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Product Note 69

Manual Fundamental and Harmonic ('Combo') Tuner Model MHMT-308-2H/3H

for manual optimization of saturated RF power transistors

Manual Microwave Tuners with fundamental and harmonic tuning capability are used for narrow-band RF load pull matching operations with close to independent control of fundamental and harmonic loads. The new manual 'combo' tuner design covers both fundamental frequencies over a wide frequency range (0.8-3GHz) and the second (-2H) or third (-3H) harmonic frequency 2fo or 3fo. The design has been derived from Focus' high isolation automatic 'combo' tuners (CCMT-2H). These use two harmonic resonators, instead of one, for each harmonic frequency, in order to increase harmonic tuning isolation between fo and 2fo (or 3fo). The harmonic frequency can be easily changed by the operators of the tuners using 'off the shelf' and custom made resonators available from Focus Microwaves for any frequency required.

Manual 'Combo' Tuners MHMT-308-2H/3H can be supplied with 7mm (APC-7) or N connectors. Special designs are available with 3.5mm or 7/16 connectors for high power.

MHMT-308-2H/3H Specifications

- Frequency range (fo): 0.8–3GHz

(Other frequency ranges on request)

- VSWR (fo): 15:1 min
- VSWR (2fo): >40:1, all phases

Or VSWR (3fo): >20:1, all phases

- Power handling: ≤ 40Watt (APC-7)

≤ 200Watt (7/16)

- Tuning Isolation: >25dB

(typically 30-40dB)

- Bandwidth (2fo, 3fo) for

Maximum isolation: 5%

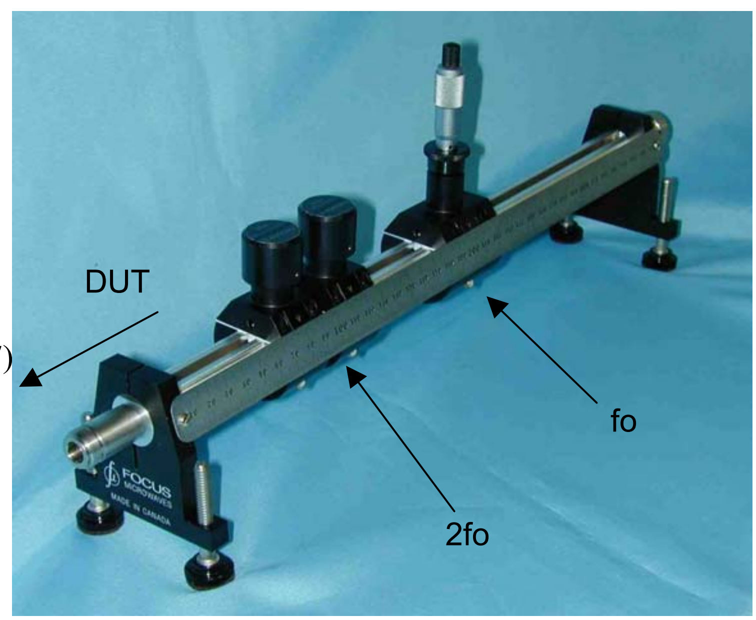

Figure 1: High Isolation Manual Combo Tuner

[1] patent pending

Frequency Response and Alignment

Manual Harmonic Tuners are aligned and tested on a VNA, which has been calibrated using TRL. Adjusting the distance between the two resonators of the same frequency (2fo or 3fo) a frequency response as shown in figure 2 can be achieved, after the change of the resonators for another frequency. In this case (fo=1.746 GHz, 2fo=3.492 GHz) the most critical bandwidth (at fo) is 140 MHz (≈8%) with 25dB harmonic tuning isolation. Figure 2 also shows that there is negligible effect of over 35 dB fundamental tuning on the second harmonic tuning (Marker 1);

The return loss obtained at 2fo is higher than 0.3dB for all phases. This tuner is connected directly to the input or output of the DUT. Using the MHMT-308-2H/3H allows matching the DUT at the fundamental frequency and recovering the remaining harmonic power and re-injecting it into the output port, thus extracting the optimum PAE, Pout or Gain from the device.

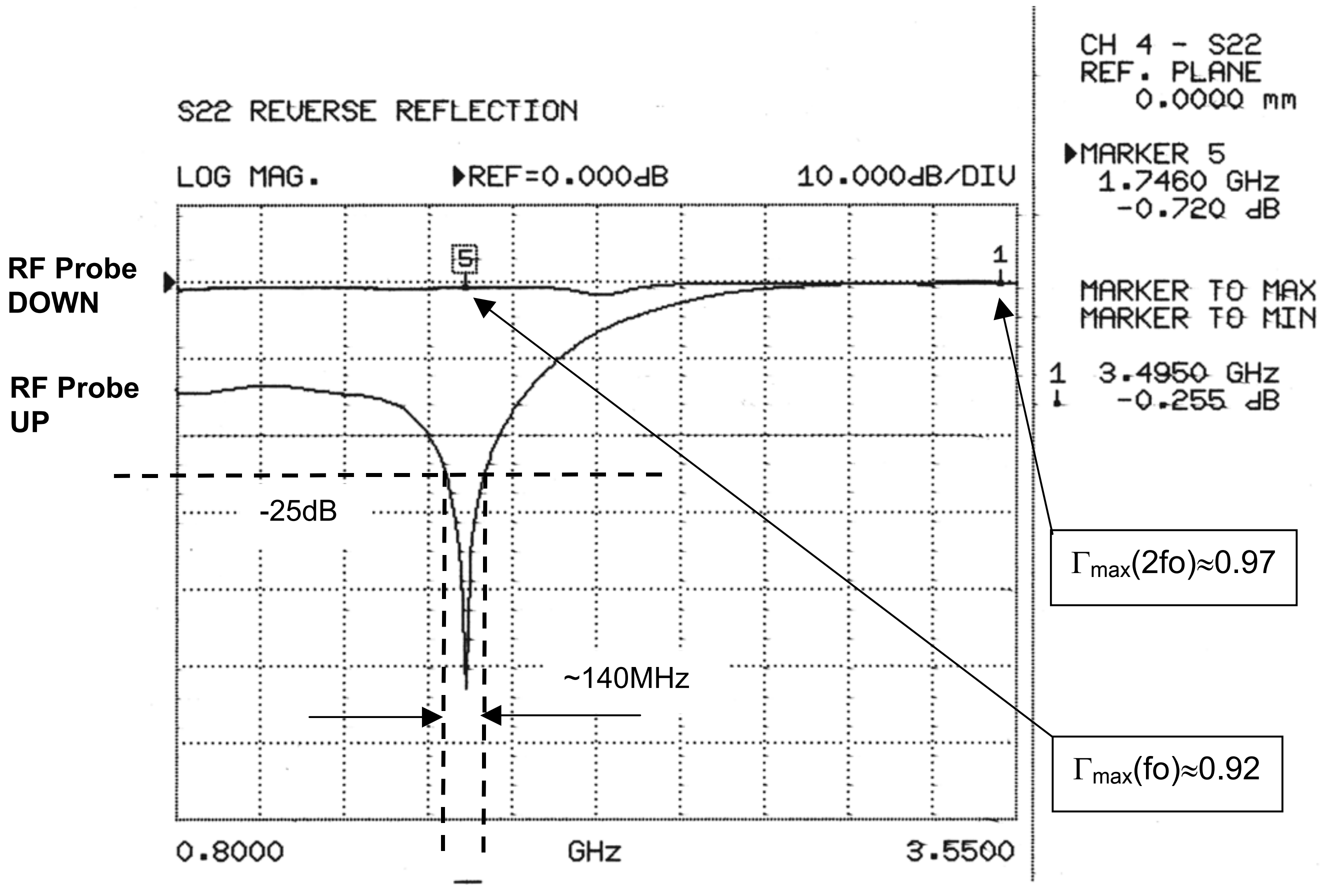

Figure 2: Tuning dynamic range over frequency for MHMT-308-2H/3H; Fo=1.746GHz, 2fo=3.492GHz. It shows 8% bandwidth at 25dB harmonic tuning isolation.

Harmonic Tuning Isolation of MHMT-308-2H

Harmonic tuning isolation is defined as the change in Z(fo) as a function of Z(2fo) and vice versa. Since Focus' harmonic tuners are connected 'in-line' with the fundamental tuners and precede the fundamental signal coming out of the DUT, both at the input and output ports, there is normally no harmonic power reaching the fundamental tuner, because the harmonic section is highly reflective (Γ(2fo) > 0.95); by consequence there is practically no effect of 'fo' tuning on '2fo' impedance. The use of a pair of resonators at 2fo also creates a high isolation for '2fo' tuning on 'fo' impedance. Figures 3 and 4 show actual values of 'cross-tuning' measured at 1.74 GHz and 0.8GHz)

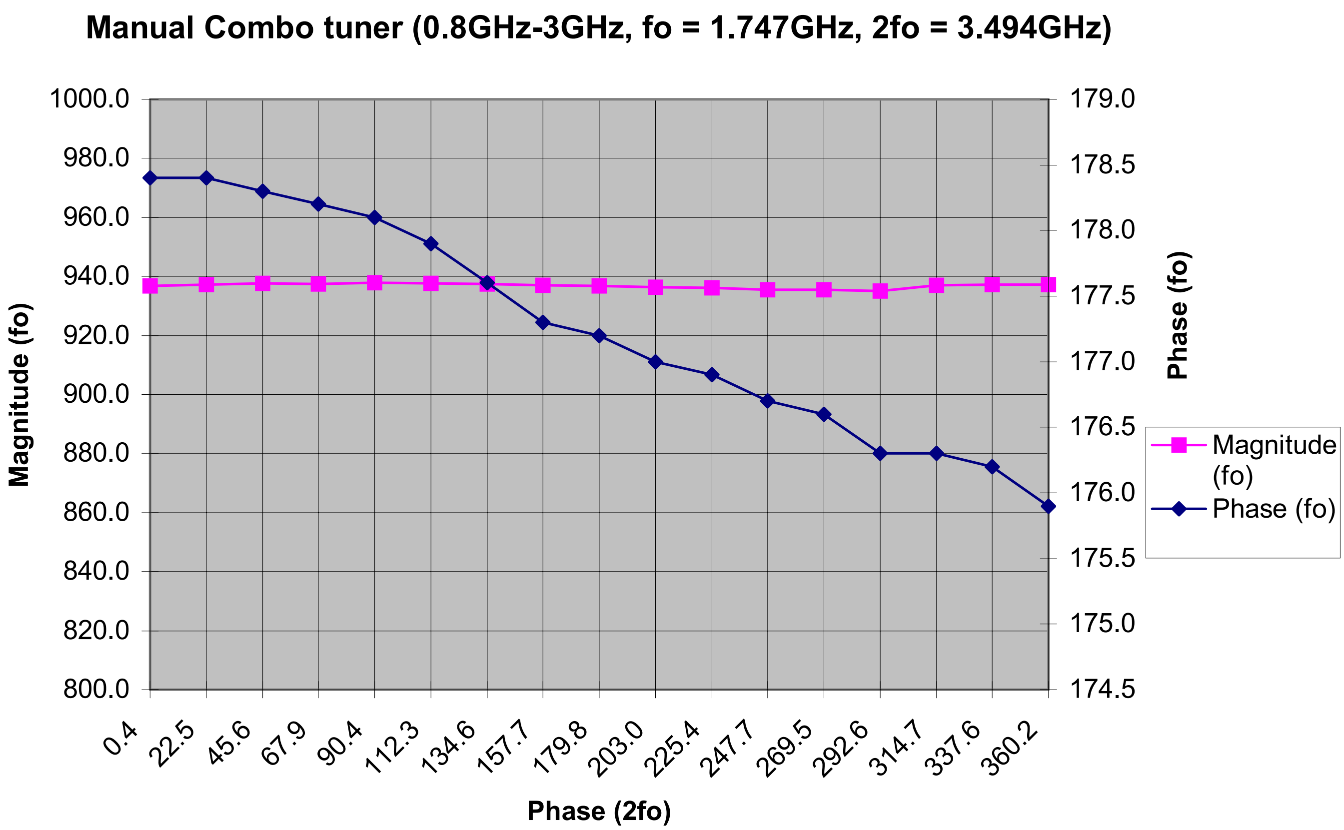

Figure 3: Cross-tuning effect of Z(2fo) on Z(fo) at fo = 1.747 GHz.

The plot shows:

$\Delta\varphi(fo)/\Delta\varphi(2fo) = 0.007°$/degree and

$\Delta\Gamma(fo)/\Delta\varphi(2fo) < 0.000015$/degree

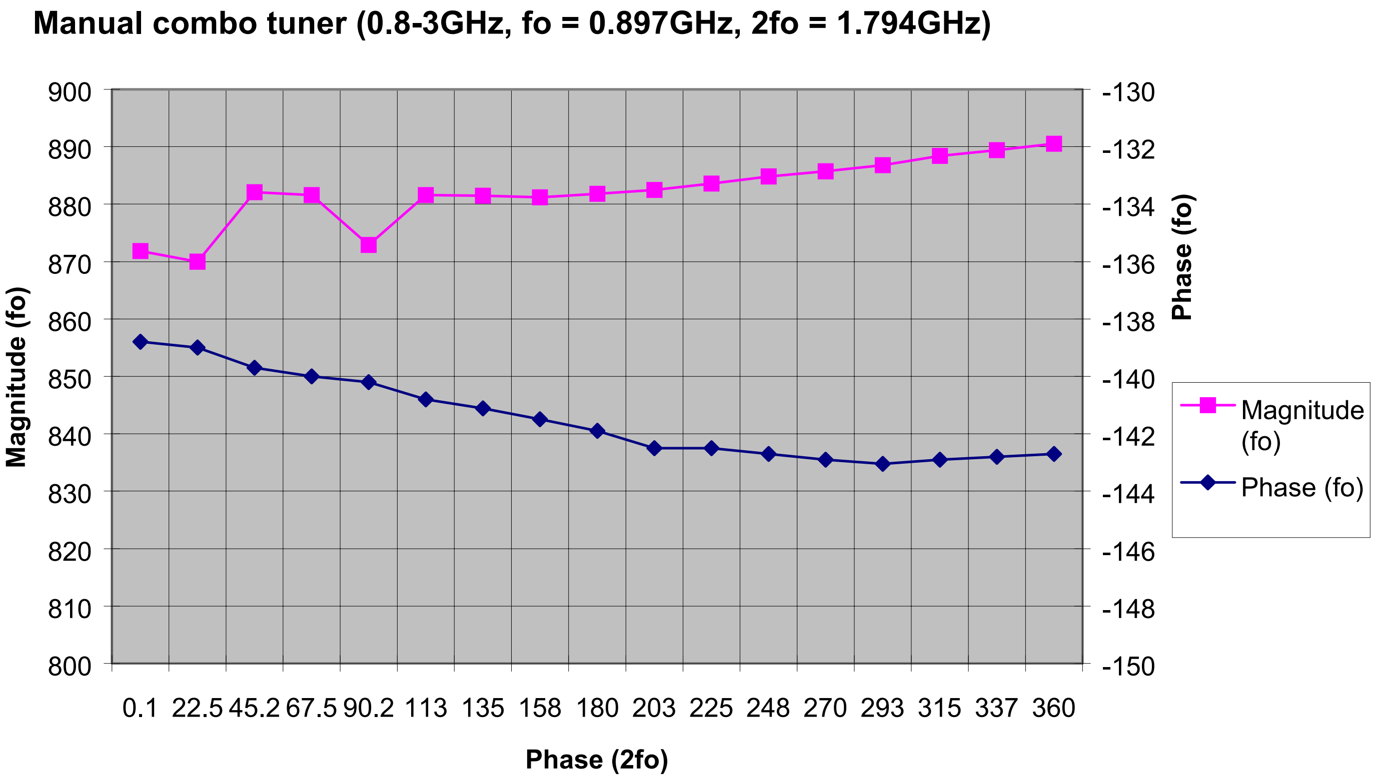

Figure 4: Cross-tuning effect of Z(2fo) on Z(fo) at fo = 0.897 GHz.

The plot shows: $\Delta\varphi(fo)/\Delta\varphi(2fo) = 0.012°/\text{degree}$ and $\Delta\Gamma(fo)/\Delta\varphi(2fo) < 0.00006/\text{degree}$

Using MHMT-308-2H in a Harmonic Load Pull Setup

MHMT-308-2H has to be inserted in a Load Pull setup between DUT and actual load, as shown in figure 3. It allows optimizing the load impedance at the fundamental frequency and the phase of the harmonic load independently of the fundamental impedance. It allows maximizing Pout, Gain or PAE. An input combo harmonic tuner can also be used in this setup. It is normally used in order to optimize DUT linearity (IMD, TOI and ACPR).

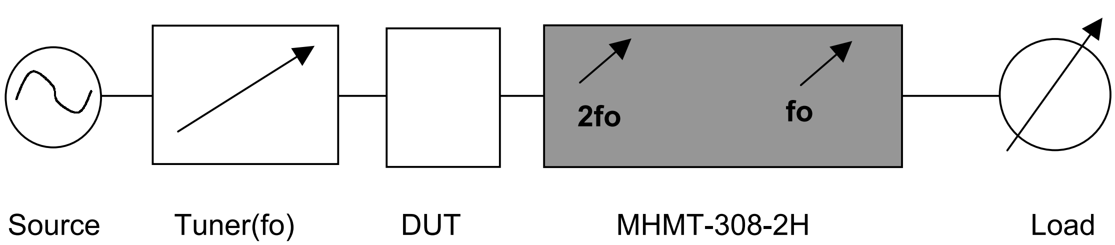

Figure 3: Manual Harmonic Load Pull setup using MHMT-308-2H