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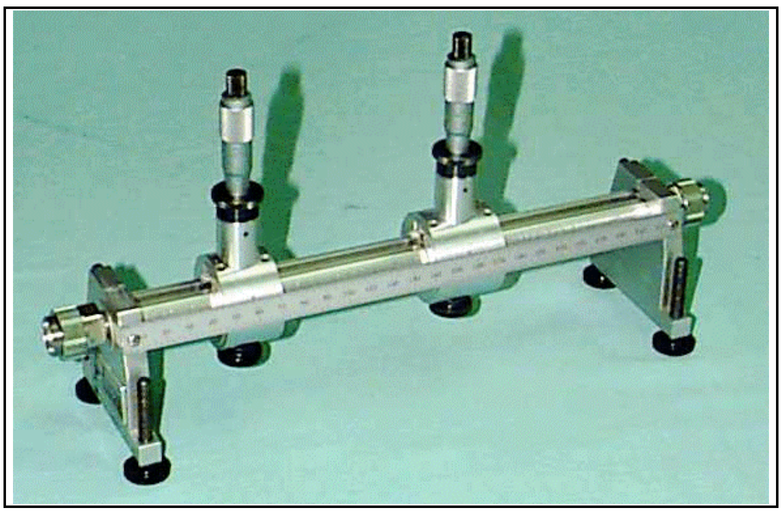
Focus microwaves

Product Note 45

Manual Microwave Tuners, model MMT

Manual Microwave Tuners are designed for critical RF impedance matching operations, like Load Pull and Noise measurements. MMTs use parallel plate airlines (slablines) and one or two sliding carriages with one vertical micrometer screw and a microwave probe (slug) each. The microwave probes and slablines are designed to generate high reflection factors over a very wide frequency band (such as 0.8 to 18 GHz with typical VSWR of 20:1). The two independently adjustable carriages allow mutual prematching of the probes and thus selectively extremely high VSWR (greater than 50:1). The sliding mechanism and the probes ensure long lasting operation, high reproducibility and insensitivity to vibrations. Manual Microwave Tuners are manufactured for frequencies from 400 MHz to over 40 GHz, using a variety of connector types. Tuners with 2.4 mm connectors for operation up to 50 GHz can be made on special order.



MMT at a glance:

MMT at a glance:	Frequency Range (different models)	0.4 to 40.0 GHz
	VSWR Tuning Range (wideband)	1.04:1 to 20:1
	Phase Tuning Range	0 to 360 degrees
	Instantaneous Bandwidth	up to 5 octaves
	Prematching capability (narrow band)	Yes (VSWR up to 50:1)
	Insertion Loss (frequency dependent)	0.1 to 0.9 dB
	Connector types	APC-7, 3.5, 2.9, N, SMA

November 1997

Tuning Capability of Manual Tuners 0.8-18 and 3-40 GHz

The following plots (2 to 9) show the tuning capability of various MMT models (1808 = 0.8 to 18 GHz with GPC-7 and N connectors, or 4003 = 3 to 40 GHz) with two RF probes mounted on two independent carriages. Some plots show the "prematched" tuning range, where one probe is used to increase the tuning range of the second one, in a narrower frequency range.

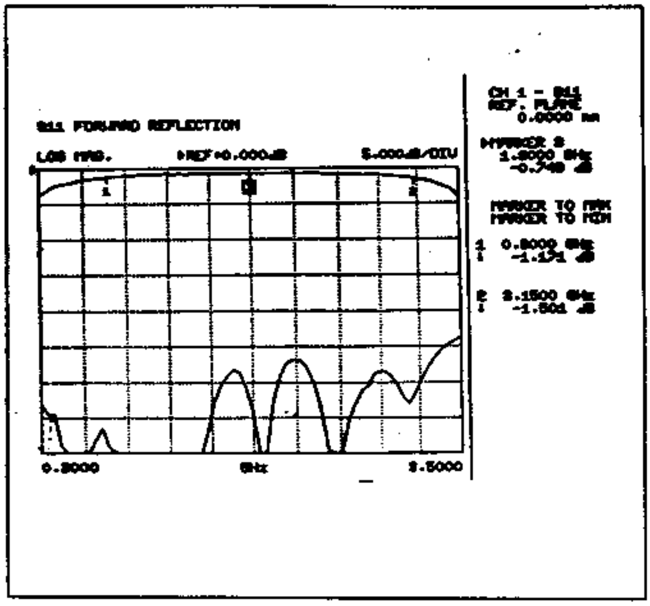


Figure 2: Tuning range of MMT-1808 (low frequency probe)

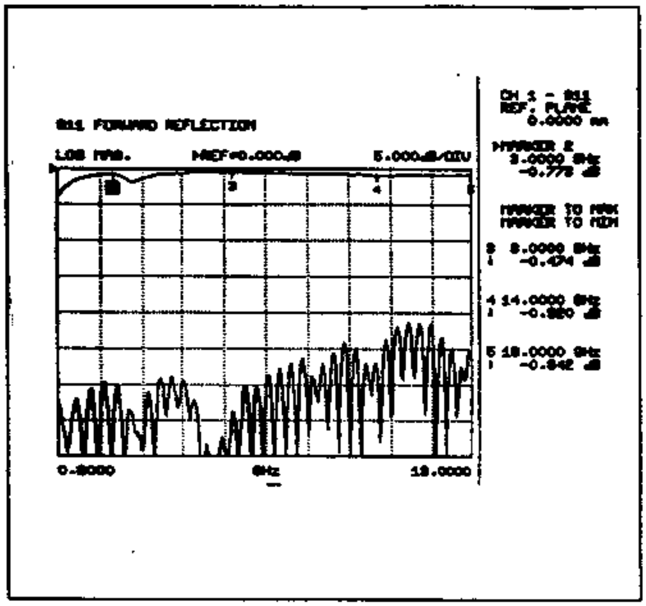


Figure 3: Tuning range of MMT-1808 (high frequency probe)

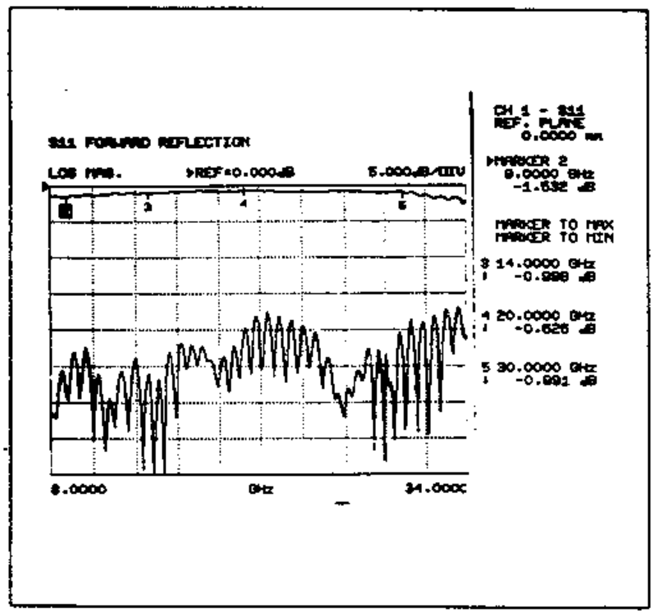


Figure 4: Tuning range of MMT-4003 (high frequency probe)

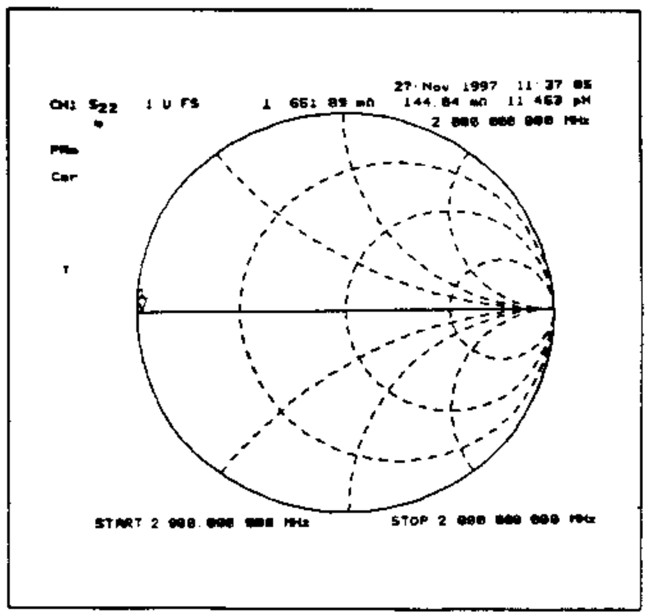


Figure 5: Tuning capability of MMT-1808-N (with N connector and Probe Prematching)

Tuning Capability of Manual Tuners 0.8-18 and 3-40 GHz

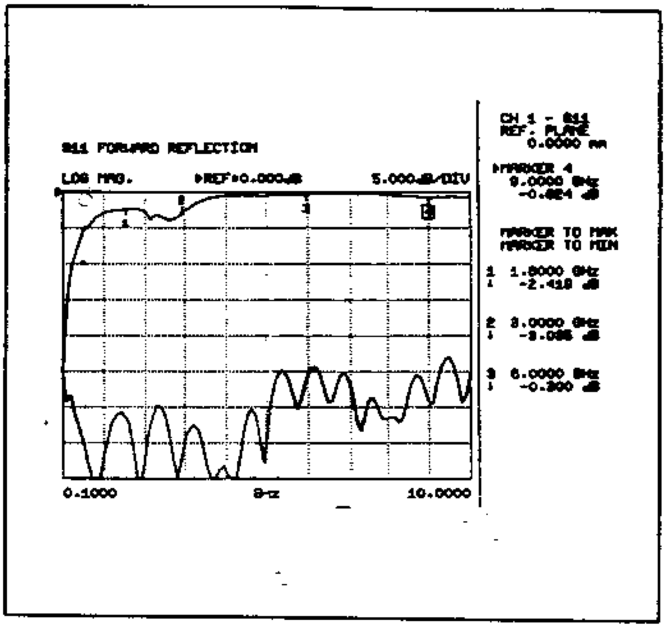


Figure 6: Tuning Capability of MMT-4003 using Probe Prematching

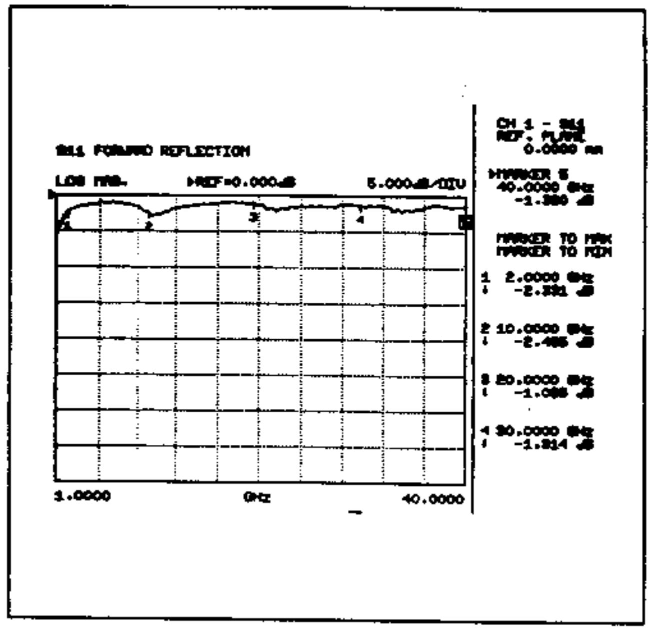


Figure 7: Tuning range of MMT-4003 (combined probes)

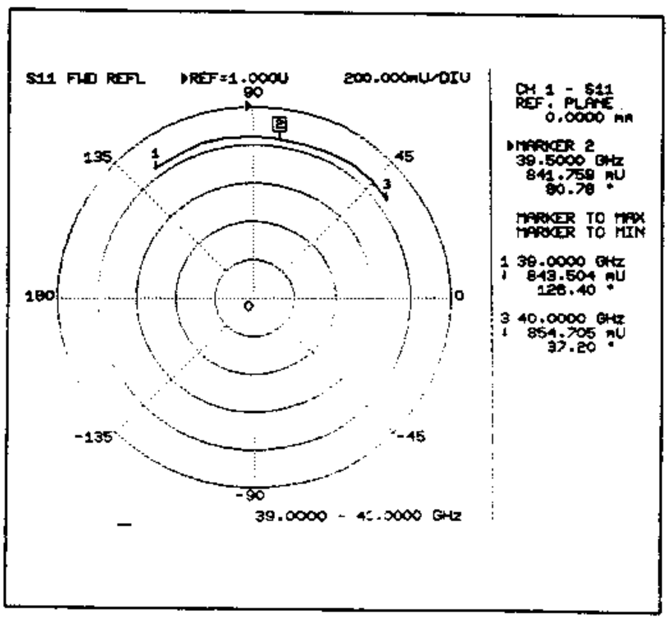


Figure 8: Tuning Capability of MMT-4003 at 39-40 GHz using Probe Prematching

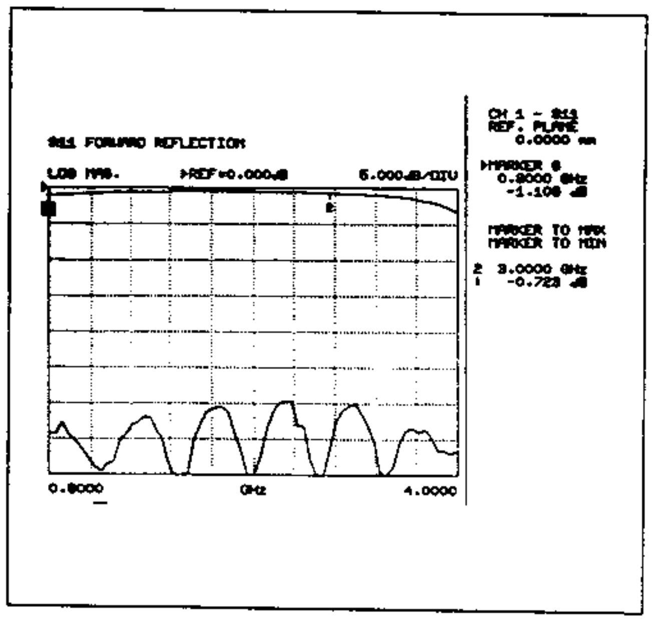


Figure 9: Tuning Capability of MMT-1808-N (with N connectors and low frequency probe)

Reproducibility of Manual Microwave Tuners

Manual Tuners are mostly used for "interactive" matching, meaning that the operator observes the total DUT performance, like Gain, Output Power or Intermod, while moving the tuner probes in phase and amplitude and then measures their S-parameters on a network analyser. It is programmable automatic tuners which are supposed to reproduce a once set and calibrated impedance.

There are cases, though, in particular when several devices shall be compared for a set of more than one impedance, or when the impedances need to be marked and determined on the network analyser later on, where the reproducibility of the four S-parameters of the tuner twoport when reset manually to the same micrometer readings is important.

This reproduction of once set positions obviously depends on the operator, the mechanical stability and smoothness of the movement and the resolution of the readings.

We verified this type of operation using some of the manual tuners model MMT-N (with N connectors) at a medium frequency of 2 GHz and a high VSWR of 15:1.

A special software is used with the tuner connected to a calibrated network analyser, which is controlled via GPIB by the control PC. The software then prompts the operator to set the tuner position and press a key in the keyboard to launch a measurement. All four S-parameters are measured with the network analyser and saved in a file, together with the power gain of the tuner. The measurement can be made under many different conditions, like not moving the tuner at all (to test the VNA reading accuracy, moving only the horizontal axis, the vertical axis or both axis) in order to see the sensitivity of the tuner on phase and amplitude separately. The result of such a test is shown in Table 1.

Manual Tuner Repeatability: **Tuner Model MMT-1808-N**

Frequency = 2.0000 GHz

Measurement Condition: **No Tuner Move (=VNA Repeatability)**

Point	S11	_ 11	S12	_ 12	S21	_ 21	S22	_ 22	Tuner Loss [dB]
001:	0.884	-36.2	0.367	32.6	0.365	32.5	0.836	-76.6	L=2.085
002:	0.888	-35.9	0.367	32.6	0.365	32.4	0.838	-76.6	L=1.955
003:	0.884	-36.1	0.367	32.5	0.365	32.5	0.838	-76.6	L=2.100
004:	0.882	-36.0	0.367	32.6	0.365	32.5	0.839	-76.4	L=2.151
005:	0.886	-36.1	0.368	32.6	0.365	32.5	0.840	-76.5	L=1.996
006:	0.886	-36.2	0.368	32.5	0.365	32.5	0.840	-76.5	L=2.018
007:	0.883	-36.1	0.368	32.6	0.366	32.5	0.839	-76.7	L=2.115
008:	0.886	-36.1	0.367	32.6	0.366	32.5	0.838	-76.6	L=2.021
009:	0.887	-36.1	0.367	32.6	0.365	32.5	0.840	-76.7	L=1.991
010:	0.888	-36.1	0.367	32.7	0.365	32.6	0.842	-76.7	L=1.954
011:	0.885	-36.0	0.367	32.6	0.365	32.5	0.838	-76.7	L=2.077
012:	0.886	-36.1	0.368	32.5	0.366	32.6	0.838	-76.8	L=2.012
013:	0.886	-36.2	0.367	32.5	0.365	32.4	0.840	-76.8	L=2.016
014:	0.884	-36.1	0.367	32.6	0.365	32.5	0.840	-76.7	L=2.097

Measurement Condition: **Move Only Horizontal Axis**

015:	0.884 -36.0	0.368 32.6	0.365 32.6	0.840 -76.7	L=2.080
016:	0.881 -36.8	0.373 33.7	0.371 33.5	0.835 -73.8	L=2.051
017:	0.885 -36.6	0.369 32.8	0.366 32.7	0.840 -75.9	L=2.014
018:	0.887 -36.9	0.363 32.5	0.361 32.5	0.840 -76.0	L=2.106
019:	0.887 -36.7	0.361 32.1	0.358 32.1	0.841 -76.5	L=2.143
020:	0.884 -36.6	0.368 32.6	0.365 32.5	0.840 -75.9	L=2.086
021:	0.883 -36.7	0.368 32.8	0.366 32.7	0.833 -75.7	L=2.103
022:	0.887 -36.4	0.365 32.5	0.363 32.3	0.842 -76.3	L=2.057
023:	0.888 -36.9	0.366 32.5	0.363 32.5	0.837 -75.9	L=2.007
024:	0.885 -36.9	0.365 32.3	0.363 32.3	0.842 -76.1	L=2.101
025:	0.891 -36.7	0.356 31.9	0.353 31.9	0.843 -76.7	L=2.125

Measurement Condition: **Move Only Vertical Axis**

026:	0.889 -37.0	0.356 31.9	0.353 31.8	0.842 -76.6	L=2.193
027:	0.888 -36.6	0.360 32.5	0.358 32.4	0.832 -76.3	L=2.137
028:	0.884 -36.3	0.364 32.5	0.362 32.4	0.842 -76.5	L=2.190
029:	0.884 -36.4	0.363 32.6	0.361 32.5	0.839 -76.5	L=2.214
030:	0.886 -36.5	0.364 32.5	0.362 32.4	0.838 -76.6	L=2.116
031:	0.886 -36.6	0.361 32.5	0.360 32.4	0.838 -76.6	L=2.148
032:	0.885 -36.5	0.361 32.3	0.359 32.3	0.839 -76.5	L=2.199
033:	0.887 -36.5	0.361 32.3	0.360 32.3	0.842 -76.7	L=2.120
034:	0.886 -36.8	0.362 33.2	0.360 33.1	0.825 -74.7	L=2.129
035:	0.888 -36.6	0.363 32.7	0.362 32.7	0.834 -75.3	L=2.033
036:	0.880 -36.0	0.375 33.2	0.372 33.2	0.834 -75.9	L=2.052
037:	0.883 -36.3	0.373 33.3	0.371 33.2	0.836 -76.2	L=2.015

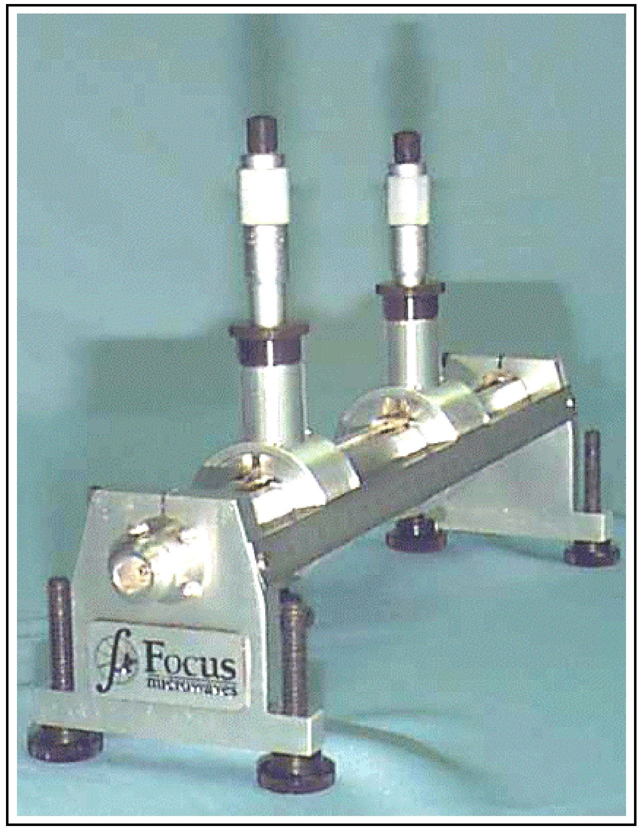
Measurement Condition: **Move Both Axis**

038:	0.883 -36.2	0.372 33.1	0.369 33.0	0.839 -76.1	L=2.038
039:	0.883 -36.3	0.366 32.6	0.364 32.5	0.842 -76.5	L=2.151
040:	0.887 -35.8	0.366 32.5	0.363 32.4	0.841 -76.8	L=2.024
041:	0.884 -35.8	0.369 32.8	0.367 32.8	0.837 -76.8	L=2.059
042:	0.884 -35.7	0.373 33.0	0.371 33.0	0.835 -76.7	L=1.964
043:	0.891 -37.2	0.352 31.7	0.350 31.6	0.847 -76.6	L=2.229
044:	0.890 -36.2	0.354 31.9	0.352 31.8	0.852 -77.2	L=2.193
045:	0.887 -35.5	0.367 32.6	0.365 32.5	0.843 -77.1	L=1.987
046:	0.884 -36.1	0.364 32.4	0.361 32.4	0.838 -76.9	L=2.168
047:	0.883 -36.1	0.365 32.7	0.363 32.6	0.832 -76.6	L=2.178

Table 1: Manual Tuner Repeatability test

This test shows the very good overall repeatability of the manual tuners. The difference in S11 is of the order of 0.005 and 0.5°. Combined with the scattering in S21 this results to Loss errors of the order of 0.2 dB, which is acceptable, considering that about 0.1 dB in Loss error may be attributed to the network analyser reading repeatability (compare with the first measurement block in Table 1).

Using N-connector Tuners for High Power Testing



When testing power devices with very low internal impedances, the tuners have to synthesize the corresponding conjugate matching conditions under high CW power. The microwave probes are then very close to the central conductor. Two types of failure are then possible:

• Occasional corona discharge between the probes and the central conductor, which may, if repeated, ultimately lead to the damage of the protective dielectric layer beneath the probes. The tuner, however, will remain operational even if the probe is not repaired immediately .

• Damage to the connector, normally at the position where it joins the adjacent components, in particular the output port of the test fixture, where most of the RF power is concentrated. Under high VSWR conditions the RF current may reach extremely high levels and we have observed thermal run-away of GPC-7 connectors, in particular.
This is because these connectors rely on a small conical spring to establish a perfect RF contact between the central conductors of the mating connector sides. In this case the connector (and the tuner) will be permanently damaged and will require repair at the factory.

To avoid the second, and more critical, failure type we use N connectors. The N connectors provide a much better transition surface between the male and female centre pins of the adjacent adapters and can handle CW power in excess of 150 Watts under VSWR conditions in excess of 15:1. Until now we have not observed an RF power-caused damage to N connectors under these conditions. Figure 6 shows a manual tuner using female N connectors. The tuners can be equipped both with male and female N connectors in order to minimize adapters and losses in the setup.
Some of the test results included in this note have been obtained with N connector equipped tuners.