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Load-Pull

Load-pull is the colloquial term applied to the process of systematically varying the

impedance presented to a device under test, most often a transistor, to assess its performance

and the associated conditions to deliver that performance in a network.

On a transmission line, Load-pull system would be used on transistor devices in the non-linear

domain. This system would help one improve the transmission on a transmission line by

determining the transistors’ performance and the associated conditions to achieve that

performance.

The article by M.H Hashmi and F.M Ghannouchi, titled “Introduction to Load-Pull Systems and

their applications” published in IEEE Instrumentation and Measurement Magazine, 1094-6969,

pp.30-36, in February, 2013 helped me get a better understanding of the Smith Chart, with the

different practical illustrations along with the results.

The reference that I found most useful in clarifying unknown terms or concepts discussed in the

paper is the: “Block diagram. (a) An enhanced loop load-pull tuner. (b) A comparison of the

maximum achievable reflection coefficient using enhanced loop load-pull and the latest

commercial pre-matched load-pull setups (@IEEE 2010, IEEE Microwave Mag., used with

permission, [5]).

Based on the impedance tuner, there are two different types of Load-pull: active and passive

load-pull systems. The main difference is that passive tuner based Load-pull is employed in

applications requiring high speed measurements while active tuner based Load-pull is more

commonly utilized in applications requiring high reflection coefficient values.

Like any other systems, passive Load-pull system and active Load-pull system have drawbacks.

The Passive Load-pull main disadvantage is the limitation of synthesized impedances due to

the limitation of the maximum achievable magnitude of reflection coefficient; and the active

Load-pull disadvantage is that this is effectively too slow for high measurements throughput

applications. The presence of the oscillations in the closed loop structure of the Load-pull

system is explained by the fact that in the closed-loop Load-pull technique, the synthesized

reflection coefficient depends on the loop parameters, such as amplifier gain, attenuation and

phase-shifter values. The oscillations are overcome by the use of an advancement closed-loop

active Load-pull application named Envelope Load-pull.

There have been several recent advancements in both the passive and the active Load-pull

techniques, and one of the results is a hybrid Load-pull, which is a technique that consists of an

impedance tuner and a passive loop cascaded together.

The quarter wave transformer is used in applications that require impedances less than one

Ohm. It is used to provide a fixed pre-matching. Actually, the function of the quarter wave

transformer is to move the matched impedance environment from 50 Ω (point ‘a’) to some other

smaller value (point ‘c’).

The maximum synthesizable reflection coefficients using the enhanced load-pull setup is higher

than the corresponding maximum values using the latest state-of –the art pre-matched load-pull

system.

There are similarities and differences between the quarter wave transformer and the

Klopfenstein transformer. Both are used to reduce the Smith Chart size, but the difference is

that the Klopfenstein covers bigger distances than the quarter wave.

The two latest developments in load-pull configurations presented in the article mentioned

earlier in this summary are: The reduced calibration and measurements time of the enhanced

loop Load-pull system, and the Envelope Load-pull.

In Load-pull systems, I would suggest the reading of “Vector-Receiver Load Pull Measurement”

by Steve Dudkiewicz, Maury Microwave Inc. 2011

And in Smith Chart applications in TLs, I would suggest the reading of “How does a Smith

Chart work?” by Rick Nelson, Senior Technical Editor, Test & Measurement World, July 2001