Electronic and Mechanical Tuners

Electronic Tuners (ETS) and Electro-Mechanical Tuners (EMT): A critical comparison

Electronic Tuners (ETS) consist of sets of PIN diodes mounted in microstrip circuits and controlled by digital signals. The diodes have only two states: ON and OFF. Due to the physical distribution along microstrip lines ETS generate irregular shapes of reflection factors, figure 1, with values up to 0.8 over a limited frequency range. Electro-mechanical tuners (EMT) generate Γ of 0.9-0.95 in normal version and up to 0.99 in prematching version from low frequencies up to millimeter waves.

Manufacturing well operating ETS tuners of this kind is critical. Manufacturing yields below 10% have been reported [1].

The size and weight of ETS tuners are small compared with Electro-mechanical tuners (EMT).

Tuning speed of ETS is in the range of milliseconds whereas tuning speed of EMT is in the range of seconds. For full size load pull testing of several RF and DC parameters however, the improvement in total testing time is of the order of a few percent only (<10%), due to the time needed to read the setup instruments via GPIB.

Tuning accuracy of ETS is −60 to −70dB. Tuning accuracy of modern EMT is −45 to −60dB. For accurate noise and load pull measurements tuning accuracies of −40dB are sufficient.

Insertion loss of ETS at operating reflection factor is very high, because of lossy microstrip lines. This requires high power driver amplifiers at the source side of the setup, which in turn raises the question of linearity of the PIN diodes and temperature drift in the
ETS. ETS operating loss of 12dB at Γ ≈0.8 is a common phenomenon, raising the cost of the setup considerably whereas EMT have only a few tenths of a dB at this Γ level.

ETS have unpredictable impedance behavior at low frequencies, whereas EMT are low pass, presenting 50Ω to the DUT. The ETS behavior is a high risk factor for uncontrollable spurious oscillations outside the test band. EMT do not create parasitic oscillations at low frequencies.

EMT have very high resolution tuning behavior, millions of continuously distributed impedances can be generated, allowing thus to tune to the optimum power or other parameter of the DUT. ETS have irregular impedance patterns with the points jumping unpredictably when the diodes are switched ON and OFF. ETS do not allow fine tuning a DUT to optimum performance. Such optimum data must be generated numerically using smoothing algorithms. The final DUT data depend on the distribution of the data points and the accuracy of the smoothing algorithm. Saturated devices are notorious in behaving differently than predicted by models and calculations, especially concerning parameters other than output power, such as IMD, ACPR, EVM etc..

Cascades of ETS can be used to generate impedances at harmonic frequencies [2] by a sheer generation of millions of impedance states, which may create the desired combination of impedances at the various.

Harmonic frequencies simultaneously, all limited to Γ 0.75-0.8 over a reasonable frequency range. A number-crunching search algorithm then identifies the impedance state of each tuner corresponding to the set of required impedances, within an error circle of about 0.05. In addition to allowing only coarse tuning, this ETS harmonic tuning technique also requires calibrating the tuners for millions of impedances at each single frequency of operation. ETS calibrationsessions may last several days. Compared to this EMT tuners in harmonic version (PHT of Focus) a llow high resolution tuning with reflection factors of 0.9-0.98 and require only a couple of minutes to calibrate.The spurious oscillation problematic of harmonic ETS tuners at low frequencies remains the same as explained above contrary to the low pass behavior of PHT.

In noise measurements the unpredictable "jumping" of impedance states for small frequency changes prohibits using ETS in double sideband setups, thus requiring either YIG filters or other expensive single sideband noise receivers. ETS do not allow measuring directly the minimum noise figure by tuning to Γopt. All 4 noise parameters are the result computations and impossible to verify directly; EMT's allow to fine tune and verify NF min. ETS setups use the "Cold Noise Source" technique; the internal noise temperature of ETS is a critical question difficult to answer, when measuring very low noise devices [3].

On wafer operation favors ETS; however, suitable wafer probe setups using EMT at frequencies even below 0.8 GHz have been in use for many years, allowing smooth and low-vibration operation.

References:

[1] Private communication, ATN Microwave Inc.
[2] "A Load Pull System with Harmonic Tuning", Microwave Journal, March 1996, ATN Microwave Inc.
[3] Private communication, Dr. Ali Boudiaf

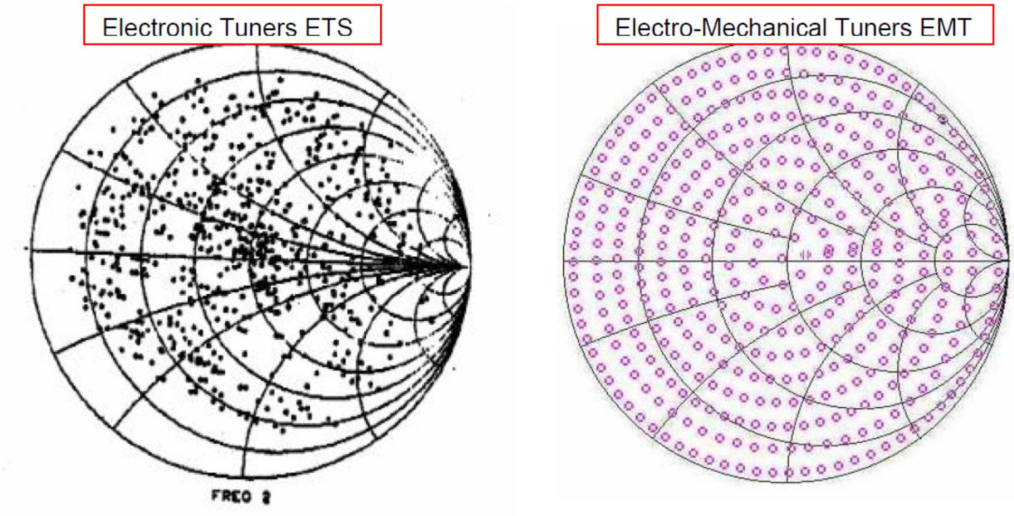

Figure 1: Tuning patterns of ETS (left) and EMT (right) at 2GHz. ETS does not allow interpolation between points; EMT (Focus) allows millions of intermediate states to be synthesized, almost continuously.

Characteristic	Electronic Tuner (ETS)	El-mech. Tuner (EMT)
Reflection Factor Γ	Noise: O Load Pull: -	++
Number of Impedances	O	++
Insertion Loss	-	+ / ++
Tuning Resolution	Noise: O Load Pull: --	++
Maximum Power	O / - / -- depending on DUT	++
Frequency Bandwidth	O	++
Spurious Oscillations	O / -	++
On Wafer operation	++	O
Tuner Size	++	On wafer: - Test fixture: ++
Tuner Speed	++	-
Test Total Speed	+	+
Tuner Linearity	O / - depending on DUT	++
DSB Noise measurement	--	+
Temperature Drift	?? / -	++

Legend: ++ Excellent; + Good; O Acceptable; -Poor/Risky; --Unacceptable for certain tasks

Table I: Comparison between Electronic Tuners (ETS) and Electromechanical Tuners (EMT)