Syed Rizvi **Prof. Viviana Vladutescu**

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" Load-Pull Systems "

The research paper we were required to read was called “Introduction to Load-Pull Systems and their Applications,” by Mohammad S. Hashmi and Fadhel M. Ghannouchi. A load pull system as stated in the article is typically used on a DUT (device under test) system in order to help deliver reliable performance in a network. It is something that is necessary when deafling with large scale operating conditions that are commonly associated with large harmonic generations from oscillating signals. The load pull system would help with modifying impedance in order to have balance within the system for the best possible performance, and it can be used at any point on the DUT itself, as long as it brings the desired result.

As an example of how this system can help improve performance, is if a Load-Pull is used at the input port, it would help balance noise characterization for the rest of the system. Another example is, when there is a long distance call done over a land line, without a load pull balancing for impedance, we might have phenomenon such as loops occur during the transmission, and the experience of the users would be affected.

The “Introduction to Load-Pull Systems and their Applications” paper is a nice addition to the knowledge we gained in the course because it helps us get a different, non-textbook perspective on how Load-Pull Systems help in the Telecommunications field. This paper extensively uses the Smith Chart and shows us how beneficial it is in order to help improve the performance of any system. Using a Smith Chart helps us cut down on time that was previously used for extensive calculations in order to resolve the challenges of dealing with DUTs that needed the Load-Pull Systems in order to be effective.

I personally found reference [4] the most useful for clarifying unknown terms and concepts; “Comparison of active versus passive on-wafer load-pull characterization of microwave MW wave power devices,” which is found in *Proc. IEEE Microwave Theory and Techniques Society’s International Microwave Symposium Digest*, by J.E. Mueller and B. Gyselinckx.

Passive Load-Pull is usually the most effective in terms of implementation and maintenance costs, but they do not provide any oscillation. Passive loads are typically not able to synthesize reflection coefficients around the boundary of the Smith Chart. Active Load-Pull systems are able to synthesize the reflection coefficients on the Smith Chart boundary, or near the boundary and provide the ability to synthesize very small impedances.

One of the main disadvantages of the Passive Load-Pull systems is the limitation of synthesized impedances because of the limitation of the maximum achievable magnitude of the reflection coefficient. One of the main disadvantages of the Active Load-Pull systems is the risk of oscillations that can happen because of the closed loop structure. It needs an amplifier with a high gain and high linearity inside the feedback loop which might strain the system. One of the ways these issues have been recently dealt with is with the introduction of a highly selective filter, which mitigates the oscillation problem with limited results. Unfortunately, it is not very cost effective and makes the system more complex. A hybrid Load-Pull System is when you have a passive impedance tuner, and an active load-pull. A hybrid Load-Pull System has the ability to produce all the desired measurements, with limited issues, but a hybrid system is also more costly, and normally utilized in the higher quality, more expensive systems.

The quarter wave transformer is used because it is an effective approach for a fixed pre-matching Load-Pull System. It is used in order to help provide a better tuning range on the Smith chart, which means the TL will perform better with a more defined tuning range. Broadband transformers such as a Klopfenstein transformer provide a wider range of frequencies. This transformer however sometimes comes at a disadvantage to the quarter wave transformer because it reduces the Smith Chart coverage with increasing impedance transformation ratios. This will result in worse performance, but it makes up for it by providing for the system to function at a much higher frequency, if necessary.

When using the Enhanced Loop Passive Load-Pull Technique, it provides the benefit of having higher maximum synthesizable reflection coefficients which are higher than the corresponding maximum values even when using the latest pre-matched Load-Pull System. Recent advances in Load-Pull Systems include the Enhanced Loop

Passive Load-Pull Technique. This new technique is utilized using an impedance tuner and a passive loop cascaded together. Another recent advancement is the Envelope Load-Pull, which is similar to the closed-loop active Load-Pull systems. Envelope Load-Pull has the ability to overcome the oscillation that's normally associated with Closed-Loop active LP by utilizing a quadrature demodulator in order to change a particular output to its base band components. Afterwards, this signal is modified by two control variables, and changed back to the carrier frequency by a quadrature modulator. After that, the signal gets amplified to show a particular traveling wave, and since this all happens at base band, then the risk of encountering RF oscillation is eliminated.

In conclusion the systems of Load-Pull can bring more efficiency in the performance of transmission lines by eliminating or diminishing undesired phenomenon such as negative propagating wave in the lines, and it is very important and indispensable in transmission line. Load pull was created more than 40 years ago, but still they are commonly used in our time. The paper also allowed us to see a practical example of the Smith chart in real life and helps us get a better grasp on how Transmission Lines work by reinforcing the concepts we learned in our class. Anyone who thoroughly read the paper prepared by Mohammad S. Hashmi and Fadhel M. Ghannouchi will surely be familiar with Load-Pull Systems, their variations, and methods to solve problems within our modern Transmission Lines.