

2305 MODULATION METER 500 kHz – 2,3 GHz

H 52305-900K
Vol. 1

FEATURES

1. 2305 is a high performance, microprocessor controlled, modulation meter with a comprehensive specification covering the carrier frequency range 50 kHz to 2.3 GHz.
2. Operation may be either local or remote. Local control is obtained via functionally grouped key switches which form the front panel controls and which direct all the instrument functions except those of SUPPLY ON and LF LEVEL.
3. Indication of measured quantities is provided by two l.c.d. 7-segment digital displays : frequency - either of the carrier or of the modulating tone - appears in the 8-digit left-hand display, modulation - in % a.m., kHz or radians deviation - appears in the 4 digit right-hand display.
4. The microprocessor allows maximum flexibility in arranging and controlling the circuit functions and permits remote operation via the GPIB* when the instrument is fitted with the GPIB interface optional accessory. The 2305 is thus as well suited for stand-alone manual operation as for incorporation in automatic systems with programmed operation and makes few demands on operator skill.



Fig. 1 50 kHz to 2.3 GHz Modulation Meter 2305

* GPIB - Marconi Instruments General Purpose Interface Bus in accordance with IEEE Standard 488 - 1978, IEC Publication 625-1 1979 and BS 6146.

5. In its simplest method of operation, the 2305 provides both automatic tuning and control of the ranging circuits, although tuning may be controlled directly by keypad entry of numerical data, and individual ranges may be retained by the use of keyboard second functions[†] if necessary. A HOLD ON/OFF key permits all ranges and functions to be locked in their present states.
6. In both forms of tuning, the local oscillator frequency retains the same sense relationship with signal frequency needed to ensure that positive frequency and phase excursions are always presented as P+.
7. In the CARRIER ERROR mode the instrument will measure small frequency drifts or offsets by continuously subtracting a stored reference value from instantaneous measurements of the carrier. The reference value can be either a numerical entry made via the keypad or a particular instantaneous measurement transferred to store by operation of the CARRIER ERROR key. Two other frequency measurement modes provide for the display of either carrier or modulating frequency.
8. When necessary, an external 10 MHz standard may be used in place of the internal reference which forms the basis for local oscillator frequency synthesis and for frequency measurement. It is also possible to provide for direct substitution of the local oscillator signal by a source of external origin. The changeover in both cases being effected by second function keying.
9. Modulation is normally measured as peak excursions of either the amplitude, frequency or phase of the carrier signal and a choice of detector modes enables the peaks of each polarity either to be measured separately or for their average to be calculated and presented as $\frac{P-P}{2}$. Two additional detector modes offer (1) an averaging detector, and (2) a PEAK HOLD function. The averaging mode (NOISE AVG) is useful when noise is to be measured, and the quantity displayed when in this mode is of the peak value of a sine wave having the same average value. In PEAK HOLD, successive peak samples are examined and store and display are up-dated each time the previous largest sample is exceeded. The PEAK HOLD mode is useful for logging transients and other aspects of modulator system performance under operational conditions. In the a.m. mode, peaks are always measured as P+ and troughs as P-.
10. The 2305 will tune and measure automatically without loss of accuracy on signal levels between -18 dBm and +30 dBm. The sensitivity increases considerably towards the bottom end of the frequency range and a substantial further increase can be obtained by reverting to manual tuning. Input protection is provided above the permitted maximum of +30 dBm. Deep amplitude modulation may reduce the signal level during troughs to a point that is insufficient to ensure proper functioning of the internal frequency counter and auto-tuning may be adversely affected. The effect is only likely to occur with a.m. greater than 90% and, if it happens, the a.m. depth should be temporarily reduced to allow auto-tuning to complete.

[†] *Keyboard second functions - A range of operating modes exceeding 50 in number which greatly extend the instrument's use for special purposes including fault diagnosis. The second functions are in 4 groups ranging from those which are directly accessible, through three further groups requiring preliminary unlocking codes of graded complexity.*

11. Frequency deviation can be measured up to a maximum of 500 kHz for modulation frequencies up to 275 kHz. The accuracy attainable varies with modulation frequency and approaches $\pm 0.5\%$ at 1 kHz.

12. Phase deviation can be measured to a maximum of 500 radians up to 1 kHz modulation frequency. Above this frequency the maximum measurable deviation decreases at 6 dB per octave.

13. Amplitude modulation up to 95% can be measured with accuracies approaching 1%, depending on modulation depth and frequency, up to a maximum modulation frequency of 50 kHz. Useful indications are given for depths up to 99.9%.

14. Measurements of all three types of modulation can be related to any reference level and expressed as dB. The reference quantity may be entered numerically via the keypad or may be a measurement selected from a series and transferred to store by a single key stroke.

15. The post detector bandwidth may be shaped by any one of five built-in filters which cover the varied requirements of mobile radio, broadcasting, telemetry etc. There is also a choice of 3 de-emphasis time constants which may be introduced into the audio output signal in f.m. mode. They may also be introduced into the measurement system by a keyboard second function. External filters may be introduced into the measurement circuit in addition to and independently of any internal selection.

16. Standards of amplitude and frequency modulation are generated within the instrument for calibration purposes. The 2305 automatically runs a self-check routine against these standards after each switch-on and displays pass/fail data. 2305 measurements can be recalibrated against these standards at any time by operation of the CAL key.

17. For systems use or production tests, up to 10 sets of control settings may be stored in non-volatile memory for subsequent recall and use.

18. In its POWER function, the 2305 will normally display the power entering the input terminal in dBm or watts. The measurement is based on peak voltage detection and will indicate peak power on amplitude modulated signals. The range may be extended upward by added external attenuation and a flexible system of power calibration with optional display in watts or dBm can be introduced by second functions.

19. Two major optional accessories extend the instrument's capabilities.

- (1) The GPIB option enables all the main controls and measurements to be operated and monitored remotely under program control.
- (2) The Distortion/Weighting Filter option provides single key stroke noise and distortion measurement and contains two standard psophometric weighting networks which may be introduced into the measurement channel.

The measurement performance of the 2305 can be changed by the user to meet special operational needs by keyboard second functions which have their status stored in non-volatile memory. If you are not certain of the state in which the instrument has been left by previous users, you should obtain a second function status display according to the procedure described in Chap. 3, page 15, before attempting any measurements.

PERFORMANCE DATA

Characteristic

Performance

RF INPUT

20. Carrier frequency range

500 kHz to 2 GHz for specified accuracy; usable from 50 kHz to 2.3 GHz. Acquisition time on AUTO TUNE is, typically, 500 ms.

21. Carrier frequency indication

8 digit l.c.d.
Resolution: 10 Hz below 1 GHz,
100 Hz above 1 GHz,
10 Hz at all frequencies
in CARRIER ERROR function.

22. Signal input

Minimum requirements :

-25 dBm (13 mV) 500 kHz to 500 MHz.
-23 dBm (16 mV) 500 MHz to 1000 MHz.
-18 dBm (28 mV) 1000 MHz to 1500 MHz.
-15 dBm (40 mV) 1500 MHz to 2000 MHz.

Maximum input :

Permitted maximum, 1 W (+30 dBm).
Overload trip provides protection
against overloads up to 25 W.

Input connector :

Type N female. 50 Ω nominal.

FREQUENCY MODULATION

23. Maximum deviation :

(1) Carrier frequencies up to 5.5 MHz.
50 kHz peak deviation at modulation
frequencies from 30 Hz to 15 kHz.

(2) Carrier frequencies above 5.5 MHz.
500 kHz peak deviation at modulation
frequencies from 30 Hz to 275 kHz.

Range selection :

Selection is automatic for best
resolution.

Display :

4 digit l.c.d., in kHz.*

Accuracy :
(for carriers >5.5 MHz)

After calibration using internal cali-
brator: $\pm 0.5\%$ of reading ± 1 least sig-
nificant changing digit at 1 kHz modu-
lation frequency measured with 50 Hz to
15 kHz filter selected for deviations
above 5 kHz and $\pm 1\%$ of reading ± 1 digit
below 5 kHz deviation.

*Note. For all three types of modu-
lation measurement, as the quantity
displayed increases from 5000 to
6000, the least significant digit
will become a fixed zero whatever
position the decimal point may
happen to be in. The process rever-
ses as the quantity falls. Wherever
accuracy statements relating to
modulation include the qualifica-
tion ' $\pm N$ digits', the digits re-
ferred to are the least significant
of the active digits i.e. XXXN or
XXN- as the case may be.

Frequency response relative to 1 kHz :
 $\pm 0.5\%$ for modulation frequencies from
20 Hz to 20 kHz measured with 10 Hz to
300 kHz filter selected.

+0.5%, -1% for modulation frequencies
from 20 Hz to 50 kHz.

+0.5%, -5% for modulation frequencies
from 20 Hz to 275 kHz.

Characteristic

Performance

Note...

Where necessary, allowance must be made for peak residual noise which will contribute to peak readings.

AM rejection :

Typically, 50% a.m. at 1 kHz will produce an indicated 40 Hz deviation with the 300 Hz to 3.4 kHz filter selected.

Residual f.m. noise :
(300 Hz to 3.4 kHz bandwidth)

<i>Carrier frequency</i>	<i>FM noise (r.m.s. values)</i>
500kHz - 50MHz	1.4 Hz
50MHz - 500MHz	15 Hz
500MHz - 1GHz	30 Hz
1GHz - 2GHz	60 Hz
500MHz typically	8 Hz

Typical performance with external low noise 28 MHz to 56 MHz local oscillator:

Below 120 MHz	0.5 Hz
500 MHz	2 Hz
1 GHz	4 Hz

PHASE MODULATION

24. Carrier frequency range :

5.5 MHz to 2 GHz, usable down to 50 kHz.

Maximum deviation :

500 radians for modulation frequencies up to 1 kHz. Decreasing at 6 dB/octave above 1 kHz.

Range selection :

Ranges automatically selected for best resolution.

Accuracy :

After calibration using internal calibrator : $\pm 2\%$ of reading ± 3 least significant changing digits at 1 kHz modulation frequency.

Frequency response relative to 1 kHz : $\pm 2\%$ ± 3 least significant changing digits from 300 Hz to 4 kHz.

Note. Where necessary, allowance must be made for peak residual noise which will contribute to peak readings. Improved accuracy in the measurement of phase modulation may be obtained for single tone modulation by using the FM

Characteristic

Performance

function. The frequency of the modulating tone may then be displayed in the FREQUENCY window and the $\phi.m.$ in radians is calculated by dividing this number (in kHz) into the frequency deviation (in kHz) displayed in the MODULATION window. The associated accuracy is comparable with that of the FM measurement.

AMPLITUDE MODULATION

25. Maximum modulation depth :	99.9%.
Modulation frequencies :	30 Hz to 15 kHz for carrier frequencies from 0.5 MHz to 5.5 MHz. 30 Hz to 50 kHz for carrier frequencies from 5.5 MHz to 2 GHz.
Range selection :	Selection is automatic for best resolution.
Accuracy :	After calibration using internal calibrator : $\pm 1\%$ of reading ± 1 least significant changing digit at 1 kHz modulation frequency and for depths up to 95%. Frequency response relative to 1 kHz : $\pm 1.5\%$ of reading for modulation frequencies from 30 Hz to 50 kHz.
	Notes...
	(1) These accuracy figures apply with 30 Hz - 50 kHz l.f. filter selected.
	(2) Where necessary, allowance must be made for peak residual noise which will contribute to peak readings.
FM rejection :	50 kHz peak deviation on carrier frequencies above 5.5 MHz will produce an indication of less than 0.5% a.m. with the 50 Hz to 15 kHz filter selected.
Residual a.m. noise : (300 Hz to 3.4 kHz bandwidth)	Less than 0.02% r.m.s. a.m. With input signals greater than 30 mV (-17 dBm) and the 300 Hz to 3.4 kHz filter selected.

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POWER MEASUREMENT

26. Range : 10 mW to 1 W (+10 dBm to +30 dBm).
Accuracy : ± 1 dB at 800 MHz.
Input v.s.w.r. : Frequency response ± 1 dB from 500 kHz to 1500 MHz, usable up to 2 GHz.
Display : < 2.00 from 500 kHz to 1500 MHz.
Temperature range : Display may be in dBm or W as selected by keyboard second function.
0 to 35°C.

27. Frequency display Front panel keys enable the following frequencies to be displayed on an 8 digit l.c.d.

CARRIER

- CARRIER ERROR : Frequency difference between measured carrier frequency and frequency reference in store.

MODULATION

Resolution

- CARRIER : 10 Hz below 1 GHz,
100 Hz above 1 GHz.
CARRIER ERROR : All carrier frequencies : 10 Hz.
MODULATION : 0.1 Hz up to 5 kHz,
10 Hz above 5 kHz.
Accuracy : ± 1 count \pm frequency standard error.
(all modes)
Frequency standard : Front panel indicator shows when external standard is selected.

28. Internal frequency standard

- Frequency change with temperature : $< \pm 0.1$ p.p.m. over the range 0 to 40°C.
Aging rate : After one month's continuous use at constant ambient temperature, -
Better than 3 parts in 10^9 per day of continuous use.
Better than 1 part in 10^7 per month of continuous use.
Better than 1 part in 10^6 per year of continuous use.
Warm-up time : Within 0.5 p.p.m. of final frequency within 5 min. from switch-on at 20°C ambient.

Characteristic

Performance

29. Modulation display

In accordance with the function selected, a 4 digit l.c.d. will show the following :

AM - % modulation depth.
FM - kHz deviation.
 ϕ M - radians deviation.
POWER - W or dBm as selected.
Relative
(REL) - dB.

30. Detector modes

The following may be selected :

Average of P+ } $\frac{P-P}{2}$
and P- }
Positive peak P+
Negative peak P-
Noise averaging NOISE AVG.
(calibrated as peak of
equivalent sine wave)

31. Display modes

The following may be selected :

Absolute - absolute values of modulation are displayed.
(ABS)
Relative - measured modulation is displayed as a ratio in dB to a reference quantity entered and stored in the instrument.
(REL)
Peak hold - holds and displays the maximum peak occurring in period of observation.
(PK HOLD) In power measurement, measures peak power.

32. Modulation bandwidths

Five post detector filter bandwidths may be selected from the front panel :

10 Hz to 300 kHz for wide band f.m. measurements.
30 Hz to 50 kHz } flat within 0.1 dB.
65 Hz to 250 Hz }
50 Hz to 15 kHz } nominal
300 Hz to 3.4 kHz } -3 dB bandwidths

Characteristic

Performance

33. De-emphasis

Three de-emphasis time constants may be selected from the front panel :

50 μ s,
75 μ s,
750 μ s.

De-emphasis may be introduced into the l.f. output circuit and relative measurements only and does not affect absolute measurements.

34. Outputs (front panel)

IF :

As carrier frequency for input carriers up to 1.5 MHz.

250 kHz nominal for carrier frequencies from 1.5 MHz to 5.5 MHz.

1.5 MHz for carrier frequencies above 5.5 MHz.

100 mV r.m.s. nominal into 50 Ω .

LF :

Demodulated, filtered and de-emphasized signal is available at BNC socket.

LF LEVEL control adjusts level from 0 to at least 3 V r.m.s. into 600 Ω for f.m. deviations >500 Hz, a.m. $>0.5\%$ and ϕ .m. >1.5 rad. at 1 kHz.

35. Distortion

FM :

For modulation frequencies up to 20 kHz, $<0.15\%$ THD (Total Harmonic Distortion) for deviation up to 100 kHz. $<0.5\%$ THD for deviation up to 500 kHz. $<1\%$ THD for modulation frequencies up to 100 kHz.

AM :

$<0.3\%$ THD for modulation depths up to 95% at 1 kHz modulation frequency and $<1\%$ THD for modulation depths up to 95% and modulation frequencies up to 50 kHz.

Stereo separation :

Better than 50 dB at 1 kHz (typically 54 dB above 100 Hz).

Characteristic

Performance

36. Store/Recall

The RCL/STO key used with the numeric keypad allows up to 10 instrument settings to be stored in non-volatile memory for later recall.

37. Rear panel connections

(1) External filter :

An external l.f. filter may be connected via a standard stereo jack into the modulation amplifier. Source impedance is low and load impedance is high.

(2) External local oscillator input :

An external local oscillator may be connected via a BNC socket and can be switched into circuit in place of the internal oscillator by keyboard action.

Frequency range 28 MHz to 56 MHz to cover input signals from 26.5 MHz to 2 GHz.

Input level, 100 mV to 1 V into 50 Ω .

(3) Internal frequency standard output :

10 MHz output from internal standard available at BNC socket. Output level at least 100 mV into 50 Ω .

(4) External frequency standard input :

10 MHz external standard input via BNC socket.

1 V r.m.s. sine wave into a nominal 100 Ω .

38. Keyboard second functions

Group P0 (unprotected) and P1 (first level protected) are concerned with extensions and modifications in operating technique and their use is described in Chapter 3 of this volume. The second and third levels of protection - groups P2 and P3 - control access to basic calibration data stored in the instrument and their description and use is covered in the Service Manual which is available as an optional extra.

Characteristic

Performance

39. GPIB operation

A GPIB interface is available as an optional accessory which may be supplied fitted, with the instrument, or may be subsequently fitted by the user without the need for special skills or equipment.

All controls except for SUPPLY and LF LEVEL are remotely programmable. Second functions are all programmable, and protected levels can be accessed via the bus directly without prior insertion of the locking code. The interface complies with the following subsets as defined in IEEE 488 - 1978, IEC 615-1 1979 and BS 6146 : SH1, AH1, T6, TE0, L4, LEO, SR1, RL1, PPO, DC1, CO, E1 - see optional accessories para. 48, page 14.

40. Psophometer weighting/distortion measurement

Incorporation of the optional kit 46883-527G enables the full potential of the 2305 to be realized and the keys controlling weighting (WTG) and distortion measurement (DIST SINAD) to become operational. The kit comprises an assembled circuit board with fitting instructions and may be retro-fitted by a user if fitting was not requested prior to despatch of the 2305.

Distortion measurement

Measurement frequencies :	300 Hz, 500 Hz, 1 kHz, automatically tuned over $\pm 5\%$.
Fundamental rejection :	greater than 65 dB.
Distortion measurement range :	0.1 to 100%.
SINAD measurement range :	0 to 60 dB.
Measurement accuracy :	± 1 dB.

Weighting filters

CCITT filter :	Frequency response conforms to CCITT recommendation P53.
CCIR filter :	Frequency response conforms to CCIR recommendation 468-2.

Characteristic

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ENVIRONMENTAL

41. Rated range of use 0 to 55°C, except power measurement.
0 to 35°C, power measurement only.
42. 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).
43. Safety Complies with IEC 348.
44. Radio frequency interference Conforms to the requirements of EEC
directive 76/889.
45. Power requirements AC mains, switchable voltage ranges:
105 to 110 V }
115 to 120 V } ±10%
210 to 220 V }
230 to 240 V }
45 to 440 Hz, 70 VA.
46. Weight and dimensions
- Height : 152 mm (6 in).
- Width : 425 mm (16.7 in).
- Depth : 535 mm (21 in).
- Weight : 13.5 kg (29.7 lb).

ACCESSORIES

47. Supplied accessories

	<i>Code no.</i>
Plastic cover	37490-180L
AC supply lead	43123-076Y
Operating manual	46881-431P
Jack plug (Con. Tel. Male 3 Free Black A)	23421-620H

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GPIB Adapter Module	54433-001U
GPIB Lead Assembly	43129-189U
GPIB Manual	46881-365R
Rack Mounting kit	46883-506M
Front Handle kit	46883-511R
Distortion/Weighting Filter kit	46883-527G
Maintenance kit, includes extender board, l.c.d. insertion and extraction tools, board extractor etc.	54711-034U
Service Manual H 52305-900K, Vol. 2	46881-432X
Attenuator 20 W, 50 Ω , 20 dB	54431-021B
Signal Sniffer. T connector for insertion between transmitter and load with pick-up to give a small signal from the T branch to the modulation meter	54452-011E
Termination 12 W, 50 Ω	54422-011A
Lead coaxial, 50 Ω , BNC, 1.5m	43126-012S
Lead coaxial, 50 Ω , type N, 457 mm	43126-026A
IEEE/IEC connector adapter	46883-408K
Stowage Cover kit. Plastic cover with storage space for accessories which clips over the front panel and protects controls during transportation and storage	PB 46883-519Y
Carrying case	46662-086S
Low leakage r.f. coaxial cable with N-type connectors, 50 Ω , 1 m	54311-095C