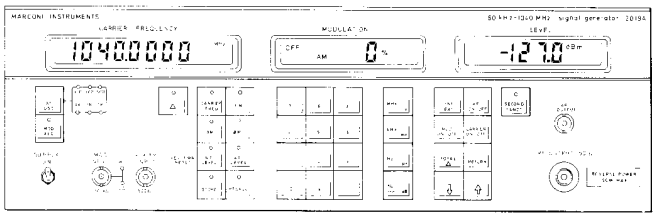
Marconi
Instruments

Marconi

2018A & 2019A

SIGNAL GENERATORS



Operating Manual

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Operating Manual
H 52018-910P Vol. 1
2nd Edition

SIGNAL GENERATORS

2018A and 2019A

80 kHz to 520 MHz

Part no.
52018-910P

and versions in -400 series
from 52018-401R to -413N

80 kHz to 1040 MHz

Part no.
52019-910E

and versions in -400 series
from 52019-401L to -413P

Printed in the UK

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CONTENTS

ASSOCIATED PUBLICATIONS

	Part No.
Service Manual, H 52018-910P, Vol. 2	46881-512Z

PREFACE

WARNINGS, CAUTIONS AND NOTES

These terms have specific meanings in this manual:-

WARNINGS contain information to prevent personal injury.
CAUTIONS contain information to prevent damage to the equipment.
Notes contain important general information.

HAZARD SYMBOLS

The meaning of hazard symbols appearing on the equipment is as follows:-

Symbol	Type of hazard	Reference in manual
	Dangerous voltages	Page (iv)
	Static sensitive components	Page (v)

MANUAL AMENDMENT STATUS

Each page in this manual bears the date of its original issue or, if it has been amended, the date and status number of the amendment. Any changes subsequent to the latest amendment status are included on Manual Change sheets coded C1, C2 etc. at front of the manual.

OPERATING PRECAUTIONS

This product has been designed and tested in accordance with IEC Publication 348 – 'Safety Requirements for Electronic Measuring Apparatus'. To keep it in a safe condition and avoid risk of injury, observe the following WARNING notices. To avoid damage to the equipment, observe the CAUTION notices.

WARNING – ELECTRICAL HAZARDS

⚠ **AC supply voltage.** This equipment conforms with IEC Safety Class 1, meaning that it is provided with a protective earthing lead. To maintain this protection the mains supply lead must always be connected to the source of supply via a socket with an earthing contact. Make sure that the earth protection is not interrupted if the supply is connected through an extension lead or an autotransformer.

Before fitting a non-soldered plug to the mains lead cut off the tinned end of the wires, otherwise cold flowing of the solder could cause intermittent contact.

Do not use the equipment if it is likely that its protection has been impaired as a result of damage.

Fuses. Note that there is a supply fuse in both the live and neutral wires of the supply lead. If only one of these fuses should rupture, certain parts of the equipment could remain at supply potential.

Make sure that only fuses of the correct rating and type are used for replacement. Do not use mended fuses or short-circuited fuse holders.

To provide protection against breakdown of the supply lead, its connectors (and filter if fitted), an external supply fuse with a continuous rating not exceeding 6 A should be used in the live conductor (e.g. fitted in the supply plug).

Removal of covers. Disconnect the supply before removing the covers so as to avoid the risk of exposing high voltage parts. If any internal adjustment or servicing has to be carried out with the supply on, it must only be performed by a skilled person who is aware of the hazard involved.

Remember that capacitors inside the equipment, including any supply filter capacitors, may still be charged after disconnection of the supply. Those connected to high voltage points should be discharged before carrying out work inside the equipment.

WARNING – OTHER HAZARDS

Parts of this equipment are made from metal pressings, therefore it should be handled with due care to avoid the risk of cuts or scratches.

Some of the components used in this equipment may include resins and other materials which give off toxic fumes if incinerated. Take appropriate precautions, therefore, in the disposal of these items.

Beryllia (beryllium oxide) is used in the construction of the following components in this equipment:

Unit AC4 : transistor TR10

This material, when in the form of fine dust or vapour and inhaled into the lungs, can cause a respiratory disease. In its solid form, as used here, it can be handled quite safely although it is prudent to avoid handling conditions which promote dust formation by surface abrasion.

Because of this hazard you are advised to be very careful in removing and disposing of these components. Do not put them in the general industrial or domestic waste or despatch them by post. They must be separately and securely packed and clearly identified to show the nature of the hazard and then disposed of in a safe manner by an authorized toxic waste contractor.

CAUTION – LCD HANDLING

When using this equipment take care not to depress the front or rear faces of the display module as this may damage the liquid crystal display elements.

CAUTION – STATIC SENSITIVE COMPONENTS

⚠ This equipment contains static sensitive components which may be damaged by handling – refer to the Service Manual for handling precautions.

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Chapter 1

GENERAL INFORMATION

FEATURES

2018A and 2019A are stable, AM/FM synthesized signal generators. 2018A covers the frequency range 80 kHz to 520 MHz. 2019A includes a frequency doubler which increases the frequency range to 1040 MHz. Both are phase locked to a frequency standard and can be set to a resolution of 10 Hz at frequencies up to 520 MHz and, for 2019A, a resolution of 20 Hz above 520 MHz.

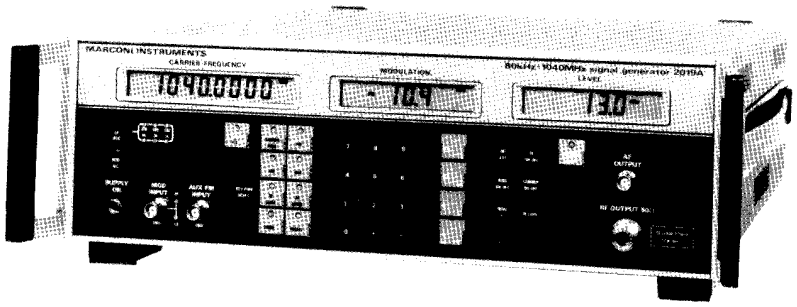


Fig. 1 80 kHz to 1040 MHz AM/FM Synthesized Signal Generator 2019A

Front panel operation is carried out by direct entry of required settings via the keyboard. Microprocessor control ensures maximum flexibility and allows programming by the General Purpose Interface Bus (GPIB).* This facility is an optional accessory enabling the instrument to be used either as a manually operated bench mounted instrument or as part of a fully automated test system.

**GPIB – Marconi Instruments General Purpose Interface Bus in accordance with IEEE Standard 488 – 1978 and IEC Publication 625–1.*

Output

Calibrated output levels from –127 dBm to +13 dBm (0.2 μV to 2 V EMF) in the CW, FM and ΦM modes and up to +7 dBm (1 V EMF) in the AM mode are provided. A choice of nine output level calibration units can be obtained on the front panel. The RF output level can be set to a resolution of 0.1 dB or better over the entire output voltage range and features a total cumulative accuracy of ±1 dB up to 520 MHz (±2 dB from 520 MHz to 1040 MHz). Protection against the accidental application of up to 50 W of reverse power is provided by a fast responding reed relay.

Modulation

Amplitude and frequency modulation can be applied from either external or internal modulation sources. The internal modulation source provides six fixed modulation frequencies suitable for most normal applications.

Front panel

The instrument settings are displayed by three liquid crystal displays that include annunciators to show the units of the displayed data. All data is entered on a keyboard that has been designed to be simple and logical to use. Non–volatile store and recall facilities are also provided by using an electrically alterable read only memory that does not require a battery back–up system. Carrier frequency, FM, ΦM, AM, RF and AF level functions may be incremented or decremented using the up/down keys.

Second function mode of operation

This includes the means of setting the GPIB address, selection of alternative RF level calibration units, access to various calibration routines, indication of instrument running hours and an identity string that displays instrument type, software issue and serial number. Up to 32 ASCII characters may also be stored in non–volatile memory by the user via the GPIB bus. Modulation input level status information is also available via the GPIB bus if required.

Variants

Four individual variants are available for both 2018A and 2019A, as follows:–

(1) **Extended FM bandwidth**, for stereo and digital signalling measurements.

(2) **Avionics**, for testing VOR and ILS systems.

(4) **Extended carrier frequency**, for measurements down to 10 kHz.

(8) **Pulse modulation**, for testing radar equipment.

These variants can be factory fitted singly or in any combination up to three as shown in Table 1–1.

TABLE 1-1 SINGLE & COMBINATION OPTIONS

Part no.		Variant			
52018-	or 52019-	(1)	(2)	(4)	(8)
401R	401L	Extended FM	-	-	-
402B	402L	-	Avionics	-	-
403K	403F	Extended FM	Avionics	-	-
404A	404G	-	-	10 kHz Carrier	-
405Z	405V	Extended FM	-	10 kHz Carrier	-
408U	408D	-	-	-	Pulse Mod
409Y	409T	Extended FM	-	-	Pulse Mod
410E	410W	-	Avionics	-	Pulse Mod
411U	411D	Extended FM	Avionics	-	Pulse Mod
412Y	412T	-	-	10 kHz Carrier	Pulse Mod
413N	413P	Extended FM	-	10 kHz Carrier	Pulse Mod

Confirmation of the variant(s) fitted can be obtained by comparing the part number on the identification plate at the rear of the instrument and the above list.

PERFORMANCE DATA

The performance specifications for 2018A and 2019A are in most respects identical, therefore the following data applies to both instruments except where otherwise stated. Variants having different parameters are specified only where a more limiting parameter applies. Where a combination of options causes a parameter to be specified more than once then the more limiting parameter will apply. Alternative parameter information that is specific to a variant is shown in italic type.

Carrier frequency

Range:

2018A: 80 kHz to 520 MHz (usable down to 30 kHz).

2019A: 80 kHz to 1040 MHz (usable down to 30 kHz).

AVIONICS VARIANTS

Range:

2018A: 1.5 MHz to 520 MHz.
2019A: 1.5 MHz to 1040 MHz.

10 kHz CARRIER VARIANTS

Range:

2018A: 10 kHz to 520 MHz.
2019A:10 kHz to 1040 MHz.

Selection:	By keyboard entry.
Frequency indication:	8 digit LCD – for details see under Keyboard and displays.
Accuracy:	Equal to the frequency standard accuracy – see under Frequency standard.
Resolution:	10 Hz up to 520 MHz. 20 Hz from 520 MHz to 1040 MHz.

RF output

Level:	0.2 μV to 2 V EMF (–127 to +13 dBm) in CW and FM modes. 0.2 μV to 1 V EMF (–127 to +7 dBm) when AM is selected.
Selection:	By keyboard entry – units may be μV, mV, V (EMF or PD) or dB relative to 1 μV, 1 mV, 1 V (EMF or PD) or dBm. Conversion between dB and voltage units may be achieved by pressing the appropriate unit key (dB or V, mV, μV).
Display:	4 digit LCD with units annunciators – see under Keyboard and displays.
Resolution:	0.1 dB or better over entire voltage range.
Level accuracy:	±1 dB from 80 kHz to 520 MHz. ±2 dB from 520 MHz to 1040 MHz.

AVIONICS VARIANTS

Level accuracy:	*±2 dB from 1.5 MHz to 5 MHz.* *±1 dB from 5 MHz to 520 MHz.* *±2 dB from 520 MHz to 1040 MHz.*

10 kHz CARRIER VARIANTS

Level accuracy:	*±1 dB from 10 kHz to 520 MHz.* *±2 dB from 520 MHz to 1040 MHz.*

PULSE MOD VARIANTS

(Pulse mod. off):	*±1 dB from 80 kHz to 520 MHz.* *±3 dB from 520 MHz to 1040 MHz.*

(Pulse mod. on and carrier on):	*±1.5 dB from 10 MHz to 520 MHz.* *±4.5 dB from 520 MHz to 1040 MHz* *Note ...* *With pulse mod. on the maximum output level is reduced to +3 dBm.*
Output impedance:	50 Ω, type N female socket to MIL 39012/3D.
VSWR:	<1.2:1 up to 520 MHz. <1.5:1 above 520 MHz.
Reverse power protection:	An electronic trip protects the generator output against reverse power of up to 50 W from DC to 1 GHz from a source with a VSWR up to 5:1. The trip may be reset from the front panel or via the GPIB.

Spurious signals

Harmonically related signals:	For output levels less than 1 V EMF, better than –30 dBc for carrier frequencies up to 520 MHz and better than –20 dBc for carrier frequencies above 520 MHz.
Sub–harmonics:	None for carrier frequencies up to 520 MHz. –20 dBc for carrier frequencies above 520 MHz.
Non–harmonically related signals:	<–70 dBc at offset frequencies greater than 3 kHz for carrier frequencies from 2.03126 MHz to 1040 MHz. <–60 dBc at offset frequencies greater than 3 kHz for carrier frequencies from 80 kHz to 2.03125 MHz.
Residual FM:	Less than 6 Hz RMS in CCITT telephone psophometric band at 520 MHz and improving by approximately 6 dB/octave with reducing carrier frequency down to 2.03216 MHz.
Single sideband phase noise:	Better than –130 dBc/Hz at 90 MHz and 20 kHz offset from carrier.
RF leakage:	Less than 0.5 µV PD generated in a 50 Ω load by a 2 turn 25 mm loop, 25 mm or more from the case of the generator with the output level set to less than –10 dBm and the output terminated in a 50 Ω sealed load.

Frequency modulation

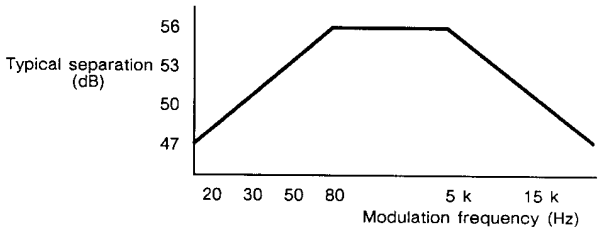
Range:	(i) Peak deviation from 0 Hz to up to 1% of carrier frequency for carrier frequencies from 2.03126 MHz to 1040 MHz. (ii) Peak deviation from 0 Hz to 100 kHz for carrier frequencies up to 2.03125 MHz.
Selection:	Internal modulation oscillator or external modulation input may be selected by the front panel keyboard.
Displays:	3 digit LCD – see under keyboard and displays.
Deviation accuracy:	±5% of deviation at 1 kHz modulating frequency excluding residual FM.
Resolution	3 digits or 10 Hz (whichever is the larger) up to 520 MHz. 3 digits or 20 Hz (whichever is the larger) above 520 MHz.
Frequency response:	±1 dB from 50 Hz to 100 kHz relative to 1 kHz. Usable down to 10 Hz with reduced deviation.

EXTENDED FM VARIANTS

Frequency response:	*±1 dB from 50 Hz to 100 kHz relative to 1 kHz.* *Usable down to 1 Hz with reduced deviation.* *The instrument is suitable for testing receivers requiring signalling tones with a frequency modulation content down to 1 Hz.* *Settling time with FM on is up to approximately 5 seconds to be within 100 Hz of final frequency.*

Stereo separation:

Better than 50 dB at 1 kHz for carrier frequencies from 88 MHz to 108 MHz.



Distortion:

<3% total harmonic distortion at 1 kHz modulating frequency and a deviation of up to 70% of the maximum available at any carrier frequency.

<0.3% total harmonic distortion at 75 kHz deviation at carrier frequencies from 88 MHz to 108 MHz at 1 kHz internal modulating frequency or external source with ALC off.

External modulation:

With modulation ALC on, the deviation is calibrated for input levels between 0.8 V and 1.2 V PD. With modulation ALC off, the deviation is calibrated for an input level of 1 V PD. HI or LO LEDs are provided as an aid to maintain calibrated modulation in the ALC off mode. Input impedance is nominally 100 kΩ.

Phase modulation

Range:

Modulation index; 0 to 10 radians for carrier frequencies below 2.03125 MHz. 0 to a value in radians equal to the carrier frequency in MHz for carrier frequencies above 2.03125 MHz subject to a maximum available phase modulation index of 999 radians.

Selection:

Internal modulation oscillator or external modulation may be selected by the front panel keyboard.

Display:

3 digit LCD – see under 'Keyboard and displays'.

Frequency response:

50 Hz to 10 kHz ±1 dB relative to 1 kHz.

Accuracy:	±5% excluding residual phase modulation.
External modulation:	With modulation ALC on, the deviation is calibrated for input levels between 0.8 V and 1.2 V PD. With modulation ALC off, the deviation is calibrated for an input level of 1 V PD. HI or LO LEDs are provided as an aid to maintain calibrated modulation in the ALC off mode. Input impedance is nominally 100 kΩ.
Distortion:	<3% total harmonic distortion at 1 kHz modulating frequency and at maximum deviation (equal to the carrier frequency in MHz) at any carrier frequency.

Amplitude modulation

Range:	0 to 99% in 1% steps.
Selection:	Internal modulation oscillator or external modulation input may be selected.
Display:	2 digit LCD - see under Keyboard and display.
Accuracy:	Better than ± (4% of depth setting +1%) for modulation depths up to 95% and 1 kHz modulating frequency for carrier frequencies up to 400 MHz.
Frequency response:	±1 dB from 20 Hz to 50 kHz relative to 1 kHz at 80% depth DC coupled.

10 kHz CARRIER VARIANTS

Frequency response:	*At 10 kHz carrier frequency AM is usable with up to 1 kHz mod. rate.*
Envelope distortion:	Less than 3% total harmonic distortion for modulation depths up to 80% at 1 kHz modulating frequency for carrier frequencies up to 400 MHz. Less than 2% total harmonic distortion for modulation depths up to 90% at 1 kHz modulating frequency for carrier frequencies up to 32 MHz.

AVIONICS VARIANTS

ILS performance: *≤0.045% AM difference in depth of modulation for ILS tones at 90 Hz and 150 Hz each at 40% modulation depth.*

External modulation input: With the modulation ALC on, the modulation depth is calibrated for input levels between 0.8 V and 1.2 V PD.

With the modulation ALC off, the modulation depth is calibrated for an input level of 1 V PD. HI or LO LEDs are provided as an aid to maintain calibrated modulation in the ALC off mode.
Input impedance is nominally 100 kΩ, DC coupled.

Pulse modulation

PULSE MOD VARIANTS

Carrier pulse response: *Rise time <100 ns.*
Fall time <100 ns.

Carrier on/off ratio: *>65 dB at 70 MHz carrier frequency, reducing to*
>50 dB at 520 MHz carrier frequency and then to
>35 dB at 800 MHz carrier frequency (usable to 1040 MHz).

Propagation delay pulse input to carrier pulse: *Typically 280 ns.*

Input: *Rear panel BNC connector.*
Input impedance 50 Ω.
Nominal signal levels 0 V for carrier off, +5 V for carrier on.

Selection and display: *Pulse modulation is selected by pressing [AM][ΦM] the two keys [PULSE][PULSE] simultaneously, followed by the MOD ON–OFF key. The modulation window then displays P and EXT.*

AF oscillator

Frequencies: 300 Hz, 400 Hz, 500 Hz, 1 kHz, 3 kHz and 6 kHz selected sequentially by repetitive pressing of the AF OSC key.

Display:	Six LEDs indicate selected frequency.
Frequency accuracy:	±5%.
Internal AF OSC output:	A front panel BNC socket provides an output for the AF signal.
Output level selection:	0.1 mV to 5 V RMS, selected by keyboard entry. Output may be entered in mV, V or as dBm into 600 Ω. Conversion between dB and voltage units may be achieved by pressing the appropriate key (dB,mV,V). The output frequency is always that of the AF OSC and is short circuit proof. At switch-on the AF level is set to 1 V.
Output level accuracy:	±5% above 50 mV RMS. ±10% from 0.5 mV to 50 mV RMS.
Maximum output:	Capable of driving a 2 kΩ load for output levels up to 5 V RMS. Capable of driving a 600 Ω load for output levels up to 2 V RMS.
Distortion	Less than 0.1% total harmonic distortion for a 1 kHz output frequency at an audio level of 5 V RMS into 100 kΩ.
Source impedance	<10 Ω.

Frequency standard

Internal or external frequency standard may be selected from the front panel. Either 1 MHz or 10 MHz standard may be selected by second function control. Annunciators show which is selected.

Frequency standard Input/Output:	A rear panel BNC socket provides an output from the internal frequency standard at either 1 or 10 MHz when internal standard is selected. This socket becomes the external standard input when external standard is selected.
Internal standard:	High stability, oven controlled 10 MHz crystal oscillator.
Temperature stability:	<±0.1 p.p.m. over temperature range of 0 to 40°C.
Warm-up time:	Within 0.5 p.p.m. of final frequency within 5 minutes from switch on at an ambient temperature of 20°C.

Internal standard output: Either 1 or 10 MHz, nominally 3 V p-p square wave may be selected by second function control. Source impedance 100 Ω nominal.

External standard input: Accepts 1 MHz or 10 MHz input of at least 1 V RMS. Maximum recommended input level is 2.5 V RMS. Input impedance is nominally 100 Ω.

Auxiliary inputs and outputs

Modulation input: A front panel BNC socket accepts an external modulation input. The input signal may be levelled by selecting the MOD ALC ON/OFF key. Two LED indicators, HI and LO provide an aid to maintain calibrated modulation in the ALC off mode.

External modulation input :

ALC ON: Input level nominally 1 V RMS into 100 kΩ - see under Frequency modulation and Amplitude modulation.

ALC OFF: 1 V RMS is required for calibrated conditions. When the HI and LO LEDs are extinguished the input voltage will be within the range 1 V ±5%.

Auxiliary FM input: The auxiliary FM input can be used to add sub-audio tones to the main modulation set. The input is enabled whenever FM or ΦM is selected and is independent of whether the instrument is set to internal or external modulation.

Deviation: With FM (INT or EXT) selected the application of 1 V RMS to the AUX FM INPUT will result in an FM deviation of 10% of that indicated in the modulation display.

With ΦM selected (INT or EXT) the application of 1 V RMS will result in an FM deviation in kHz equal to the phase deviation in radians shown in the modulation display.

Accuracy: ±15%.

Impedance: 600 Ω.

This facility is intended to allow the insertion of signalling tones used in receiver testing.

Frequency standard input/output: A rear panel BNC socket provides an output from the internal frequency standard when internal standard is selected and becomes the external standard input when external standard is selected. The choice of 1 MHz or 10 MHz reference standard may be made by a second function control.

Internal standard output: 1 MHz or 10 MHz at nominally 3 V p-p square wave. Source impedance 100 Ω nominal.

External standard input: Accepts either a 1 MHz or 10 MHz signal of at least 1 V RMS. Maximum recommended input level 2.5 V RMS. Frequency selected by second function control. Input impedance 100 Ω nominal.

Alternative RF and modulation sockets: Blanked holes are provided so that the RF output and modulation input socket can be fitted to the rear panel for systems use etc.

Keyboard and displays

Main and secondary keyboard functions: These are described in Chap. 3, Operation. All instrument settings are controlled by the front panel keyboard.

Displays: The main function of the three liquid crystal displays is to provide a simultaneous readout of carrier frequency, modulation and RF level.

(i) **Carrier frequency display** – 8 digit with annunciators to show frequency units, external frequency standard, frequency limit exceeded, remote operation selected and instrument addressed.

(ii) **Modulation display** – 3 digit with annunciators to show modulation units, FM, ΦM, AM, modulation off, external modulation selected, and modulation limit exceeded.

(iii) **RF level display** – 4 digit with annunciators to show RF level units, RF output off, reverse power trip operated, RF level limit exceeded and AF level units.

GPIB interface

A GPIB interface is available as an optional accessory and can be easily fitted by the user. All functions except the SUPPLY ON switch are remotely programmable. In addition to allowing full GPIB control of the instrument, the GPIB module has an auxiliary output socket which can be used to control relays etc.

Capabilities: Complies with the following subsets as defined in IEEE 488 – 1978 and IEC Publication 625-1: SH1, AH1, T6, TE0, L4, LE0, SR1, RL1, PP0, DC1, DT0, C0, E1.

Environmental

Conditions of storage and transport

Temperature: –40°C to +70°C.

Humidity: Up to 90% relative humidity.

Altitude: Up to 2500 m (pressurized freight at 27 kPa differential i.e. 3.9 lbf/in²).

Rated range of use (over which full specification is met)

Temperature: 0 to 55°C.

Safety

Complies with IEC Publication 348.

Radio frequency interference

Conforms to the requirements of EEC Directive 76/889 as to limits of RF interference.

Power requirements

Voltage: AC supply. Voltage ranges (switchable):

105 V – 120 V ±10%.
210 V – 240 V ±10%.

Frequency: 45 Hz – 440 Hz.

Consumption: 85 VA maximum.

Dimensions and weight (over projections but excluding optional front panel handles).

Height:	152 mm (6 in).
Width:	425 mm (16.7 in).
Depth:	525 mm (20.7 in).
Weight:	16 kg (35.2 lb).

ACCESSORIES

Supplied accessories

	Part no.
AC supply lead	43123-076Y
Operating manual H 52018-910P (Vol. 1)	46881-511A
Front panel blanking kit	46883-654E

Optional accessories

Service manual H 52018-910P (Vol. 2)	46881-512Z
GPIB module	54433-001U
Maintenance kit, includes RF extender cables, LCD insertion and extraction tools etc.	54711-033E
Rack mounting kit	46883-506M
Front handle kit	46883-511R
GPIB manual H 54811-010P (contains details of general GPIB protocols)	46881-365R
GPIB lead assy.	43129-189U
Screened GPIB lead assembly (for enhanced RFI performance)	43129-279M
GPIB IEEE/IEC connector adapter	46883-408K
RF connecting cable TM 4969/3; 50 Ω, 1.5 m (5 ft) BNC	43126-012S
RF coaxial cable (N to N type)	54311-095C
Coaxial adapter type N to BNC	54311-092P
Impedance adapter 50/75 Ω	54411-051X

Chapter 2

INSTALLATION

UNPACKING AND REPACKING

Retain the container, packing material and the packing instruction note (if included) in case it is necessary to reship the instrument.

If the instrument is to be returned for servicing attach a label indicating the service required, type or model number (on rear label), serial number and your return address. Pack the instrument in accordance with the general instructions below or with the more detailed information in the packing instruction note.

(1) Place supply lead in suitable plastic bag and tape it to the instrument rear panel.

(2) Place the instrument within its plastic cover.

(3) Ensure that the padded fitting is in place within the inner carton and slide the instrument in, rear panel first, leaving the front panel exposed at the open end.

(4) Fit the separate front panel protecting cover over the panel and close and seal the inner carton.

(5) Place one of the moulded plastic cushions in the bottom of the outer carton and insert the inner carton to locate in the cushion recess.

(6) Place the other plastic cushion over the other end of the inner carton and close and seal the outer carton.

(7) Wrap the container in waterproof paper and secure with adhesive tape.

(8) Mark the package FRAGILE to encourage careful handling.

Note ...

If the original container or materials are not available, use a strong double-wall carton packed with a 7 to 10 cm layer of shock absorbing material around all sides of the instrument to hold it firmly. Protect the front panel controls with a plywood or cardboard load spreader; if the rear panel has guard plates or other projections a rear load spreader is also advisable.

MOUNTING ARRANGEMENTS

Excessive temperatures may affect the instrument's performance; therefore, completely remove the plastic cover, if one is supplied over the case, and avoid standing the instrument on or close to other equipment that is hot.

CONNECTING TO SUPPLY

Before connecting the instrument to the AC supply check the position of the two voltage selector switches on the rear panel. A locking plate fixes both switches into one of four possible combinations and only the selected voltage range is displayed when the locking plate is fixed to the back panel. The instrument is normally despatched with the switches selected to 230/240 V. To select a different voltage range remove the locking plate and re-position the switches to the required range as shown in Fig. 2-1 and refit the locking plate into its alternative position.

Note ...

The a.c. supply fuse may also have to be changed. An indication of the correct fuse rating is given with each displayed voltage range:-

i.e. 1 A-T (1 amp time lag) - 105 V to 120 V ±10%
0.5 A-T (0.5 amp time lag) - 210 V to 240 V ±10%

The fuses are 20 mm x 5 mm cartridge type.

The free AC supply cable is fitted at one end with a female plug which mates with the AC connector at the rear of the instrument. When fitting a supply plug ensure that conductors are connected as follows:

Earth - Green/yellow
Neutral - Blue
Live - Brown

When attaching the supply lead to a non-soldered plug it is recommended that the tinned ends of the lead are first cut off owing to the danger of cold flow resulting in intermittent connections.

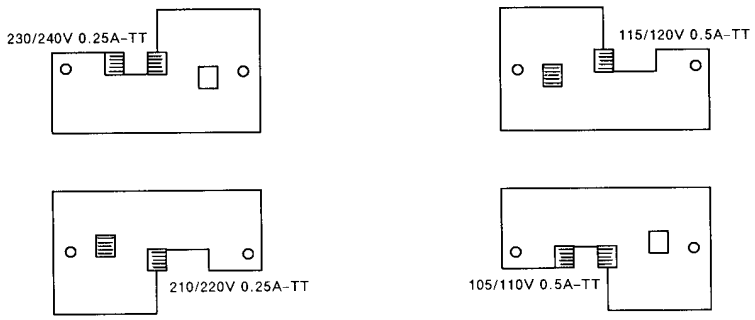


Fig. 2-1 Voltage ranges showing switch and locking plate positions

SAFETY TESTING

Where safety tests on the AC supply input circuit are required, the following procedures can be applied. These comply with BS 4743 and IEC Publication 348. Tests are to be carried out as follows and in the order given, under ambient conditions, to ensure that AC supply input circuit components and wiring (including earthing) are safe.

(1) Earth lead continuity test from any part of the metal frame to the bared end of the flexible lead for the earth pin of the user's AC supply plug. Preferably a heavy current (about 25 A) should be applied for not more than 5 seconds.

Test limit : not greater than 0.5 Ω.

(2) 500 V DC insulation test from the AC supply circuit to earth.

Test limit : not less than 2 MΩ.

GPIB INTERFACE

The GPIB interface is an optional accessory and can easily be fitted by the user as follows:-

(1) Remove and discard the rectangular cover plate from the left-hand side of the rear panel.

(2) Withdraw the interconnecting lead from inside the instrument and connect this to the GPIB assembly taking care that the ribbon cable connector SKAK is correctly aligned with GPIB module connector PLAK.

(3) Switch instrument on temporarily and check that the front panel displays data correctly. If satisfactory switch off and continue with step (4). If the display is corrupted however then re-check the alignment of SKAK and PLAK as indicated in step (2).

(4) Using the four retaining screws provided, secure the GPIB assembly to the rear panel where four pre-positioned captive nuts are fitted. The interface is now ready for GPIB operation.

(5) Connection to other equipment which has a 24-way bus connector to IEEE Standard 488 can be made with the GPIB lead assembly 43129-189U, availalble as an optional accessory. Where conformity with the radio frequency interference limits specified by VDE (Verband Deutscher Electrotechniker) is required, an alternative double screened GPIB lead assembly 43129-279M is available. An IEEE-to-IEC adapter 46883-408K is also available for interfacing with systems using a 25-way bus connector to IEC Recommendation 625 - see Fig. 2-2.

GPIB connector contact assignments

The contact assignment of the GPIB cable connector and the device connector is as shown in Fig. 2-2.

To set the GPIB address see page 3-13, Second function 2.

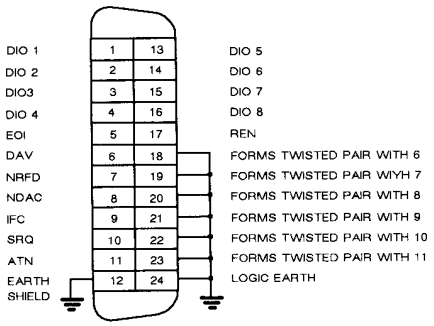


Fig. 2–2 GPIB connector contact assignments

RACK MOUNTING

The instrument may be mounted in a standard 19 inch rack using the kit 46883–506M available as an optional accessory. Fitting instructions are as follows:–

(1) Remove both top and bottom outer covers, detach and discard front and rear feet on bottom cover.

(2) Detach and discard side trim infills, countersunk screws and screw cups.

(3) If you wish to transfer the RF output and modulation input sockets on the rear panel complete steps 4 to 10. If not go straight to step 10.

(4) Remove the front panel assembly by slackening the two screws exposed in each side and lay face down protecting the LCDs.

(5) Disconnect the semi-rigid coaxial plug PLAV situated at the rear of the top RF box and remove the four RF box securing screws (one in each corner bracket); raise the box into the servicing position.

(6) Unsolder the yellow and orange wires from the front panel MOD–IN socket and adjacent earth tag. Unfasten and remove the socket from the front panel mounting, remove and discard the blind grommet from the MOD–IN alternative rear panel position. Uncleat excessive modulation cableform from the lower RF box and re–route this to the rear panel. Refix MOD–IN BNC socket to the rear panel position. Now reconnect the yellow wire to the MOD–IN socket and the orange wire to the adjacent earth point. Select a BNC replacement blind grommet (issued with the included blanking kit) and fit this into the front panel position. Recleat the cable to the lower RF box.

(7) Disconnect the RF output connector from SKBA on AT0/1 attenuator and also the RF OUTPUT socket from the front panel assembly. Withdraw the connector and socket through the front panel. Similarly, remove the blind grommet from the alternative rear panel RF OUT position, discard this and fit the replacement 'N' type grommet (supplied in the blanking kit) into the front panel position.

(8) Pass the RF output connector through the alternative rear panel position and secure the RF OUTPUT socket to the rear panel. Re-route the cable over the bottom RF box and reconnect SKBA to AT0/1 attenuator.

(9) Lower the top RF box and secure this, reconnect PLAV to the rear of the box. Replace and secure the front panel assembly and side trim, also refit front handles if previously fitted.

(10) Fit rack brackets in front panel handles or side trim recesses using the M4 x 16 pan head screws and washers supplied. Finally refit top and bottom covers.

Note ...

When fitting the unit into the rack; support at the rear should also be given, e.g. a shelf located within the rack or cubicle.

FRONT PANEL HANDLES

Front handles are supplied only as optional accessories, fitting instructions are as follows:-

(1) Remove the side trim infills and side trims. Discard the side trims but retain the side trim infills, screws and washers for re-use. Position the instrument on its side.

(2) Fit the panel handles without the side trim infills first, aligning all four screws. Tighten down the two inner screws and washers and remove the two outer screws.

(3) Refit the side trim infills, replace the outer two screws and washers and tighten down.

Chapter 3

OPERATION

PRINCIPLES OF CONTROL

All operations of the generator are carried out from the front panel keyboard which is divided into five distinct colour coded areas. Remote operation from a GPIB controller is possible if the optional GPIB interface is fitted.

FRONT PANEL

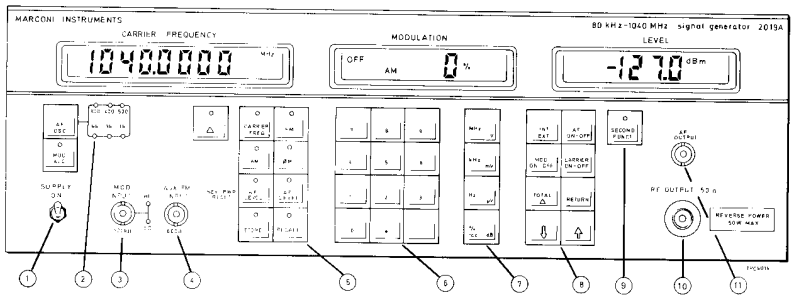


Fig. 3–1 Front panel controls

1 **SUPPLY switch.** Applies the AC supply voltage.

2 **AF OSC, MOD ALC keys (black).** These control the internal modulation frequency and the modulation automatic level control. The MOD ALC key has an integral LED to indicate that selection has been made. When MOD ALC is selected a MOD input of between 0.8 and 1.2 V will be automatically levelled.

3 **MOD INPUT (100 kΩ) socket.** Accepts an input from an external modulation source of 1 V ±5%. If the input is outside this range the HI or LO LED lights.

4 **AUX FM INPUT socket.** Enables the use of additional modulation tones with either internal or external modulation source applied. An input of 1 V RMS produces an additional FM deviation of 10% of the FM display value.

5 **Function keys (orange).** Nine keys each with an integral LED to indicate the function selected.

6 **Numerical keypad (black).** For entering the numerical value for the function selected, including minus sign and decimal point.

7 **Units keys (grey).** These four keys assign units of measure and also terminate the numerical entry.

8 **Miscellaneous functions (black).** This right-hand group of eight black keys is for switching the carrier and modulation on and off, incrementing/decrementing and selecting internal and external modulation.

[9] **SECOND FUNCT key (blue).** This key with an integral LED accesses additional secondary control and calibration facilities.

[10] **RF OUTPUT.** 50 Ω N type socket with reverse power protection.

[11] **AF OUTPUT.** BNC type socket providing low impedance output at the frequency selected by the internal AF OSC control which is available when either INT or EXT modulation is selected. This allows the testing of transceiver audio circuits (microphone inputs etc.).

REAR PANEL

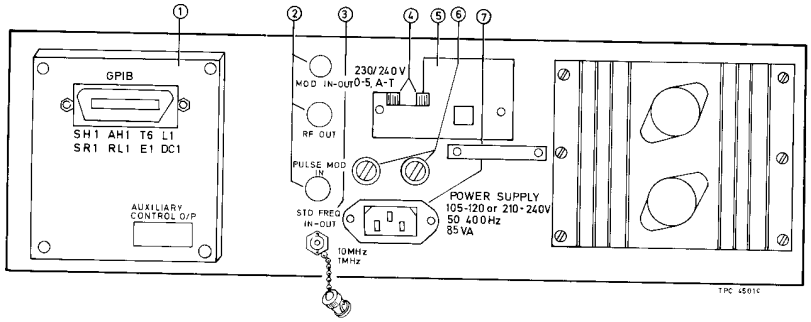


Fig. 3–2 Rear panel controls with optional GPIB interface

[1] **REMOTE CONTROL GPIB INTERFACE.** This optional accessory allows remote control of the instrument and in addition has an auxiliary output socket which can be used to control relays etc. Accepts the 24–way IEEE GPIB connector.

[2] **MOD IN and RF OUT.** These blanked holes provide alternative connector locations when the instrument is rack mounted. See Chap. 2 for fitting instructions. **PULSE MOD IN.** Used only if the pulse modulator option is fitted.

[3] **STD FREQ IN–OUT.** BNC socket provides an output from one of two possible internal reference standard frequencies (1 MHz or 10 MHz), or alternatively allows the use of a 1 MHz or 10 MHz external reference.

[4] **VOLTAGE SELECTOR switches.** A combination of four positions which select ranges of 105/110 V, 115/120 V, 210/220 V or 230/240 V, each with a 10% tolerance to afford a complete cover over the voltage ranges 95 V to 132 V and 190 V to 264 V.

[5] **Selector switch plate.** Can be turned and/or reversed to secure the VOLTAGE SELECTOR switches in one of four pre–selected positions.

[6] **AC fuses.** Supply input fuses are rated at 0.5 A (slow–blow) for the 190 V to 264 V range or 1 A (slow–blow) for the 95 V to 132 V range.

[7] **AC supply input.** The AC supply is connected through this plug which mates with the connector fitted to the supply lead.

PREPARATION FOR USE

(1) Switch SUPPLY on and check that the LEVEL window displays the software issue number for about a second and then takes up the initial operating mode, that is

CARRIER FREQUENCY: 520 MHz (or 1040 MHz for 2019A)
MODULATION: 0
LEVEL: –127 dBm (or equivalent)
and AF OSC 1k (on the LED ring).

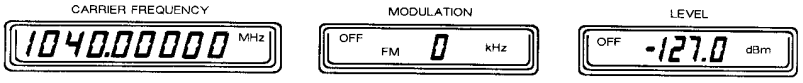


Fig. 3–3 2018A initial operating mode displays

Notes...

(i) If the instrument has developed a fault an error number will be continuously displayed – see page 3–25.

(ii) If 2nd function 16 was in use before the previous switch–off, the store 10 contents will be displayed instead of the initial conditions above.

(iii) If you have just switched on and are using an external frequency standard, error 15 may be displayed until the internal standard reaaches normal operating temperature.

(2) Check that the CARRIER FREQUENCY window does not indicate EXT STD, unless an external frequency standard input is required. If this has been inadvertently selected press CARRIER FREQ and INT/EXT keys to reselect internal frequency standard.

(3) During normal operation the instrument's internal reference standard will give an accuracy within the rated performance after a warm–up period of 5 minutes at normal ambient temperatures.

OPERATING PROCEDURES

The general procedure for selecting a numerical parameter such as frequency, modulation or RF level is to enter the following sequence:

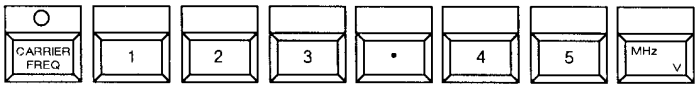
FUNCTION (orange key) which lights the integral LED.
NUMERICAL VALUE (black key) including decimal marker and negative sign.
UNITS (grey key) which acts as terminator.

If an error is made while keying, clear the entry by re–selecting the function key.

Note...

If a value entered is outside the rated range, a LIMIT annunciator will appear in the relevant display and the instrument will set to the nearest end–of–range value. (An exception to this is if a carrier frequency less than 80 kHz is selected – see CARRIER FREQUENCY overleaf.)

CARRIER FREQUENCY



Press the orange CARRIER FREQ key (unless its LED is already lit). Enter the required value via the numerical key pad and note that the data entered appears in the CARRIER FREQUENCY display. Terminate the instruction by pressing the MHz, kHz or Hz key.

If a request lower than the minimum specified frequency of 80 kHz is made, the LIMIT annunciator is displayed and the instrument tunes to the requested frequency but with a degraded performance. When selections below 30 kHz are made the accuracy of the RF level output will be impaired.

Note ...

If the 10 kHz Carrier frequency variant is fitted the accuracy of the selected output level will be maintained down to the lower specified limit of 10 kHz. If the Avionics variant is fitted then the lowest specified limit is 1.5 MHz.

Carrier on/off

The carrier may be switched off or on at any time by pressing the CARRIER ON–OFF key.

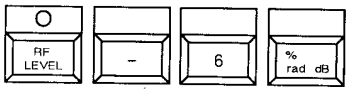
Internal/external frequency standard

At switch-on the instrument will set to either internal or external frequency standard, depending on its last state before switch-off. External standard control is indicated by the annunciator EXT STD in the CARRIER FREQUENCY display. Pressing the INT/EXT key whilst the LED in the CARRIER FREQ key is lit will toggle between internal and external standard.

When INT is selected, the frequency is controlled by an internal high stability 10 MHz crystal controlled oscillator. The internal standard is also available as an output at 1 MHz or 10 MHz of nominally 3 V p-p at 100 Ω source impedance at the rear panel STD FREQ IN–OUT socket.

When EXT is selected, an external 1 MHz or 10 MHz signal of at least 1 V RMS is required at the rear panel STD FREQ IN–OUT socket. The instrument will lock automatically to this signal. The choice of external standard frequency is determined by Second function 14.

RF LEVEL



Press the RF LEVEL key and enter the required value including any decimal point or minus sign. The terminator keys give a choice of 3 linear units (volts, millivolts and microvolts) and a logarithmic unit (decibels). These units can be further qualified by second function 15 which offers the choice of EMF or PD and allows the logarithmic units to be expressed in dBμV, dBmV or dBm. The units in use will be shown on the LEVEL display.

Note...

To convert an RF level indication from linear to log units or vice versa, simply press the new units key. For example, to convert an indication in mV to dBm press the dB key.

Reverse power protection

Accidental application of reverse power to the RF OUTPUT socket will trip the reverse power protection (RPP) unit and the REV PWR LIMIT will appear on the LEVEL display. During this time the keyboard will not respond except to reset commands.

After the source of power has been disconnected reset the RPP by pressing the RF LEVEL function key. Attempting to reset the RPP with power still applied will result in the RPP tripping again.

When the instrument is switched OFF, the output socket is automatically disconnected from the output attenuator – a further safety feature.

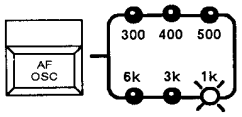
Operation with 75 Ω loads

The performance specification for the instrument assumes operation into 50 Ω loads, but often it is desirable to work into mismatched loads. This is in general possible although an uncertainty of performance may be introduced. In the particular case of a 75 Ω load, this can be accurately matched for carrier frequencies up to 500 MHz by using the 50/75 Ω Impedance Adapter, Part No. 54411–051X, offered as an optional accessory. This 25 Ω series load maintains the correct (open circuit) voltage calibration and allows the reverse power protection circuit to function correctly.

MODULATION

The instrument normally switches on in the internal modulation mode.

Internal modulation frequency



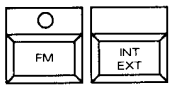
The internal AF modulation oscillator frequency can be controlled by successive presses of the AF OSC key. The six LEDs adjacent to the AF OSC key indicate the oscillator frequency selected.

AF OUTPUT level

Pressing the AF ON-OFF key makes the output of the AF modulation oscillator available at the AF OUTPUT socket at a default level of 1 V RMS, unless 'Recall store 10' has been set – see 'Second function 16'.

To change the level press the AF LEVEL key followed by the required numerical value and units terminator. (Voltage units are always in PD and logarithmic units in dBm into 600 Ω.) The value and units will appear on the LEVEL display, with the MODULATION and CARRIER FREQUENCY display blank.

External modulation



Press FM, ΦM, or AM function key as appropriate followed by the INT/EXT key to select external modulation. This will set the EXT annunciator on the MODULATION display. Pressing the INT/EXT key again to return the instrument to the internal mode.

Apply a modulating signal at nominally 1 V RMS to the MOD INPUT socket.

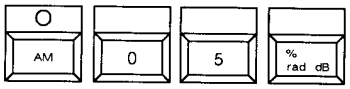
With MOD ALC on (LED lit) the signal will be internally levelled to 1 V provided the input is between 0.8 V and 1.2 V.

With MOD ALC off, HI and LO LEDs indicate if the input goes outside the range 1 V ±5%.

Modulation on/off

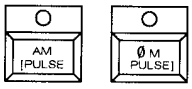
To turn the modulation off whilst still retaining its current value press the MOD ON/OFF key. The OFF condition is indicated by the setting of an OFF annunciator in the MODULATION display window. Entering a new value of modulation depth or deviation will automatically restore the modulation.

Amplitude modulation



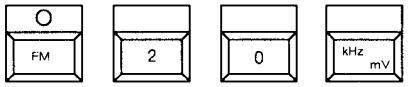
Press the AM function key (unless its LED is already lit). Enter the required value of modulation depth followed by the % terminator. If the requested value of AM exceeds that allowed by the current RF level setting then the level is reset to the maximum available for the AM mode and the LIMIT warning appears on the LEVEL display.

Pulse modulation

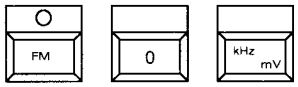


The above keys are only fitted if the pulse modulation option is fitted to the instrument. To select pulse modulation press both keys simultaneously. Pulse modulation is indicated by a "P" in the MODULATION display. Apply the pulse signal to the rear panel PULSE MOD IN socket. An input level of +5 V turns the carrier on; 0 V turns it off.

Frequency modulation

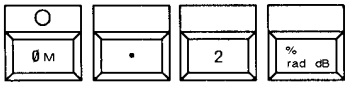


Press the FM function key (unless its LED is already lit). Enter the required value of deviation followed by the MHz, kHz or Hz terminator.



If the instrument is to be used for signal-to-noise measurements within a narrow bandwidth a useful reduction of residual noise level may be obtained from the instrument at frequencies adjadent to the carrier. This can be achieved by the selection of FM and a setting of '0' deviation. A useful alternative method for controlling the FM deviation setting is to use the DOWN key to reduce the value to zero and the RETURN key to return to a previous setting.

Phase modulation



Press the ΦM function key (unless its LED is already lit). Enter the required value of deviation followed by the RAD terminator.

AUX FM INPUT socket

This input enables simultaneous auxiliary modulation to be superimposed on the main FM or ΦM, whether the instrument is set to internal or external modulation.

With FM on, the application of 1 V RMS to the AUX FM INPUT will result in an FM deviation of 10% of that indicated on the modulation display.

With ΦM on, the application of 1 V RMS will result in an FM deviation in kHz equal to the phase deviation in radians shown on the modulation display.

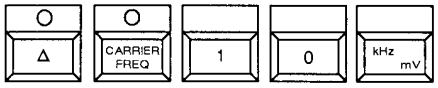
INCREMENTS

Assigning increment values

To display the current set of increment values press the orange Δ (delta) key. Unless the values have been changed, the following default set will be displayed.

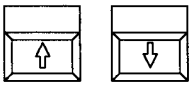
Carrier frequency: 1 kHz
Modulation: FM 1 kHz or ΦM 0.1 rad or AM 1%
RF level: 1 dB

To return to the normal display without affecting the current increment values press any function key twice.



To change the increment value of any function press the Δ key followed by the function key; then enter the new value and the terminator. For example to select a carrier frequency increment of 10 kHz follow the sequence shown above. FM, ΦM, AM or RF LEVEL may be similarly incremented but note that for RF LEVEL increments the only valid terminator is the dB key.

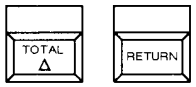
Applying increments



Each press of the ↑ (UP) key increments the function parameter by the selected value; likewise pressing the ↓ (DOWN) key decrements by a similar amount.

Holding the UP or DOWN key pressed results in continuous incrementing or decrementing after a delay of one second.

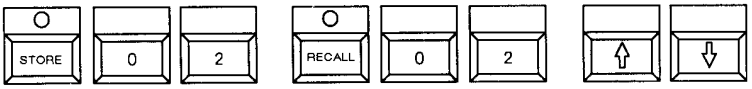
To change from the incrementing mode to the decrementing mode without the one second delay keep the UP key continuously pressed, allowing the instrument to increment, then press the DOWN key also. When the UP key is released the instrument will immediately decrement. Similarly, to change from down to up without delay press the UP key before releasing the DOWN key, and when the DOWN key is released the instrument will immediately increment.



To find the total shift from the original setting press the TOTAL Δ key. While this key is pressed all the displays will show the total shift of each function from its starting value.

To return to the initial value of the selected function press the RETURN key.

STORE AND RECALL



The instrument has 100 non-volatile stores available. Stores numbered 00 – 19 store complete instrument settings (including increment values). Stores 20 – 99 store settings of carrier frequency only. Store key selection is indicated by an integral LED and the store number currently selected is briefly displayed in the LEVEL window.

Storing CARRIER FREQUENCY 0 Hz will enable the carrier frequency currently displayed to be kept when the store is recalled. This facility allows any of the twenty complete instrument setting stores to be used to hold details of modulation settings and levels which can then be applied to any carrier frequency.

Store 10 can be used to implement a pre-selected set of conditions when power on is initiated. For details of this facility see 'Second function 16'.

Access to stores may be protected using second function 191. Any attempt to over-write a store will result in Error number 11 being displayed in the CARRIER FREQUENCY window. Digital information within the store will be retained. Details of this second level operation are given in the Service Manual.

Another second level operation, second function 192, can be used to disable carrier frequency, modulation and level displays when Stores 01 to 99 are recalled. (RECALL store 00 will always produce a valid display). This facility is of value when secrecy is important. As stores are recalled all display windows will remain blank unless incremental values have been used. In this event pressing the TOTAL SHIFT key will give a valid display of the total shift in the appropriate window.

SECOND FUNCTIONS

Second function operations provide a means of controlling various secondary features and calibrations within the instrument. Access to many of these operations is generally not required during routine use of the instrument and some should only be accessed by skilled personnel during the course of realignment, fault finding, or repair. There are three levels of operation as follows.

Normal operation. Second functions 0,1,2,3,4,9,11,12,13 and 18 are unprotected and can be accessed directly.

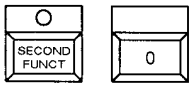
First level operation. Second functions 5,6,14,15 and 16 have a first degree protection. Access to this level can be gained after operating an unlocking procedure – see 'Second function 0'.

Second level operation. Second functions 7,8,9,10,17,190,191 and 192 have second degree protection and can only be accessed by the operation of a special key code. Details of the code are given in the Service Manual.

In general the second function mode is entered by pressing the blue 2nd FUNCT key followed by the numerals corresponding to the second function required. Pressing the 2nd FUNCT key inhibits the action of some keys; however the instrument can always be restored to its normal operating mode by pressing any of the orange function keys. This means of exit from second function operation is always safe, i.e. it will not corrupt any data or alter any status bits and the displays will revert to their normal functions.

No data will be permanently altered unless the STORE key is pressed. The operation of each of the secondary functions is as follows:–

Second function 0 : 'Unlock'



Switching on the instrument automatically locks all second functions that have a first or second degree of protection. Access to first level operation is obtained by the UNLOCK procedure;–

(1) Press the 2nd FUNCT and '0' keys and note that '0' appears in the MODULATION window.

(2) Then press the AF ON–OFF and MOD ALC keys simultaneously until a '1' is displayed in the CARRIER FREQUENCY window.

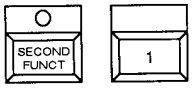
The instrument will then be unlocked at the First level and allow further selection of the required second function in that group. If the sequence is in error, or aborted part way through, the instrument will remain locked. Once unlocked the instrument remains so until either the 2nd FUNCT and '0' keys are once more pressed or until the instrument power is switched off.

Notes ...

(i) Access to all levels of operation is available over the GPIB (where fitted) without the protection of an unlocking procedure for first and second levels. Access to second functions via GPIB selection should therefore be restricted to personnel who have a full knowledge of these operations and require access to them in the course of re-alignment, fault finding or repair only. If inadvertent selections are made it is possible to invalidate the instrument's calibration.

(ii) The instrument always reverts to the locked state after using the bus.

Second function 1 : 'Status'



Entering Second function 1 will result in the instrument displaying status information as shown below in Fig. 3-4.

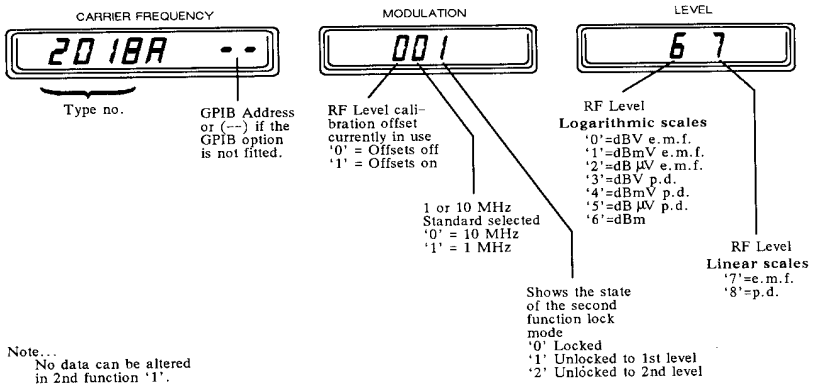
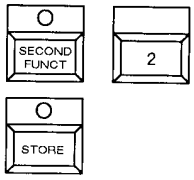


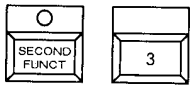
Fig. 3-4 Second function '1' status mode

Second function 2 : 'GPIB address setting'



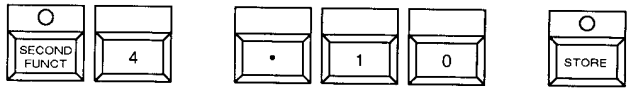
If the GPIB option is not fitted the sign "--" is displayed in the CARRIER FREQUENCY display; otherwise the current GPIB address is displayed. If a new address is required, this may be entered via the keyboard. Numbers rotate in from the right. When the required address is displayed pressing the STORE key will, if the address is acceptable (00 - 30), replace the previous one. If the address is too large it will be ignored and the current address re-displayed instead.

Second function 3 : 'Manual latch setting'



This function allows an 8 bit binary instruction to be directed to any of the instrument's internal latches for testing and fault finding. On entering the latch address (for example A7L1), current data on the latch is displayed in binary on the CARRIER FREQUENCY display. Information is entered from the left and rotates to the right. A decimal point indicates the "pointer" between old and new data. Pressing the STORE key sends the displayed data to the latch. This facility is fully described in tne Service Manual and is an invaluable aid when diagnosing internal instrument bus or latch faults. On exiting from second function 3 all latch data which may have been over-written is restored. Second function 18 provides a direct method of controlling the data set on the GPIB auxiliary output pins.

Second function 4 : 'SRQ mask setting'



Select 2nd FUNCT mode followed by the numeral '4'. The SRQ mask allows an instruction to be made for the instrument *not* to request service over the GPIB for particular conditions. 25 possible error conditions are listed in the GPIB functions section although provision has been made for 30. At switch on all error numbers previously masked are automatically reset to the unmasked state i.e. '0' and displayed as a 6-bit binary number in the FREQUENCY display.

To give access to error numbers 1 to 30 inclusive requires five pages. At switch on, page 1 is automatically selected and error numbers 1–6 are represented from right to left as shown in Fig. 3–5. To access error numbers 7–12 press the '.' (decimal point) key which selects page 2 of 5; pressing this key again selects 3 of 5 to represent error numbers 13–18 etc.

To reselect page 1 after selecting page 5, press the decimal point key again. The page number currently selected is shown in the LEVEL display.

Note ...

In a GPIB controlled system the SRQ mask setting will normally be selected by a GPIB instruction sent by the controller.

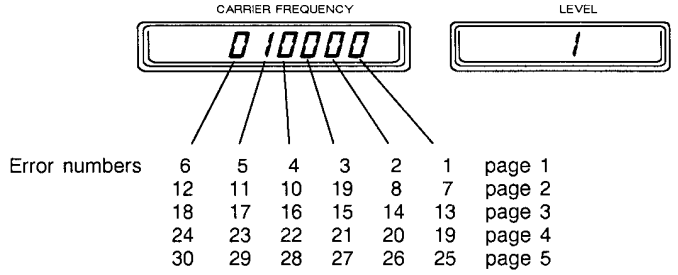
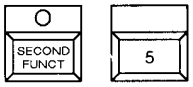


Fig. 3–5 SRQ mask setting display

Binary notation is entered via the keyboard and ones or zeros rotate in from the right. Enter a bit '1' to mask the required error(s). When these are in position press the STORE key to terminate the entry. Fig. 3–5 shows the mask set to ignore a GPIB bus error (Error No. 05).

Second function 5 : 'RF level units setting'

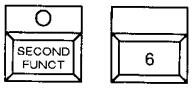


Unlock the instrument to the first level of operation by completing the unlocking procedure – see 'Second function 0'. Then select 2nd FUNCT and the numeral '5' keys. On entering second function 5 two digits are displayed on the LEVEL display. These represent the two scales of RF level units which are currently selected, the left–hand digit representing the logarithmic scales and the right–hand digit the linear scales as shown overleaf:–

Left digit (logarithmic scale)	Right digit (linear scale)
0. dBV EMF	7. EMF
1. dBmV EMF	8. PD
2. dBμV EMF	
3. dBV PD	
4. dBmV PD	
5. dBμV PD	
6. dBm	

These units may be selected via the keyboard by entering the numbers corresponding to the units required and then pressing the STORE key.

Second function 6 : 'RF level offsets'



First select a carrier frequency within the chosen band (see below) followed by a suitable RF level. Complete the unlocking procedure – see 'Second function 0'. Then select 2nd FUNCT and numeral '6' keys. In addition to the standard calibration for RF output level, the instrument has a capability for overall level adjustment to facilitate matching with other equipment. The output level can be raised or lowered by approximately 2 dB in the offset mode.

In 2018A there are two carrier frequency bands, 0–260 MHz and 260–520 MHz, and in 2019A an additional band, 520–1040 MHz. One offset value may be set for each frequency band as follows:–

'Offset on'

'Offset off'

Indication of the selected state is displayed in the CARRIER FREQUENCY window with either a '1' or '0' as appropriate.

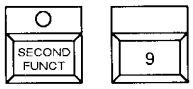
The presence of offsets can be quickly established by using Second function 1 – a '1' in the left-hand position of the MODULATION display shows that offsets are in use. Having set 'Offset on' select either the ↑ (UP) or the ↓ (DOWN) key to increment or decrement the RF level by 0.1 dB. Each successive 'UP' or 'DOWN' selection will then increment or decrement the RF by a further 0.1 dB. When sufficient offset has been determined press the STORE key to finalize the selection which will, together with the offsets – on selection, remain valid until further adjustment is made.

If an offset value of +0.1 dB is selected when the instrument is set to the limit of its operating range i.e., +13 dBm or equivalent, a maximum indicated RF level of +12.9 dBm will be imposed, (a further +0.1 dB offset increment will decrease this to +12.8 dBm).

Note ...

When an offset value has been selected and stored it will remain valid for all subsequent power on sequences. RF level accuracy of the instrument is therefore impaired and care should be taken to account for this.

Second function 9 : 'Elapsed time display'

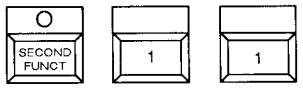


This facility enables you to observe the total number of instrument running hours accumulated since the facility was last set to zero. The elapsed time is shown in the CARRIER FREQUENCY display in hours with a resolution of 0.5 and is not updated while being viewed. After switch-on the timer is updated by 0.25 after 7.5 minutes of operation (to avoid rounding errors) and thereafter at 15 minute intervals. The purpose of this display is to allow calculation of calibration intervals or similar periodicities.

Reset to zero can be achieved by first unlocking the instrument to the second level of operation, then selecting 2nd FUNCT 9 followed by '0' and STORE keys. Details of the unlocking procedure are restricted to the Service Manual.

A further elapsed time display - second function 10, 'Read total instrument running hours' - can also be accessed after unlocking to second level of operation. No means of reset is available for this display.

Second function 11 : 'Read identity string'



Selection of this facility enables you to confirm the type number, serial number and software issue number of the instrument. This is indicated with two separate displays. The first display shows type and software issue number; the second half of the string, indicating the instrument serial number, is displayed when the decimal point key is pressed. Both displays are shown in Fig. 3-6.

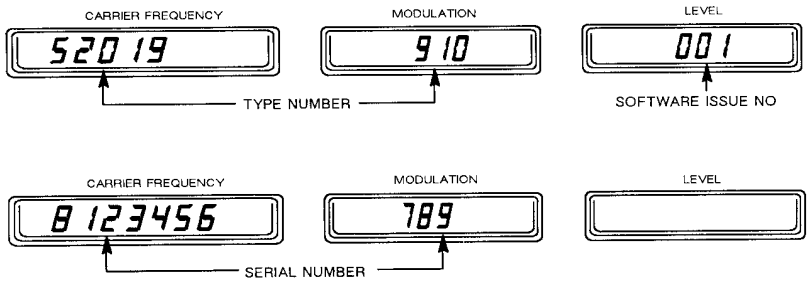


Fig. 3-6 'Read identity' display

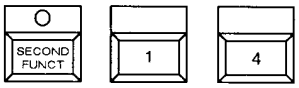
Second function 12 : 'Write user-definable string'

This is a GPIB only facility whereby a string of data may be set – see 'GPIB function SF12'.

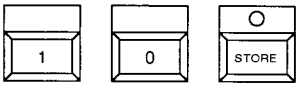
Second function 13 : 'Read user-definable string'

This read only facility provides the means of reading back data set by the GPIB SF12 write facility. Like Second function 12 this is used only in conjunction with the GPIB – see 'GPIB function SF13'.

Second function 14 : '1 or 10 MHz standard setting'

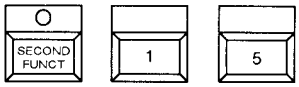


This function allows you to select either 1 MHz or 10 MHz frequency standard. First carry out the unlocking procedure – see 'Second function 0'. Then select 2nd FUNCT and the numerals '1' and '4'. The frequency standard currently selected is then displayed in the CARRIER FREQUENCY window.



Press 1 to select 1 MHz, or '0' to select 10 MHz, followed by the STORE key.

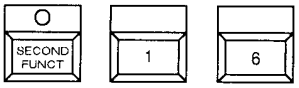
Second function 15 : 'Old/new GPIB command set'



This function is of use in automatic test areas where a 2018A or a 2019A is required for test purposes to be addressed with a set of instructions for the earlier models 2018 or 2019. This allows a full range of tests to be carried out using 2018A/19A where parameters are the same as the 2018/19 series.

Unlock to first level – see 'Second function 0' and select 2nd FUNCT and the numerals '1' and '5'. The CARRIER FREQUENCY window will then display the current selection, '0' for 2018A GPIB set or '1' for 2018 GPIB set. To select 2018A press the numeral '0' key, to select 2018 press the numeral '1' key. Terminate the selection by pressing the STORE key.

Second function 16 : 'Recall STORE 10 at switch on'



This facility allows the instrument to be operated in a remote or unattended location with a pre-selected set of conditions which will remain unchanged in the event of inadvertent switching off and on of the input supply voltage. In the normal operating mode if this happens, the instrument would resume the initial operating mode, that is CARRIER FREQ 520 MHz (or 1040 MHz for 2019A), internal MOD OSC 1 kHz, no MODULATION and minimum RF LEVEL (-127 dBm or equivalent). These conditions can be superseded by storing the required operating conditions into STORE 10 and carrying out an automatic recall of the 'STORE 10' settings using second function 16.

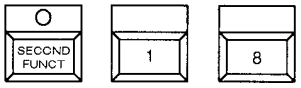
(1) First select the required CARRIER FREQ., MODULATION and RF LEVEL keyboard settings.

(2) Press the STORE key followed by the numerals '10'.

(3) Complete the unlocking procedure - see 'Second function 0'. Then select 2nd FUNCT and the numerals '16'. Then press the '1' key to select automatic recall of STORE 10. Finally press the STORE key.

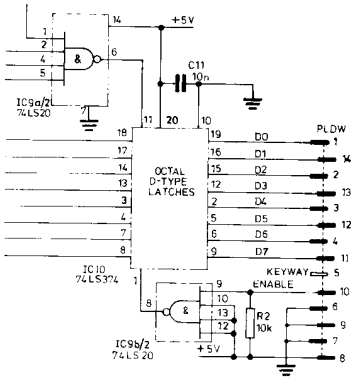
If the supply voltage is interrupted, then restored, the instrument will first reset to the initial operating mode, then automatically carry out a 'RECALL 10' instruction and reset to the STORE 10 conditions previously set. To disable the facility first unlock the instrument to First level operation, select 2nd FUNCT 16 followed by the numeral '0'. and finally the STORE key.

Second function 18 : 'Set data on GPIB Auxiliary output pins'



In addition to allowing full GPIB control of the Signal Generator, the GPIB module AG0 has an AUXILIARY output socket which can be used to control external relays or circuits. This 14 pin plug fitted on the rear panel GPIB interface can easily be accessed by removing a plastic cover. Data is set to control the eight external data lines after selecting 2nd FUNCT 18. Connections from the AUXILIARY output are best made using an IDC ribbon cable connector (provided with the optional GPIB interface kit). Interconnections and operation are as follows:-

(1) Plug PLDW pin 5 may be keyed to prevent incorrect insertion of the IDC connector. Pin connections as seen from the rear panel are shown below:



PLDW

14	13	12	11	10	9	8
1	2	3	4	↑	6	7

Fig. 3–7 GPIB AUXILIARY output plug and socket connections

(2) Data is set on the pins in the same manner as Second function 3 – Manual latch setting. Current data (if any) is displayed in the CARRIER FREQUENCY window. New data is entered in binary using the front panel '0' and '1' keys, most significant bit first.

(3) If the outputs are to be connected to a load that has its own integral +5 V supply line available it is preferable to connect this to the enable line on pin 10, (pins 6,7 and 9 are internally connected to earth). In the event of an external power failure the enable circuit will then be set 'low' and the data lines disabled. Where an external +5 V supply is not used pins 8 and 10 should be interconnected to enable the data output.

Second functions 7,8,9,10,17,190,191and 192 : (Second level operation)

All the following facilities have second degree protection. Further information on these facilities and details of the special key code to access them are contained in the Service Manual.

Second function	Facility
7	RF level calibration
8	FM tracking
9	Reset of elapsed time display
10	Read – total instrument operating time
17	Calculation and storage of amended EAROM checksum
190	Write – identity string setting
191	Protection of store settings
192	Display blanking of recalled stores

GENERAL PURPOSE INTERFACE BUS (GPIB) FUNCTIONS

The GPIB interface, offered as an optional accessory, allows the instrument to be coupled to a controller. The essential purpose of each GPIB function is described below. Further information on the general features and applications of the GPIB system can be obtained from 'The GPIB Manual' - see page 1-14.

2018A/2019A have both talker and listener capabilities. One address is used for both talking and listening and is set via the front panel or via the GPIB using Second function 2. The instrument can request service (assert SRQ) on certain error conditions under the control of an SRQ mask which is set using Second function 4.

SH1 : Source handshake (complete capability)

The source handshake sequences the transmission of each data byte from the instrument over the bus data lines. The sequence is initiated when the function becomes active, and the purpose of the function is to synchronize the rate at which bytes become available to the rate at which accepting devices on the bus can receive the data.

AH1 : Acceptor handshake (complete capability)

The acceptor handshake sequences the reading of the data byte from the bus data lines.

T6 : Talker function (no talk only function)

The talker function provides the 2018A with the ability to send device dependent messages over the bus to other devices. The ability of any device to talk exists only when it has been addressed as a talker.

L4 : Listener function (no listen only function)

The listener function provides a device with the ability to receive device dependent messages over the bus. The capability only exists where the device is addressed to listen via the bus by the controller.

SR1 : Service request function (complete capability)

The service request function gives the 2018A the capability to inform the controller when it requires attention.

RL1 : Remote/local function (complete capability)

The remote/local function allows the 2018A to be controlled either by the local front panel keys or by device dependent messages over the bus.

DC1 : Device clear function (complete capability)

Device clear is a general reset and may be given to all devices in the system simultaneously (DCL) or only to addressed devices (SDC). 2018A resets to the default power-up mode, that is :

Maximum carrier frequency : 520 MHz (1040 MHz for 2019A)
No AM, FM, ΦM or pulse modulation
Minimum RF level : -127 dBm or equivalent
Modulation oscillator frequency : 1 kHz
Internal modulation selected
Increment settings:

Carrier frequency :	1 kHz
Modulation :	1 kHz FM, 1 rad ΦM or 1% AM
RF level :	1 dB
AF level :	1 dB

Before these conditions are set, a checksum is calculated for the calibration data (FM tracking and RF level) and referred to a number held in the non-volatile memory. If this test of calibration validity fails, the instrument responds by asserting SRQ. The status byte will contain the number 6 to signal a calibration data fault in addition to the 'SRQ asserted' bit. In order to continue with the device clear (and normal operation thereafter) the instrument must be restarted by sending any valid instruction code (e.g. "CF"). This serves only as a reset and will not be interpreted in the normal way.

E1 : Open collector drivers

The GPIB drivers fitted to 2018A have open collector, rather than tristate, outputs.

Setting the GPIB address

The instrument's talk/listen address is selected by means of second function 2. Acceptable addresses (00 to 30) can be set by this means and the instrument's internal address register will be updated by reading the address at power-on and on receipt of a device clear message. The current GPIB address is shown in the frequency display when the interface is correctly installed.

GPIB programming codes

Functions		Miscellaneous functions	
DE	Delta (Increment/Decrement)	C1	Carrier On
CF	Carrier frequency	C0	Carrier Off
FM	Frequency modulation	ST	Store } followed by a
PM	Phase modulation	RC	Recall } number 00-99
AM	Amplitude modulation	RT	Return
PU	Pulse modulation (if option is fitted)	UP	Increment up
LV	RF level	DN	Increment down
AL	Audio output level	H0	Set triggered output mode Off
IS	Internal Freq. Std.	H1	Set triggered output mode On
XS	External Freq. Std.	GO	Trigger output
QU	Query - send current function setting to GPIB buffer - see Talking function	QL	Query modulation input level
SF	Second function		
RS	Reset RPP		

Units		Mod OSC/ALC	
		F0	Mod osc freq. 300 Hz
MZ	Megahertz	F1	Mod osc freq. 400 Hz
KZ	Kilohertz	F2	Mod osc freq. 500 Hz
HZ	Hertz	F3	Mod osc freq. 1 kHz
PC	Percentage	F4	Mod osc freq. 3 kHz
VL	Volts	F5	Mod osc freq. 6 kHz
MV	Millivolts	M1	Modulation On
UV	Microvolts	M0	Modulation Off
DB	Decibels	IM	Internal modulation
RD	Radians	XM	External modulation
		A1	Audio output On
		A0	Audio output Off
		L1	Mod ALC On
		L0	Mod ALC Off

Listening function

The 2018A is remotely controlled over the GPIB by strings of two-character codes and digits sent in upper case ASCII format. Where possible these codes correspond directly to the front panel keys. However, where the normal front panel control requires a knowledge of the previous state of the instrument (e.g. toggling controls such as on/off), special codes are provided to simplify programming.

In order to improve the readability of control strings, the codes may be separated by commas or spaces after each code pair or data group. These are ignored by the instrument. When data is entered, the syntax is the same over the GPIB as that used in control from the front panel. For example to enter a complex string of instructions such as a carrier frequency of 123.45 MHz with an increment of 25 kHz and an RF level of 1.2 μV the string can be sent as follows :

"CF 123.45 MZ, DE CF 25 KZ, LV 1.2 UV".

Similarly, if it is required to change the RF level units setting to dBm (second function 5, logarithmic scale 6), the string "SF 5, 6, ST" should be sent.

The ON/OFF and INT/EXT controls operate on the function currently active for data entry. This may be specified, e.g. "FM M1", "AM XM" or implied, e.g. "FM 1.5 KZ, IM" but it is recommended that the function is specified within the string to ensure that the string will always have the same result. Selection of a second function via the GPIB will result in a display of the SF number being shown in the MODULATION window.

Talking function

On receipt of the QU command the current function setting (e.g. CF,FM) is transferred to the GPIB output buffer in a format corresponding to the GPIB commands needed to set the instrument to the current state. RF level will be displayed in log. or linear units but without a specific reference since this information cannot be re-entered directly. Increment settings are also available if QU is sent whilst in DELTA mode with a current function LED lit. The following tables give the format for each type of string.

TABLE 3-1 MODULATION STRING (18 characters)

NUMBER OF CHARACTERS IN FIELD							
2	2	4	2	2	2	2	2
DE **	FM PM AM PU	3 digits or leading spaces plus decimal point or space	MZ KZ HZ PC RD	M0 M1	IM XM	L0 L1 **	F0 F1 F2 F3 F4 F5 **

* Represents a space which is used when the field has no relevance, such as the levelling field when internal modulation is selected.

e.g. DE,FM,1.00, KZ,M1,IM,**,**
or **,FM,1.23,KZ,M1,IM,**,F2

TABLE 3-2 FREQUENCY STRING (17 characters)

NUMBER OF CHARACTERS IN FIELD				
2	2	9	2	2
DE **	CF	8 digits or leading spaces plus decimal point or space	MZ KZ	IS XS

e.g. **,CF,123.45678,MZ,IS

TABLE 3-3 LEVELS STRING (14 characters)

NUMBER OF CHARACTERS IN FIELD						
2	2	1	1	4	2	2
DE **	LV AL	- *	1 0 *	3 digits or leading spaces plus decimal point or space	DB VL MV UV	C0 C1 A0 A1

e.g. **,LV,*,1.000,VL,C1

Provision for talking second function values can also be made by a similar use of QU when the function is engaged, the format being numeric strings only for calibration data etc., e.g. FM tracking, and a numeric string representing hours for the elapsed time indicator. Three further data strings are available, Status string, Identity string and a User string; these are accessed by means of second function controls and the QU function.

The external modulation input level status indicated by the front panel HI and LO LEDs can also be accessed on receipt of the QL command. The current level is transferred to the GPIB output using two ASCII characters to indicate one of the three possible states:

HI input too high
LO input too low
OK input within range

Requesting a string to be output will overwrite any string data waiting to be sent. Addressing the instrument to talk without specifying a string to be sent or re-addressing to talk after a string has been completed will result in an error (and SRQ if not masked).

SF1, QU Status string

When accessed by SF1, QU the status of the instrument is sent to the controller, each data field being delimited by one space in the following format:-

2018A or 2019A	XX GPIB ADDRESS	X OFFSETS ON/OFF	X FREQ STD. 1/10 MHZ	X LEVEL OF PROTECTION	X LOG UNITS	X LINEAR UNITS

GPIB Address: 00 to 30

Offsets: '0' = off
'1' = on

Freq. standard: '0' = 10 MHz
'1' = 1 MHz

Level of protection: '0' = locked
'1-2' = unlocked to 1st or 2nd level

Log units: 0-6 - see 'Second function 5'

Linear units: 7-8 - see 'Second function 5'

SF11, QU Identity string (read only)

The identity string accessed by SF11, QU allows instrument type number, software issue number and serial number to be read by the controller. The information is stored in non-volatile memory and in 2018A is also used to tell the software which version of the instrument it is to drive. The string is displayed as described under 'Second function 11'. Each data field is delimited by one space.

SF12, User string write facility

Up to 32 ASCII characters can be stored in non-volatile memory by the user. This bus only facility is useful for recording such information as date next calibration is due, test gear numbers etc. The string is terminated by the LINEFEED character <lf> (ASCII code 10) which is included as the last character stored. If an attempt is made to store too many characters then <lf> is automatically inserted as the 32nd.

SF13, QU User string read facility

This facility provides a means of reading back data set by means of SF12 write facility and is again a bus only facility.

Service requests (SRQ)

The instrument can request service to warn the controller of certain error conditions. In response to a serial poll after asserting the SRQ line, the unit will provide a status word (8 bits) in which bit 6 is set to indicate a service request and the first five bits 0 to 4 indicate an error number. The error number is also displayed in the CARRIER FREQUENCY window. Errors 10,12,13,14 will result in the instrument not functioning. Error 06 can be overridden with a restart command (any function code or digit). Similarly Error 01 (RPP tripped) can be overridden with the reset instruction (RS).

Error numbers

No.	Error condition	Action taken
01	RPP TRIPPED	Wait for reset instruction (RS)
02	INVALID FM TRACKING DATA (Greater than 255)	
03	INVALID GPIB CHARACTER	
04	OPTION NOT FITTED	
05	GPIB BUS ERROR	
06	CAL DATA CHECKSUM FAILURE	Wait for restart instruction (any function code or digit)
07		
08		
09		
10	PROM CHECKSUM FAILURE	
11	ATTEMPT TO OVERWRITE PROTECTED STORE	
12	MAIN RAM CHECKSUM FAILURE (IC18)	
13	STACK RAM CHECKSUM FAILURE (IC12)	
14	BOTH RAMS CHECKSUM FAILURE	
15	EXTERNAL FREQ. STD. ERROR	
16	ILLEGAL STORE NUMBER	
17	INVALID STORED DATA RECALL	
18	EAROM WRITE FAILURE	
19	INVALID FIRST CHARACTER OF PAIR	
20	INVALID SECOND CHARACTER OF PAIR	
21	INCOMPLETE CHARACTER PAIR	
22	NO TALK FUNCTION SELECTED	
23	NO SUCH FUNCTION	
24	EAROM READ FAILURE	
25	INTERNAL FREQ. STD. ERROR	

SRQ mask

The SRQ response to the errors listed above can be suppressed by setting a 3 page 8-bit mask via second function 4. The first 8 bits of page 1 refer (reading from right to left) to error numbers 1 to 8; page 2, error numbers 9 to 16; and page 3, error numbers 17 to 24, i.e. the right-most bit set on page 1 indicates no response to error 1, the second from right no response to error 2, etc. The modulation display gives an indication of the page currently selected.

The mask is displayed by selection of second function 4, and may be changed by entering '1's and '0's via the keyboard. The STORE key is pressed to finalize a change. The SRQ mask is *not* stored, either in the instrument setting stores or when power is removed. When the instrument is initially switched on the mask is set to all '0's.

Reverse power protection

When tripped by an overload applied to the RF OUTPUT socket, the GPIB SRQ line is asserted, and the status byte (obtainable by the controller conducting a serial poll) will contain the value 65 (decimal). The RPP can be reset via the bus by sending the RS command.

Clear, switch on, and return to local

SDC and DCL clear 2018A to the following state:-

Maximum carrier frequency:	520 MHz (1040 MHz for 2019A)
Minimum RF level:	-127 dBm or equivalent
No modulation	
Internal modulation selected	
Increment settings:	
Carrier frequency:	1 kHz
Modulation:	1 kHz FM, 1 rad ΦM or 1% AM
RF level:	1 dB
AF level:	1 dB

To revert from GPIB to front panel control, press the 'RETURN' key. If a local lock out command has been given the RETURN key operation will be ignored.

Notes...

(1) Int/Ext frequency standard selection and instrument store contents are unaffected by the SDC and DCL commands.

(2) Switching on clears the 2018A to the same state as SDC or DCL unless 'Recall STORE 10 at switch on' conditions apply.

Fast output facility (GPIB only)

This facility enables the instrument to be changed from one complete setting to another with the minimum possible transition time. Two ASCII character pairs, H1 and H0, are used to set the facility on or off and a third, 'GO' Trigger output, is used to implement the instruction as follows:-

(1) Set H1 - Trigger output mode is set to on causing all instrument outputs to remain unchanged when new settings are entered, thus allowing the pre-setting of several functions.

(2) Set GO - Trigger output now instructs the instrument to change settings.

(3) Set H0 - Trigger output mode is set to off and instrument resumes normal operation.

Chapter 4
BRIEF TECHNICAL DESCRIPTION

The 2018A is an 80 kHz to 520 MHz synthesized signal generator providing calibrated output levels from –127 dBm to +13 dBm. 2019A is similar to 2018A except that a frequency doubler circuit enables it to cover frequencies up to 1040 MHz with the same output level range. The output frequency of both 2018A and 2019A is phase locked to a frequency standard and can be set to a resolution of 10 Hz at frequencies up to 520 MHz and to a resolution of 20 Hz above 520 MHz (2019A only).

Both instruments can be frequency, phase or amplitude modulated from external or internal modulation sources. The internal modulation source provides six fixed modulation frequencies; re-selection of components within the instrument allows alternative frequencies to be set if required.

Calibrated output levels from –127 dBm to +13 dBm (0.2 μV to 2 V EMF) in the CW, ΦM and FM modes and up to +7 dBm (1 V EMF) in the AM mode are provided. A choice of nine output level calibration units can be obtained on the front panel. The RF output level can be set to a resolution of 0.1 dB or better over the entire output voltage range and features a total cumulative accuracy of ±1 dB up to 520 MHz (±2 dB from 520 MHz to 1040 MHz). Protection against the accidental application of up to 50 W of reverse power is provided by a fast responding reed relay.

Front panel operation is carried out by direct entry of required settings via the keyboard. Microprocessor control ensures maximum flexibility and allows programming by the General Purpose Interface Bus (GPIB). This facility is offered as an optional accessory enabling the instrument to be used both as a manually operated bench instrument or as part of a fully automated test system. Provision is also made for the use of an external standard reference frequency when this is preferred.

A second function mode of operation includes means of setting the GPIB address, selection of alternative RF level calibration units, access to various calibration routines and a facility to aid diagnostic fault finding and a measure of the total number of hours that the instrument has been switched on.

The Signal Generator is divided into three main areas. The first area is the digital control system by which the microprocessor board AA2/1 receives and sends data to the various PCBs in the instrument. This is accomplished by means of an internal instrument bus.

The second area consists of a frequency synthesizer and the analogue signal conditioning circuits that are controlled by the data bus in order to produce the required output signal.

The third area is the modulation control system controlling the audio signals used to amplitude modulate (AM), frequency modulate (FM) or phase modulate (ΦM) the carrier output.

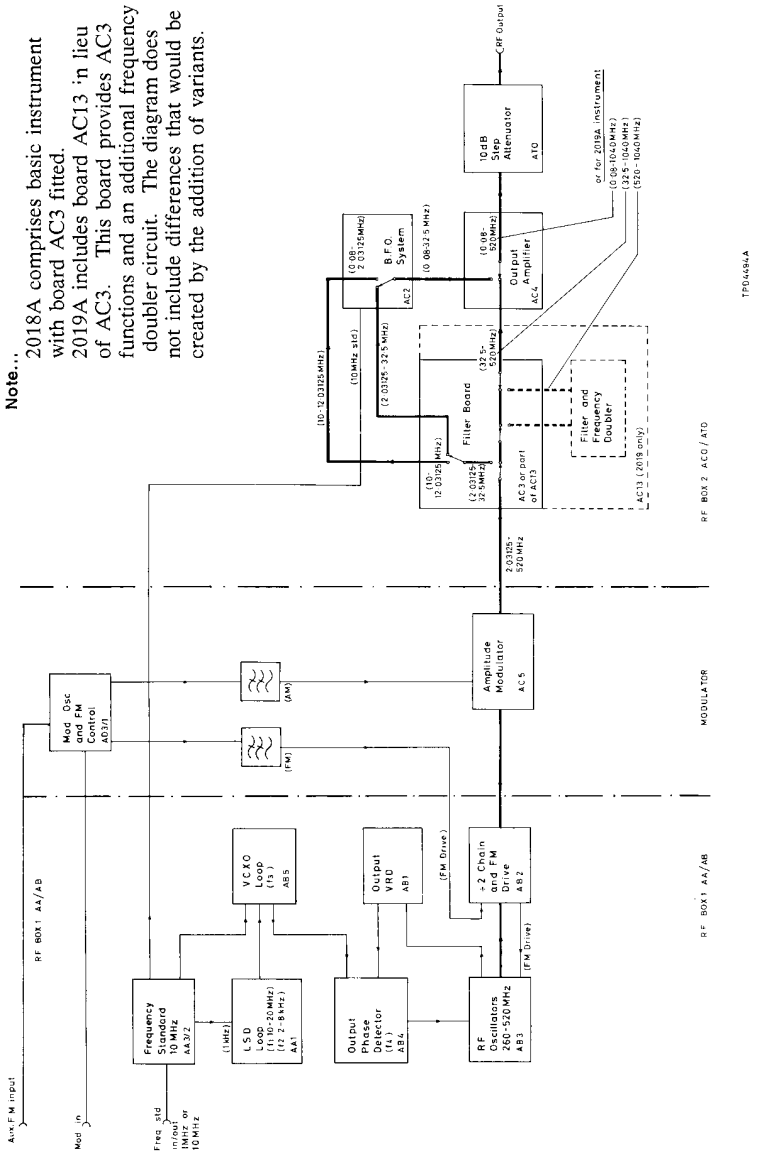


Fig. 4–1 Block schematic diagram