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Product Note 43

W Band Programmable Tuner Model 11075

The millimetre wave programmable tuner, model 11075 operates from 75 to 110 GHz.
It uses the robust and proven technology of the 1816 tuners (figure 1), but has smaller steps and a Teflon stabilized vertical axis for higher amplitude and phase resolution and stability of the reflection factor.
The transmission media is precisely slotted gold plated WR-10 (W) waveguide with a gold plated non contact probe moving in, out and along the waveguide slot to generate controllable Γ and phase with a total play of less than ±1μm.
The 11075 tuners are fully compatible with the IBM-PC based WinCCMT control and measurement software for Calibration, Noise and Load Pull measurements. They are available with an **"on-wafer-operation option"** which includes connectors on the side and a wafer-probe holder. Obtainable VSWR exceeds 10:1, and reaches up to 19:1 in most parts of the band (figures 2,3).

11075 Tuner Characteristics

Frequency Range	75 - 110 GHz
VSWR min	1.4:1, max
VSWR max	10:1 (19:1), min
Insertion Loss [1]	1.6 dB max @ VSWR.min
RF resetability	40 dB min
Calibration	compatible with Wiltron 360 and HP 8510.
Max Tuning Resolution	0.14°/step @ 94 GHz
Max Tunable points	2,500,000 @ 94 GHz
Mechanical - Accuracy	±1 step
Step Size	Vertical 0.75 μm, Horizontal 1.27 μm
RF Connectors	WR-10
Overall Size	8.3 x 6 x 5 inches
Weight	4.3 kg
Power Handling	50 W/CW
Operation	Automatic - Manual - Mouse Tuning for WR-10 fixture or 'on-wafer' setups.

[1] Tuner loss at VSWR.min is not important for load pull measurements. Operating tuner loss at high VSWR is directly proportional to the transmission loss between DUT and Tuner, which dominates, so it is useless to specify it on the tuner reference plane alone (see also page 4).

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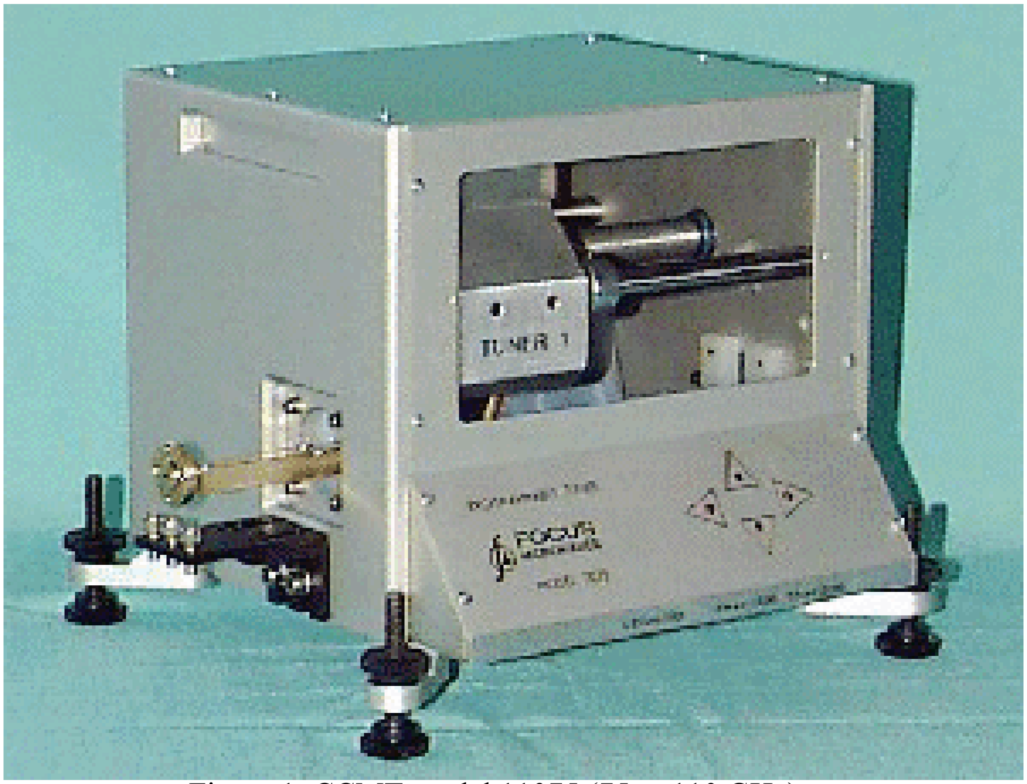

Figure 1: CCMT model 11075 (75 to 110 GHz)

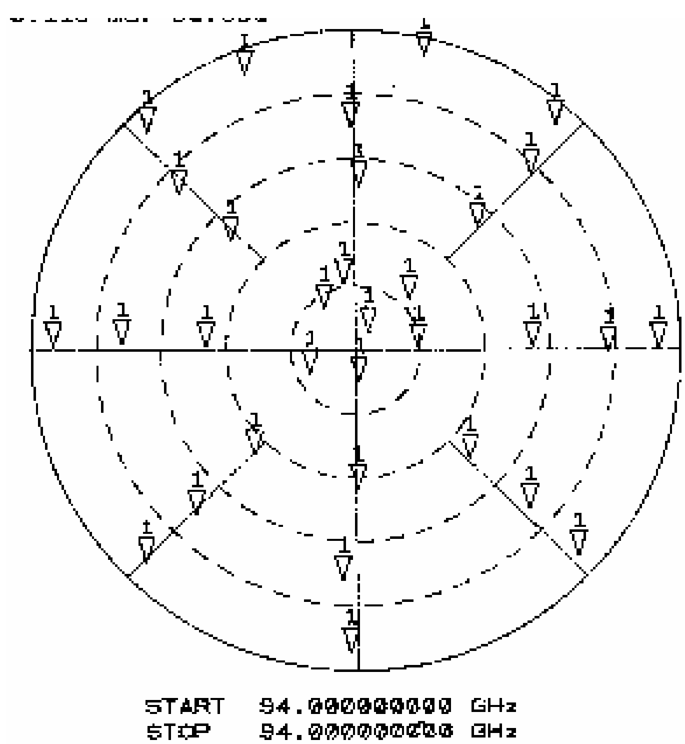

Figure 2: Real Tuning Capability of model 11075 at 94 GHz

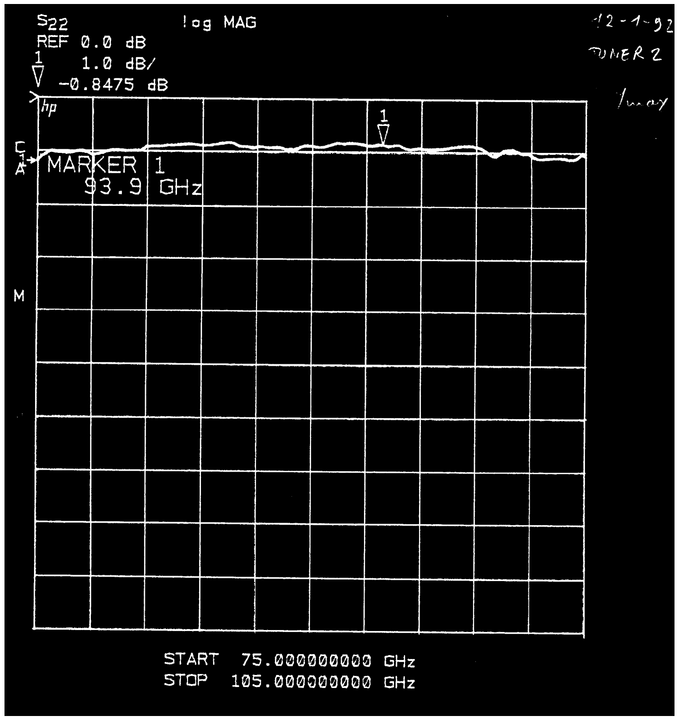

Figure 3: Frequency Response of Γ.max for model 11075
(1dB Return Loss => VSWR: 17.3:1 => Γ=0.891)

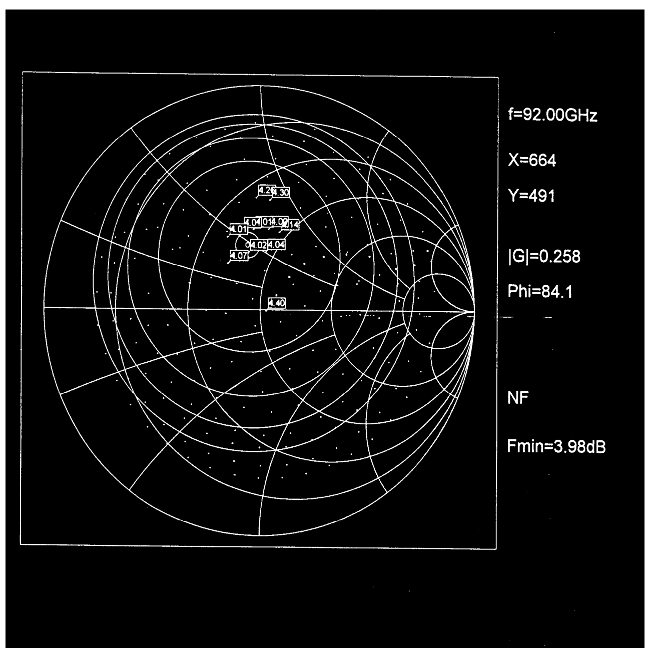

Figure 4: On-Wafer Noise Measurements at 92 GHz
using model 11075 tuner.

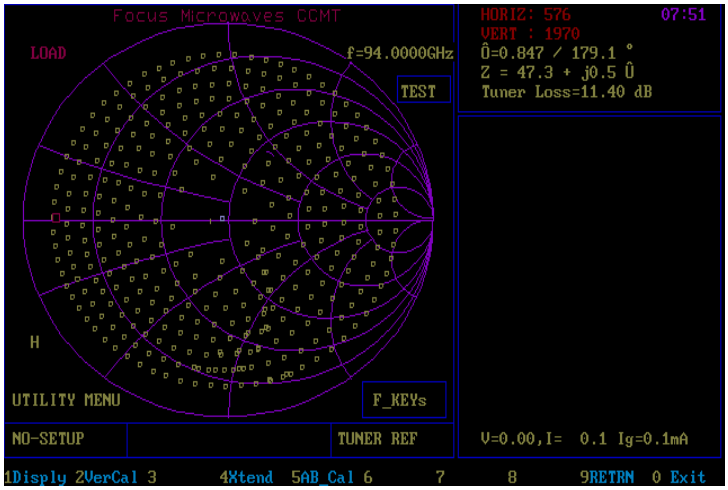

Figure 5: CCMT-11075 Calibration at 94 GHz (Γ.max=0.85, VSWR=12:1)

Some remarks about "Tuner Loss"

As mentioned on page 1 it is misleading to specify the maximum loss of a mechanical tuner at its internal ports, as some tuner vendors do. In general this loss does not differ much among the different models available on the market, since the transmission media is air. Electronic tuners have more loss since they use microstrip dielectric material.
The quantity of practical importance is the "operating tuner loss" (for the input tuner this equals to "available loss", for the output tuner to "power loss").
This loss is directly proportional to the insertion loss between the DUT and the tuner probe (slug). The proportionality factor depends on the reflection factor created by the tuner probe at its reference plane and increases sharply for $\Gamma > 0.8$. At $\Gamma = 1$ this factor reaches ∞ since there is no power transfer to the load.
As a rule of thumb "the operating loss, at $\Gamma \approx 0.95$ on probe level, resulting from additional insertion loss before the tuner probe is ≈ 15 times higher than this additional insertion loss".
The waveguide section of the tuner in figure 1 stands out of the tuner body by about 2 inches in order to fit on the wafer probe. This explains the displayed loss of over 11 dB (figure 5). The insertion loss of this tuner at VSWR.min is 1.25 dB. Therefore the extra loss due to the waveguide extension needed for the mounting on the probe is approximately:

$$\frac{2.0}{8.3} \bullet 1.25 \bullet 15 \approx 4.5dB$$

where
2.0 = extended waveguide length (inches)
8.3 = total waveguide length (inches)
1.25 = insertion loss at VSWR.min
15 = mismatch factor (we must assume an internal reflection factor at the probe level of about 0.95, which does not appear at the input port of the tuner, because of the insertion loss of the section between "Probe" and "Input-Port").
The remaining loss of about 6.5 dB is due to the tuner itself, but this value is not of any practical use, since the tuner will, ultimately, have to be connected to a DUT or a wafer probe. In fact also any additional "probe insertion loss" will create extra "overall operating loss" due to the same mismatch effect and following the same rule of thumb.