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Product note 92

Hybrid Tuners

Summary

Electro-mechanical impedance tuners (CCMT) control impedances over a wide frequency range. However insertion loss between the tuner and the DUT, especially at 5G (28-36GHz) frequencies, limit the tuning range and the capacity of the tuners to test some devices.

This shortcoming is overturned using the Hybrid wideband and harmonic Tuner concept* (CCMT+/MPT+). A feed-forward active loop added to the multi-carriage tuner allows reaching reflection factor at DUT reference plane $|\Gamma_{DUT}|=1$.

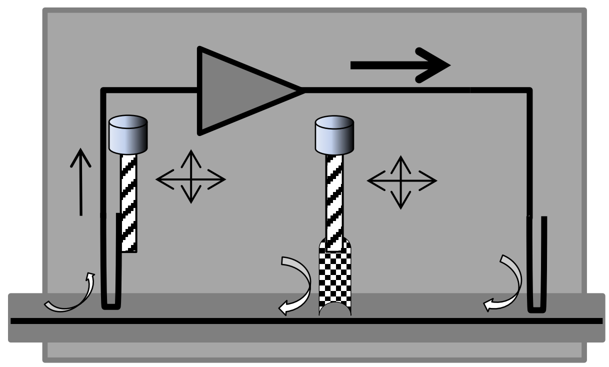

Fig. 1: Concept of CCMT+

Impedance tuners use a slotted airline (slabline) and metallic (reflective) probes. The slabline has two vertical sidewalls and a round center conductor. The tuning probes (slugs) have a concave bottom matching the radius of the center conductor. A set of integrated fixed and mobile directional couplers allows sampling the signal delivered by the DUT, amplify, phase-correct and re-inject it backwards towards the DUT where it is vector-added to the signal reflected by the passive tuner probe. The coherent feedback signal is added only to the Fo component. This allows complete impedance control at Fo and simultaneous reduction of the fed-back injected power due to pre-matching by the passive tuner at Fo. Harmonic tuners also control independently passive Γ(2Fo) and Γ(3Fo).

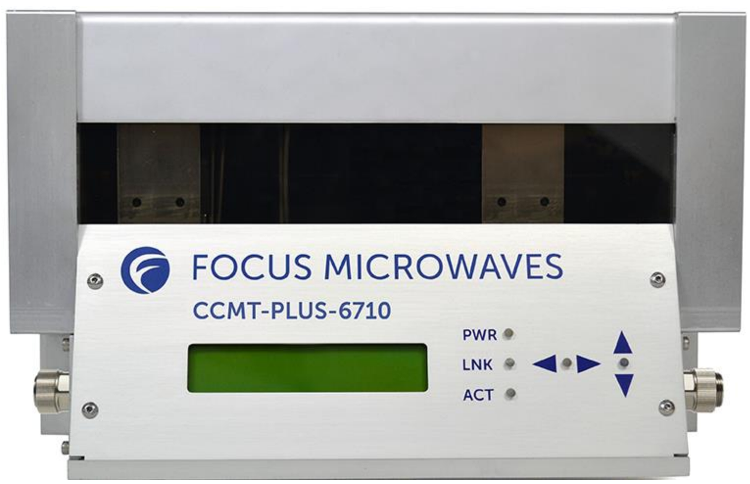

Fig. 2:CCMT+ 5G, 10-67GHz; active tuning @Fo=28-36GHz

Figure 3 shows the tuning mechanism: Active and passive tuning can be analyzed separately.

Both tune around the center of the Smith chart at |Γ| sensibly <1. However one part acts as pre-matching to the other with a final result shown in the combination plot. Because neither of both tuning mechanisms is static the end result shows reflection factors at 28GHz covering the entire Smith chart, despite insertion loss of approximately 1.2dB between tuner and DUT. Because of the frequency limitation of the used PA the operation frequency of the specific hybrid tuner is restricted here to 28-36GHz, whereas the passive tuner and the couplers are operational from 10 to 67GHz. A change in PA allows covering other, user defined, bands.

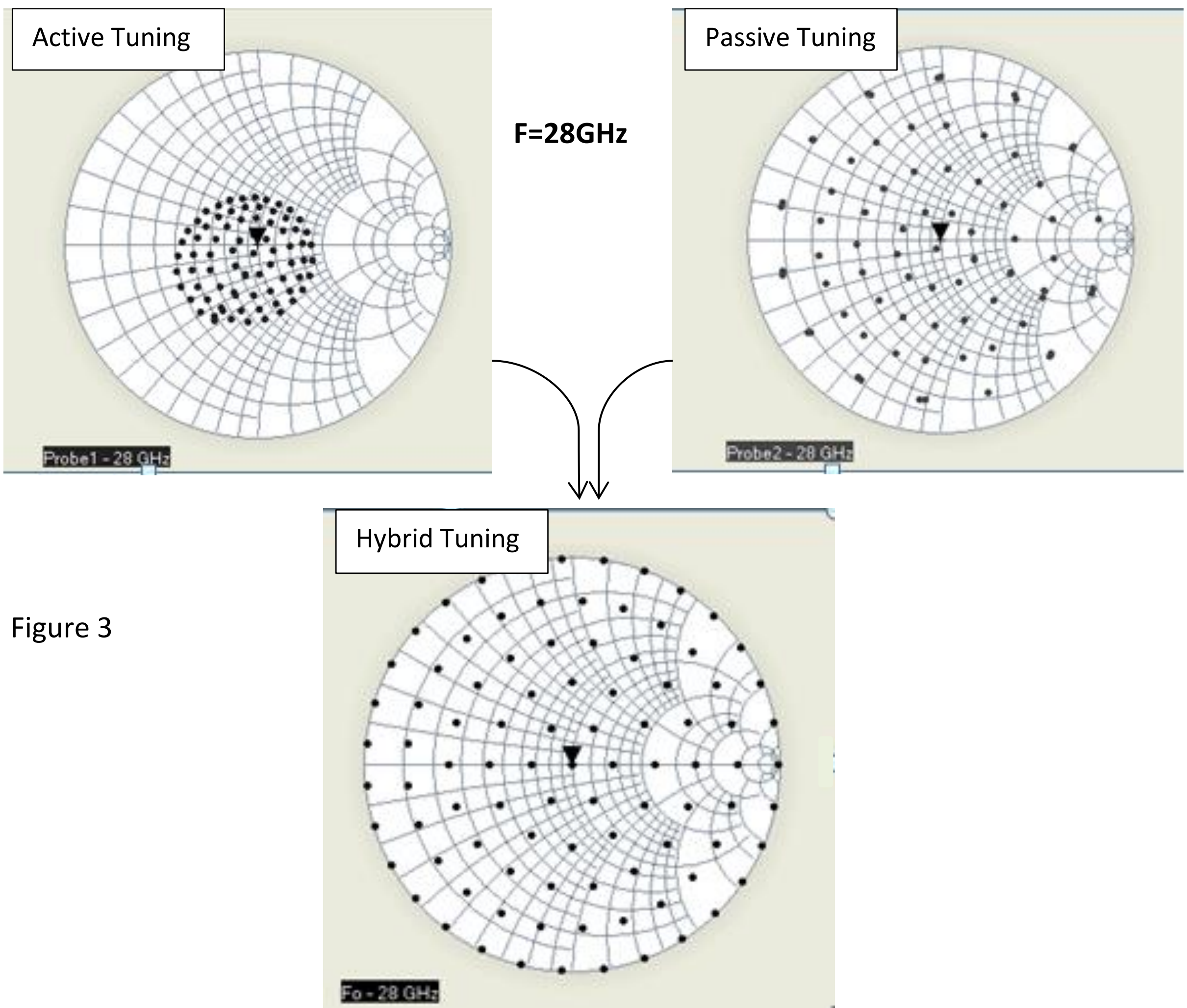

Figure 3

The bandwidth of the adjustable couplers is shown in Figure 4:

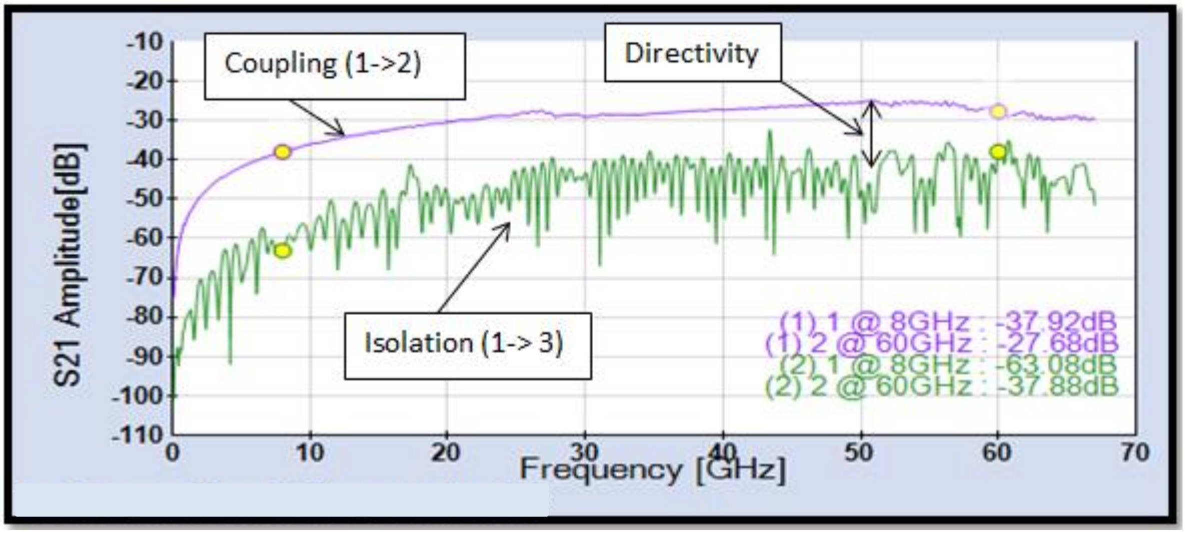

Figure 4: Coupling and directivity of adjustable couplers.

The overall tuning composition at 28GHz is shown in Figure 5.

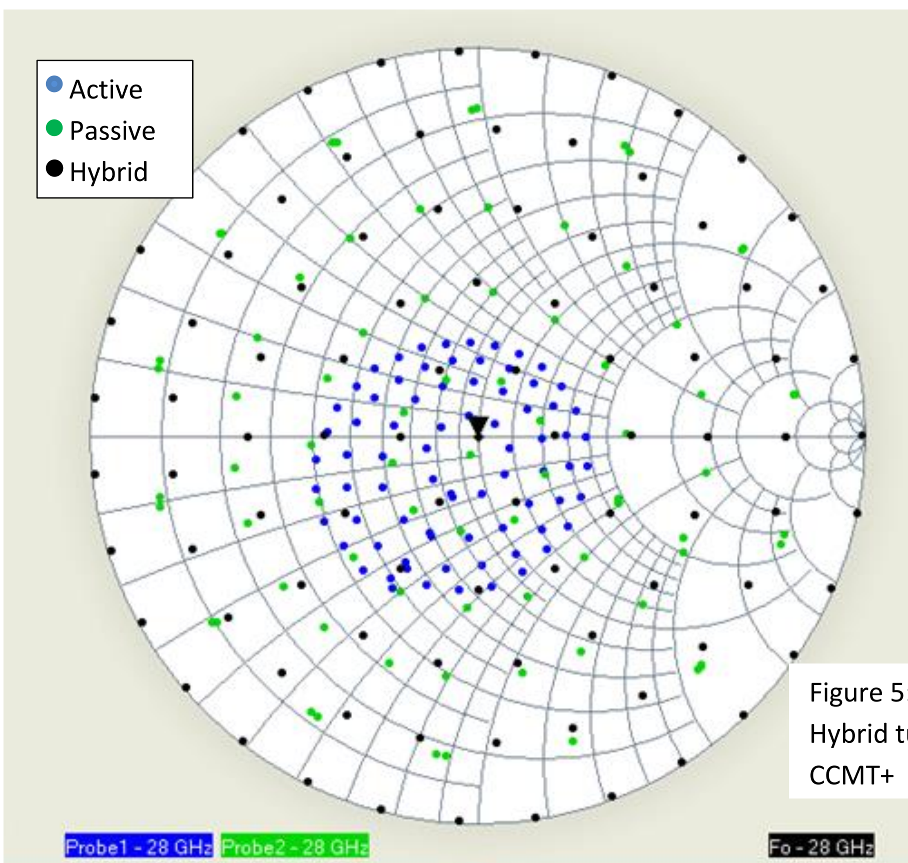

Figure 5: Active-Passive and Hybrid tuned points, Γ_{DUT}, of CCMT+

System Verification

The simplest way for verifying the accuracy of an active system is to compare with an already verified* passive system measuring the same DUT. This has been done in this case. Two setups have been used, one using a passive harmonic tuner MPT-6710 (10 to 67GHz) and the second one using the MPT-Lite-Plus 6080, shown in Figure 2. The proof of accuracy is self evident, as shown in Figure 6.

**A passive system is linear and verified using the "back-to-back" method, whereby the transducer gain G_T of the cascade of two conjugate matched tuners at any impedance is measured and found to be within a range of $G_T \approx 0 \pm 0.05dB$.*

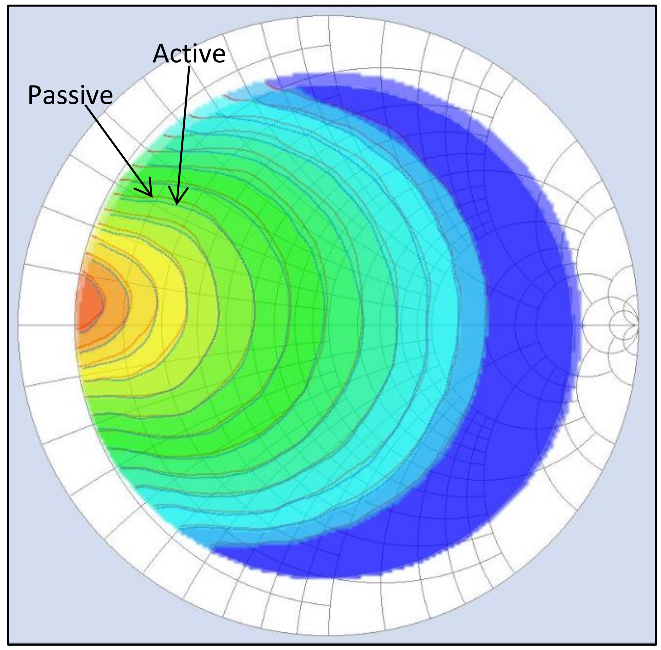

Figure 6: Active & Passive L/P on the same DUT

Tuned points and Actual Data

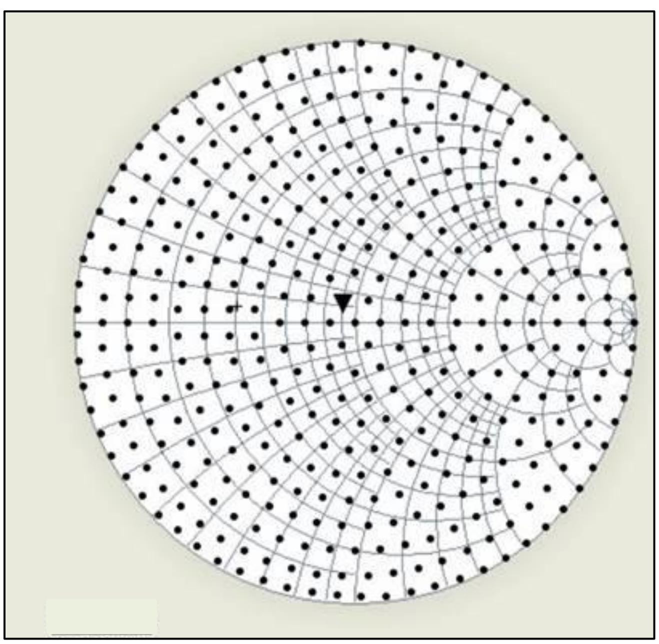

Figure 7: Tuned points of Hybrid CCMT+ at 28GHz

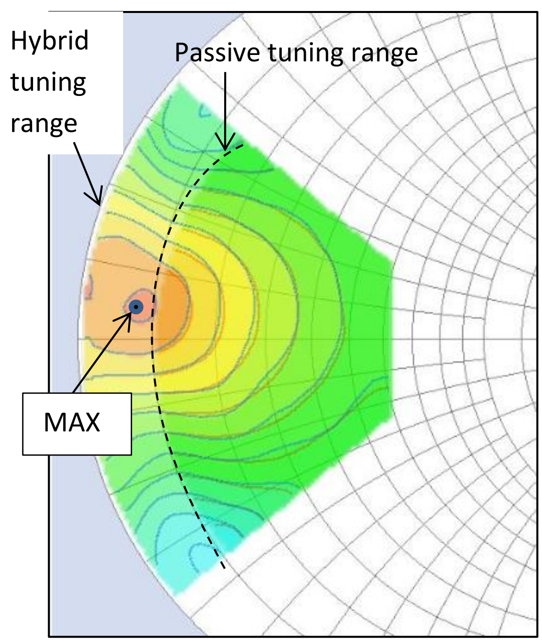

Figure 8: Load Pull Contours at 28GHz