HART MICROWAVE

ENGINEERING TEST REPORT

CERTIFICATION TESTING
OF
SAFETY WARNING SYSTEMS TRANSMITTER

Manufactured by MPH Industries, Inc.
Under License From
Safety warning System, L.C.
Model No. Programmable
Serial No. ENGR002
FCC ID: CJR—SWS-K90XMIT

Tested in Accordance With
Code of Federal Regulations, Chapter 1, Title 47, Parts 2 and 90
As Amended By
The Commissions Part 90 Rules Concerning
Private Land Mobile Radio Services
Adopted January 28, 1999

Certification Testing Performed from March 13, 1999 to April 2, 1999

April 3, 1999

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CERTIFICATION TEST DATA

Per CFR Ch. 1, Subpart J

Unit Tested: SAFETY WARNING SYSTEMS TRANSMITTER
Model Programmable
Serial #: ENGR002

	Parameter	Applicable 47 CFR ¶	Limit	Measured
1)	Output Power	¶2.1046	120 mW as spec'd in equip. authoriz.	80 mW
2)	Antenna gain	Req'd. to Calc. ERP	Not spec'd	16.0 dB
3)	Antenna 3 dB beamwidth		Not spec'd.	
	Forward antenna		"	Horiz. 21.0°
			"	Vert. 34.0°
	Rearward antenna		"	Horiz. 23.3°
			"	Vert. 31.7°
4)	Output frequency drift vs temperature	¶2.1055	2000 PPM	± 300 PPM
5)	Occupied bandwidth	¶2.1049	6.002 MHz necessary BW	5.56 MHz @ -23 dBc
6)	Spurious emissions	¶2.1053 ¶2.1057(a)(2)	-32 dBc	-40.6 dBc @ 48.2 GHz
7)	Output frequency drift vs input VDC	¶2.1055	2000 PPM	± 12 PPM
8)	Radio frequency radiation exposure level	¶2.1091	3 Watts ERP	1.94 Watts ERP

Summary Based on the data shown above, it is my conclusion that the Safety Warning Systems Transmitter Model # Programmable, Serial # ENGR002 meets all the requirements of the Code of Federal Regulations as amended January 28, 1999. I certify that I conducted these tests and verify the results as presented in this report.

[signature] Date 4 Apr. 99

Robert H. Merriam, Consulting Engineer
Hart Microwave, Owensboro KY 42303

DISCUSSION OF TEST DATA AND TEST PROCEDURES

1) Output power CFR ¶2.1046(a). In order to measure the output directly at the "RF Output Terminals" the test setup of Fig. 1 was used.

2) Antenna gain (Gain is required for calculation of Radiation Exposure Level ¶2.1091) Measurements were made in the far field at a range of 36". The calibrated antenna has a gain of 20.1 dB. The test setup is shown in Fig. 2.

$$G_T + P_{RX} - P_T - GRX + P_L$$

Where

G_T	=	Transmit antenna gain	= Unknown
P_{RX}	=	Power received	= -7.5 dBm
P_T	=	Power transmitted	= +15.7 dBm net
G_{RX}	=	Receive antenna gain	= 20.1 dB
P_L	=	Path loss	= 59.3 dB

P_L = 163.6 (GHz) (Range in feet) = 59.3 dB

Calculation of antenna gain G = 16.0 dB including radome

Note that this antenna is a dual symmetrical forward firing and backward firing antenna. Data was taken on one antenna at a time. With a dual split of transmitter power, with an internal magic T, each antenna feed receives half the transmitter power less an estimated L.O. drive of 1.0 mW and magic T loss of 0.3 dB. This nets a power of +15.7 dBm to each antenna throat.

3) Antenna beamwidth The 3 dB antenna horizontal beamwidth was measured for each of the two antenna ports as shown in Fig. 2. Similarly, the vertical beamwidth was measured by repositioning the transmitter on edge on the turntable post. Beamwidths measured were:

	Horiz. 3 dB BW	Vert. 3 dB BW
Forward antenna	21.0°	34.0°
Rearward antenna	23.3°	31.7°

The noise level or minimum discernible signal level of the measurement system is as follows:

Test setup	Frequency range	Noise level
Fig. 5	4.7 MHz to 1000 MHz	-116 dBm
Fig. 6	1 GHz to 6 GHz	-90
Fig. 6	6 GHz to 10 GHz	-85
Fig. 6	10 GHz to 12 GHz	-80
Fig. 4	12 GHz to 18 GHz	-75
Fig. 4	18 GHz to 40 GHz	-68
Fig. 7	33GHz to 50 GHz	-50
Fig. 7	50 GHz to 75 GHz	-50
Fig. 7	75GHz to 100 GHz	-50

From 4.7 MHz to 40 GHz, the measurement system could not detect any spurious signals above the measurement noise floor. These setups are shown in Fig's. 4, 5, and 6. The false signals detected on the spectrum analyzer were verified by either turning off the transmitter, or by using the signal identifier on the analyzer.

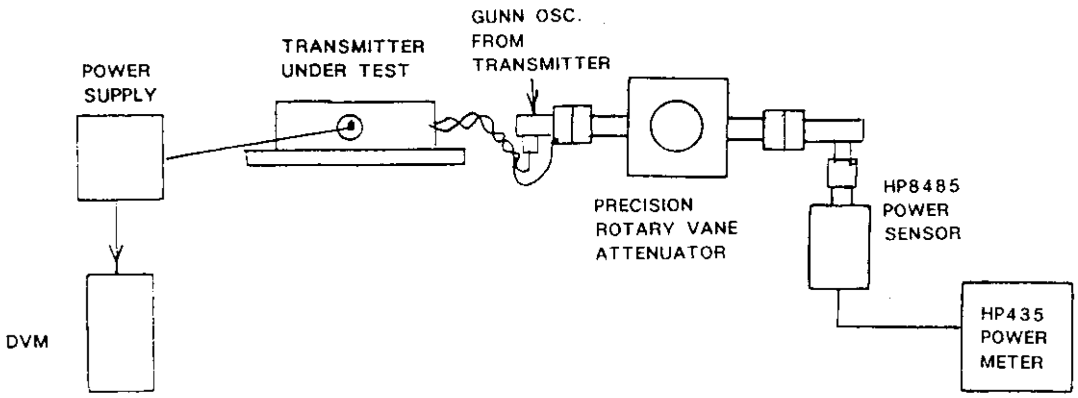
Emission and spurious radiation tests using the 36" range from transmitter to pickup antenna were made in an outdoor environment with the nearest reflective surfaces well over 15 feet distant. For the tests with the Kerr horn at a distance of 18", tests were made in a room with the transmitter placed on top of a 29 inch high corrugated cardboard box. The box rested on concrete. The ceiling was 48 inches above the top of the transmitter. Ceiling material was acoustic tile and wooden joists. The nearest metallic reflective surface was 5 feet distant which was the spectrum analyzer. These dimensions represent the far field for measurements above 1 GHz. Below 1 GHz, measurements were made with close field probes where nearer metal reflections become insignificant.

Above 40 GHz, a wideband horn/lens pickup antenna was used. Calibration of this antenna showed a constant effective aperture from 24.0 GHz to 105 GHz of 12.2 cm^2 ±0.3 dB. A matching horn to waveguide transition was used for different bands as shown in Fig. 7. With a constant aperture antenna from 24 GHz up through the 4^{th} harmonic, and with all measurements taken at a range of 36", relative effective power density or microvolts per meter can be measured by directly comparing received powers. These measurements above 40 GHz were taken on the outdoor 36" range.

Measurements of transmitter spurious between 40 GHz and 100 GHz revealed only one signal above the system noise floor. This was the 2^{nd} harmonic at 48.2 GHz with a level of -40.6 dBc at one antenna port and -46.9 dBc at the other antenna port. These are well within the system requirement of -32dBc.

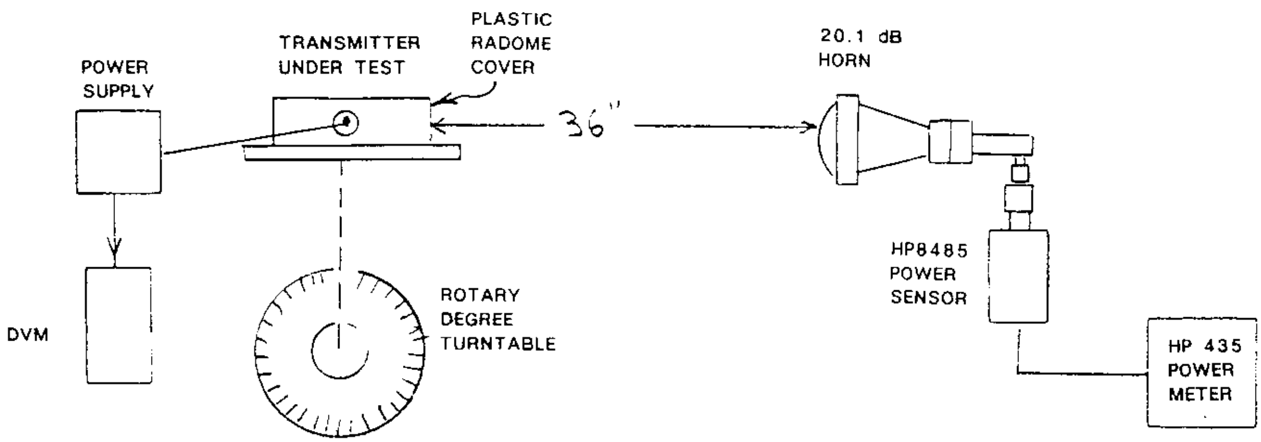
EQUIPMENT LIST

ITEM	DESCRIPTION	CALIBRATION DATE
Power Sensor	Hewlett Packard 8485A SN#1933A00631	4 Mar 99
Power Sensor	Hewlett Packard K486A SN#04079	4 Mar 99
Power Sensor	Hewlett Packard Q8486 - WR22 - SN#2741A00729	4 Mar 99
Power Meter	Hewlett Packard 435A SN#1750A06148	4 Mar 99
Power Meter	Hewlett Packard 432A SN#1948A18756	4 Mar 99
Precision Attenuator	Hewlett Packard Ku-band P382A SN#210	Original Cal.
Precision Attenuator	Flann K-Band 2011 SN#347	26 Aug 94
Precision Attenuator	Memco Ka-band Mod. KA-151-V-0-50 SN#034	31 Aug 95
Spectrum Analyzer	Hewlett Packard System HP8555A SN#2028A11186	4 Mar 99
Spectrum Analyzer Mixer	Hewlett Packard 11517A with waveguide adapters	4 mar 99
Detector - WR15	Quinstar DEA-1500AA SN#110	13 Dec 98
Detector - WR10	Quinstar DEA-1000AA SN#112	13 Dec 99
Preamplifier, low noise	Minicircuits ZFL1000LN/ZFL100 0.1 to 1000 MHz	4 Mar 99
Antenna, Close Field Probe	Hewlett Packard 11941A, 9 KHz to 30 MHz, SN#2807A02746	Original Cal.
Antenna, Close Field Probe	Hewlett Packard 11940A, 30 MHz to 1 GHz, SN#2650A03820	Original Cal.
Antenna, Wideband Horn	Kerr design, 900 MHz to 12.4 GHz	24 Aug 94
Antenna, X-band horn	Cast, 2.3" X 2.6" - UG 39 flange	22 Sep 88
Antenna, K-band horn	Sperry 56K1 SN#626178-a	5 Dec 87
Antenna, Ka-band horn	Fabricated, 0.79" X 0.91"	27 Jul 94
Antenna, Horn/lens	SRKa, 2" diam., constant aperture, 12.2 cm², 24 to 100 GHz	14 Mar 99
Counter, Microwave	HP5345/HP5355/HP5356C, SN# ME-SY-6a	
Counter, Microwave	EIP 548A SN#01306	25 Mar 99
Voltmeter, Digital	Hewlett Packard 34401 - SN#ANUS36035368	9 Sep 98
Hot/Cold Plate	Environmental Stress systems, Mod. T40006-34, SN#9190401 with Fluke 52 Temperature meter SN#4516222	4 Mar 99



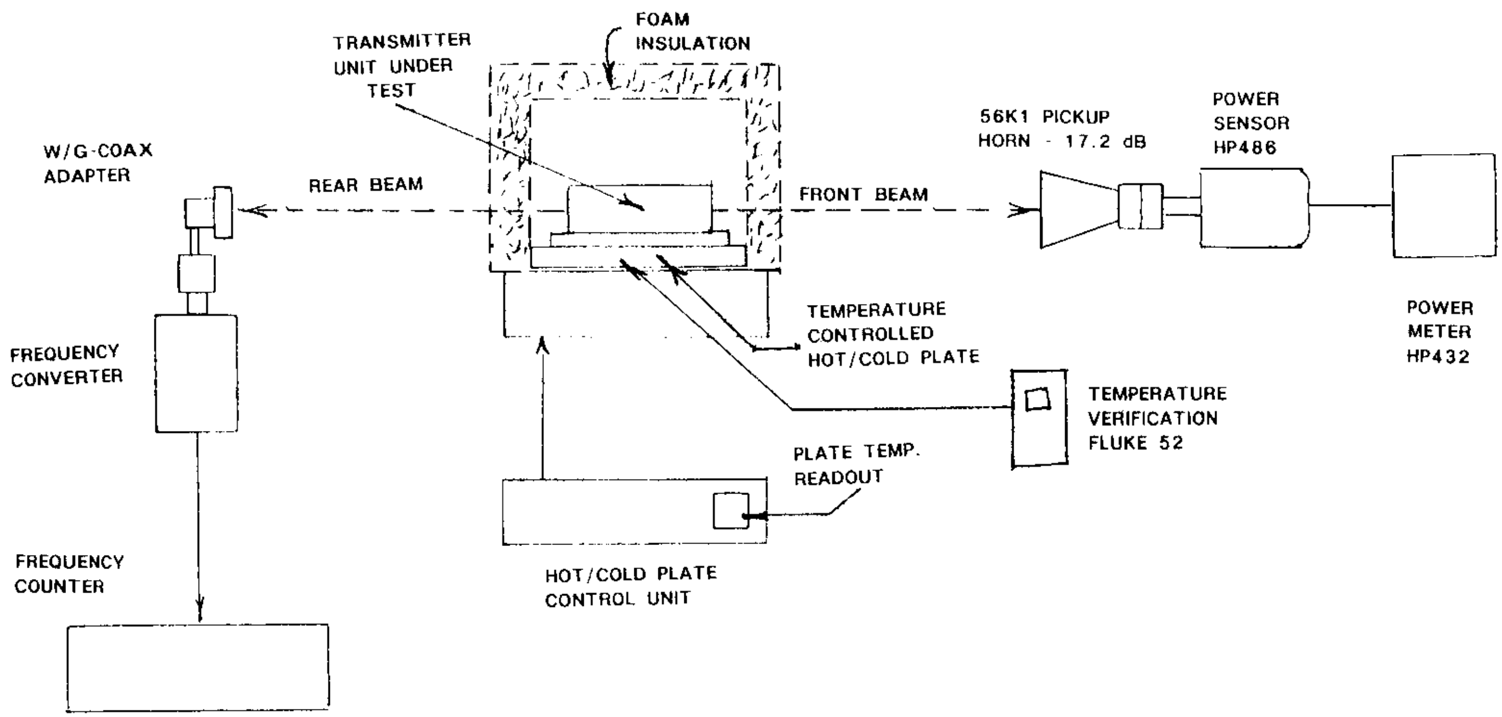
TEST SETUP FOR MEASUREMENT OF:
OUTPUT POWER

FIG. 1



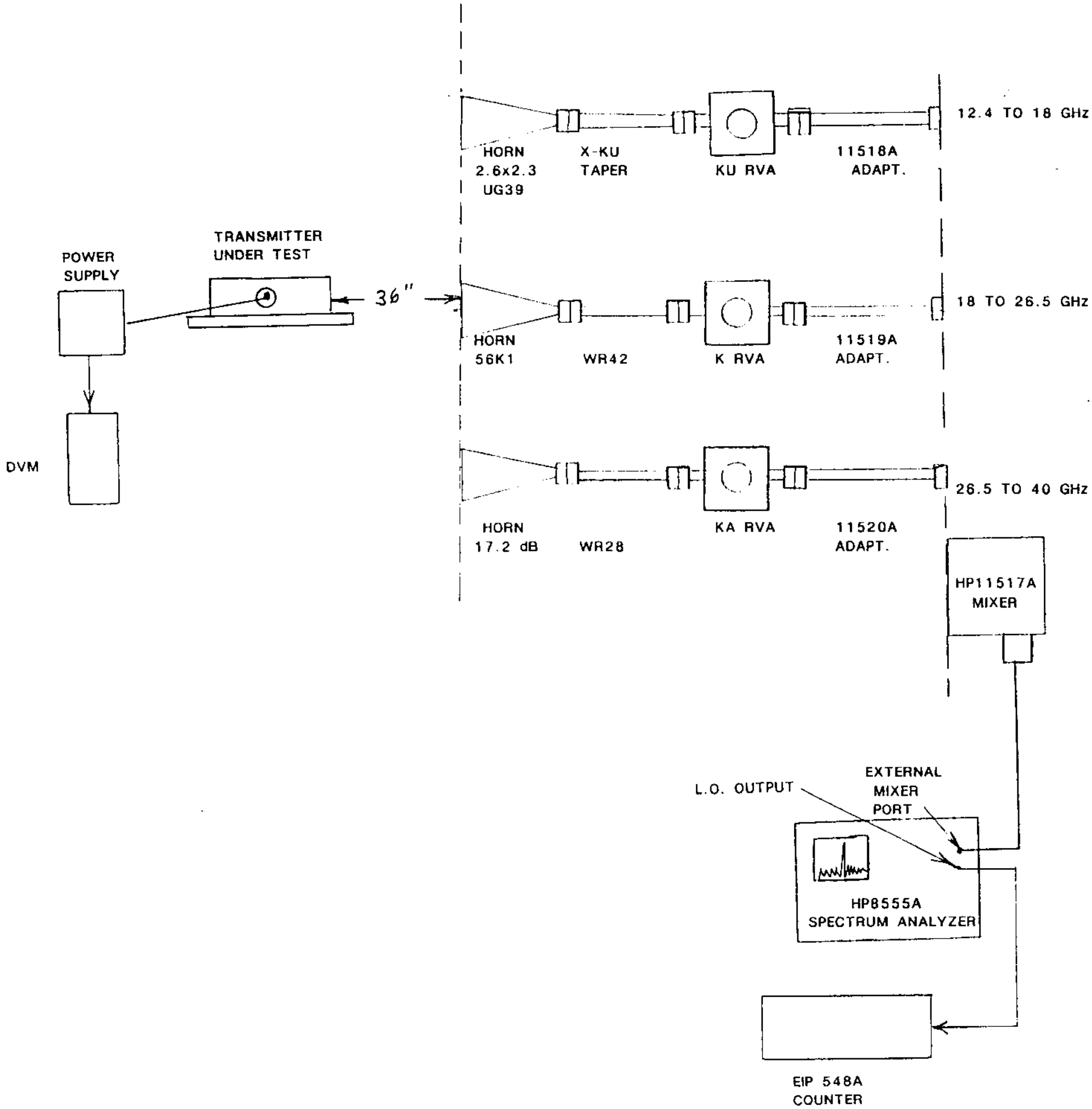
TEST SETUP FOR MEASUREMENT OF:
ANTENNA GAIN,
3 dB ANTENNA BEAMWIDTH

FIG. 2



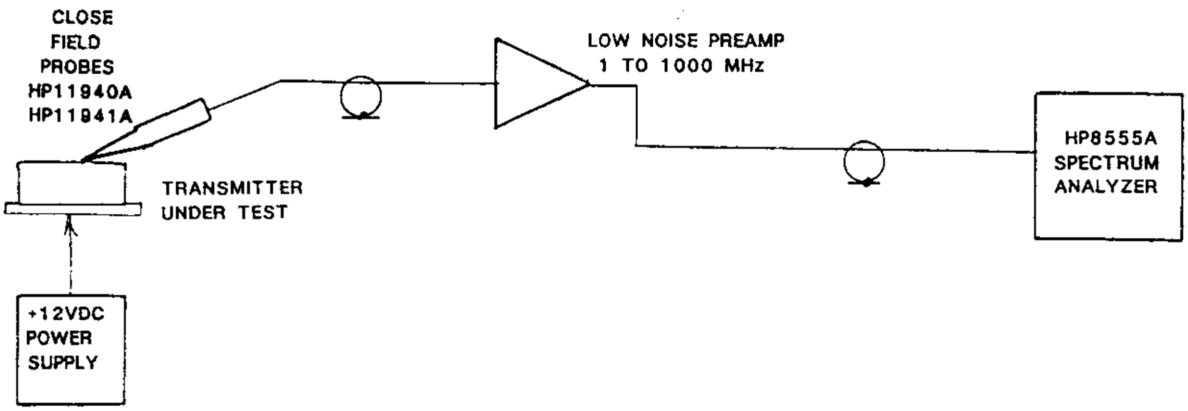
TEST SETUP FOR MEASUREMENT OF:
OUTPUT FREQUENCY vs TEMPERATURE,
RELATIVE POWER OUTPUT vs TEMPERATURE

FIG. 3



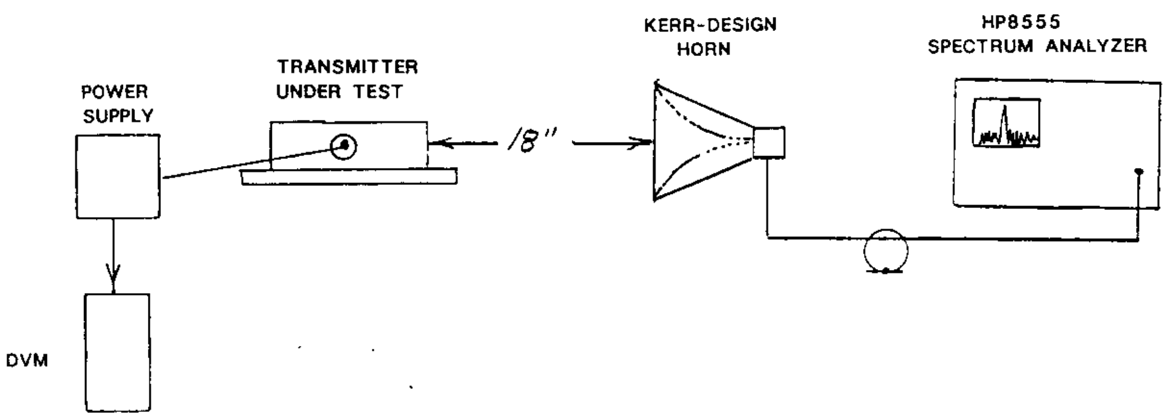
TEST SETUP FOR MEASUREMENT OF:
OCCUPIED BANDWIDTH,
SPURIOUS EMISSIONS FROM 12.4 TO 40 GHz

FIG. 4



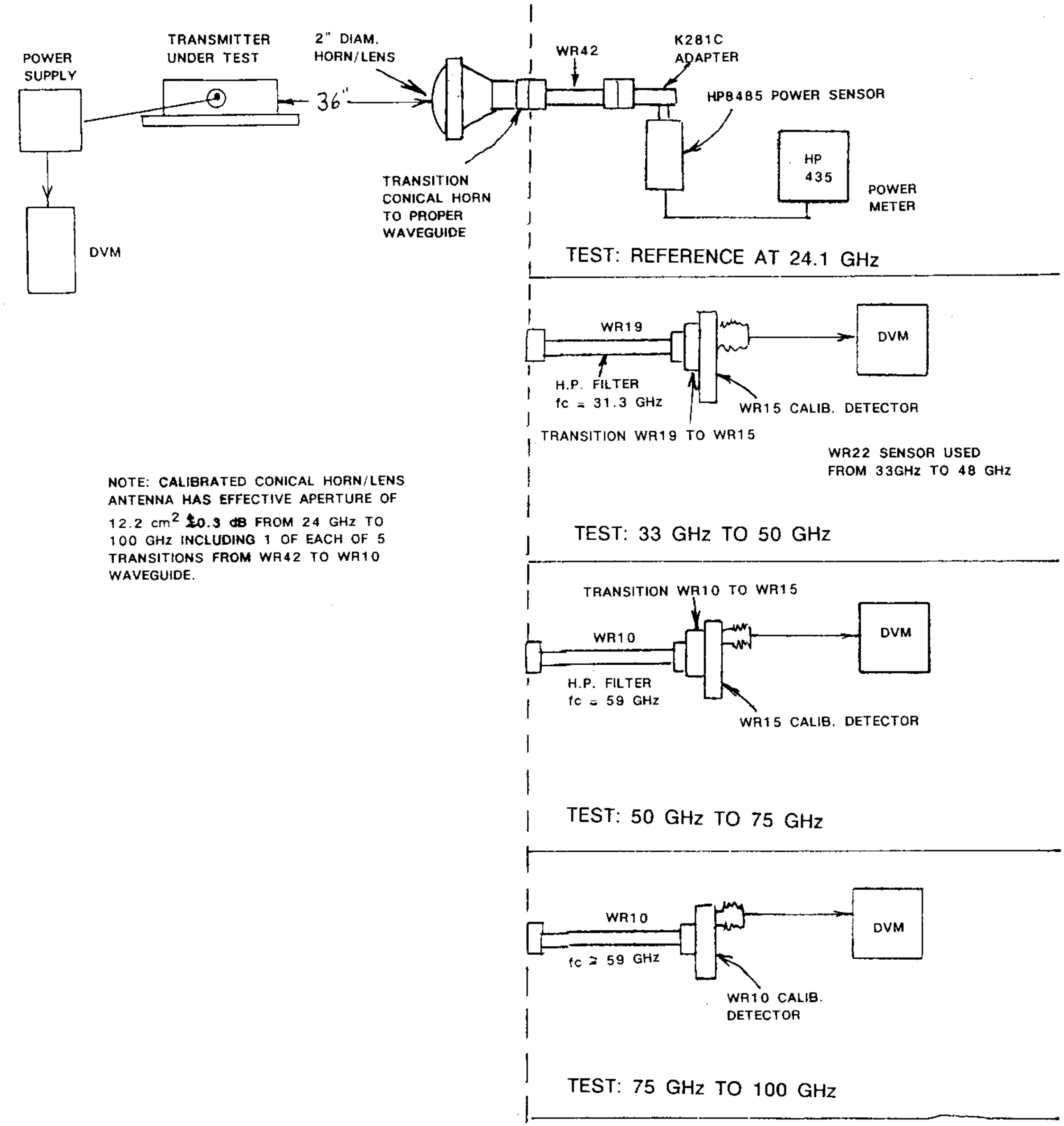
SETUP FOR MEASURING SPURIOUS EMISSIONS - 4.7 TO 1000 MHz

FIG. 5



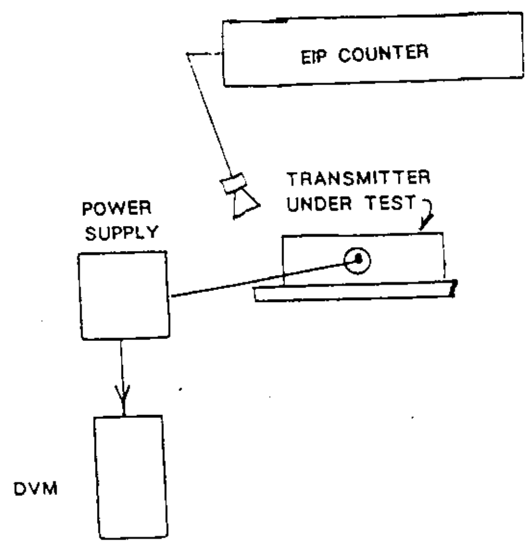
TEST SETUP FOR MEASUREMENT OF:
SPURIOUS EMISSIONS - 1 GHz TO 12.4 GHz

FIG. 6



TEST SETUP FOR MEASUREMENT OF:
HARMONICS AND SPURIOUS RADIATION
FROM 40 GHz TO 100 GHz

FIG. 7



TEST SETUP FORMEASUREMENT OF
FREQUENCY OUTPUT vs POWER SUPPLY VOLTAGE

FIG. 8