-1. Test Voltages for Current Sources

|                                                                            | Vernier position |        | Applicable Ranges and Duty Cycle     |
|----------------------------------------------------------------------------|------------------|--------|--------------------------------------|
|                                                                            | CCW              | CW     |                                      |
| TP3 Voltage swing                                                          | -0.1 V           | -1.4 V | (1 Hz-1 MHz Ranges, fixed 50 % DTY)  |
|                                                                            | -0.6 V           | -7.8 V | (1 Hz-1 MHz Ranges, variable DTY)    |
|                                                                            | -0.26 V          | -3.1 V | (1 Hz-10 MHz range) } fixed 50 % DTY |
|                                                                            | -2.6 V           | -6.4 V | (10 - 20 MHz Range) }                |
| The given values are referenced to +15 V (TP4).<br>Tolerance: $\pm 10\%$ . |                  |        |                                      |

Table 8-7-2. Voltage drops across Range resistors

| Frequency Range                               | Selected R<br>(Operative Resistors) | Freq. vern. pos.: | CCW    | CW    |
|-----------------------------------------------|-------------------------------------|-------------------|--------|-------|
| 1 Hz – 1 MHz                                  | R54/55                              | voltage drop      | 0.45 V | 5.5 V |
| 1 – 10 MHz                                    | R52/53                              |                   | 0.45 V | 5.5 V |
| 10 – 20 MHz                                   | R56                                 |                   | 0.45 V | 1.1 V |
| Tolerance: 10 %                               |                                     |                   |        |       |
| given values are for fixed<br>50 % DUTY CYCLE |                                     |                   |        |       |

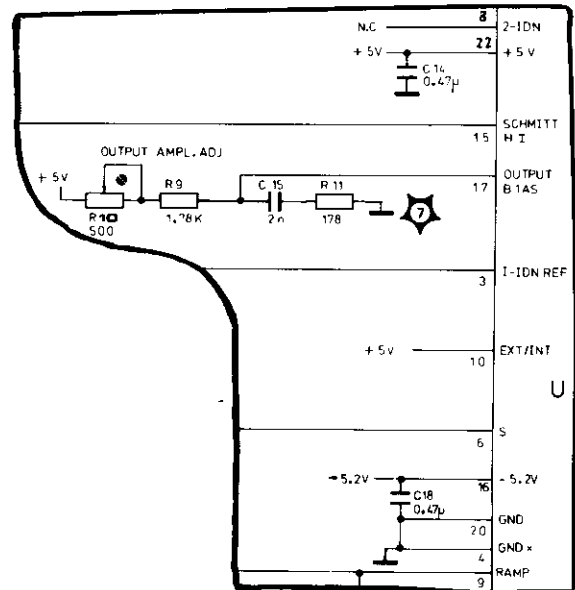
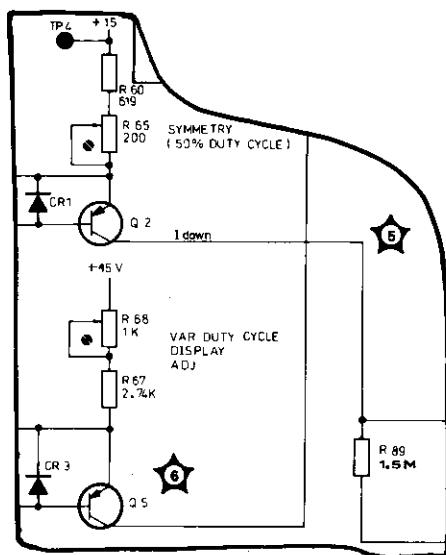
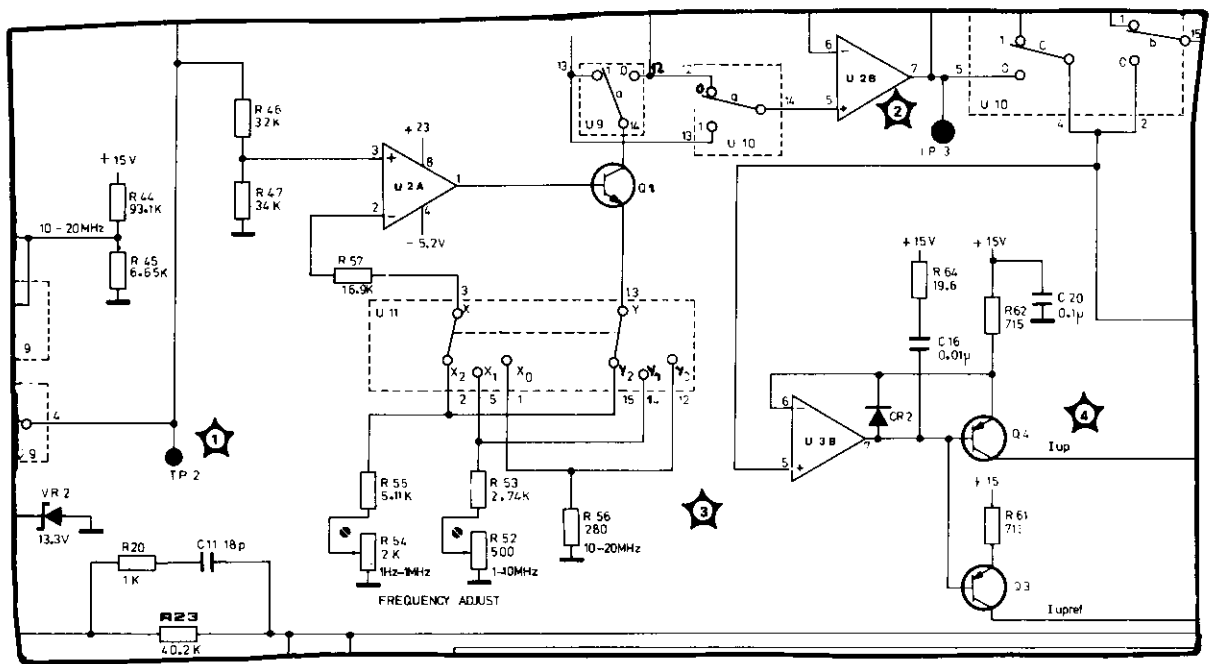


Figure 8-7-2. Troubleshooting Test Points

**$I_{up}$  Current Source**

★ The  $I_{up}$  current may be checked by connecting a current meter between the collector of Q4 and ground (therefore routing  $I_{up}$  to ground). Set the 8111A to TRIGGER mode and fixed 50 % DUTY. Verify that Q6 is switched on and Q7 off.

Check, when the FREQUENCY vernier is adjusted, that the values are as in Table 8-7-3.

**Variable Duty Cycle Display Current Source**

★ The current source U4, Q5 etc. outputs a current which is proportional to  $I_{up}$ , the resulting voltage drop produced across A11R18 is then used to produce the displayed DUTY CYCLE percentage value. The circuit operation can be checked by setting the 8111A to fixed 50 % DUTY and checking the voltage at Q5 collector. The value should change as shown when the FREQUENCY vernier is adjusted:

 **$I_{downref}$  Current Source**

★  $I_{downref}$  can be measured (after removing U1 from its connector) by connecting a current meter between Q2 collector and ground. The values and test conditions for  $I_{down}$  are as given in Table 8-7-3 previously.

**Output Bias Control Current**

★ This current, which controls the output amplifier of U1 is typically 2.5 mA and pin 17 of U1 must be at 0 V (virtual ground).

Table 8-7-3.  $I_{up}$  Values

|           | Vernier Position |        | Applicable Frequency Ranges |
|-----------|------------------|--------|-----------------------------|
|           | CCW              | CW     |                             |
| Current } | 0.14 mA          | 1.9 mA | (1 Hz – 1 MHz Ranges)       |
|           | 0.36 mA          | 4.3 mA | (1 MHz – 10 MHz Range)      |
|           | 3.6 mA           | 8.9 mA | (10 MHz – 20 MHz Range)     |

Tolerance:  $\pm 10\%$ .

Table 8-7-4.

|                                   | Vernier Position |        | Applicable Frequency Range |
|-----------------------------------|------------------|--------|----------------------------|
|                                   | CCW              | CW     |                            |
| Voltage at the collector of Q5: } | 70 mV            | 0.87 V | (1 Hz – 1 MHz Ranges)      |
|                                   | 0.15 V           | 1.9 V  | (1 MHz – 10 MHz Range)     |
|                                   | 1.6 V            | 4.0 V  | (10 MHz – 20 MHz Range)    |

Tolerance:  $\pm 10\%$ .

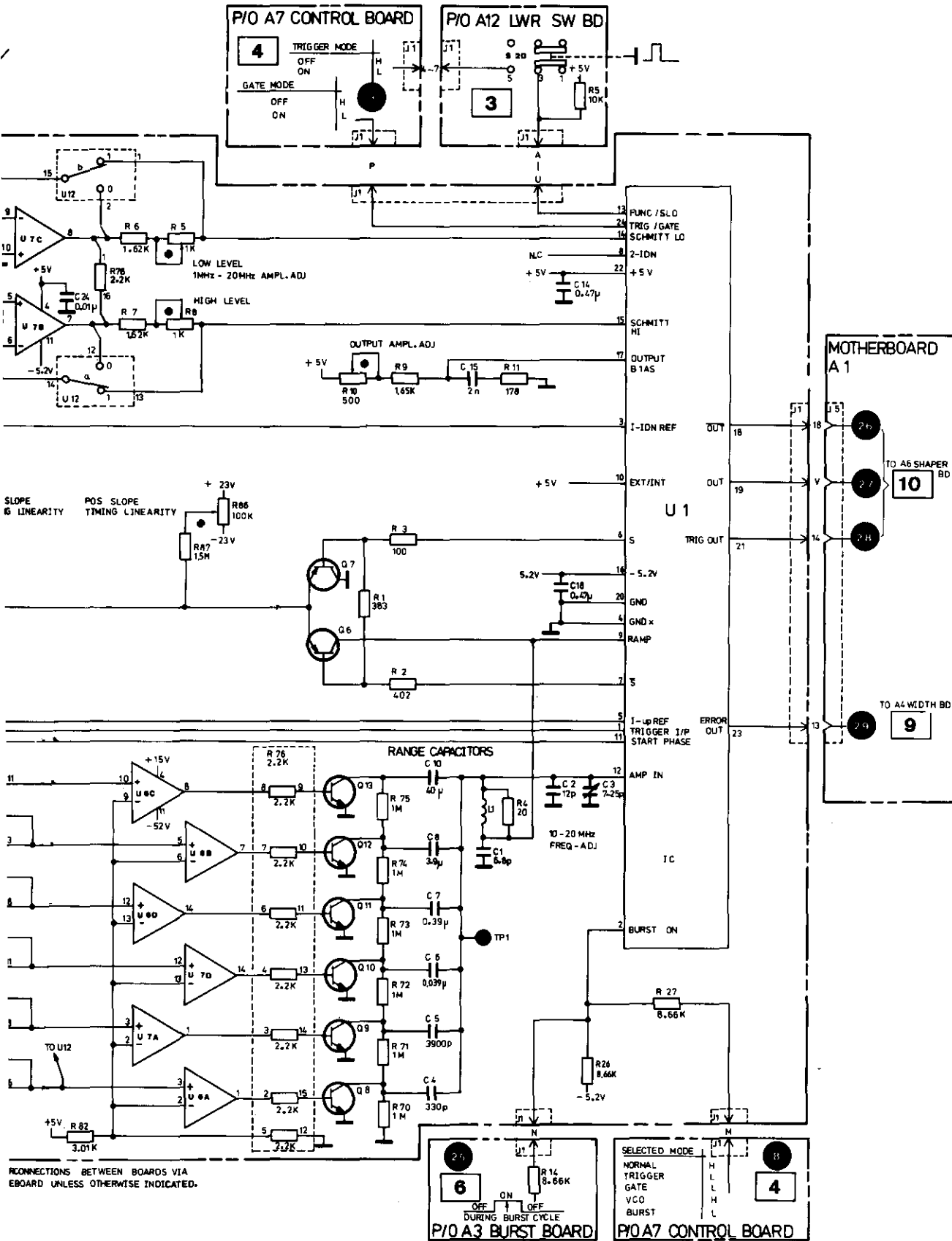
### 3. Digital Data

If the fault appears to be related to range capacitor selection i.e. a digital data decoding problem then use Table 8-7-4 to verify that the appropriate devices are operating correctly.

The truth table of the other digital devices are given on schematic 8.

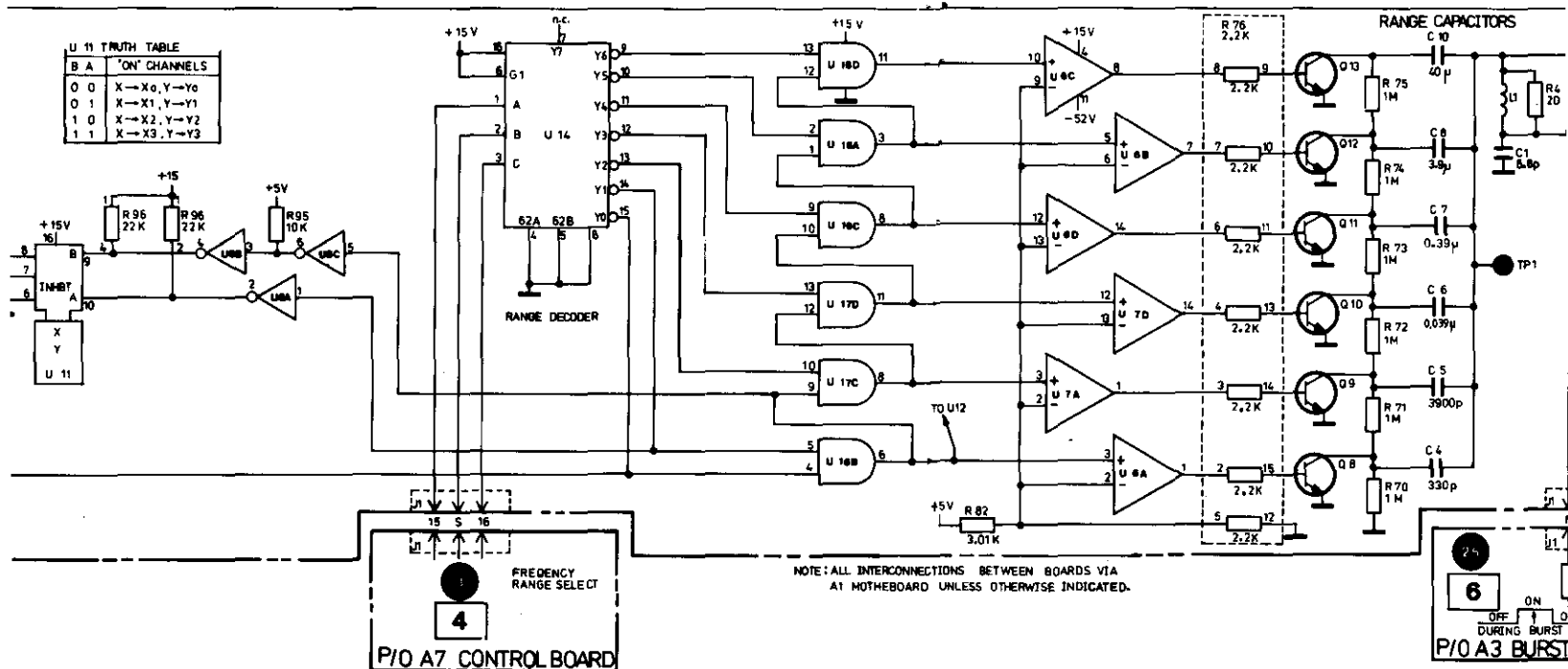
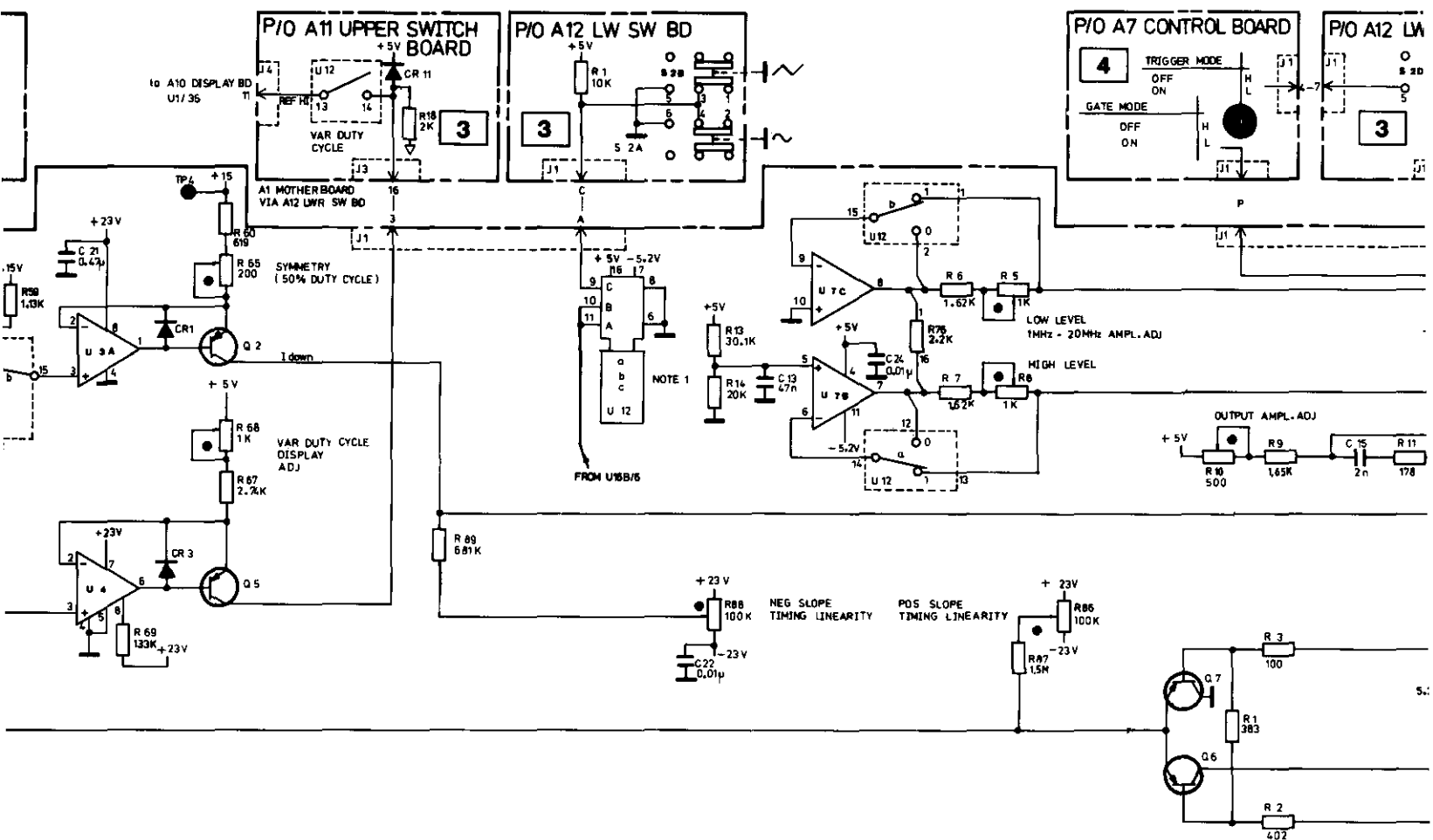
Table 8-7-5. Range Capacitor Selection Truth Table

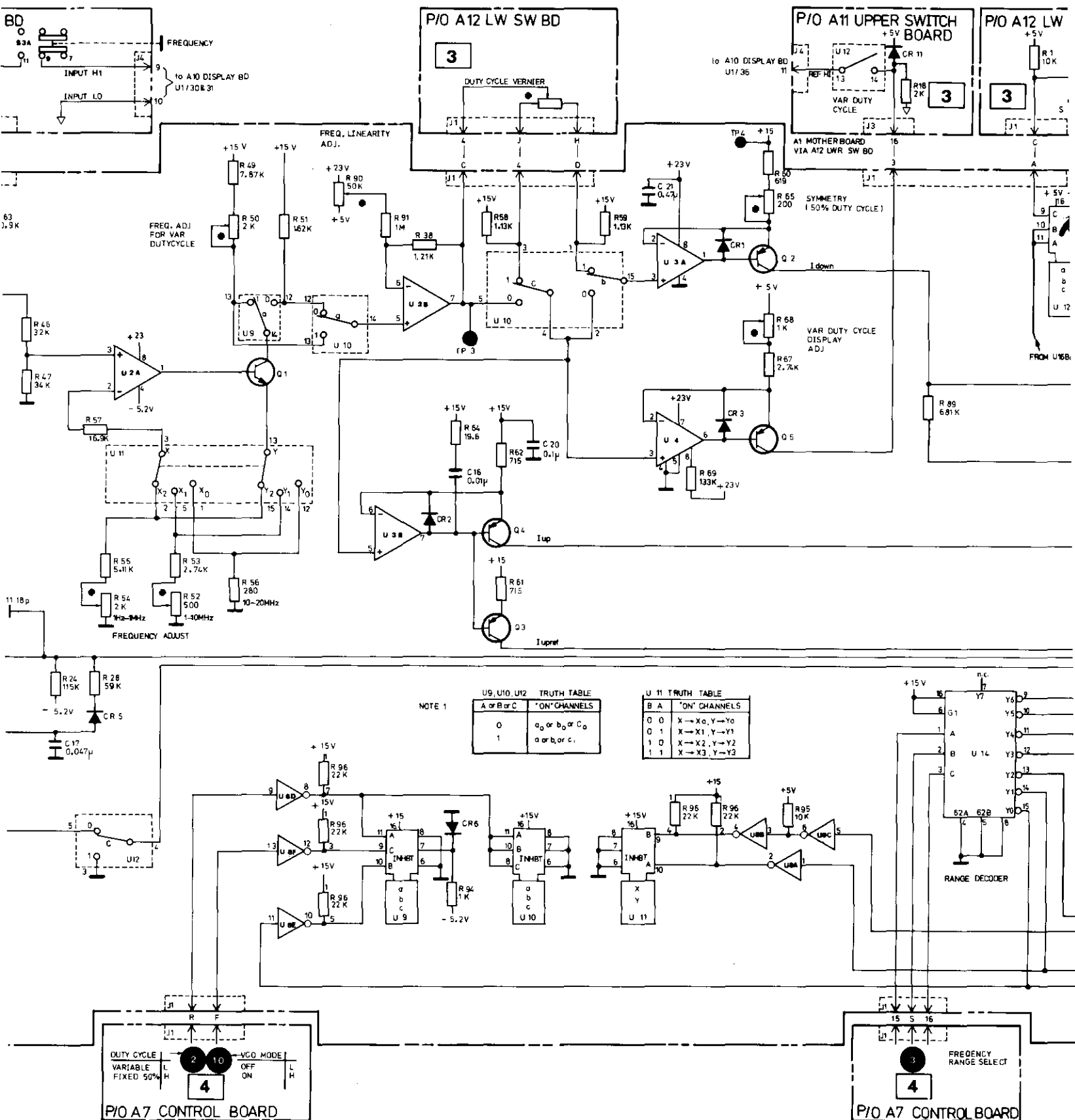
| Frequency Range | U14 pin No. |   |   |    |    |    |    |    |    |   | U16<br>pin No. | U17<br>pin No. | U16<br>pin No. | Selected Capacitors<br>* (C2 and C3 are<br>selected in all ranges) |    |   |        |
|-----------------|-------------|---|---|----|----|----|----|----|----|---|----------------|----------------|----------------|--------------------------------------------------------------------|----|---|--------|
|                 | 3           | 2 | 1 | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 11             | 3              | 8              |                                                                    | 11 | 8 | 6      |
| 10 – 20 MHz     | 0           | 0 | 0 | 0  | 1  | 1  | 1  | 1  | 1  | 1 | 0              | 0              | 0              | 0                                                                  | 0  | 0 | *      |
| 1 – 10 MHz      | 0           | 0 | 1 | 1  | 0  | 1  | 1  | 1  | 1  | 1 | 0              | 0              | 0              | 0                                                                  | 0  | 0 | *      |
| 0.1 – 1 MHz     | 0           | 1 | 0 | 1  | 1  | 0  | 1  | 1  | 1  | 1 | 0              | 0              | 0              | 0                                                                  | 0  | 1 | C4     |
| 10 – 100 KHz    | 0           | 1 | 1 | 1  | 1  | 1  | 0  | 1  | 1  | 1 | 0              | 0              | 0              | 0                                                                  | 1  | 1 | C4, C5 |
| 1 – 10 KHz      | 1           | 0 | 0 | 1  | 1  | 1  | 1  | 0  | 1  | 1 | 0              | 0              | 0              | 1                                                                  | 1  | 1 | C4–C6  |
| 0.1 – 1 KHz     | 1           | 0 | 1 | 1  | 1  | 1  | 1  | 1  | 0  | 1 | 0              | 0              | 1              | 1                                                                  | 1  | 1 | C4–C7  |
| 10 – 100 Hz     | 1           | 1 | 0 | 1  | 1  | 1  | 1  | 1  | 1  | 0 | 0              | 1              | 1              | 1                                                                  | 1  | 1 | C4–C8  |
| 1 – 10 Hz       | 1           | 1 | 1 | 1  | 1  | 1  | 1  | 1  | 1  | 1 | 1              | 1              | 1              | 1                                                                  | 1  | 1 | C4–C10 |



VCO BOARD A5

8





A5 BD AY VCO 08111-66505

P/O FRONT PANEL  
3

3

FREQUENCY  
VERNIER

MAN

START  
PHASE

MOTHER  
BOARD  
A1

2

POWER  
SUPPLY

2

POWER  
SUPPLY

2

POWER  
SUPPLY

2

POWER  
SUPPLY

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POWER  
SUPPLY

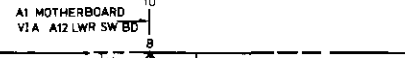
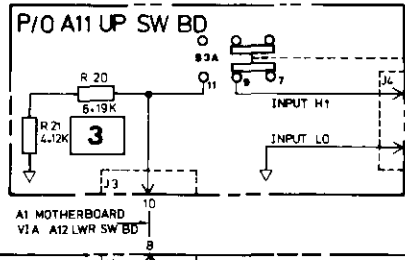
2

POWER  
SUPPLY

2

POWER  
SUPPLY

2



FREQUENCY

to A10 DISPLAY BD  
U1/30 & 31

FREQ. LINEARITY  
ADJ.

FREQ. ADJ.  
FOR VAR  
DUTYCYCLE

FREQ. ADJ.

FREQ. ADJ.

FREQ. ADJ.

FREQ. ADJ.

FREQ. ADJ.

FREQ. ADJ.

FREQ. ADJ.

FREQ. ADJ.

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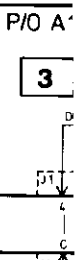
FREQ. ADJ.

FREQ. ADJ.

FREQ. ADJ.

FREQ. ADJ.

FREQ. ADJ.



FREQ. LINEARITY  
ADJ.

FREQ. ADJ.  
FOR VAR  
DUTYCYCLE

FREQ. ADJ.

FREQ. ADJ.

FREQ. ADJ.

FREQ. ADJ.

FREQ. ADJ.

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FREQ. ADJ.

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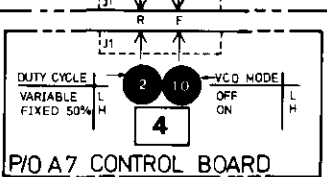
FREQ. ADJ.

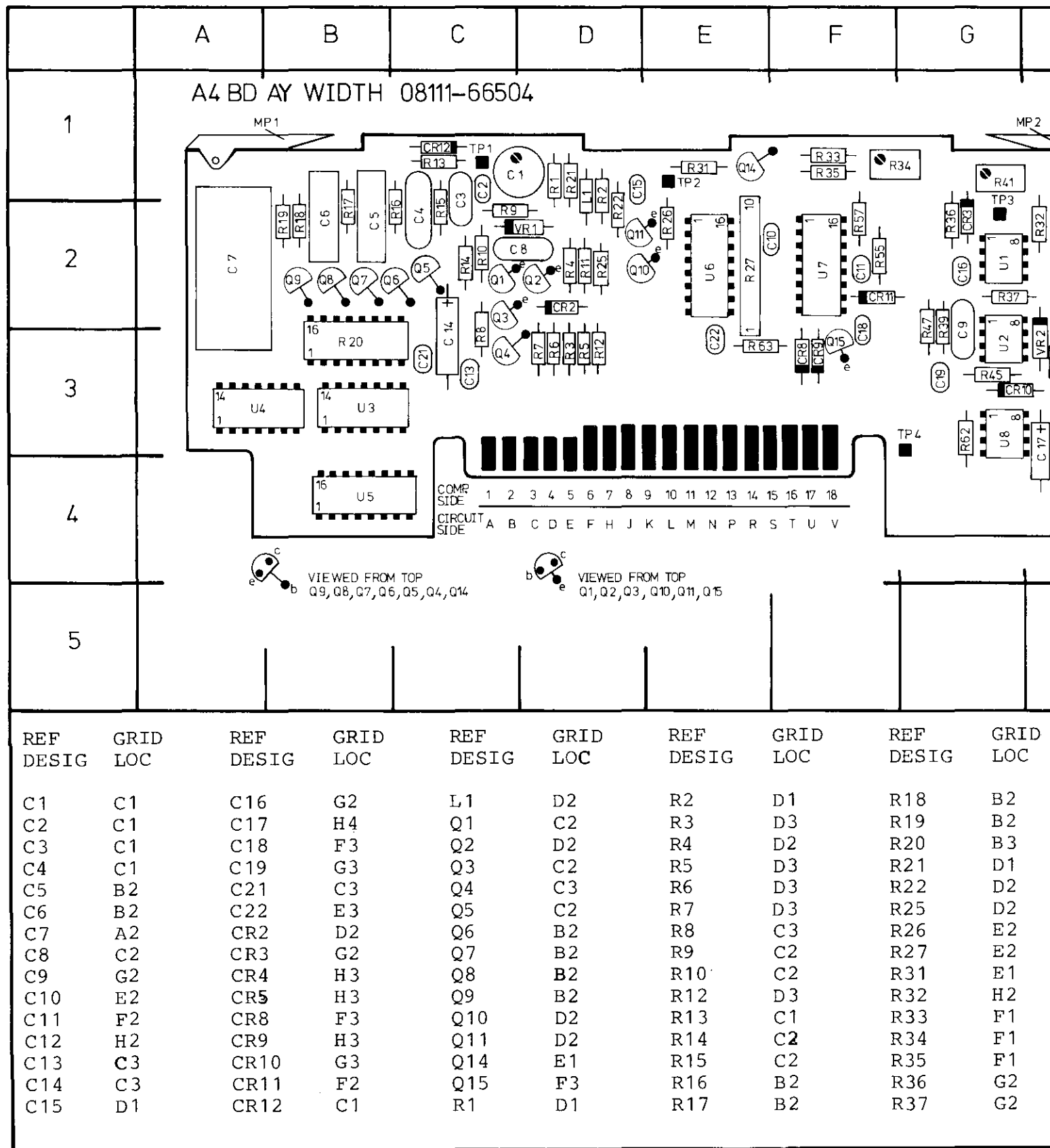
FREQ. ADJ.

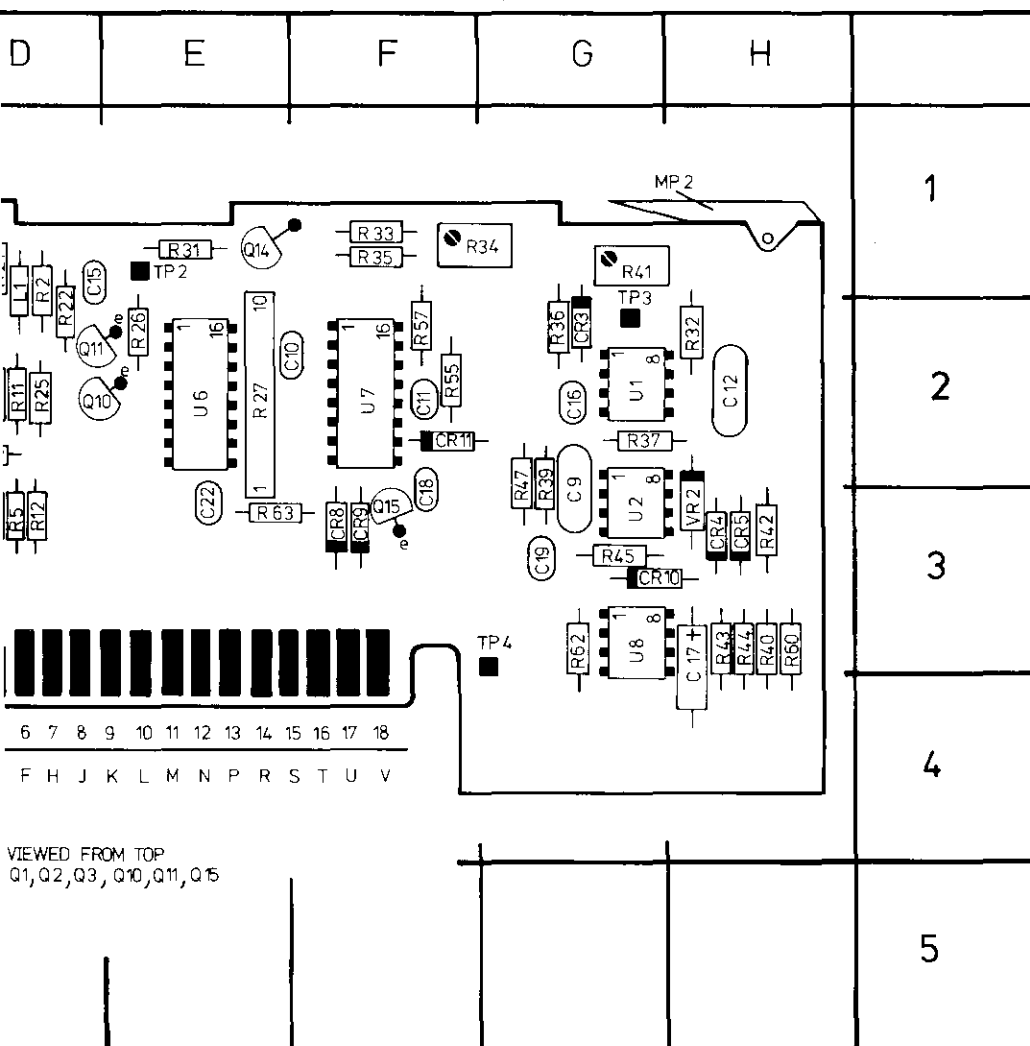
FREQ. ADJ.

FREQ. ADJ.

FREQ. ADJ.







| ID<br>C | REF<br>DESIG | GRID<br>LOC | REF<br>DESIG | GRID<br>LOC | REF<br>DESIG | GRID<br>LOC |
|---------|--------------|-------------|--------------|-------------|--------------|-------------|
|         | R2           | D1          | R18          | B2          | R39          | G3          |
|         | R3           | D3          | R19          | B2          | R40          | H3          |
|         | R4           | D2          | R20          | B3          | R41          | G1          |
|         | R5           | D3          | R21          | D1          | R42          | H3          |
|         | R6           | D3          | R22          | D2          | R43          | H3          |
|         | R7           | D3          | R25          | D2          | R44          | H3          |
|         | R8           | C3          | R26          | E2          | R45          | G3          |
|         | R9           | C2          | R27          | E2          | R47          | G3          |
|         | R10          | C2          | R31          | E1          | R55          | F2          |
|         | R12          | D3          | R32          | H2          | R57          | F2          |
|         | R13          | C1          | R33          | F1          | R60          | H3          |
|         | R14          | C2          | R34          | F1          | R62          | H3          |
|         | R15          | C2          | R35          | F1          | R63          | E3          |
|         | R16          | B2          | R36          | G2          |              |             |
|         | R17          | B2          | R37          | G2          |              |             |

| REF<br>DESIG | GRID<br>LOC |
|--------------|-------------|
| U1           | G2          |
| U2           | G3          |
| U3           | B3          |
| U4           | A3          |
| U5           | B4          |
| U6           | E2          |
| U7           | F2          |
| U8           | G3          |
| VR1          | D2          |
| VR2          | H3          |

## SERVICE BLOCK 8 WIDTH GENERATOR A4 9

### THEORY OF OPERATION

#### General

The function of the width generator (applicable only in pulse mode) is to provide an output pulse of known, predetermined width in accordance with the 8111A front panel settings.

The Width board (A4) includes the circuitry to do this and also a width error detector/display driver.

The width range, as stated in the Specifications Table, is from 25 ns to 100 ms, this is divided into seven ranges the fastest being 25 ns to 100 ns and then reducing in decade steps from 100–1000 ns to the slowest, 10 ms – 100 ms.

A block diagram of the main sections of the board is shown in Figure 8–8–1, these are: a current source and associated control devices, a set of range capacitors, a range data decoder and associated capacitor selection devices, a Schmitt trigger, a trigger signal converter and error detector/display driver.

Reference to schematic 9 should be made when reading the following operational description.

#### OPERATION

The basic operation of the width generator is as follows: A trigger signal (WIDTH TRIGGER) produced either by the VCO or an external source and routed via A6 Shaper, is input to A4.

This sets the Schmitt trigger which then causes the width output signal to go high and enables a constant current to charge up a range capacitor. When the capacitor (or ramp) voltage reaches the Schmitt trigger threshold the width output signal is "reset": – width cycle completed. The capacitor is rapidly discharged and the overall circuit is now ready to receive the next trigger signal from A5.

If, prior to completion of the width cycle the next trigger signal should arrive an error signal will be generated. A more detailed description of the operation of the individual functional "blocks" of the overall circuit will now be given.

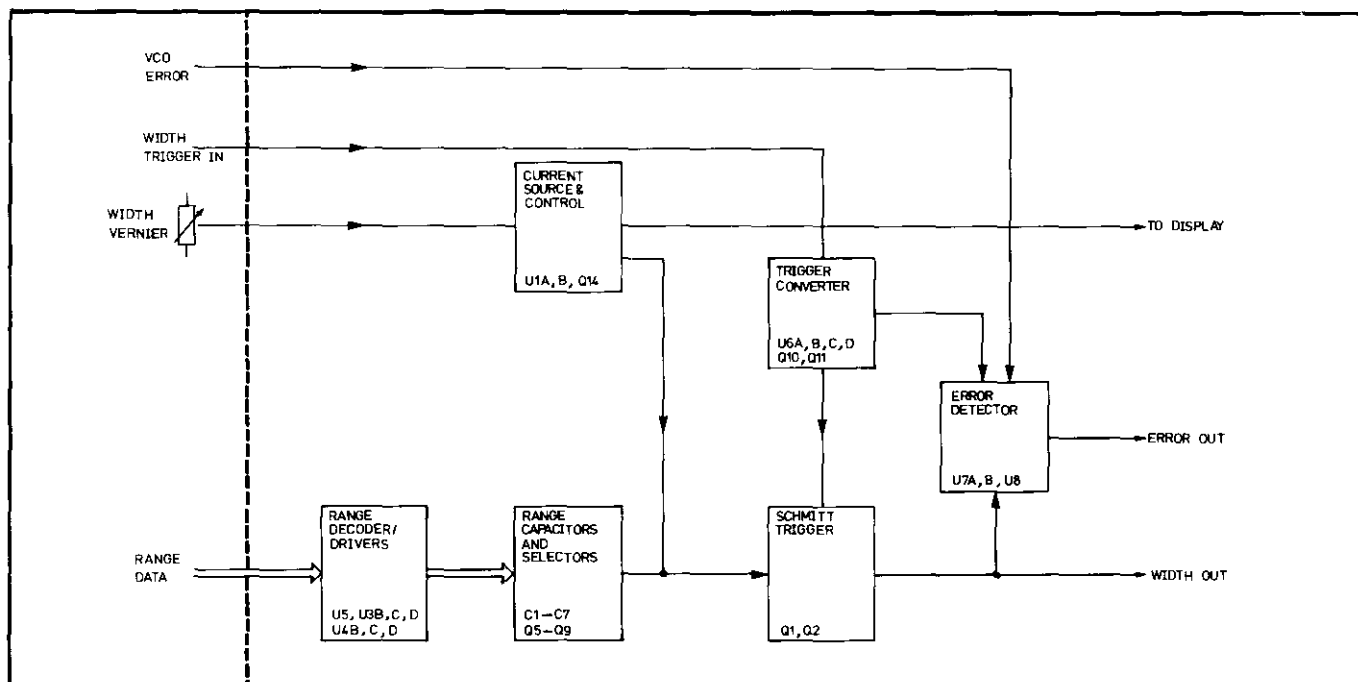


Figure 8–8–1. Simplified Width Board Block Diagram

### Current Source

Figure 8-8-2 shows a simplified diagram of the current source.

The front panel mounted width vernier controls the output voltage of U2A, CCW or zero resistance for highest output voltage/fastest value and vice-versa for CW. The adjustable range of output values is dependent on the two reference voltages  $-5.2\text{ V}$  and  $-4.16\text{ V}$ . In the fastest width range (25 ns – 100 ns), "switch" S2 is open, so the adjustable range is dependent only on the  $-5.2\text{ V}$  reference voltage.

The output voltage of U2A together with R41 + R39 controls the current supplied to the range capacitors except when in the fastest range, here S1 is closed to increase the current by a factor of 10 (compared to that required for the other ranges) and therefore achieving faster ramp times. "Switch" functions S1 and S2 as shown in the figure are provided by U1B and U2B together with associated peripheral components. In all ranges except the fastest S2 is closed and S1 open.

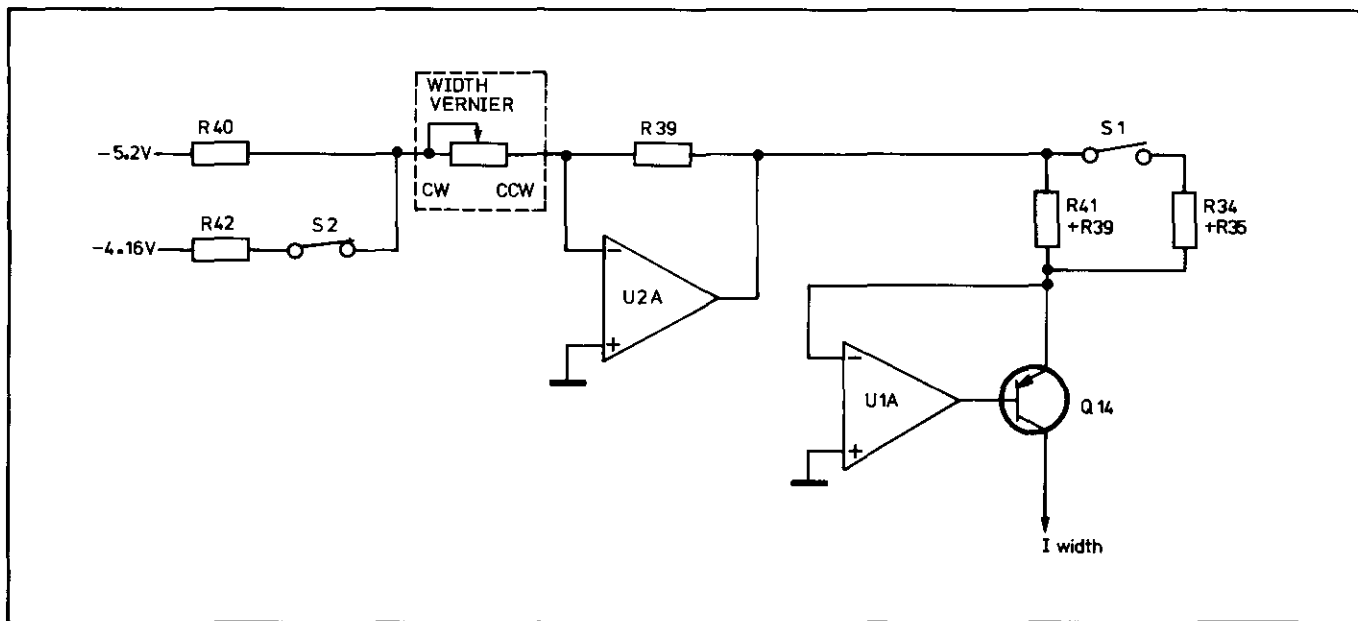


Figure 8-8-2. Simplified Current Source Circuit

### Width Range Decoder and Capacitors

Range data, from the front panel switch via board A7, is decoded by the 3-8 decoder U5 (see Figure 8-8-3) to enable either one of the five capacitors C3-C7 plus C1, C2 or only C1, C2. C1, C2 are in fact permanently switched in and are used either as a stand-alone pair for the two fastest width ranges or combined with any of the other five capacitors for all other ranges. The capacitor select/enable transistors Q5-Q9 are operated in both the forward and reverse modes to enable current to flow to charge and also discharge the capacitors.

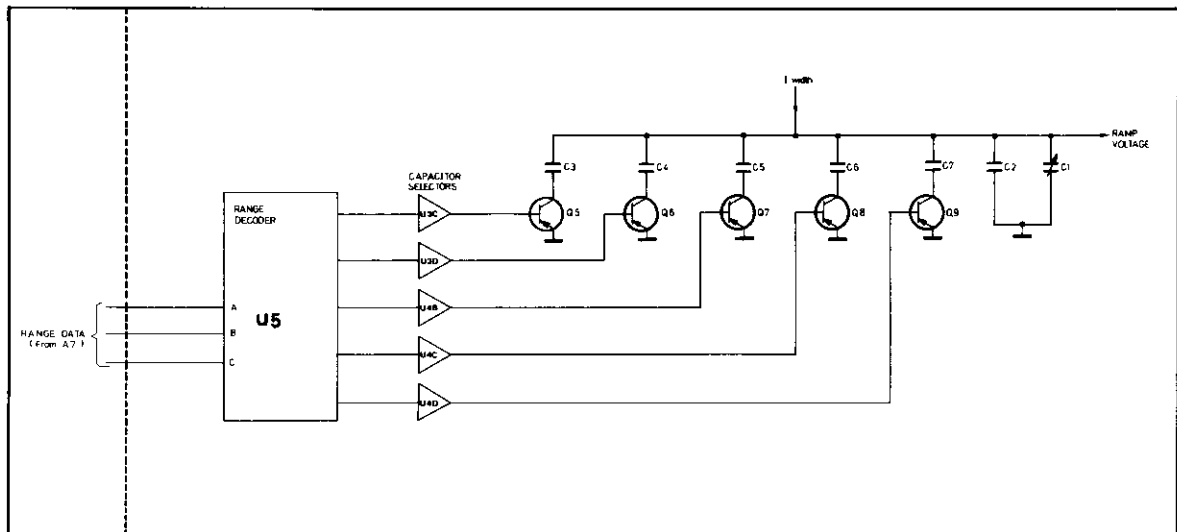


Figure 8-8-3. Simplified Width Range Selector Diagram

### Error Detector Circuit

Reference to schematic 9 shows that the width trigger input signal is connected to the clock input of U7A (D type flip-flop) and the width output signal to the D input. A positive going edge at the clock input will cause the data at the D input to be transferred to the Q output, i.e. if D is still high (width signal not completed) when a trigger signal arrives an error signal is produced. A timing diagram to illustrate the error detection process is shown in Figure 8-8-4.

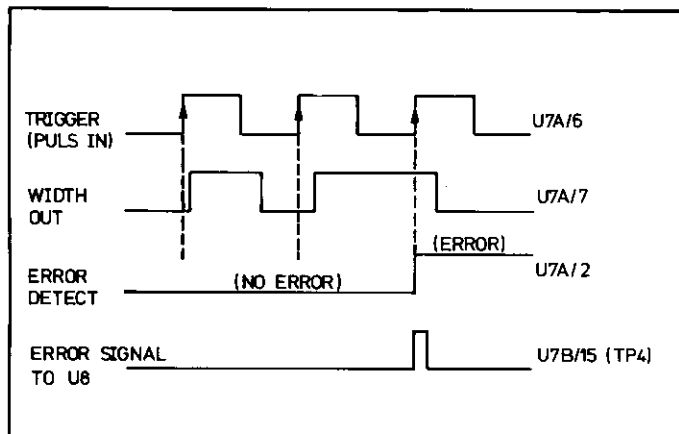


Figure 8-8-4. Error Detection Timing Diagram

Comparator U8 lengthens the output pulse of the monostable U7B and provides a signal suitable for driving the ERROR LED.

### Schmitt Trigger

Reference to schematic 9 shows that the Schmitt trigger circuit comprises a differential amplifier with feedback-Q1, Q2 etc. and an emitter follower Q3, Q4.

In the non-active state Q1 conducts and Q2 is turned off. The output voltage of the range capacitors' common connection is clamped at  $-7.4\text{ V}$  via the emitter follower Q3, Q4. CR2 is biased on and provides base current for Q1 and quiescent current for Q4.

On receipt of a positive trigger pulse, Q2 turns on and switches Q1 off allowing the width output signal to go "high" or active.

The potential at the base of Q4 increases, CR2 is biased off and Q4 is therefore turned off. A charging current is now allowed to flow through the selected range capacitor until the threshold level of the Schmitt trigger is reached. Q1 is then turned on which switches Q2 off and the width output signal goes "low" or off.

The ramp capacitor voltage is discharged to  $-7.4\text{ V}$  via emitter follower Q4.

### Trigger Converter

Refer to schematic 9, the trigger converter generates a 12 ns output pulse (at U6A output) on the positive going edge of the VCO derived input signal. The pulse length is derived from the propagation delay of R27/C10 and the ECL NOR gate U6A. This pulse is then used to set the Schmitt trigger.

Referring to Figure 8-8-5, check the conditions at the following test points, this assists in isolating the fault.

- ★ 1 The voltage at TP3 is used to control the current source. It should vary by turning the width vernier as follows:

|               |                             |
|---------------|-----------------------------|
| CW            | CCW                         |
| from 0.7 V to | 9.8 V                       |
| or 0.7 V to   | 3.9 V in 25 ns-100 ns Range |

- ★ 2 The voltage drop across R31 indicates the current supplied by the current source. Depending on the width vernier position it should vary as follows:

|               |                             |
|---------------|-----------------------------|
| CW            | CCW                         |
| from 50 mV to | 650 mV                      |
| or 0.5 V to   | 2.6 V in 25 ns-100 ns Range |

- ★ 3 ★ 4 ★ 5 and ★ 6 see below :

### TROUBLESHOOTING

When troubleshooting the width board set the 8111A Waveform to Pulse Mode.

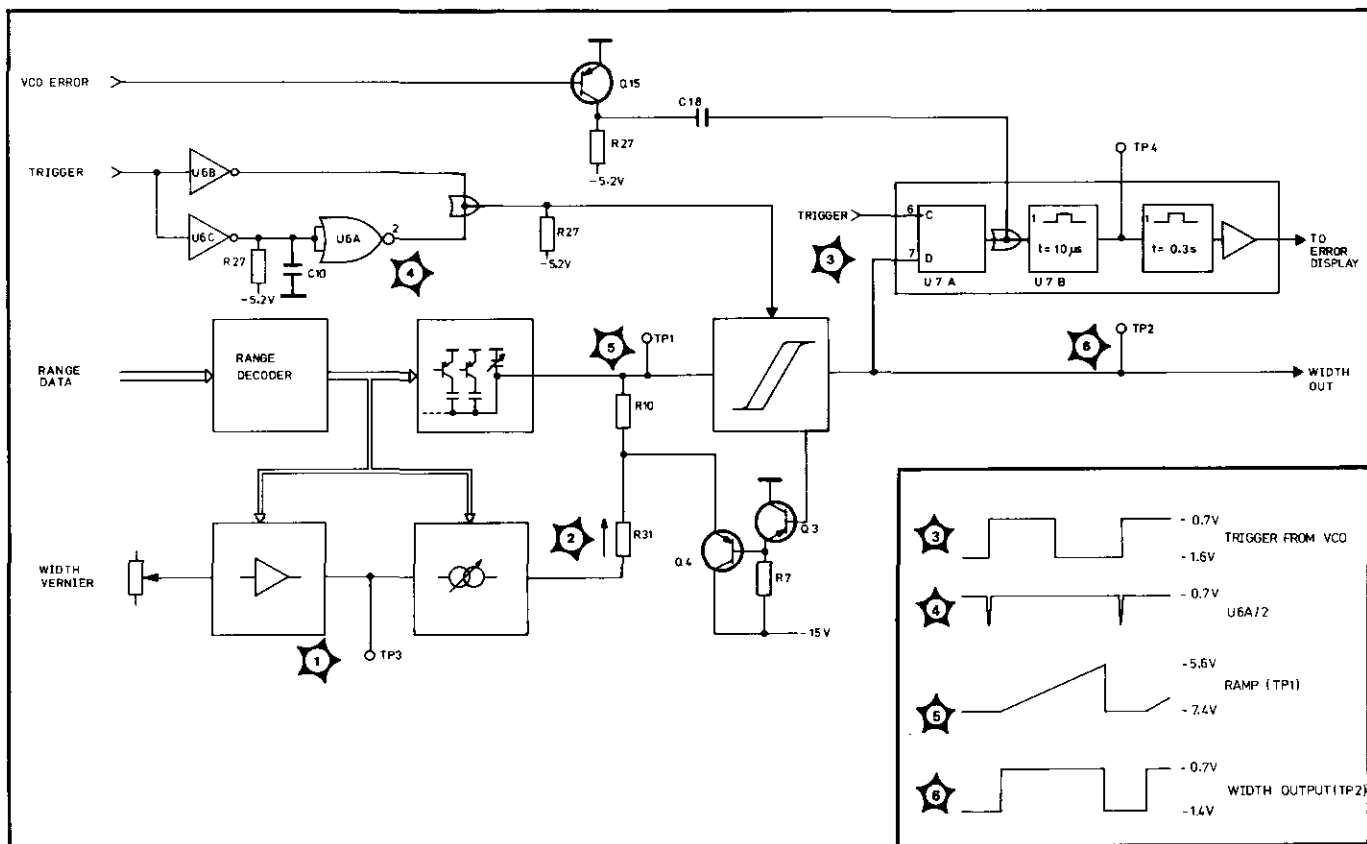


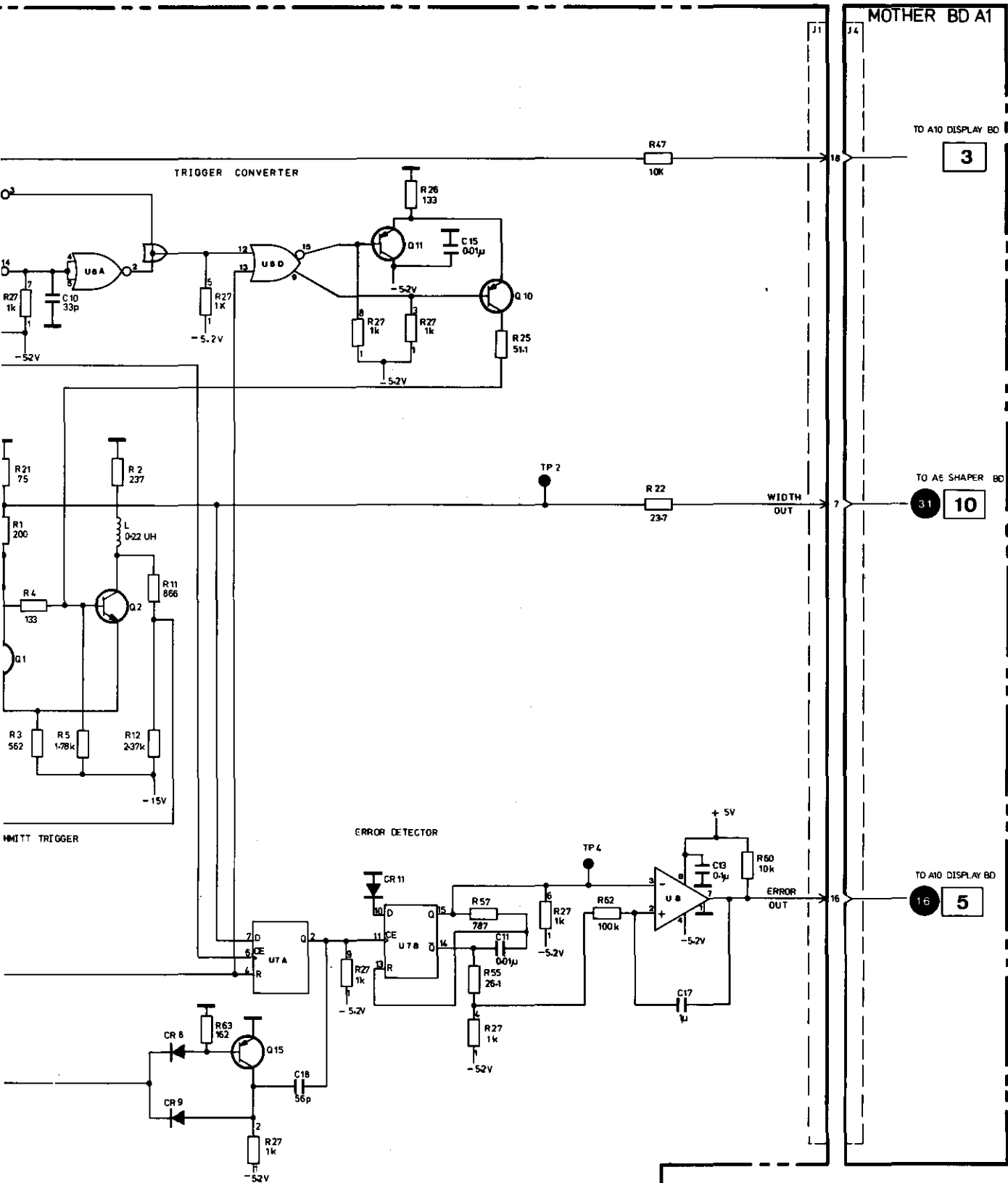
Figure 8-8-5. Width Troubleshooting Diagram

For checking standby conditions of the width board it is recommended that the 8111A be set to a non-pulse waveform. Should the fault appear to be in the WIDTH RANGE SELECTOR section, U5 outputs can be checked against the truth Table 8-8-1.

Table 8-8-1. Range Decoder (U5) Truth Table

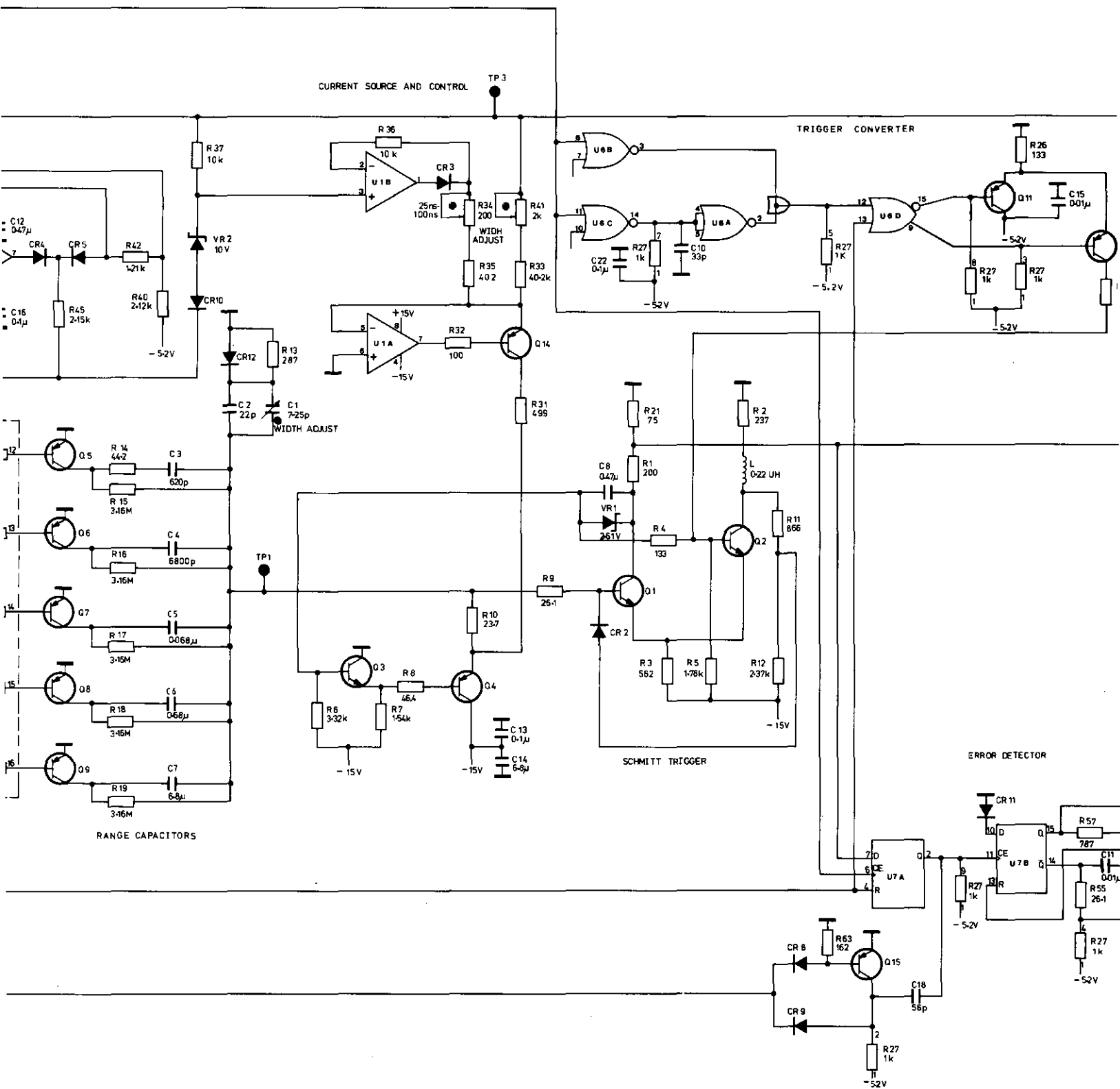
| Width Range              | Range Data (U5 Inputs) |            |            | Range Data (U5 Outputs)  |                          |                          |                          |                          |                         | Selected Capacitor |
|--------------------------|------------------------|------------|------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|-------------------------|--------------------|
|                          | C<br>pin 3             | B<br>pin 2 | A<br>pin 1 | Y <sub>0</sub><br>pin 15 | Y <sub>1</sub><br>pin 14 | Y <sub>2</sub><br>pin 13 | Y <sub>3</sub><br>pin 12 | Y <sub>4</sub><br>pin 11 | Y <sub>6</sub><br>pin 9 |                    |
| 10 ms — 100 ms           | 0                      | 0          | 0          | 0                        | 1                        | 1                        | 1                        | 1                        | 1                       | C7                 |
| 1 ms — 10 ms             | 0                      | 0          | 1          | 1                        | 0                        | 1                        | 1                        | 1                        | 1                       | C6                 |
| 100 $\mu$ s — 1 ms       | 0                      | 1          | 0          | 1                        | 1                        | 0                        | 1                        | 1                        | 1                       | C5                 |
| 10 $\mu$ s — 100 $\mu$ s | 0                      | 1          | 1          | 1                        | 1                        | 1                        | 0                        | 1                        | 1                       | C4                 |
| 1 $\mu$ s — 10 $\mu$ s   | 1                      | 0          | 0          | 1                        | 1                        | 1                        | 1                        | 0                        | 1                       | C3                 |
| 100 ns — 1 $\mu$ s       | 1                      | 0          | 1          | 1                        | 1                        | 1                        | 1                        | 1                        | 1                       | —                  |
| 25 ns — 100 ns           | 1                      | 1          | 0          | 1                        | 1                        | 1                        | 1                        | 1                        | 0                       | —                  |

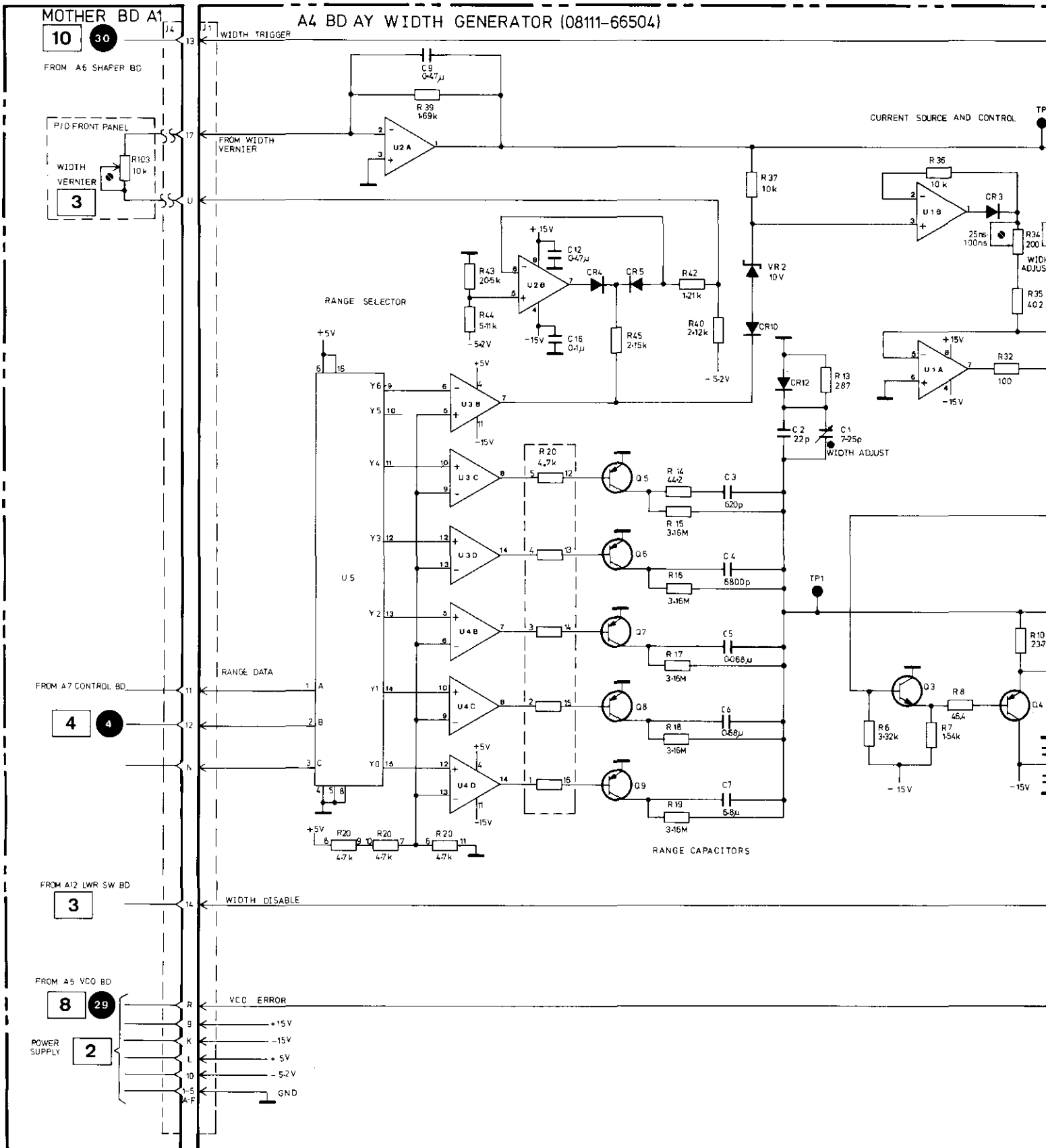


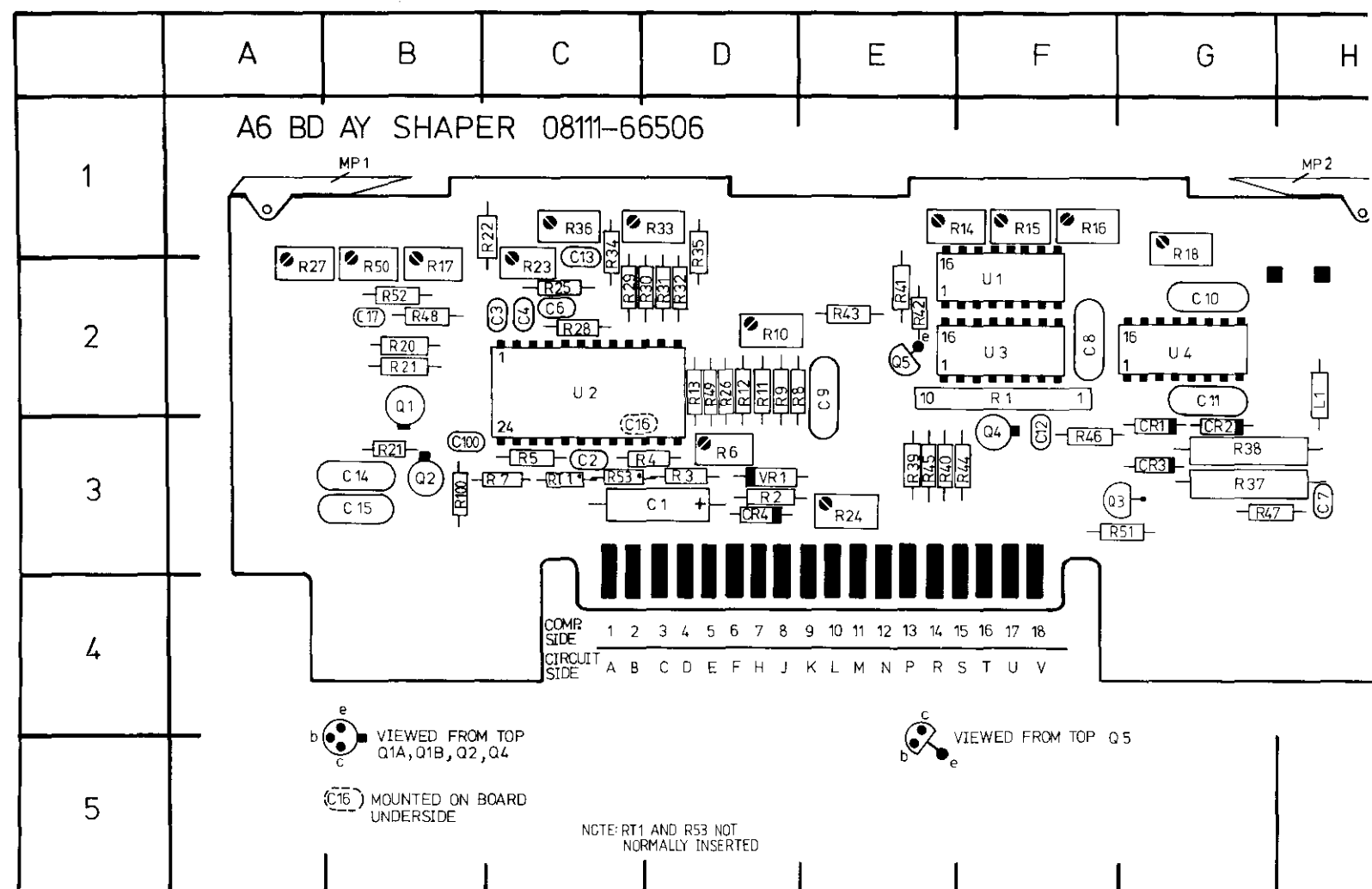


WIDTH GENERATOR A4

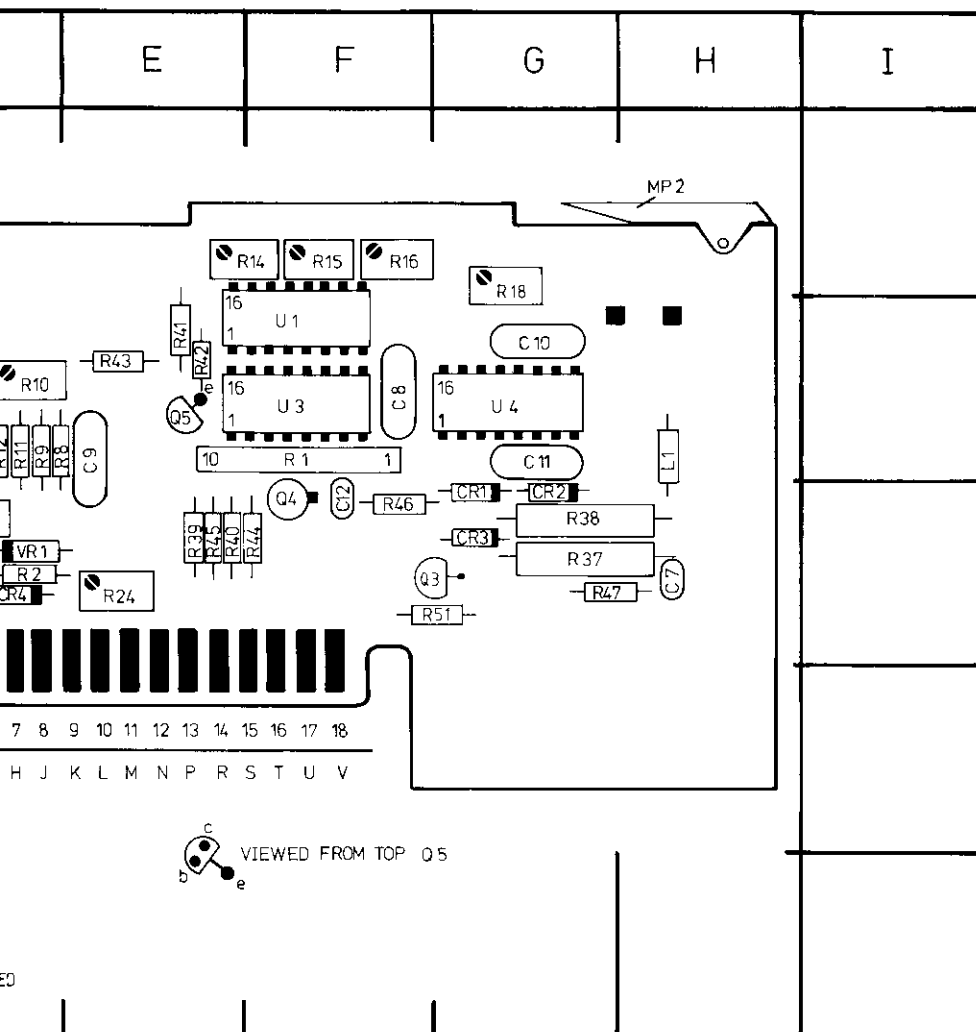
9







| REF<br>DESIG | GRID<br>LOC | REF<br>DESIG | GRID<br>LOC | REF<br>DESIG | GRID<br>LOC | REF<br>DESIG | GRID<br>LOC | REF<br>DESIG | GRID<br>LOC | REF<br>DES |
|--------------|-------------|--------------|-------------|--------------|-------------|--------------|-------------|--------------|-------------|------------|
| C1           | D3          | C16          | C3          | R3           | D3          | R18          | G1/2        | R33          | D1          | R48        |
| C2           | C3          | C17          | B2          | R4           | C3          | R19          | B2          | R34          | C1          | R49        |
| C3           | C2          | CR1          | G3          | R5           | C3          | R20          | B2          | R35          | D1          | R50        |
| C4           | C2          | CR2          | G3          | R6           | D3          | R21          | B2          | R36          | C1          | R51        |
| C5           | B2          | CR3          | G3          | R7           | C3          | R22          | B1          | R37          | G3          | R52        |
| C6           | C2          | CR4          | D3          | R8           | D2          | R23          | C2          | R38          | G3          | R53        |
| C7           | H3          | L1           | H2          | R9           | D2          | R24          | E3          | R39          | E3          | RT1        |
| C8           | F2          | Q1           | B2          | R10          | D2          | R25          | C2          | R40          | E3          | U1         |
| C9           | E2          | Q2           | B3          | R11          | D2          | R26          | D2          | R41          | E2          | U3         |
| C10          | G2          | Q3           | F3          | R12          | D2          | R27          | A2          | R42          | E2          | U4         |
| C11          | G2          | Q4           | F3          | R13          | D2          | R28          | C2          | R43          | E2          | VR1        |
| C12          | F3          | Q5           | E2          | R14          | E1          | R29          | C2          | R44          | F3          |            |
| C13          | C1          | R1           | F3          | R15          | F1          | R30          | C2          | R45          | E3          |            |
| C14          | B3          | R2           | D3          | R16          | F1          | R31          | D2          | R46          | F3          |            |
| C15          | B3          | R3           | D3          | R17          | B2          | R32          | D2          | R47          | G3          |            |



## SERVICE BLOCK 9 SHAPER BOARD A6 10

### THEORY OF OPERATION

#### General

The function of the Shaper board is to process the input signal delivered by either the VCO (A5) if in function mode or Width board (A4) if in pulse mode. Its main operational features include triangle to sinewave conversion and a pulse transition time speed up circuit. This is operative for both pulse and square waveforms.

Additional features of the Shaper are a 1:10 attenuation stage for all output signals controlled by a simple external reference voltage (potentiometer), a level shifter enabling positive and negative offset output signals and a normal/complement switching facility.

The OUTPUT signal from A6 is fed to the Output board (A8) and the TRIGGER OUTPUT goes directly to the front panel connector.

#### OPERATION

The most significant part of the board is the IC-U2 which performs the signal shaping and conversion functions. A simplified diagram of the board is shown in Figure 8-9-1

and this clearly illustrates the significance of U2. The various IC capabilities are enabled by control inputs, these include the two mode select pins which enable either linear preamplifier mode (for triangular waveforms), triangle to sine conversion of fast pulse. This last mode requires the application of an EECL (Emitter Emitter Coupled Logic) level input signal whereas the "triangle and sine" modes require the application of normal and complement triangular waveforms. Additional control inputs enable NORM/COMPLEMENT control (Pin 15) and POS/SYMMETRICAL/NEG (pins 10 and 11) biasing.

Apart from U1 and its input, biasing and adjustment components, the two remaining significant circuit elements comprising the board are the input stage for square or pulse operation — U3, Q4, Q5, etc. — and the output or "current mirror" stage.

#### Square/Pulse Input Stage

Either the TRIGGER IN or the WIDTH IN signal is selected, selection depends on U1B and U3B (WIDTH DISABLE) pin 11 status. Q4 converts the incoming trigger signal to an ECL level and Q5 changes this to the special EECL levels ( $-0.6\text{ V}$  for "low" and  $0\text{ V}$  for "high"). The TRIGGER OUTPUT signal is derived from Q4 emitter, and converted from ECL to TTL by A6 U4.

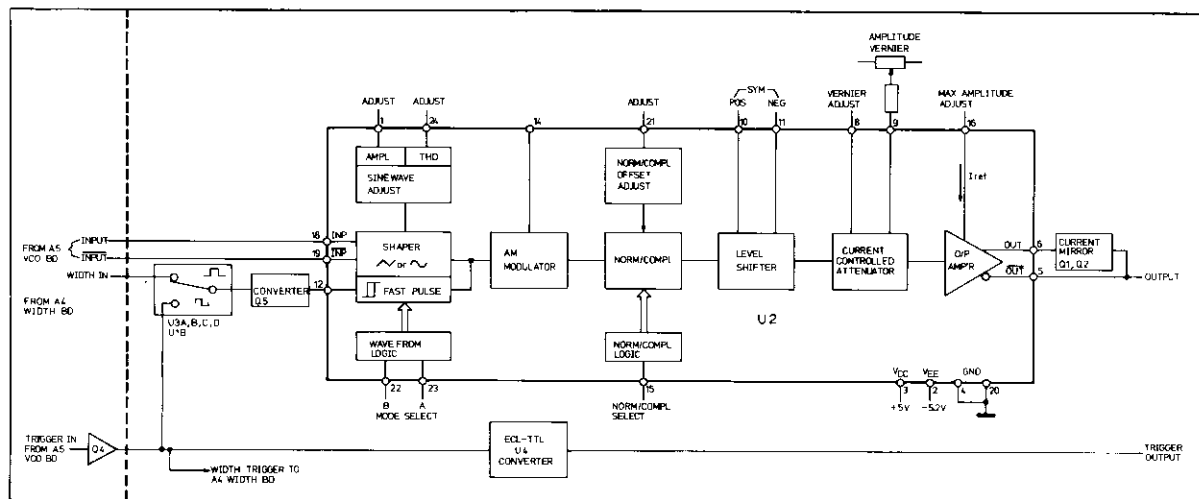


Figure 8-9-1. Simplified Shaper Board Block Diagram

### Output Stage (Current Mirror) or)

The output waveforms from U2 comprise differential current stages, by summing these with a "current mirror", undesirable offset effects are reduced to zero and a doubling of the available output signal amplitude is achieved. The operating principle is shown in Figure 8-9-2, the Current mirror performs a current inversion (without this the summing would result in a zero output) and in effect produces an output current which is a true "reflection" of its input current provided that Q1A and Q1B are a matched pair.

By summing the differential output currents, the quiescent currents  $I_q$  and their effect is eliminated.

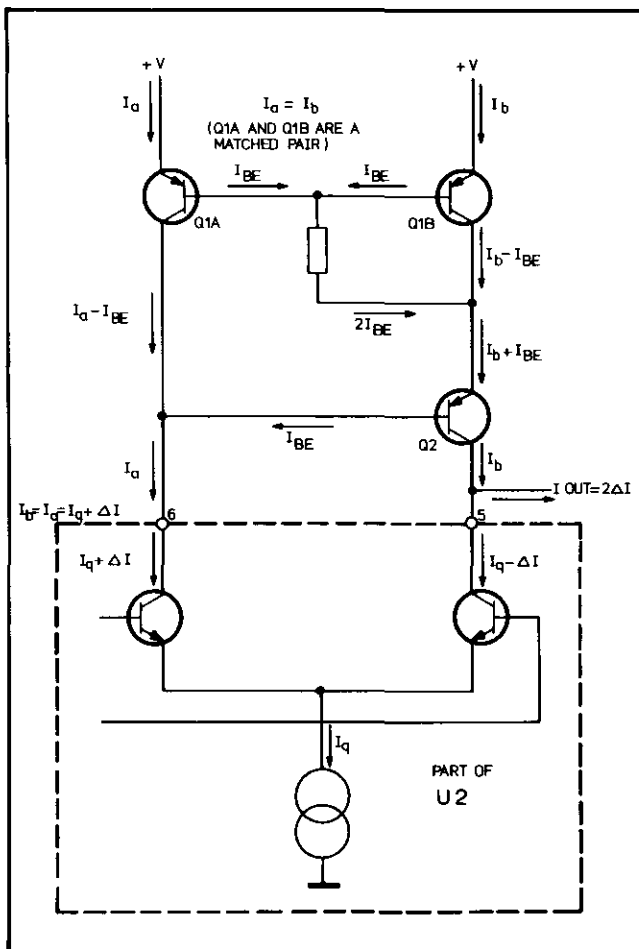


Figure 8-9-2. Current Mirror Operating Principle

## TROUBLESHOOTING

### General

As a first step confirm that the problem is in fact at the Shaper board by ensuring that the required input signals as shown in Figure 8-9-3 are present.

Once these conditions are confirmed check that the appropriate adjustment potentiometer is not open or short circuited since this type of fault can cause a failure condition which appears to come from U2.

If maximum signal amplitude is not obtainable check that the voltage across VR1 is at least +5.12 V. The output amplitude level from A6 for all waveforms should be approximately 500 mV<sub>pp</sub> when the front panel AMPLITUDE vernier is fully CW.

### Current Mirror

To confirm correct operation check that the signal levels at Q1A and A1B emitters are the same (the transistors are a matched pair).

### Signal Output in Pulse or Square Waveform

If a fault is seen only when in pulse or squarewave then check that the logic conditions of gates U3A, B, C and D is in accordance with Table 8-9-1. These levels are ECL and can be checked with an ECL probe.

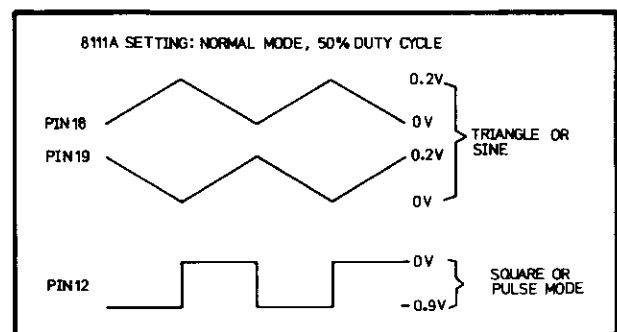


Figure 8-9-3. Input Signals

Waveform and Output Mode Selection

The various control signal logic levels input to IC U2 can be checked against Tables 8-9-2 and 8-9-3. The logic levels in the tables are all TTL.

Table 8-9-1. Waveform and Output Mode Selection

| 8111A Setting                                                                     | U3/5 R11 | U3/14 | U3/6 | U1B/4 → 3      |
|-----------------------------------------------------------------------------------|----------|-------|------|----------------|
|  | H        | L     | H    | non conducting |
|  | H        | L     | L    | conducting     |
|  | L        | H     | H    | conducting     |

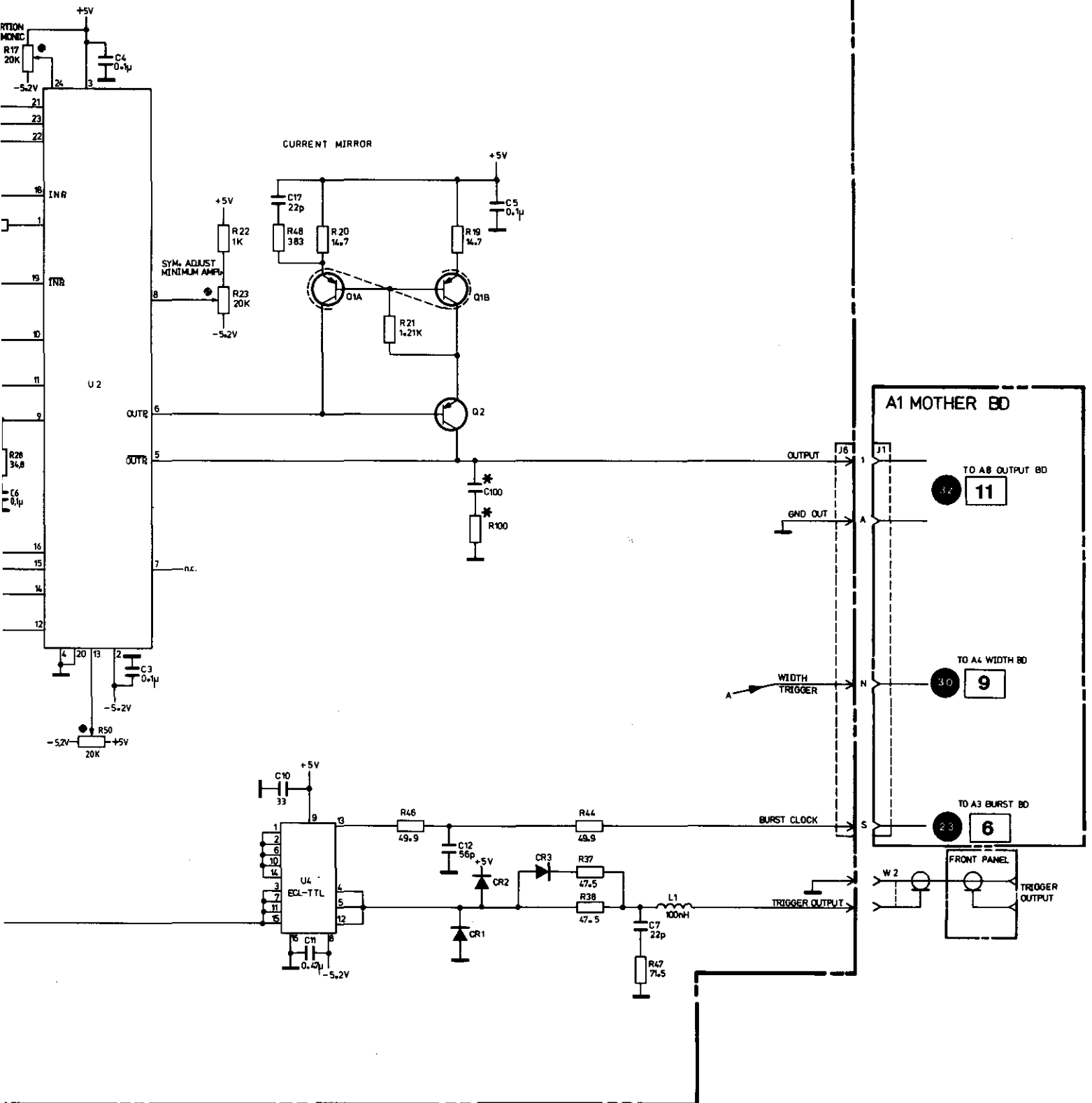
Table 8-9-2.

| 8111A                                                                               | U2/23 | U2/22 |
|-------------------------------------------------------------------------------------|-------|-------|
|  | L     | L     |
|  | L     | H     |
|  | H     | H     |

Table 8-9-3.

| 8111A Setting      | U2/15 |
|--------------------|-------|
| NORMAL, POS or SYM | L     |
| NORMAL, NEG        | H     |
| COMPL, NEG         | L     |
| COMPL, POS or SYM  | H     |



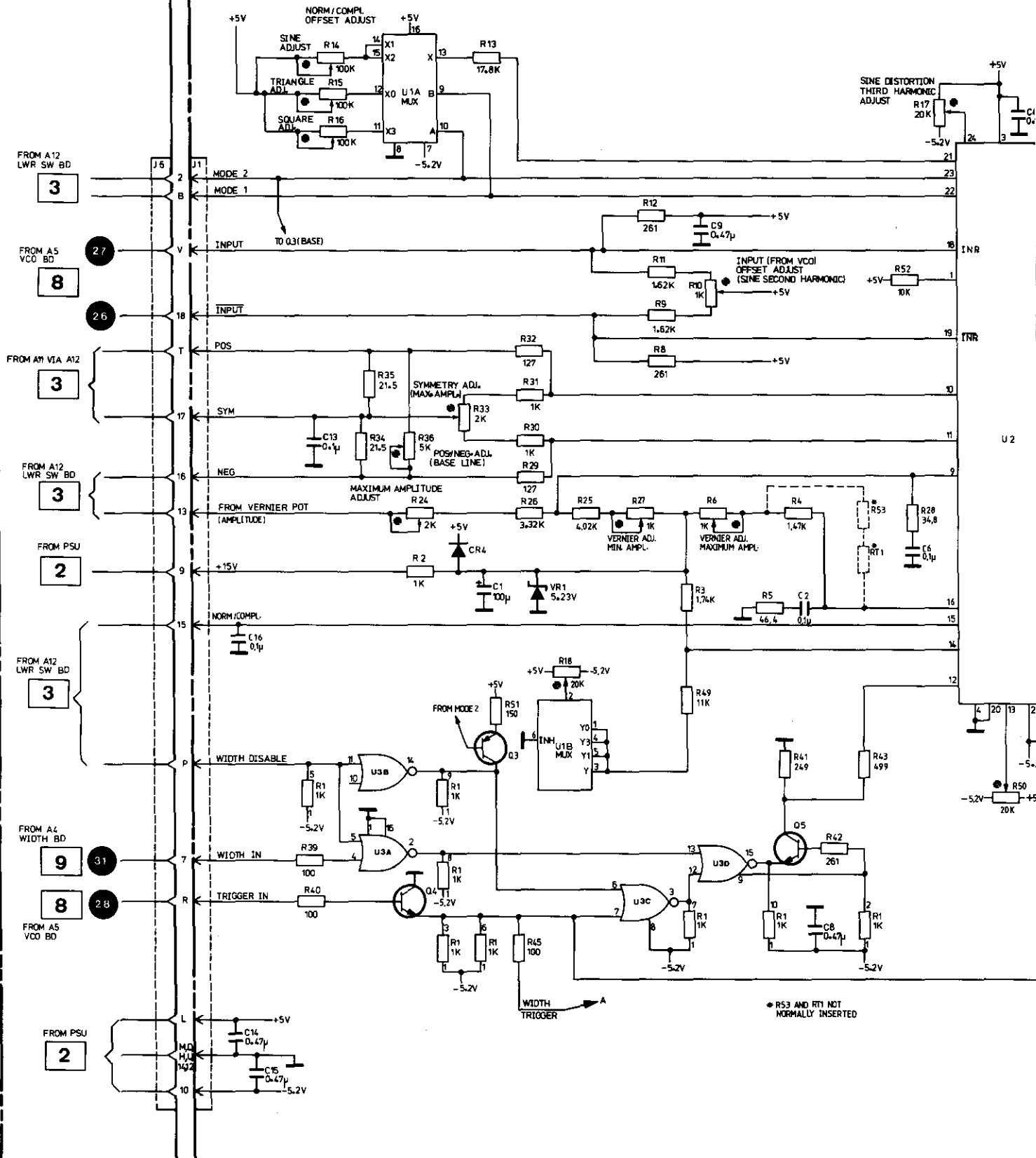


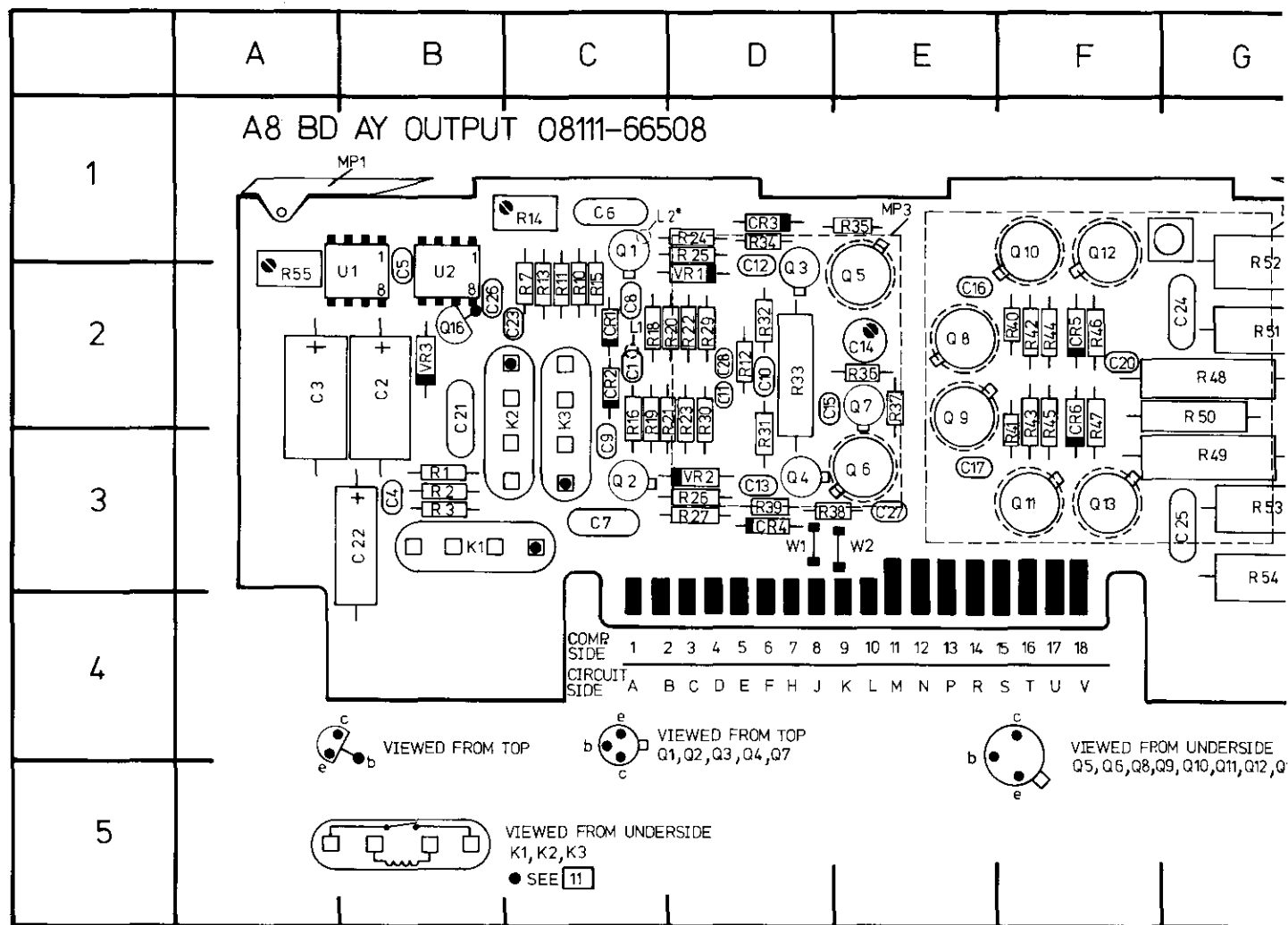
SHAPER BOARD A6

10

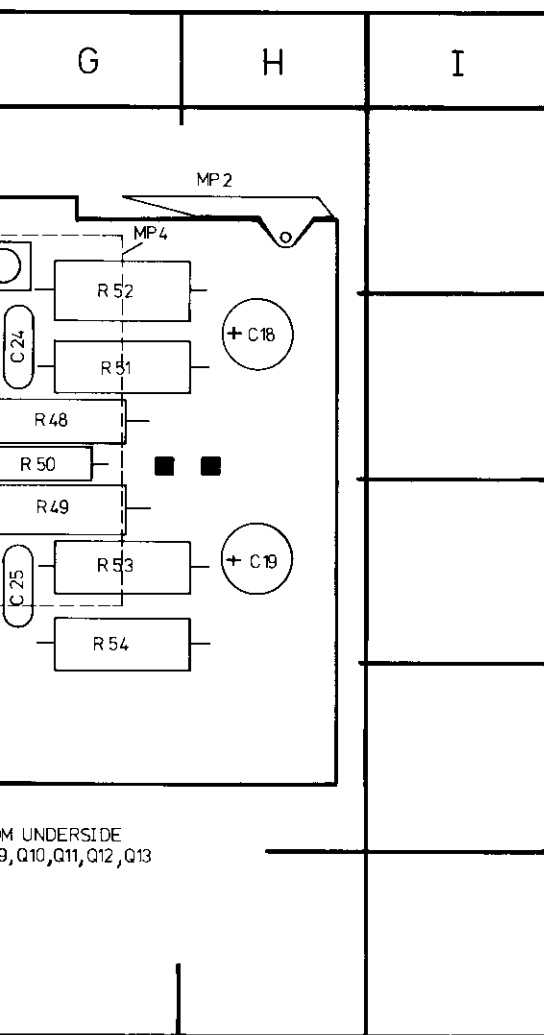
## A1 MOTHER BD

## A6 BD AY SHAPER 08111-66506





| REF<br>DESIG | GRID<br>LOC | REF<br>DESIG | GRID<br>LOC | REF<br>DESIG | GRID<br>LOC | REF<br>DESIG | GRID<br>LOC | REF<br>DESIG |
|--------------|-------------|--------------|-------------|--------------|-------------|--------------|-------------|--------------|
| C1           | C2          | C16          | E2          | CR3          | D1          | Q8           | E2          | R14          |
| C2           | B2          | C17          | E3          | CR4          | D3          | Q9           | E2          | R15          |
| C3           | A2          | C18          | H2          | CR5          | F2          | Q10          | F1          | R16          |
| C4           | B3          | C19          | H3          | CR6          | F2          | Q11          | F3          | R18          |
| C5           | B2          | C20          | F2          | K1           | B3          | Q12          | F1          | R19          |
| C6           | C1          | C21          | B2          | K2           | B2          | Q13          | F3          | R20          |
| C7           | C3          | C22          | B3          | K3           | C2          | Q16          | B2          | R21          |
| C8           | C2          | C23          | C2          | L1           | C2          | R1           | B3          | R22          |
| C9           | C3          | C24          | G2          | Q1           | C1          | R2           | B3          | R23          |
| C10          | D2          | C25          | G3          | Q2           | C3          | R3           | B3          | R24          |
| C11          | D2          | C26          | B2          | Q3           | D2          | R7           | C2          | R25          |
| C12          | D1          | C27          | E3          | Q4           | D4          | R10          | C2          | R26          |
| C13          | D3          | C28          | D2          | Q5           | E2          | R11          | C2          | R27          |
| C14          | E2          | CR1          | C2          | Q6           | E3          | R12          | D2          | R29          |
| C15          | D2          | CR2          | C2          | Q7           | E2          | R13          | C2          | R30          |



| REF<br>DESIG | GRID<br>LOC | REF<br>DESIG | GRID<br>LOC |
|--------------|-------------|--------------|-------------|
| R14          | C1          | R31          | D3          |
| R15          | C2          | R32          | D2          |
| R16          | C2          | R33          | D2          |
| R18          | C2          | R34          | D1          |
| R19          | C2          | R35          | E1          |
| R20          | C2          | R36          | E2          |
| R21          | C2          | R37          | E3          |
| R22          | D2          | R38          | D3          |
| R23          | D2          | R39          | D3          |
| R24          | D1          | R40          | F2          |
| R25          | D1          | R41          | F3          |
| R26          | D3          | R42          | F2          |
| R27          | D3          | R43          | F2          |
| R29          | D2          | R44          | F2          |
| R30          | D2          | R45          | F2          |

| REF<br>DESIG | GRID<br>LOC |
|--------------|-------------|
| R46          | F2          |
| R47          | F2          |
| R48          | G2          |
| R49          | G3          |
| R50          | G2          |
| R51          | G2          |
| R52          | G2          |
| R53          | G3          |
| R54          | G4          |
| R55          | A2          |
| U1           | B2          |
| U2           | B2          |
| VR1          | D2          |
| VR2          | D3          |
| VR3          | B2          |
| W1           | D3          |
| W2           | E3          |

## SERVICE BLOCK 10 OUTPUT BOARD A8 11

### THEORY OF OPERATION

#### General

The main functions of the Output board are to amplify the signal derived from the Shaper (A6) and add (or subtract) the required offset voltage as set by the front panel vernier. In addition, 20 dB of attenuation can be applied to the signal (if -20 dB pushbutton pressed) by a passive attenuator. The output signal from A8 is fed to the Upper Switch board (A11) where it is either further attenuated (40 dB) or output directly to the front panel socket.

The main feature of board A8 is the actual output amplifier, this is in principle an inverting operational amplifier and is shown in simplified form in Figure 8-10-1. The voltage gain, as can be seen in the figure, is determined by  $R_{in}$  and  $R_{fb}$ ,  $A_v = R_{fb}/R_{in}$ . The main amplifier (or HF AMP) has offset voltages and currents which have to be compensated for. This is achieved by U1 and U2. U1 compares the voltage at the inverting input of HF AMP with ground and maintains it at zero difference by supplying a current through  $R_c$  and therefore ensuring a "virtual ground". U2 detects any undesired offset voltage at HF AMP output via the feedback network  $R_{inXV}/R_{fbXV}$  and compensates it via the non-inverting input.

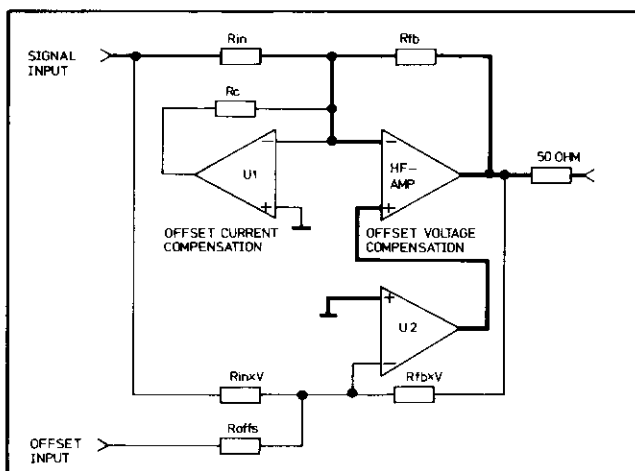


Figure 8-10-1. Simplified Output Amplifier

The offset Input (derived via the offset vernier and fixed 20 dB attenuator as required) is added to the HF AMP output via  $R_{offs}$  and U2 etc.

As can be seen from Figure 8-10-2, the HF Amplifier can be considered as three stages — Input, Voltage Gain and Output. The operation of these will now be described:

#### Input Stage

The input signal (I/P-) is amplified by Q1, Q2 (common base amplifiers), CR1 and CR2 provide the required bias voltages. The offset signal (I/P+) is applied between CR1 and CR2, which ensures a constant reference point. The output signals, produced across  $R_{24}$ ,  $R_{27}$ , are applied to the bases of Q3 and Q4.

#### Voltage Gain Stage

Transistors Q3, Q4 (operating as emitter follower) drive Q5 and Q6 respectively to provide the actual voltage amplification.

#### Output Stage

The emitter followers Q10, Q12 and Q11, Q13 decouple the low output impedance of  $R_{out}$  from the voltage gain stage.

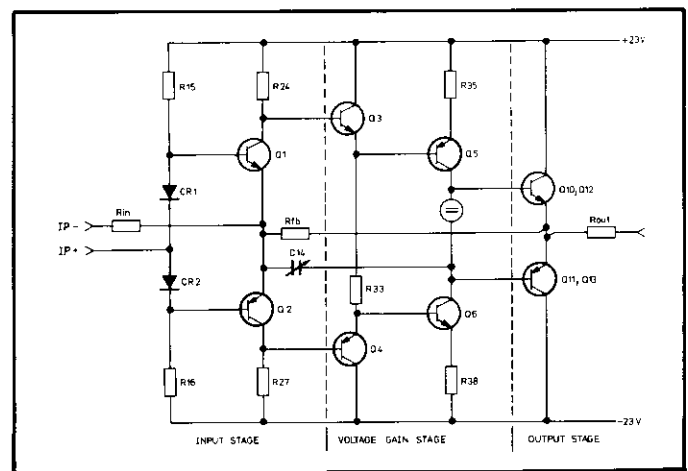


Figure 8-10-2. HF Amplifier Simplified Diagram

## TROUBLESHOOTING

### CAUTION

Do not operate without heat sinks on board A8. If replacement of one of the transistors Q5—Q13 is necessary, first remove all heat sink securing screws, then plate or bracket and finally, if necessary, the transistor adaptors. Do not attempt to remove a complete heat-sink assembly i.e. plate and transistor adaptors together since damage to transistors will be likely.

The troubleshooting information is given in two sections, first for the HF AMP and then the Offset Control.

### HF Amplifier

The following hints will help to isolate a fault in the 8111A output amplifier.

The voltages, shown on Service sheet 11 in blue, should be measured by a DVM with the low terminal connected to ground.

The following test conditions are required:

- A6 Shaper board disconnected from connector
- 20 dB AMPL-ATTENUATOR pushbutton pressed
- Offset Vernier set to 0 V

If the voltage between CR1 and CR2 (★ 2) is fully negative (approx.  $-15\text{ V}$ ) check Q2, Q4 and Q6. If it is fully positive (approx.  $+15\text{ V}$ ) check Q1, Q3 and Q5. If Q10/Q11 or Q12/Q13 fail (emitter/collector short circuit) the 8111A regulated power supply rails will switch off. If it is necessary to replace any of the output stage transistors Q8—Q13, check that CR5 and CR6 are not defective.

### Distorted Leading and Trailing Edges

If the output from A8 in pulse or square wave has distorted leading or trailing edges, and the input signal from A6 is undistorted, then make the following test:

Set the 8111A to high output amplitude (16 V, Symmetrical)

If the leading edge is distorted, check Q3 and Q5.

If the trailing edge is distorted, check Q4 and Q6.

### Offset Control

The offset of the 8111A output signal depends on the current through R7.

- ★ 1 The offset control voltage at the offset input of A8 varies: from  $-0.9\text{ V}$  for  $+8\text{ V}$  offset at the 8111A output to  $+0.9\text{ V}$  for  $-8\text{ V}$  offset at the 8111A output.

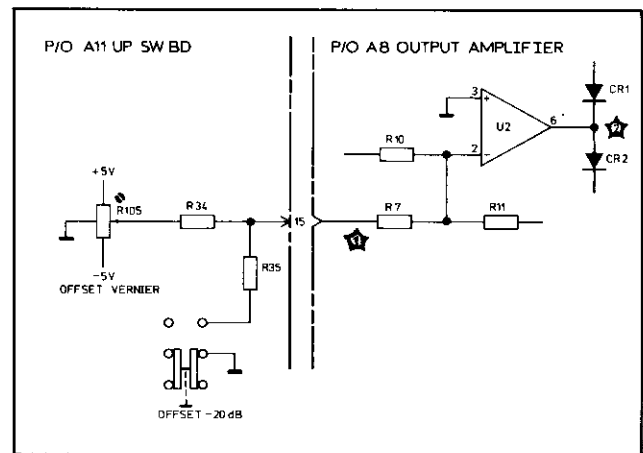
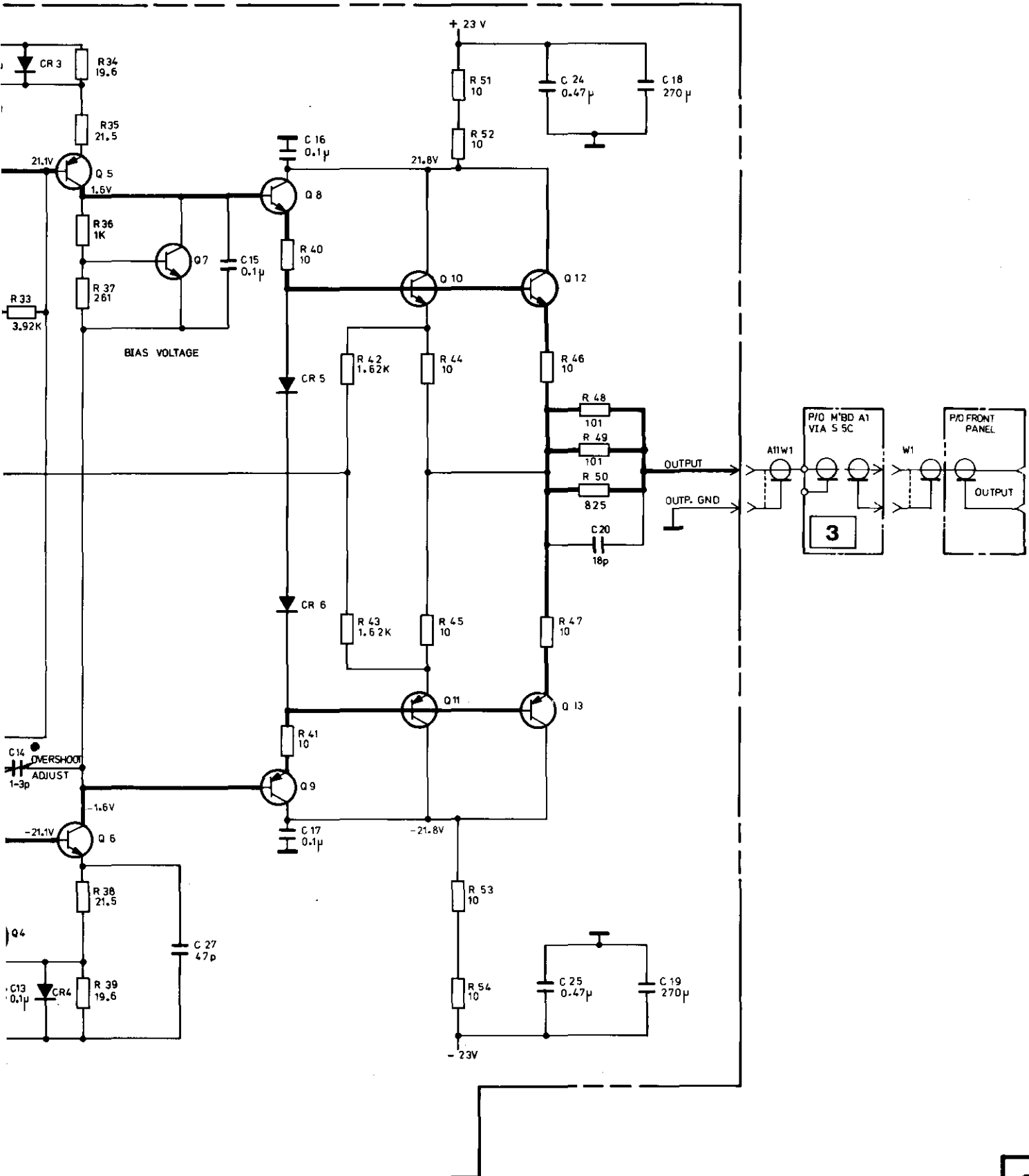


Figure 8-10-4 Offset Control.

Figure 8-10-3. Offset Control

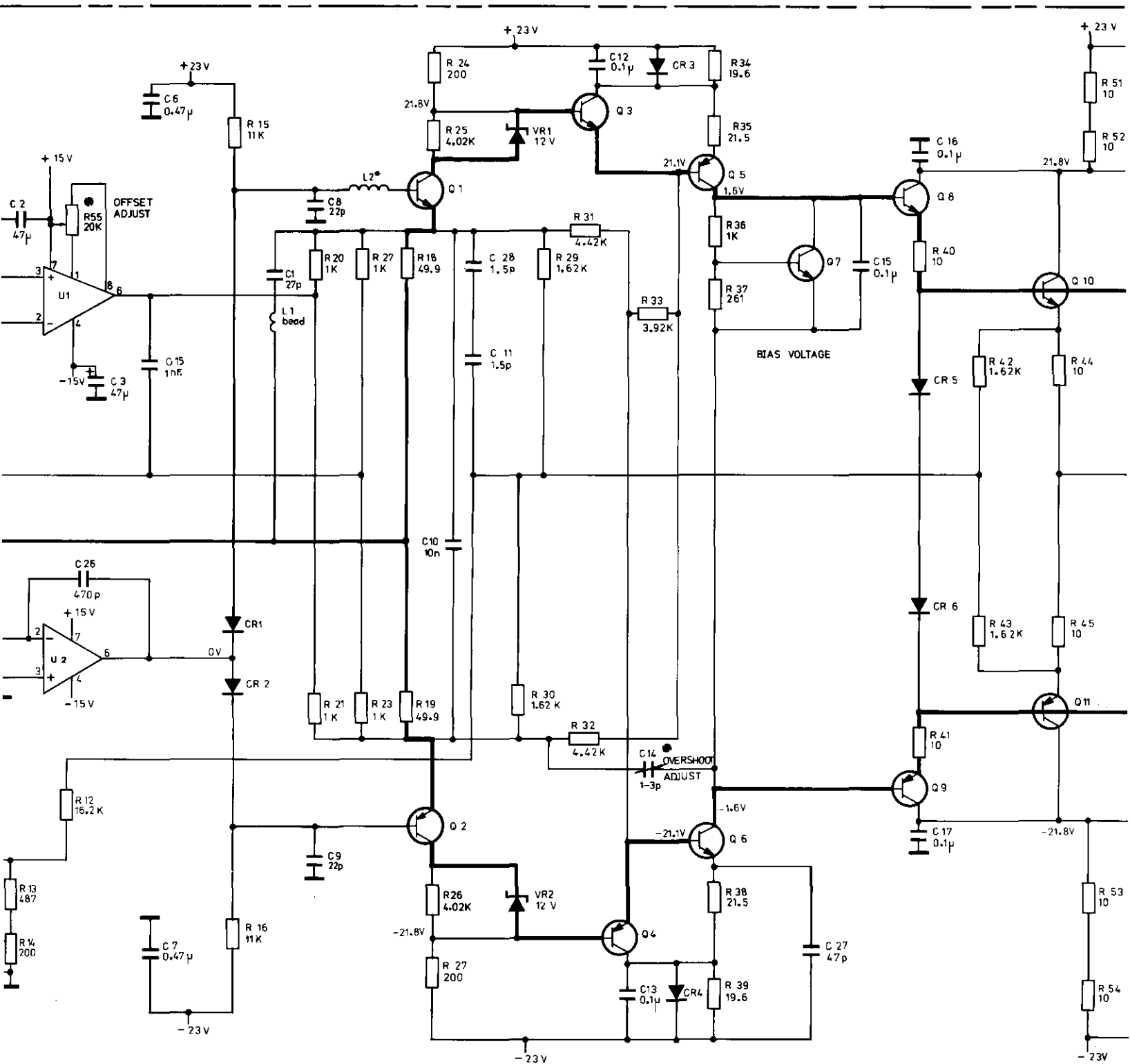
- ★ 2 Due to high internal gain of the HF-AMP, the voltage at its non-inverting input varies by only approximately 4 mV about 0 V over the whole offset range. If the voltage is at either the maximum positive or negative rail value ( $\pm 15\text{ V}$ ) then, either U2 or the HF amplifier is defective.

An offset error or failure can also be caused by a fault at U1.



OUTPUT BOARD A8

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# P/O MOTHERBOARD A1

## A8 BD AY OUTPUT (08111- 66508

