Programmable synthesizer / function generator 0.1 mHz – 2 MHz

PM 5191

9445 051 91001

Operating manual
Gebrauchsanleitung
Notice d'emploi

9499 450 08401
87 08 15

PHILIPS

Please note

In correspondence concerning this instrument, please quote the type number and serial number as given on the type plate.

Bitte beachten

Bei Schriftwechsel über dieses Gerät wird gebeten, die Typennummer und die Gerätenummer anzugeben. Diese befinden sich auf dem Typenschild an der Rückseite des Gerätes.

Noter s. v. p.

Dans votre correspondance et dans vos réclamations se rapportant à cet appareil, veuillez toujours indiquer le numéro de type et le numéro de série qui sont marqués sur la plaquette de caractéristiques.

Important

As the instrument is an electrical apparatus, it may be operated only by trained personnel. Maintenance and repairs may also be carried out only by qualified personnel.

Wichtig

Da das Gerät ein elektrisches Betriebsmittel ist, darf die Bedienung nur durch eingewiesenes Personal erfolgen. Wartung und Reparatur dürfen nur von geschultem, fach- und sachkundigem Personal durchgeführt werden.

Important

Comme l'instrument est un équipement électrique, le service doit être assuré par du personnel qualifié. De même, l'entretien et les réparations sont à confier aux personnes suffisamment qualifiées.

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1. GENERAL

1.1. INTRODUCTION

PM 5191 is a cost-effective multifunctional combination of programmable frequency synthesizer and function generator. The microprocessor control enables simple and rapid operation. The actual set up of the generator is automatically stored in a non volatile register, after power off and on again these parameters can then be used for a new instrument setting.

PM 5191 frequency range covers 10 decades, from 0,1 mHz to 2 MHz. And to make working with this high precision instrument as simple as possible 5 different wave forms are directly selectable. That includes stadard functions like sine, square wave, sawtooth and ramps.

High precision and stability are essential factors in this instrument. With a crystal oscillator that serves as a reference standard for all generated frequencies, a high standard of accuracy is achieved. Together with outstanding long-term stability, ensuring that today's signals can always be reproduced precisely.

Frequency resolution is 8 digits, so that full advantage can be taken of the instruments high precision, for example in the identification and measurement of phenomena occuring at precisely defined frequencies.

Full IEEE/IEC bus compatibility adds an important extra dimension to PM 5191 versatility. All functions are remotely selectable, and all settings and status data can be transmitted to a remote controller and recalled whenever required.

Completing its impressive specification, PM 5191 combines powerful user features with operation that could not be simpler. The front panel is divided into clear, separate keypad areas, and two LED displays show together wirh the key LEDs frequency, output level, status and the modulation function.

In addition to this manual please find attached an operating/programming card for short-form operating instruction of the instrument.

For adequate customer support and in order to facilitate the service, a test program is built in. Service is done on component level, so no complete module must be exchanged.

1.2. CHARACTERISTICS

1.2.1. Safety Characteristics

This apparatus has been designed and tested in accordance with safety class I requirements of IEC-Publication 348, Safety Requirements for Electronic Measuring Apparatus, and has been supplied in a safe condition. This manual contains some information and warnings which must be followed by the user to ensure safe operation and to retain the apparatus in a safe condition.

1.2.2. Performance Characteristics, Specifications

Properties expressed in numerical values with stated tolerance are guaranteed by the manufacturer. Specified non-tolerance values indicate those that could be nominally expected from the mean of a range of identical instruments.
These specifications are valid after a warming-up time of 30 minutes (reference temperature 23° C) and for a termination of the signal output with 50 Ohm.
If not stated otherwise, relative tolerances relate to the set value.

1.2.3. Frequency

frequency range	0.1 mHz – 2 MHz	depending on function and wave form
setting range		
– sine wave	0.1 mHz – 2.147 MHz	
– square wave	0.1 mHz – 2.147 MHz	
– triangular wave	0.1 mHz – 200 kHz	
– pos. sawtooth	0.1 mHz – 20 kHz	
– neg. sawtooth	0.1 mHz – 20 kHz	
setting		numerical keys decimal point key dimension key Hz/kHz step function
measuring unit	Hz, kHz	selectable with key Hz/kHz. When controlling via IEC/IEEE bus frequency values can only be entered in Hz.
indication	8-digits	7-segment LED-display; decimal point free selectable
max. resolution	0.1 mHz	
setting error	$\pm 1 \times 10^{-6}$	
temperature coefficient	$<$ 0.2 ppm/K	
long term drift	$<$ 0.3 ppm within 7 hours	
aging	$<$ 1 ppm/year	
phase noise	$<$ – 80 dBc/Hz	1 kHz from carrier
phase jitter rms	$<$ 3 mrad	
signal-noise ratio (SNR)	$\geqslant$ 55 dBc	for a 30 kHz band centred on the carrier excluding ± 1 Hz about the carrier.

1.2.4. Signal Output — BNC-connector OUTPUT at the front plate

impedance	50 Ω	
wave forms	sine wave square wave triangular wave pos. sawtooth neg. sawtooth	indication with LEDs in the keys
amplitude setting		numerical keys, decimal point key, step function
indication	max. 2 1/2-digits	7-segment display
measuring unit	V	amplitude pp or rms, dc-voltage
	dBm	ac-level, indication of the measuring unit with LEDs in the keys

1.2.4.1. Sine Wave

frequency range		0.1 mHz – 2.147 MHz	
voltage pp			
setting range		0 – 30 V	
– subranges	I:	3.1 – 30 V	resolution 0.1 V
	II:	0.31 – 3.00 V	resolution 0.01 V
	III:	0 – 0.300 V	resolution 0.001 V

error limits of the output voltage pp with 50 Ω termination
(nominal value = 1/2 open circuit voltage)

subranges of open circuit voltage	FREQUENCY RANGES			
	0.1 mHz – 1 Hz	1 Hz – 200 kHz	200 kHz – 1 MHz	> 1 MHz
I 3.1 – 30 V	± 2.5 %	± 2 % (± 0.1 dB)	± 2.5 % (± 0.15 dB)	± 4.5 % (± 0.3 dB)
II 0.31 – 3.00 V	± 3 %	± 2.5 % (± 0.1 dB)	± 3 % (± 0.15 dB)	± 5 % (± 0.3 dB)
III 0 – 0.300 V	± 3.5 %	± 3 % ± 0.3 mV (± 0.15 dB)	± 3.5 % ± 0.3 mV (± 0.2 dB)	± 5.5 % ± 0.3 mV (± 0.4 dB)

The values in brackets specify the flatness of the amplitude response related to the corresponding lower limit of the frequency subrange.

temperature coefficient	< 0.1 %/K	
distortion	< 0.35 %	f = 1 Hz – 200 kHz open circuit voltage > 10 mVpp
harmonics	< – 35 dBc	open circuit voltage ⩾ 10 mVpp, f > 200 kHz
	< – 25 dBc	open circuit voltage < 10 mVpp, f > 200 kHz
spurious		distance from carrier > 15 kHz
	< – 40 dBc (< – 50 dBc)*	open circuit voltage ⩾ 31 mVpp
	< – 34 dBc (< – 40 dBc)*	open circuit voltage ⩾ 10 mVpp
	< – 14 dBc (< – 20 dBc)*	open circuit voltage < 10 mVpp
		* (spectral range ⩽ 10 MHz)

voltage rms open circuit

setting range		0 – 10.6 V	
– subranges	I:	1.1 – 10.6 V	resolution 0.1 V
	II:	0.11 – 1.00 V	resolution 0.01 V
	III:	0 – 0.100 V	resolution 0.001 V

error limits of output voltage rms with 50 Ω termination
(nominal value = 1/2 open circuit voltage)

subranges of open circuit voltage	FREQUENCY RANGES			
	0.1 mHz – 1 Hz	1 Hz – 200 kHz	200 kHz - 1 MHz	> 1 MHz
I 1.1 – 10.6 V	± 3 %	± 2.5 %	± 3 %	± 5 %
II 0.11 – 1.00 V	± 4 %	± 3.5 %	± 4 %	± 6 %
III 0 – 0.100 V	± 5 % ± 0.1 mV	± 4 % ± 0.1 mV	± 4.5 % ± 0.1 mV	± 6.5 % ± 0.15 mV

level with 50 Ω termination

setting range – 45 . . . + 27 dBm resolution 1 dB

error limits of the output level dBm

subranges	FREQUENCY RANGES			
	0.1 mHz – 1 Hz	1 Hz – 200 kHz	200 kHz – 1 MHz	> 1 MHz
I + 8 . . . + 27 dBm	± 0.35 dB	± 0.3 dB	± 0.35 dB	± 0.55 dB
II – 12 . . . + 7 dBm	± 0.4 dB	± 0.35 dB	± 0.4 dB	± 0.65 dB
III – 30 . . . – 13 dBm	± 0.45 dB	± 0.4 dB	± 0.45 dB	± 0.75 dB
III – 45 . . . – 31 dBm	± 0.85 dB	± 0.8 dB	± 0.85 dB	± 1.15 dB

1.2.4.2. Square Wave

frequency range		0.1 mHz – 2.147 MHz	
duty cycle		50 %	
rise-/fall time		< 35 ns	general
		typ. 24 ns, < 28 ns	3.1 – 20 Vpp 0.31 – 2 Vpp 0.03 – 0.2 Vpp
aberrations (overshoot, ringing, tilt)		< 2 % ± 20 mVpp	subrange I
		< 2 % ± 3 mVpp	subrange II
		< 3 %	subrange III
voltage pp open circuit			
setting range		0 – 30 V	
– subranges	I:	3.1 – 30 V	resolution 0.1 V
	II:	0.31 – 3.00 V	resolution 0.01 V
	III:	0 – 0.300 V	resolution 0.001 V
error limits (50 Ω termination)		± 2 %	subrange I
		± 3 %	subrange II
		± 4 %	subrange III
temperature coefficient		< 0.15 %/K	
voltage rms open circuit			
setting range		0 – 15 V	
– subranges	I:	1.6 – 15 V	resolution 0.1 V
	II:	0.16 – 1.50 V	resolution 0.01 V
	III:	0 – 0.150 V	resolution 0.001 V
error limits (50 Ω termination)		± 2 %	subrange I, < 400 kHz
		± 3 %	subrange II, < 400 kHz
		± 4 %	subrange III, < 400 kHz
level			with 50 Ω termination
setting range		– 45 . . . + 30 dBm	resolution 1 dB
– subranges	I:	+ 11 . . . + 30 dBm	
	II:	– 9 . . . + 10 dBm	
	III:	– 45 . . . – 10 dBm	
error limits		± 0.25 dB	subrange I, < 400 kHz
		± 0.40 dB	subrange II, < 400 kHz
		± 0.80 dB	subrange III, < 400 kHz

1.2.4.3. Triangular Wave

frequency range		0.1 mHz – 200 kHz	
linearity error		< 1 %	related to amplitude pp
voltage pp open circuit			
setting range		0 – 30 V	
– subranges	I:	3.1 – 30 V	resolution 0.1 V
	II:	0.31 – 3.00 V	resolution 0.01 V
	III:	0 – 0.300 V	resolution 0.001 V
error limits		as sine wave	refer to tolerance table sine wave amplitude pp
temperature coefficient		< 0.1 %/K	
voltage rms open circuit			
setting range		0 – 8.6 V	
– subranges	I:	1.1 – 8.6 V	resolution 0.1 V
	II:	0.11 – 1.00 V	resolution 0.01 V
	III:	0 – 0.100 V	resolution 0.001 V
error limits		as sine wave additionally ± 1 %	refer to tolerance table sine wave amplitude rms
level			with 50 Ω termination
setting range		– 45 . . . + 25 dBm	resolution 1 dB
error limits		as sine wave additionally ± 0.1 dB	refer to tolerance table sine wave amplitude dBm

1.2.4.4. Sawtooth Voltage

unipolar positive or negative going ramps selectable

frequency range		0.1 mHz – 20 kHz	
linearity error		< 1 %	related to amplitude pp
fly-back time		< 1 µs	
voltage pp open circuit			
setting range		0 – 15 V	
– subranges	I:	1.6 – 15 V	resolution 0.1 V
	II:	0.16 – 1.50 V	resolution 0.01 V
	III:	0 – 0.150 V	resolution 0.001 V
error limits		as sine wave additionally ± 1 %	refer to tolerance table sine wave amplitude pp
temperature coefficient		< 0.1 %/K	

voltage rms open circuit

setting range		0 – 4.3 V	
– subranges	I:	1.1 – 4.3 V	resolution 0.1 V
	II:	0.11 – 1.00 V	resolution 0.01 V
	III:	0 – 0.100 V	resolution 0.001 V
error limits		as sine wave additionally ± 1 %	refer to tolerance table sine wave amplitude rms
level			with 50 Ω termination
setting range		– 45 . . . + 19 dBm	resolution 1 dB
error limits		as sine wave additionally ± 0.1 dB	refer to tolerance table sine wave amplitude dBm

1.2.4.5. DC Voltage — adjustable independently of the ac-voltage within a ± 15 V window

open circuit voltage

setting range	– 10 . . . + 10 V	resolution 0.1 V
error limit	± 2 % ± 40 mV	with 50 Ω termination
temperature coefficient	< 1 %o/K ± 2 mV/K	with adjusted value ≠ 0
additional error voltage for sine –	max. ± 80 mV	subrange I
and triangular wave	max. ± 30 mV	subrange II + III
– temperature coefficient	< 5 mV/K	subrange I
	< 1 mV/K	subrange II + III

1.2.5. Amplitudemodulation AM — AM internal, AM external — the voltage setting and indication is related to twice the carrier amplitude

carrier wave forms	all
carrier frequency range	0.1 mHz – 2 MHz

AM internal

modulation frequency	1 kHz	sine wave
error limit	± 3 %	
modulation depth	30 %	
error limit	(30 ± 2) %	
envelope distortion	< 0.6 %	
Lf-suppression	> 40 dB	
MODULATION OUTPUT	0.3 V ± 3 %	sine wave amplitude rms

	AM external		including static amplitude control
	modulation frequency range	0 – 200 kHz	
	modulation wave form	any wave form possible	
	modulation depth	0 – 100 %	
	MODULATION INPUT-voltage	+ 1.4 V – 1.4 V	for doubling the carrier amplitude for zero carrier amplitude
	envelope distortion	< 1.5 % < 0.7 %	modulation depth < 98 % modulation depth < 50 %
1.2.6.	**Step Functions**		
	frequency step function		these functions can only be used manually via the keyboard
	– control keys	△ FREQ + STEP – STEP	altering the frequency in programmable steps
	amplitude step function		
	– control keys	△ LEVEL + STEP – STEP	altering the amplitude in programmable steps
1.2.7.	**Connectors**		All signal in- and outputs at front and rear are BNC connectors
1.2.7.1.	**Outputs**		
	front panel:		
	OUTPUT	main signal output	short-circuit proof, max. external voltage ± 15 V (< 3 min)
	– impedance	50 Ω	
	TTL OUT – fan out	TTL-output 5 TTL-standard inputs	
	rear:		
	INT CLOCK – frequency – fan out	internal clock signal 8.58993 MHz (2^{33} mHz) 5 TTL-standard inputs	for synchronisation purposes
	INT MODULATION – voltage – impedance	modulation voltage 0.3 V (eff) 1 k Ω	

1.2.7.2. Inputs

EXT CLOCK	external TTL-signal	rear; for synchronisation purposes; the external clock supply is automatically switched on when clock signal is fed to EXT CLOCK.
frequency (fc)	7.5 – 10 MHz	resulting generator output frequency $f = fp \cdot fc \cdot 2^{-33} \cdot 10^9$ (fc in MHz) fp = programmed frequency
impedance	10 k Ω	
EXT MODULATION	input of external modulation voltages for the modulation modes	
input voltage	max. ± 10 V	
impedance	50 k Ω	

1.2.8. IEEE/IEC-Bus

all generator functions can be remote controlled

interface functions	AH1	acceptor handshake
	SH1	source handhake
	L4	listener function
	T6	talker function
	RL1	local/remote with local lockout
	SR1	service request
address range	Ø – 3Ø	address adjustment via the keyboard with key ADDRESS, stored in the battery buffered ram; initial value = 2Ø
remote control commands	consisting of – header – numerical extension – numerical value	not for all commands
frequency header	F	basic frequency, carrier frequency
amplitude header	LA	amplitude pp
	LR	amplitude rms
	LL	dBm-level
	LD	DC-level
modulation header	MA 'X'	amplitude modulation 'on'
	MO	amplitude modulation 'off'
		the header MA requires a numerical extension 'X' to select between internal and external modulation.

numerical extension 'X'	Ø	'off'
	1	internal
	2	external
wave form-header	WS	sine wave
	WT	triangular wave
	WQ	square wave
	RP	pos. sawtooth
	RN	neg. sawtooth
	ACØ	AC 'off'
	AC1	AC 'on'
dimensions	V	for voltages,
	dBm	for levels,
	Hz	for frequencies

format of the numerical values: integers, reals or exponentials; the sign may be left out if mantissa or exponent is positive

string format: a complete string may consist of one or more commands. Spaces and separators are ignored.

string delimiter	CR or	decimalcode ASCII: 13 or
	LF or	1Ø or
	ETX or	3 or
	ETB	23

string length: not limited

transfer time	ca. 5.9 ms	wave form
	ca. 3.Ø ms	frequency
	ca. 1.Ø ms	modulation mode
	ca. 7.2 ms	amplitude
	ca. 2.6 ms	dc-voltage

execution time: 5 ms typ.

status byte:
Bit 6: request for service: SRQ
Bit 5: error message
Bit 4: (not used)
Bit 3: (not used)
Bit 2: syntax error
Bit 1: out of range
Bit Ø: incompatibility between parameters

masking for SRQ: MSR 'x' — 'x' = decimal value which binary pattern masks the status byte. The individual bit of the status byte is activated for SRQ if the corresponding bit of the binary pattern is '1'.

learn-mode-command	IS?	When receiving this command the PM 5191 emits a string to the controller defining the complete generator setting. This string is formatted in a way that it can directly be used for a new setting.
identification-mode-command	ID?	When receiving this command the PM 5191 emits a string to the controller which contains the type number and the software status identification.

1.2.9. Storage of Parameter Settings

The actual set ups of the generator are automatically stored in a non volatile register. After power on these parameters are automatically recalled (execution with ENTER-key).

storage time	appr. 5 years	if the instrument is always switched off; with power switched on, the RAMs will be supplied from power supply – this increases the storage time.
battery	Lithium battery	

1.2.10. Diagnostic Program

When power is switched on, the voltage display field shows the software status for approx. 1 s. After this the processor checks the PROM(s) and the RAM chip and switches on all display segments and LEDs in the keys for approx. 2 – 3 s.

Beside this the program contains a very detailed diagnostic part to ease the fault finding.

1.2.11. Overflow, Misoperating

In case of incorrect or insufficient inputs the relevant part of the display and the key-LEDs start flashing.

1.2.12. Power Supply

ac mains

reference value	220 V
nominal values	100/120/220/240 V, selectable by wiring
nominal operating	± 10 % of selected nominal value
operating limits range	± 10 % of selected nominal value
nominal frequency	50/60 Hz
– tolerance range	± 5 % of nominal frequency range
power consumption	100 W

1.2.13 Environmental Capabilities

The following environmental data are valid only if the instrument is checked in accordance with the official checking procedure. Details on these procedures and failure criteria are supplied on request by the PHILIPS organization in your country or by PHILIPS International B. V., Industrial & Electro-acoustic Systems Division, EINDHOVEN, THE NETHERLANDS.

ambient temperature	
– reference value	+ 23° C ± 1 K
– nominal working range	+ 5° C . . . + 40° C
– limits for storage and transport	– 20° C . . . + 70° C
relative humidity	
– reference range	45 % . . . 75 %
– nominal working range	20 % . . . 80 %
– limit range of use	10 % . . . 90 %
– limit range for storage and transport	0 % . . . 90 %
air pressure	
– reference value	1013 hPa (≙ 760 mm Hg)
– nominal working range	800 hPa . . . 1060 hPa (≙ 600 . . . 800 mm Hg; up to 2200 m height)
air speed	
– reference value	0 m/s . . . 0.2 m/s
– nominal working range	0 m/s . . . 0.5 m/s
heat radiation	direct sunlight radiation not allowed
vibration	
– limits for storage and transport	max. amplitude 0.35 mm (10 to 150 Hz) max. 5 g
operating position	normally upright on feet (horizontal position) or with bow fold down
warm-up time	30 min.

1.2.14. Safety- and Quality Data; Cabinet

protection type (see DIN 40 050)	IP 20
protection class (see IEC 348)	class I, protective conductor
line connection	mains connector
call rate	⩽ 0.15
radio interference voltage radio interference radiation	acc. to VDE 0871 class B ("Grenzwertklasse B")
overall dimensions	19", 2 E high
width	440 mm
height	105 mm
depth	430 mm
weight	10 kg

1.3. ACCESSORIES

1.3.1. Standard

operating manual 9499 450 08401
with operating/programming card 9499 450 08511
mains cable
fuses 1.25 AT, 1.6 AT
adapters for 19"-rack mounting (see Appendix 2)
labels for mains voltage
4 foot rubbers

1.3.2. Optional

PM 9074	coaxial cable BNC-BNC / 50 Ω (1 m)
PM 9051	adapter BNC (male)/banana jack
PM 9585	50-Ohm-termination 1 W
PM 9581	50-Ohm-termination 3 W
PM 2295/10	IEEE-Bus-cable (1 m)
PM 2295/20	IEEE-Bus-cable (2 m)
PM 2296/50	IEEE/IEC-adapter
PM 2296/60	IEC/IEEE-adapter
PM 9613	Rack-mount slide kit
	Service-Manual, order no. 9499 455 00111; Philips Instrumentation Systems
	Reference Manual, order no. 9499 997 00411

1.4. OPERATING PRINCIPLE, Fig. 2 (Block diagram)

1.4.1. General Operating Principle

The basic functional units, performing the generation, processing and conditioning of the generator output signals, are named

- DFS, Digital Frequency Synthesizer, on unit 2
- MODULATOR on unit 1
- PULSE GENERATOR on unit 1
- AMPLIFIER on unit 1

These functional units are under control of the CPU (Central Processing Unit), consisting of a microprocessor and its peripheral components on unit 2. Primary control data for the CPU is derived from the front-end KEYBOARD & DISPLAY on unit 3 or from an external controller via the IEEE/IEC bus interface. The output-signal parameters are displayed numerically on a 7-segment-LED display. Key LEDs are provided for operating mode indication. Subsequently a brief description of the over-all block diagram (fig. 2) of the generator is given.

1.4.2. Description of the Block Diagram

DFS

The primary signals – sine, triangular, positive and negative sawtooth waves – are generated by direct digital signal synthesis.

Binary samples of the wave are created in the SIGNAL SYNTHESIZER section and converted to analogue voltages by a fast DAC at the clock rate fc. The output frequency fo is directly related to fc, according to

$$fo = 0.1 \cdot N \cdot 2^{-33} \cdot fc = N \cdot 10^{-4}\ Hz$$

where N is the decimal equivalent of the binary frequency word, routed to the SIGNAL SYNTHESIZER from the CPU via U2-CONTROL BUS. fc is generated by an x-tal oscillator, the 8.59 MHz CLOCK. The AUTOMATIC SWITCH alternatively routes the external clock frequency to the SIGNAL SYNTHESIZER, if this is applied to the CLOCK INPUT. The DAC output signal is smoothed by the 3 MHz LPF, an anti-aliasing low-pass filter.

PULSE GENERATOR

The PULSE GENERATOR basically represents an electronical switching circuitry, creating a TTL signal and a square wave, each signal with a 50 % duty cycle. The instants of the positive and negative edges of these signals are determined by the zero-crossings of the DFS signal, e.g. a sine wave, fed to the ZERO CROSSING DETECTOR as reference.

Only if square wave at the generator output is programmed, the TTL output of the ZERO CROSSING DETECTOR is routed to the SQUARE WAVE CONDITIONER by the CONTROL CIRCUITRY. The TTL OUTPUT STAGE and the SQUARE WAVE CONDITIONER are creating the TTL output voltage of the generator and the primary square wave with accurate amplitude and waveform.

MODULATOR

By the VOLTAGE CONDITIONER the DFS sawtooth wave is halved in amplitude and shifted in dc, resulting in unipolar signals. The sine wave and the triangular wave are routed without change through the VOLTAGE CONDITIONER.

By the SELECTOR I either the output signal of the VOLTAGE CONDITIONER (sine, triangle, sawtooth) or the square wave of the PULSE GENERATOR is routed directly or through the AMPLITUDE MODULATOR to the AMPLIFIER.

In internal AM mode the modulating signal is derived from the MODULATION OSCILLATOR output. The modulating sine wave is fed to the AMPLITUDE MODULATOR through SELECTOR II. Alternatively – in the external modulation mode – the modulating signal is supplied from the generator MODULATION INPUT.

AMPLIFIER

The vernier setting of the generator output amplitude is performed by the AMPLITUDE CONTROLLER. After amplification by the POWER AMPLIFIER the signal either directly or after 20 dB respectively 40 dB attenuation by the STEP ATTENUATOR is routed to the OUTPUT socket. The DC GENERATOR adds the programmed dc voltage.

CPU

An 8-bit microprocessor (8031) and a 10 MHz clock are the constituents of the PROCESSOR & CLOCK. The PROGRAM MEMORY is a 8 Kbyte EPROM. In an external data memory, the 128 byte RAM, the storage register contents of the generator are stored. By the CONTROL BUS DRIVER the required load capability of the U1- and U2 CONTROL BUS serial data linie (SDA), and the clock line (SCL), is achieved. The device selecting strobe signals STR1...15 – used for CPU components and latching-data-shift registers in the various functional units controlled by the CPU – are derived from 4 ports of the PROCESSOR by the STROBE DECODER.

The IEEE/IEC bus interface of the generator consists of the IEC BUS CONTROLLER, the DEVICE ADDRESS LATCH & SHIFT REGISTER and the 3-STATE GATE & LATCH.

2. INSTALLATION INSTRUCTIONS

2.1. INITIAL INSPECTION

Check the contents of the shipment for completeness and note whether any damage has occurred during transport. If the contents are incomplete, or there is damage, a claim should be filed with the carrier immediately, and the Philips Sales or Service organisation should be notified in order to facilitate the repair or replacement of the instrument.

2.2. SAFETY INSTRUCTIONS

Upon delivery from the factory the instrument complies with the required safety regulations, see para. 1.2. To maintain this condition and to ensure safe operation, the instructions below must carefully be followed.

2.2.1. Maintenance and Repair

Failure and excessive stress:
If the instrument is suspected of being unsafe, take it out of operation permanently.
This is the case when the instrument

- shows physical damage
- does not function anymore
- is stressed beyond the tolerable limits (e.g. during storage and transportation)

Dismantling the instrument: When removing covers or other parts by means of tools, live parts or terminals could be exposed. Before opening the instrument, disconnect it from all power sources.

If the open live instrument needs calibration, maintenance or repair, it must be performed only by trained personnel being aware of the risks. After disconnection from all power sources, the capacitors in the instrument may remain charged for some seconds.

2.2.2. Earthing (grounding)

Before any other connection is made the instrument shall be connected to a protective earth conductor via the three-core mains cable. The mains plug shall be inserted only into a socket outlet provided with a protective earth contact. The protective action shall not be negated by the use of an extension cord without protective conductor.

WARNING: Any interruption of the protective conductor inside or outside the instrument, or disconnection of the protective earth terminal, is likely to make the instrument dangerous. Intentional interruption is prohibited.

2.2.3. Connections

The circuit earth potential is applied to the external contacts of the BNC sockets and is connected to the cabinet by means of parallel-connected capacitors. By this means hum loops are avoided and a clear HF earthing is obtained.

If the circuit earth potential in a measurement set-up is different from the protective earth potential, it must be noticed,

- that the BNC sockets can be touched and that it must not be live, see the safety regulations on the subject (VDE 0411),
- that all sockets marked with the sign ⊥ are internally interconnected.

2.2.4. Mains Voltage Setting and Fuses

Before inserting the mains plug into the mains socket, make sure that the instrument is set to the local mains voltage.

The instrument shall be set to the local mains voltage only by a qualified person who is aware of the hazard involved.

WARNING: If the mains plug has to be adapted to the local situation, such adaption should be done by a qualified person only.

On delivery from the factory the instrument is set to a mains voltage which is indicated on the rear panel as the corresponding fuse:

PM 5191	220 V	630 mAT
PM 5191 M (USA)	120 V	1.25 AT

For modification to other local mains voltages please use the 'Appendix' of this manual or the service manual of this instrument.

Make sure that only fuses of the required current rating, and of the specified type are used for renewal. The use of repaired fuses, and/or the short-circuiting of fuse holders, are prohibited.

The fuse is located in a holder on the rear panel above the mains socket.

100 V	1.6 AT
120 V	1.25 AT
220 V / 240 V	630 mAT
	DIN 41571 Slow blow

WARNING: The instrument shall be disconnected from all voltage sources when a fuse is to be renewed.

2.3. OPERATING POSITION OF THE INSTRUMENT

The instrument may be used in the positions indicated in clause 1.2.13. For use in sloping position erect the tilting support at the bottom. The characteristics mentioned in section 1.2. are guaranteed for the specified positions.
Ensure that the ventilation holes are free of obstruction.
Do not position the instrument on any surface which produces or radiates heat, or in direct sunlight.

2.4. RADIO INTERFERENCE SUPPRESSION

Radio interference of the instrument is suppressed and checked carefully. In connection with deficient suppressed base units and further units radio interference can be generated, which have to be suppressed by means of additional activities.

3. OPERATING INSTRUCTIONS

3.1. GENERAL INFORMATION

This section outlines the procedures and precautions necessary for operation. It identifies and briefly describes the functions of the front and rear panel controls and indicators, and explains the practical aspects of operation to enable an operator to evaluate quickly the instrument's main functions.

3.2. SWITCHING ON THE INSTRUMENT

After the instrument has been connected to the mains voltage in accordance with clauses 2.2.4., it can be switched on by operating the mains switch POWER. The white spot on the POWER switch mechanically indicates that the instrument is switched on.

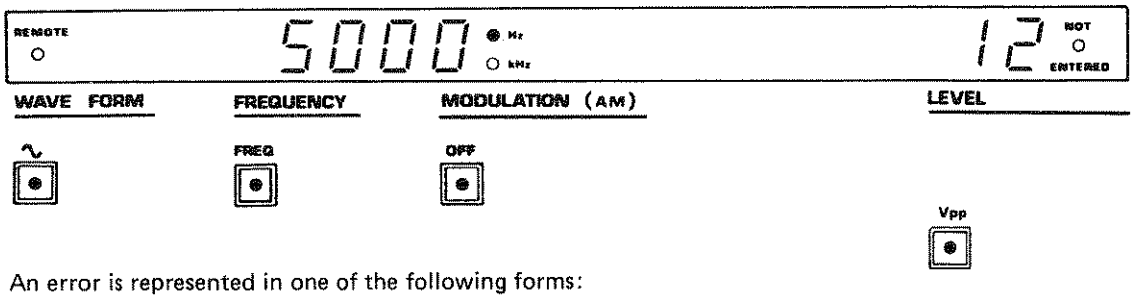
Having switched on the instrument, it is immediately ready for use. With normal installation in accordance with section 2.3. and after a warming-up time of 30 minutes, the characteristics specified in section 1.2. are valid.

After switching power off a time interval of at least 5 s should pass by – allowing the capacitors of the power supply to discharge – before the device is switched on again. This measure is necessary to set the internal logic circuitry to its correct initial condition.

3.3. SELFTEST ROUTINE

When switched on, the instrument first carries out a selftest whereby the PROMs and RAMs are checked. If the instrument is in order all the segments and decimal points of the figures and all LEDs light up for approx. 3 s. The instrument then passes to its default status, indicated by a figure in the sectors of the display according with the last setting before switch off, the LED Hz or kHz in the display and the LEDs in the keys according with the last setting.

Example:



An error is represented in one of the following forms:

Err 1	PROM	checksum error
Err 2	RAM (processor)	read/write error
Err 3	RAM (CPU)	operation possible but memory contents is destroyed

For further examples see chapter 3.5.6. Error Messages.

3.4. BRIEF CHECKING PROCEDURE

3.4.1. General

The purpose of this operation is to check the functions of the PM 5191 with the least amount of time and effort.

It is assumed that the operator is familiar with the PM 5191 and its characteristics. If the test is carried out shortly after being switched on, the individual testing steps could lead to incorrect results owing to the warming-up time being inadequate.

WARNING: Before switching on ensure that the equipment has been put into operation in accordance with chapter 2.

3.4.2. Operations Test

Immediately upon being switched on, a self-test is carried out. The instrument then automatically returns to its basic status (see chapter 3.3.). The equipment's last operational status prior to being switched off is displayed. Using key [ENTER] execute this setting.

If you prefer a different operation mode, then just input new parameters.

example:	wave form	sine
	frequency	150 Hz
	modulation	off
	level: amplitude (Vpp)	1 V
	DC offset (Vdc)	0 V

– Earlier settings that remain unchanged do not need to be entered again.

[∿]	[FREQ]	[1]	[5]	[0]	[Hz/kHz] *	frequency
[OFF]						modulation
[Vpp]	[1]	[Vdc]	[0]	[ENTER]		level

*(press key Hz/kHz only if LED "Hz" doesn't lit)

– connect the oscilloscope to socket OUTPUT (see chapter 3.5.2.1.) (Zo = 50 ohm) and check the signal. If it is correct, the operations test is finished. If not, repeat the procedure with other settings. For input examples see the concise form of the operating instructions "Operating Card" and chapter 3.5.

3.5. OPERATION AND USE

3.5.1. Configuration of the display and control panel (Fig. 1)

This display (3) consists of 2 sectors for the following indications (from left to right):

- frequencies (8 digits):
  basic frequency or frequency increment
- output voltage/address (4 digits)
  output voltage or level, or voltage or level increment, or remote control address.

The keyboard is subdivided into five functional main sectors:

- WAVE FORM (15)
  direct setting of the wave form
- FREQUENCY (13)
  setting of the basic frequency and frequency interval for the frequency STEP-function
- MODULATION (12)
  setting of the modulation mode internal or external.
- OUTPUT SIGNAL (11)
  setting and stepping of the output voltage or level as well as setting the remote addresses.
- NUMERIC KEYBOARD (5,8,9)
  input of figures and decimal point, erasing the last figure entered for correction purposes, and the ENTER function (implementation of the numeric input values).

LEDs in the respective keys on the control panel indicate the actual parameters.

There are two kinds of keys:

- keys having a direct effect on the output signal.
  keyboard WAVE FORM: all
  keyboard FREQUENCY: Hz/kHz, STEP–, STEP+
  keyboard MODULATION: OFF, EXT, INT
  keyboard LEVEL: STEP–, STEP+

  These keys have direct effect on the output if their respective parameters are complete and within the correct range.

- keys with a „pre-selection" character.
  keyboard FREQUENCY: FREQ and ΔFREQ
  keyboard LEVEL: Vpp, dBm, Vrms, Vdc, ΔLEVEL and ADDRESS

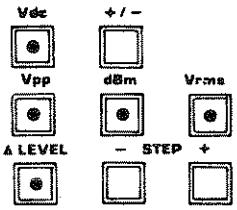
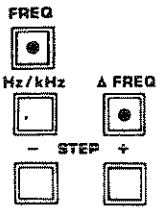
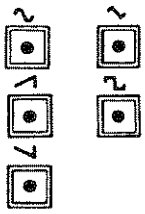
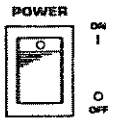
  The „pre-selection" keys have a dual function:
  - when pressed once the respective display is blanked and ready for a numeric entry.
  - when operated twice, the respective display is blanked and then the actual numerical value is displayed. This way every parameter not already being shown can be displayed.

When the display is blanked by operating one of the pre-selection keys once and during the following numerical input, the unit is in a NOT ENTERED state, i.e. the input parameter value has not yet been activated and can be corrected using the key RUB OUT. This state is recognised by the NOT ENTERED LED flashing at the right-hand side of the display. The input value is implemented after the ENTER key has been pressed.

3.5.2. Display, Control Elements and Connectors (see fig. 1, front view/rear view)

3.5.2.1. Controls and Indicators at the Front Panel

Controls/Indicators	Function
LOCAL	Key (1). This allows the equipment to be switched over from „remote operation" to local operation
REMOTE ○	LED (2) indicating remote operation via IEEE/IEC bus.
20000000.0 MHz kHz 20.0	LEDs and display (3) for: – frequency (8 digits) and frequency dimension (LED) – output level (2 digits) or output voltage (3 digits) or remote operation address (2 digits).
NOT ○ ENTERED	LED (4) flashes if the input parameters have not yet been entered or in the case of an input error.
7 8 9 4 5 6 1 2 3 0 .	Numeric keyboard (5) with decimal point to input the parameter values. When the ENTER key is pressed, the input values are transferred from the input store to the working memory.
TTL OUT ⊥	Output socket (6) for TTL signal
OUTPUT ⊥ Z=50Ω	Output socket (7)
ENTER	Key (8) to execute the data input
RUB OUT	Correction key (9) to cancel the input in reverse order.
ADDRESS	Key (10) to input the device address (0 . . . 30).

Controls/Indicators	Function
LEVEL 	Keyboard (11) to input the output level and offset voltage Additional functions: – conversion of Vpp/dBm/Vrms – changing the output amplitude stepwise either in a positive or negative direction with the keys STEP+ or STEP– – changing the sign of the offset voltage (Vdc) and the LEVEL (dBm) with the key +/–.
MODULATION (AM) 	Keyboard (12) to select the modulation mode internal: INT external: EXT
FREQUENCY 	Keyboard (13) to set the frequency.
	Key (14) to switch the AC output signal on and off without influence on the offset voltage.
WAVE FORM 	Keyboard (15) to select the wave form.
	Mains switch (16). The white circle shows that the equipment is switched off.

3.5.2.2. Rear Connections

Output socket (17) for internal reference frequency of 8.59 MHz for synchronisation purposes.
Output socket (18) for the modulation frequency (1 kHz fixed).
Fuse (19).
Mains socket (20).
IEEE/IEC bus for remote operation (21).
Input socket (22) for modulating the carrier in AM, external.
Input socket (23) for external reference frequencies.

3.5.3. Manual Input Procedure

The PM 5191 can be controlled either via the keyboard or via the IEEE/IEC bus. The keyboard is inhibited when controlling via the bus and the REMOTE LED lights.

In LOCAL mode, the maximum number of digits that can be entered is identical with the number of positions in the display. If too many digits are entered or decimal points entered at illegal positions, these are ignored.

Illegal input or values are shown by flashing of key LEDs and display. The PM 5191 does not accept illegal inputs so that no damage can be caused by such wrong operations.

Numerical inputs have to be terminated using the key ENTER. Not terminated inputs are indicated by the flashing NOT ENTERED LED.

The parameters can be entered in any sequence. Previously entered values that remain unchanged do not need to be entered again. (See chapter 3.5.4.).

Corrections can be made during input by using the key RUB OUT or by starting this parameter input again.

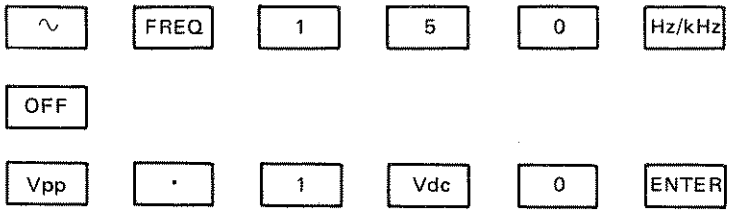
Formular signs:

fo	=	frequency, carrier frequency
Δf	=	frequency steps
fm	=	modulation frequency
m	=	modulation depth (degree of modulation)
Vpp	=	output amplitude peak-peak
Vdc	=	DC offset

Input formats:

FREQUENCY	x.x.x.x.x.x.x.x.	Hz/kHz
Δfrequency	x.x.x.x.x.	Hz/kHz
LEVEL		
Vpp, Vrms, ΔVpp, ΔVrms	x.x.x.	
Vdc, ΔVdc (+ is not shown) +/–	x.x.	
dBm, ΔdBm (+ is not shown) +/–	x x	
address (external control)	0 . . . 30	

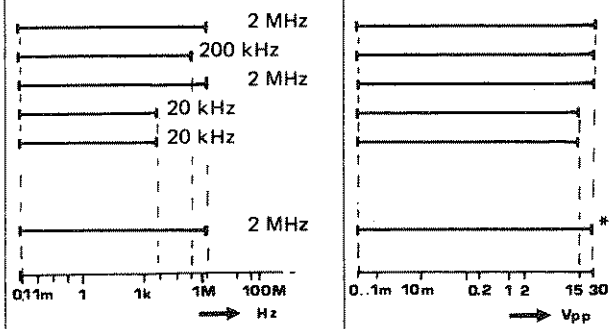
Example: sine wave, fo = 150 kHz, Vpp = 0.1 V, Vdc = 0 V



3.5.3.1. Frequency Input

By pressing the ΔFREQ key the instrument is set to accept frequency inputs in the following ranges:

WAVE FORM	symbol	frequency range	amplitude (open circuit)
sine wave	∿	2 MHz	
triangle	∿	200 kHz	
square	⊓	2 MHz	
pos. sawtooth	◿	20 kHz	
neg. sawtooth	◺	20 kHz	
MODULATION sine wave	AM	2 MHz	*



*) carrier amplitude reduced by 6 dB

- The FREQUENCY display is blanked.
- A new frequency value of max. 8 digits can now be entered.
- When the first digit of the new value has been input the LED NOT ENTERED starts flashing to indicate that the number not yet has been executed. At this moment input errors can still be corrected by operating the key RUB OUT.
- By actuating the ENTER key the frequency value just input is executed. This value can now only be changed by inputting new data.

The frequency can be input either in Hz or kHz. The frequency dimension currently operative is indicated by the LEDs Hz or kHz. Key Hz/kHz is used to change the dimension.

The numeric values are entered from left to right, whereby leading zeros in front of the decimal point are omitted, with the exception of the units column. For the Hz frequency dimension a maximum of 4 digits is permissible behind the decimal point, for the kHz dimension 7 are allowed.

Example: fo = 169 kHz.

[FREQ] [Hz/kHz] [1] [6] [9] [ENTER]

Frequency steps (ΔFREQ)

After the key ΔFREQ has been actuated a frequency step can be defined by which the indicated frequency can be increased or decreased (keys +STEP, –STEP).

Continuously pressing the STEP keys results in a continuous sequence of steps.

Example: Δf = 5 kHz

[ΔFREQ] [5] [ENTER]

[+STEP] frequency rising

[–STEP] frequency falling

3.5.3.2. Input of the Output Level

The output level can be input either in the dimensions Vpp, dBm or Vrms. Selection is done with the keys on the LEVEL keyboard.

During the input of the output level care should be taken to ensure that the amplitude (Vpp) and the offset (Vdc) together do not exceed the value +/– 15 V. The output levels that can be set for the different wave forms are:

WAVE FORM	symbol	max. frequency	output level		
			Vpp	Vrms	dBm (R_L = 50Ω)
sine wave	∿	2 MHz	1 m . . . 30	1 m . . . 10.6	– 45 . . . + 27
triangle	∿	200 kHz	1 m . . . 30	1 m . . . 8.6	– 45 . . . + 25
square	⊓	2 MHz	1 m . . . 30	1 m . . . 15	– 45 . . . + 30
pos. sawtooth	◿	20 kHz	1 m . . . 10	1 m . . . 4.3	– 45 . . . + 19
neg. sawtooth	◺	20 kHz	1 m . . . 10	1 m . . . 4.3	– 48 . . . + 19

Vpp and Vrms values are open circuit voltages.

The keys Vpp, Vrms and dBm allow the conversion between these measuring units by pressing the according key twice:

Example:

Input: sine wave, 20 Vpp		display shows 20 (Vpp)
pressing 2 x	Vrms	display shows 7.1 (Vrms)
pressing 2 x	dBm	display shows 24 (dBm)

Key Vdc on the LEVEL keyboard allows the input of a DC offset that can be added to the AC voltage; the polarity of the offset voltage can be selected using key +/–.

Stepping of the Output Level (ΔLEVEL)

The output level can be altered into discrete steps using keys +STEP, –STEP. The smallest step ΔLEVEL that can be programmed corresponds with the resolution of the output level in the respective range (see table).

	range	resolution ΔLEVEL
Vpp	1 mV . . . 0.300 V	1 mV
	0.31 V . . . 3.00 V	10 mV
	3.1 V . . . 30.0 V	100 mV
Vrms	1 mV . . . 0.100 V	1 mV
	0.11 V . . . 1.00 V	10 mV
	1.1 V . . . 15.0 V	100 mV
dBm	resolution 1 dBm across the entire range	

Example: ΔVpp = 0.5 V

Vpp	display is blanked		Vpp	actual value (Vpp) is displayed.	
ΔLEVEL	0	•	5	ENTER	0.5 V step width is entered. (the input of ΔLEVEL is related to the actual displayed output value.)
+STEP	Vpp rising				
–STEP	Vpp falling				

The increments for LEVEL, Vpp, Vrms and Vdc must be entered separately. Using the keys +STEP or –STEP the just displayed parameter, indicated by LED in the respective key, will be altered.

NOTE:

If the numerical and operational inputs are incompatible, actuating the ENTER key does not lead to implementation of the inputs.

- The NOT ENTERED LED continues flashing.
- The LEDs of those keys corresponding with the incompatible parameters are flashing, this necessitates a correction by inputting permissible parameters.

Incompatibilities of the inputs can be derived from the tables in chapters 3.5.3.1. and 3.5.3.2.

3.5.4. Modulation Mode AM (Amplitude Modulation)

This modulation mode is switched on by operating the key INT or EXT.

One can choose between internal and external modulation. External modulation ist performed by an external modulation signal at INPUT MODULATION at the rear. The change-over is carried out using keys INT and EXT.

Modulation frequency and depth:

internal: 1 kHz fixed, modulation depth 30 % fixed
external: 0 Hz . . . 200 kHz , modulation depth depends on the amplitude of the modulation signal

Example: Amplitude Modulation (AM), internal

intended settings			key operations
wave form	:	sine	∿
frequency (carrier)	:	25 kHz	START 2 5 Hz/kHz *
amplitude	:	1.7 V	Vpp 1 . 7
offset voltage	:	0.5 V	Vdc . 5 ENTER
modulation mode	:	internal	INT
modulation frequency	:	1 kHz (fixed)	*(press key Hz/kHz only if LED "kHz" doesn't lit)
modulation depth	:	30 % (fixed)	

The modulation signal (1 kHz with 30 % modulation depth) is switched on automatically if the internal modulation mode AM is selected.

The modulation mode is switched off using key OFF.

To alter single parameters it is only necessary to operate the according keys, all others parameters remain unchanged.

e.g. Vdc = 0.1 V instead 0.5 V

key operation:

Vdc . 1 ENTER

or frequency 100 kHz instead 25 kHz

key operation:

FREQ 1 0 0 ENTER

3.5.5. Error Messages, Operating Errors

3.5.5.1. Error Messages when Switching on

Apart from the normal service routines, the program memory of the PM 5191 contains a selftest routine that starts automatically when the instrument is switched on. The selftest routine checks the battery buffered RAM, the microprocessor RAM and the contents of the program memory (PROM).

Then all LEDs and segments of the numeric displays are switched on for approx. 3 s — any errors in the decoders and drivers can then be recognised instantly.

If the selftest routine discovers an error, then one of the following error messages will appear in the display:

Err 1 This is a PROM checksum error. The PROMs have to be replaced.

Err 2 The processor containing the working memory RAM has to be replaced.

Err 3 This is a checksum error of the battery buffered RAM, it lost its data since last being switched off. This can be caused either by a defective Rattery, a defective RAM chip or a RAM test (see diagnostic program).
Before servicing it is recommended to create new input data and to repeat the initial selftest.

3.5.5.2. Operating Instructions, Operating Errors

If the required setting of the equipment cannot be attained, then try once more using the examples given (chapter 3.5.3. and 3.5.4.1).

Operating errors are indicated by a flashing display:

- FREQUENCY or LEVEL display flashes:
  In step operation (working with the keys +STEP or –STEP) the permissible frequency or level range is left. The display flashes three times and stops at the last value. (See chapter 3.5.3.1. and 3.5.3.2.).
- FREQUENCY display flashes continued:
  Frequency is greater or smaller than the permissible frequency range of the selected wave form. (See chapter 3.5.3.1.).
- LEVEL display flashes continued:
  The input value exceeds the permissible range or Vpp + Vdc exceed + 15 V or – 15 V. (See chapter 3.2.).

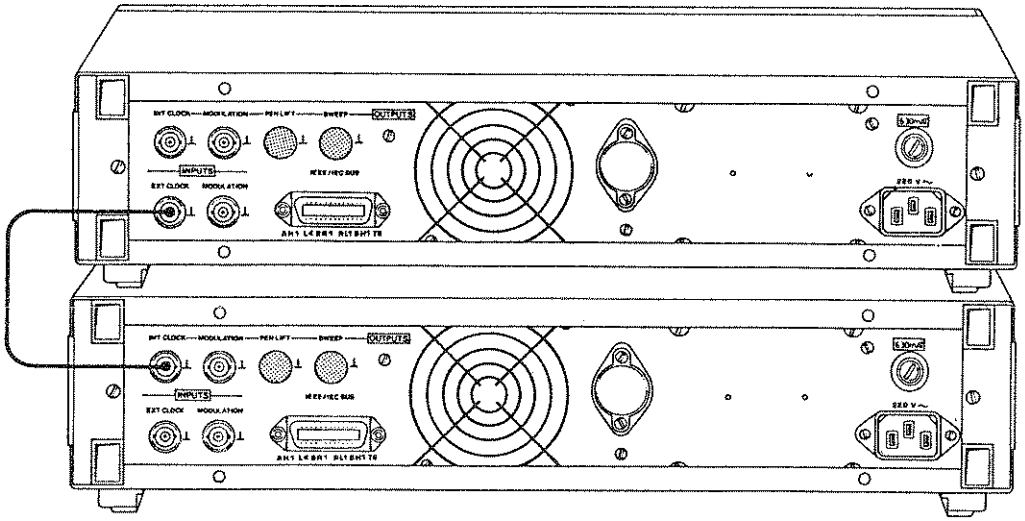
3.6. SPECIAL APPLICATIONS

The high versatility of the PM 5191 allows applications in many measurement sectors, as well as a table-top model or installed in a system with remote control by IEEE/IEC-bus.

Another facility is the possibility to connect several instruments via the CLOCK INPUTs/OUTPUTs for frequency synchronisation.

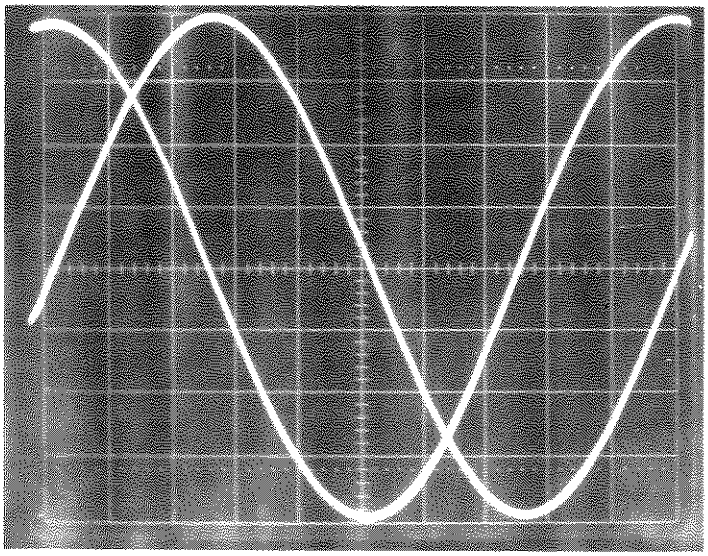
Example 1:

The following example shows the connection of two instruments to generate a sine wave and a cosine wave. The synchronisation is realized by a connection between the INT CLOCK OUTPUT of the first and the EXT CLOCK INPUT of the second instrument.



Settings:

According to the required function, both instruments must be set to the same frequency. In order to reach the desired phase angle between the signals, one of the instruments must be programmed with a frequency increment ΔFREQ of e.g. 0.01 Hz, which must be executed with the key +STEP. This frequency difference effects a phase shift between the two signals of $2\pi\,\Delta$FREQ, i.e. one of the two signals shifts within the time of $\frac{1}{\Delta FREQ} = \frac{1}{0{,}01\ Hz} = 100\ s$ over 2π. By pressing the key –STEP at the right moment, the frequency difference will be = 0 and the phase shift stops. The phase angle between the two signals remains fixed.



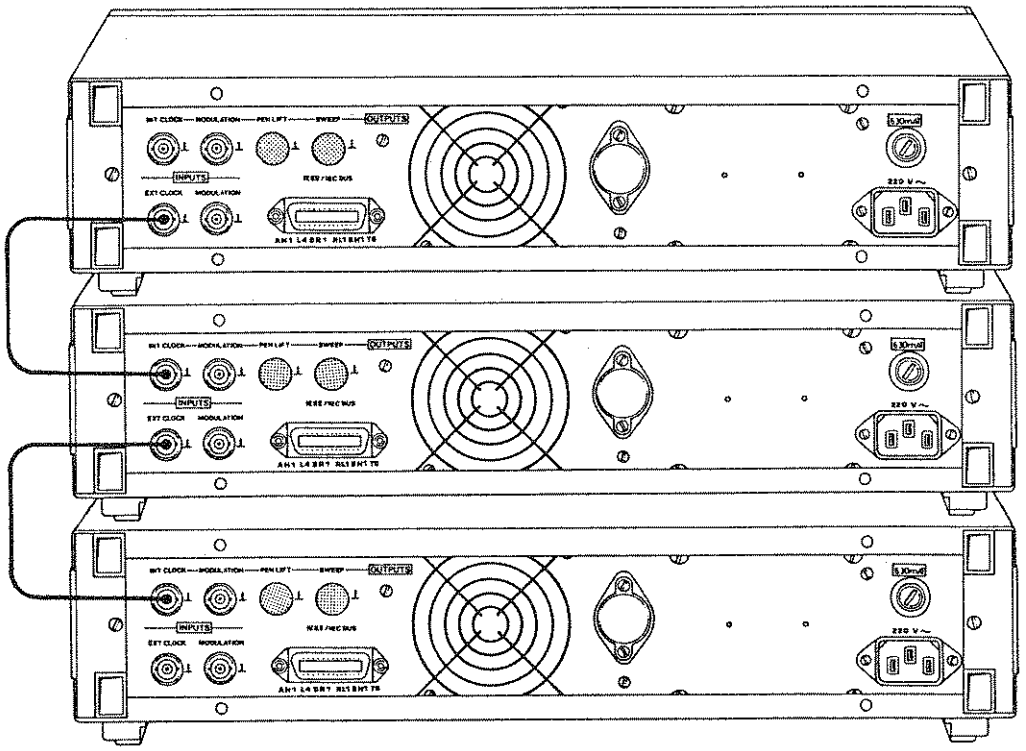
B = cosine wave

A = sine wave

Example 2:

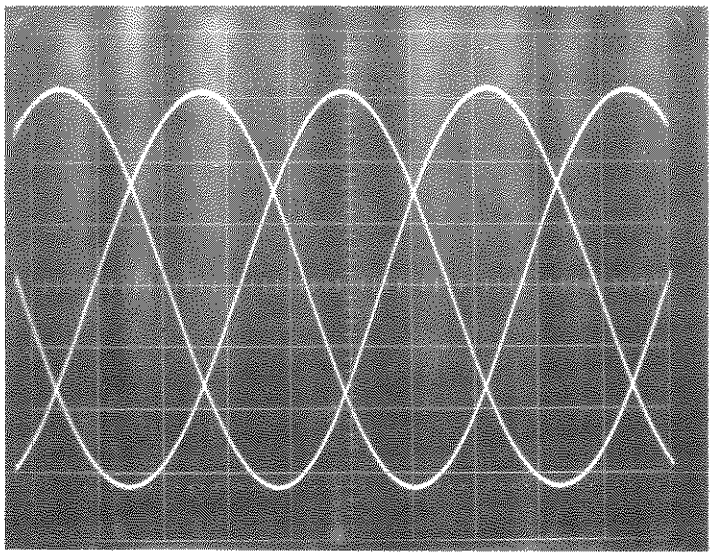
The second example shows three PM 5191s generating the same signals with a fixed phase angle as shown in the example before.

In this case there are three sine waves with phase displacements of 120^{o} (2/3 π). The generators are synchronized by two connections from INT CLOCK OUTPUT of the first to EXT CLOCK INPUT of the second instrument and from this instrument's INT CLOCK OUTPUT to the EXT CLOCK INPUT of the last one.



Settings:

All instruments are set to the same frequency. Two of the three instruments must be programmed with a frequency increment ΔFREQ, which value is relevant for the speed of the phase shift. By pushing the key +STEP the phase of this generator starts to shift with the speed $2\pi\Delta$FREQ. By pushing −STEP, at the right moment, the phase shift stops at the desired point and remains fixed. The phase angle of the third generator output is adjusted in the same way.



——— B = sine wave with -120^{o} phase difference to A

——— C = sine wave with -240^{o} phase difference to A

——— A = reference sine wave

3.7. REMOTE CONTROL OF THE INSTRUMENT

Apart from using the keyboard, all operations of the function generator PM 5191 with the exception of the 'STEP' operation can also be controlled via the IEC/IEEE interface. The following table shows which interface functions are implemented:

AH 1: acceptor handshake
SH 1: source handshake
L4: listener function
T6: talker function
RL 1: local/remote with local lockout
SR 1: service request SRQ

Control of the PM 5191 synthesizer requires knowledge of the device address. When first using the equipment as well as when the contents of the memory have been destroyed (e.g. after a RAM test), the default address 2Ø is set. Using the 'ADDRESS' key on the 'LEVEL' keyboard this address can be checked and altered. The permissible range for the IEC/IEEE device address is Ø – 3Ø.

The following tables show which remote control commands are necessary to enter parameters and to control the operation mode.

– Remote control headers for the waveforms

WS	sine
WT	triangular
WQ	square wave
RP	sawtooth positive
RN	sawtooth negative
ACØ	AC off; switches off AC voltage
AC1	AC on; switches on AC voltage

Input dimension are: Hz for frequency
V for amplitude
dBm for level

– Remote control header for frequency setting

F	basic frequency	(≙ key FREQ)

– Remote control headers for amplitude and DC offset setting

LA	amplitude (Vpp)	(≙ key Vpp)
LR	amplitude (Vrms)	(≙ key Vrms)
LL	amplitude (dBm)	(≙ key dBm)
LD	DC offset (V)	(≙ key Vdc)

Parameters can be sent to the device either as integer, real or exponential values.

Examples: F1ØØØ = frequency input 1 kHz
F3.125 = frequency input 3.125 Hz
F2E6 = frequency input 2 MHz

If the parameter is input in the exponential form, then please note that only the first digit of the exponent is considered; further digits are accepted but ignored.
The frequency value F 4E23, for example, is identified as F4E2 = 4ØØ Hz. The size of the mantissa in exponential values, of integers and reals are restricted to the largest possible number of digits on the corresponding display panel, i. e. 8 digits for frequency inputs, 3 digits for the input of levels etc.. More digits can be entered than are actually possible, but only the first digits of the input string will be recognised.

– Remote control headers for modulation AM

MA (x)	amplitude modulation
MO	"modulation off"

– Numeric extensions for modulation

X = Ø switches off the operation
= 1 internal modulation (≙ key INT)
= 2 external modulation (≙ key EXT)

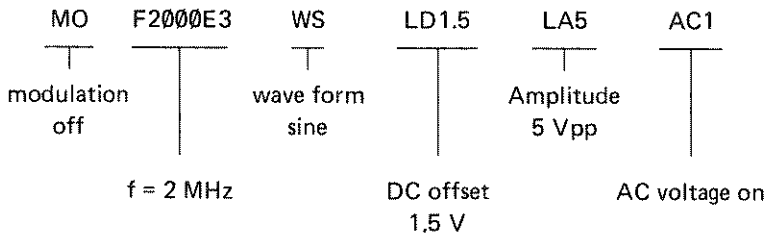
The numeric extension must be sent in addition to the command 'MA' in order to transmit the required additional information; the figure Ø switches off the respective function.

Bus learn mode

In addition to the remote control commands described above, the IEC/IEEE bus also allows the respective parameters to be read out of the working store. This so-called 'learn mode' is called up using the command 'IS?' and, when the generator is addressed as talker, it emits a string to the computer. This string contains all information of the generator setting and can be used for re-establishing this setting later on.

Example 1: Command 'IS?' is sent to the PM 5191, the following string of data is accepted:

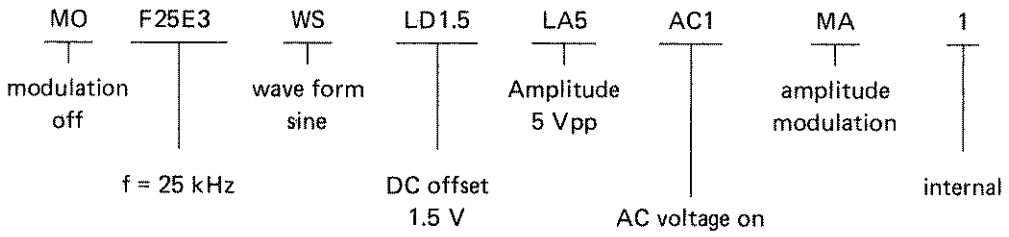
MOF2ØØØE3WSLD1.5LA5AC1



Note: Every string sent to the controller after 'IS?' begins with 'MO' (modulation off) to ensure safe acceptance of the string in every operation mode.

Example 2: The following string is received by the controller after 'IS?' has been sent

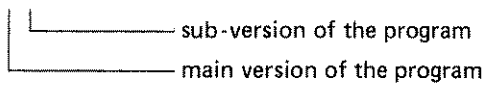
MOF25E3WSLD1.5LA5AC1MA1



Identification mode

Another remote control command permits identification of the device by a controller. When the command 'ID?' is sent to the PM 5192 this reflects e.g. the following string to the controller:

PM 5191/V 2.1



Status byte

When the remote control commands or the data has been received by the instrument, this is checked for syntax as well as for its validity with regard to the specifications. The result of this check is written into the status byte and can be called up by the IEC controller at any time when in serial poll.

6	5	4	3	2	1	Ø	Bit
SRQ	error message	not used	not used	syntax error	range exceeding	incompatibility of parameters	status byte PM 5191
64	32	16	8	4	2	1	value (dec.)

The status byte can be taken by the IEC controller either with or without a service request. If there is no service request the computer has to carry out a serial poll. In the course of this polling, the IEC controller sends the talker address to the PM 5191 for the output of the status byte.

Example for HP 85:

S = SPOLL (7Ø5)

When this Basic command has been executed, the variable S contains the sum of the decimal values of the individual bits set in the status byte. For example, if the variable S has the value 33 (= decimal value), then this is the sum of the individual values 32 + 1 that means bit 5 = '1' and bit Ø = '1'.

If the status byte is to be entered using SRQ, then the read out and evaluation is precisely the same as described above.

Activating of SRQ and masking the status byte is performed by 'MSR x' command, where 'x' is the decimal value sent to the PM 5191. The individual bit of the status byte is activated for SRQ if the corresponding bit of the binary pattern of the sent decimal value is '1'.

Example 1: masking with 'MSR 65';
i. e. bit 6 and bit Ø (dec. 64 + 1) of the status byte are activated. When the instrument sets one of these bits in the status byte, an SRQ is initiated.

Example 2: masking using 'MSR 103';
i. e. bits Ø, 1, 2, 5 and 6 (dec. 64 + 32 + 4 + 2 + 1) are activated. When the intrument sets one or several of these bits, an SRQ is initiated.

The status byte is accepted in the serial poll mode.

The bits Ø, 1, 2 and 5 serve to indicate erroneous data; if one of these bits is set, this corresponds with the flashing of one or more LEDs on the keyboard. If these bits are activated, the SRQ initiates an error output (status byte).

Use

When sending commands from the IEC controller to the PM 5191, the basic procedure is such that

1. the IEC computer sends the listener address of the PM 5191 via the bus,thus addressing the device as listener.

2. the IEC computer begins to send commands and data to the PM 5191.

The procedure for the transfer of data from the PM 5191 to the IEC computer, e. g. in the learn mode, is as following:

1. The IEC computer sends the talker address to the PM 5191, thus addressing the device as talker.

2. The IEC computer receives data from the PM 5191.

Attention:
If the PM 5191 is not prepared by 'ID?' or 'IS?' before addressing as talker the interface function is blocked. No further communication with the PM 5191 is possible until the device has been de-addressed, i. e. when the 'untalk' command has been sent by the computer. In this situation it would be advisable to make use of the 'time out' functions of the IEC computer.

1. Programming examples using the Philips P 2000 C computer

The following program is one example of how easily the frequency, amplitude and wave form can be set by a Philips P 2000 C computer.

device address = 4

```
10 IEC INIT
20 INPUT " BASIC FREQUENCY"; A$
30 INPUT " AMPLITUDE      "; B$
40 INPUT " WAVEFORM       "; C$
50 D$="F"
60 E$="LA"
70 F$=D$+A$+E$+B$+C$
80 IEC PRINT #4,F$
90 GOTO 10
100 IEC END: END
```

In lines 2Ø, 3Ø and 4Ø the values for the frequency, amplitude and wave form characters are entered via the computer's keyboard. Together with the two headers D$ = F for frequency and E$ = LA for amplitude in Vpp, these values are linked together in line 7Ø to form a common string (F$) and sent to the PM 5191 in line 8Ø. In this example, the device address must be set to '4'.

The following example shows the control of the PM 5191 by the Philips P 2000 C computer using a service request for error messages. This program also permits the intake of data strings for the learn and identification modes of the instrument.

```
                                                    device address = 5
10 DIM A$(50)
20 DIM B$(50)
30 B$=""
40 IEC INIT
50 IEC REMOTE
60 IEC LOCAL LOCKOUT
70 IEC PRINT #5,"MSR 103"                           A initialisation
80 IEC TIMEOUT 1
90 ON ERROR GOTO 240
100 IEC ON SRQ GOSUB 220
110 REM
120 REM ---------------------                       ------------------------
130 REM
140 INPUT "COMMAND= ";A$
145 IF A$="//" THEN 195
150 IF A$="ID?" THEN 170
155 IF A$="IS?" THEN 170
160 IEC PRINT #5,A$:GOSUB 250
165 GOTO 140                                        B command received
170 IEC PRINT #5,A$                                   from keyboard,
175 IEC INPUT #5,B$                                   sent to PM 5191
180 PRINT B$
185 B$=""
190 GOTO 140
195 IEC LOCAL
200 STOP
205 GOTO 140
210 REM ----------------------                      ------------------------
215 REM INTERRUPT ROUTINE
220 IEC POLL #5,S                                   C interrupt routine
225 PRINT "INPUT ERROR  S= ";S
230 RETURN
235 REM ----------------------                      ------------------------
240 IEC UNT
245 RETURN
250 FOR I=1 TO 250                                  D time out error routine
255 NEXT I
260 RETURN
265 IEC END:END
```

Lines 10 – 100 of this program serve to initialize the IEC interface of both devices as well as to set the dimensions of the two string lengths A$ and B$.

In line 140 A$ picks up the command for the PM 5191. In the following lines 145, 150 and 155 the program checks on whether this command is 'IS?' for the learn mode, 'ID?' for the identification of the device, or '//' to switch back to local. If one of the two strings 'ID?' and 'IS?' is keyed in, the output of the command is followed immediately by taking in the string B$ with the consequent output on the VDU (lines 175 and 180). In case of an error the status byte is output using the service request (SRQ); bits 0, 1, 2, 5 and 6 were activated in line 70 using command 'MSR 103'. If an SRQ occurs, the program branches out at line 220 and carries out a serial poll there; the decimal value of the entered status byte is displayed as the variable 'S' in line 225.

If the PM 5191 is controlled by the P 2000 C via the IEEE interface, it should be taken into account that the respond time of the PM 5191 at the IEC bus is considerably slower than that of the P 2000 C. It is for this reason that line 160 calls up a short waiting loop using GOSUB 250 after the command (string A$) has been sent to the PM 5191. If an error occurs, then SRQ can be received before the next INPUT is started in line 140.

2. Programming example using an HP 85 computer

This example shows a possibility of controlling the PM 5191 via the IEC/IEEE bus using an HP 85. With this program all commands can be sent to the instrument, strings accepted and error messages (= status byte) received after a SRQ.

```
 10 DIM A$[30]                                  device address = 5
 20 DIM B$[30]
 30 B$=""
 40 REMOTE 705
 50 LOCAL LOCKOUT 7
 60 OUTPUT 705 ;"MSR 103"
 70 ON TIMEOUT 7 GOSUB 360                      A
 80 SET TIMEOUT 7;100
 90 ON INTR 7 GOSUB 280
100 CONTROL 7,1 ; 8
110 REM
120 REM ----------------------
130 REM
140 DISP "COMMAND =";
150 INPUT A$
160 IF A$="//" THEN 220
170 OUTPUT 705 ;A$
180 ENTER 705 ; B$                              B
190 DISP B$
200 B$=""
210 GOTO 140
220 LOCAL 705
230 STOP
240 GOTO 140
250 REM
260 REM ----------------------
270 REM
280 CONTROL 7,1 ; 0
290 S=SPOLL(705)                                C
300 DISP "INPUT ERROR ! ! ! S="; S
310 CONTROL 7,1 ; 8
320 RETURN
330 REM
340 REM ----------------------
350 REM                                         D
360 ABORTIO 7
370 RETURN
380 END
```

A) Initialisation is carried out in this part of the program. Lines 7Ø and 8Ø prepare the call-up instruction for the error routine (D) that is called up in case of a time out. Timeout time is 1ØØ milliseconds.

The line 4Ø switches the device to 'remote' and prevent the keyboard from being used manually. Line 5Ø disables the function of the LOCAL key. In line 6Ø of the program the masking command 'MSR 1Ø3' is sent to the PM 5191, thus permitting error messages and status information to be sent with a service request (SRQ). Line 9Ø of the program determines the address of the service routine that is called up when the interrupt appears; the command in line 1ØØ means interrupt (SRQ) enable to the computer.

B) In this part of the program the commands for the PM 5191 are given by the computer's keyboard (line 15Ø) and sent to the device via the IEC bus (line 17Ø). The ENTER command in line 18Ø permits data strings to be taken up in the learn mode (command 'IS?') as well as identification of the device (command 'ID?') and for this to be indicated (line 19Ø). Line 16Ø, 22Ø and 23Ø of the program serve only to switch back to local after '///' has been entered.

C) This is the service routine called up by the program as soon as the PM 5191 has set the SRQ sequence. The command in line 28Ø blocks any further interrupts, line 29Ø carries out a serial poll and passes the value (decimal value) of the status byte received from the generator to the variable 'S'. In line 3ØØ of the program this variable 'S' is shown together with the command 'INPUT ERROR' at the VDU of the computer. And finally the command in line 31Ø enables the interrupts for the computer again.

D) Timeout routine.

3.8. TEST-PROGRAM PM 5191

This test program contains 5 submodules:

TEST 1: Display and LED test
TEST 2: Keyboard test
TEST 3: Storage register test
TEST 4: Strobe test (test of the internal interfaces)
TEST 5: Test for the IEEE/IEC-BUS interface

To activate this test program, press the key MODULATION OFF while power is switched on and keep it pressed for about 3 seconds.

The return to the main operating mode is only possible by switching power OFF and ON again.

When the test program is activated, the display shows "TEST x" where 'x' is a number from 1 to 5. This number changes continuously and slowly, and by pressing the key MODULATION OFF at the right moment, the respective test-submodule will be started.

To leave the test submodules, press the key MODULATION OFF for about 2 seconds.

TEST 1 : Display and LED test

Step 1: 7-segment-display

All display segments and LEDs are switched on for about 2 seconds.
After this the program starts to switch on one segment after the other for four display positions simultaneously. Finally, the decimal points of these four positions remain lit and the program starts to do the same with the next four display positions.
After the last four digits were tested, the program switches on all segments and LEDs and remain in this state until the key MODULATION OFF was pressed once again.

Step 2: LEDs

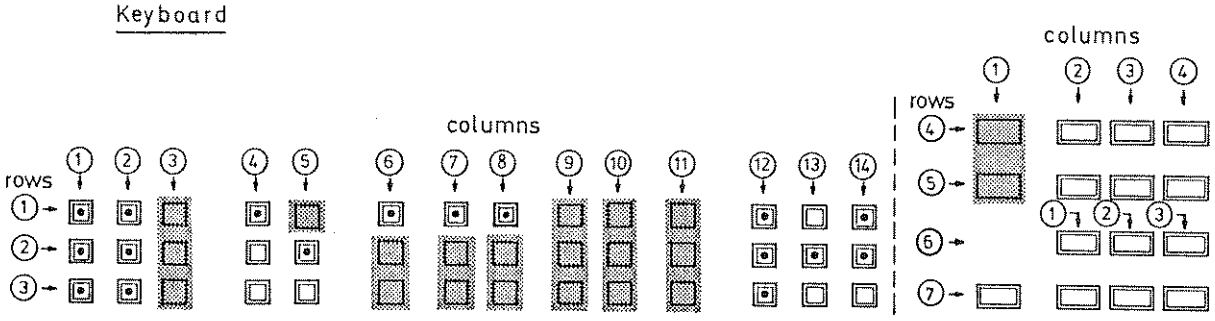
All LEDs will be switched on sequentially, one after the other, for approx. 0.5 seconds beginning with the uppermost left one (inside the key sine wave). When the last LED was switched on (key △LEVEL) it remains lit and the indication "End" appears at the display until the key MODULATION OFF was pressed. Then the program returns to the test-menu.

TEST 2: Keyboard test

The display shows the indication: 1 – Ø1 – – – –

Now you must press the first key of the first row: 1 – Ø1 – – – –
(row 1) – (column 1)

Keyboard



When the right key was pressed, the display shows

1 – Ø1 1 1 1 1

for about 1 second and changes then to

1 – Ø2 – – – –

as a request to press the second key in the first row. In case of a failure, the display would show

Err 1 – Ø1 x – xx

where x – xx indicates the wrong code (row and column). This error indication will only be reset by pressing the requested key – in case of a hardware failure at the keyboard unit it would not be possible to get the right code and thus to reset the error message.

When the last key was pressed, the keyboard test is finished and the display indicates "End". To leave this diagnostic submodule and to get back to the test menue, the key MODULATION OFF must be pressed.

TEST 3 : Storage register test

Attention:
This memory test damages the register contents. When the instrument is switched on after the storage register test was executed, the display indicates "Err 3" which means that there are now no parameters in the storage register – the complete contents (parameters) are destroyed.

The display indicates

MEMO 1 –

and the program starts to write a test pattern into each location of the memory chip, reads it again, and checks this value for correctness. When no failure was detected, the same will be done with a second pattern. In case that there is no failure, the display shows

MEMO 1 – 1

and in case of a failure

MEMO 1 – Ø

With MODULATION OFF the program returns to the test menu.

TEST 4 : Strobe test

The display indicates

STRO x

where x is a number from 6 to 15. This number changes continuously and slowly. By pressing the key "MODULATION OFF" at the right moment the required strobe line will be selected. The display shows then e. g.:

STRO Ø8 – 1

which means that the output lines of the shift registers controlled by strobe line 8 show a specific bit-pattern. If MODULATION OFF was pressed once for a short moment all output lines of the shift registers change their state. Now the display shows:

STRO Ø8 – Ø

Each time the MODULATION OFF-key is pressed for a short moment, the states of these output lines will be inverted. If MODULATION OFF is pressed for longer than about 1 second, this subprogram will be left and the display shows again:

STRO x

If the key MODULATION OFF is pressed again for longer than about 1 second, the program will return to the test menu.

This strobe test serves the fault finding in the internal C-bus system. More detailed information, e. g. measuring points, positions of ICs and measuring values are described in the service manual.

TEST 5 : IEC-Bus test

The display shows the indication

IEC BUS

Each character sent from the controller via the IEC (IEEE)-Bus will be decoded and displayed with its hexadecimal code, e. g.

ASCII 'A' indication 41 H
ASCII '3' indication 33 H
etc.

The device address of the PM 5191 is fixed to 2Ø.

With the key MODULATION OFF the program returns to the test menu.