Tyrell Miles April 1, 2013 Transmission Lines Prof. Vladutescu

Project#1

The focus of study in this project is the load-pull system. What I wanted to know about this was its connection to transmission lines and the fundamentals behind it. The information about this that I discovered came from an article written by Mohammad H. Hashmi and Fahdel M. Ghannouchi. There article went into great detail as they used diagrams to explain how this system is designed and how all components in it behave when it is active.

* What is a load-pull system?

A load-pull system is a process in which impedance is applied to something known as a device under test (a DUT). This device can range from a transistor to an amplifier to an oscilloscope. The whole reason for impedance being applied to this device is to be able to maximize its performance. In general, the way to measure load pull and performance is to vary impedances inside of a transmission line as well as the frequency and biasing in order to be able to understand when a DUT is performing at its best. A real-world analogy to this system would be sports and the relationship between coaches and their athlete(s). From team sports like basketball and football to individual sports like boxing and tennis, the job of a coach is to maximize the potential of his/her athlete(s) and motivate them to compete with their best effort. Load-pull system is meant to combat non-linearity inside of a device and the signal it produces. What that means is that when a device produces a large signal, the change in that signal isn’t at a fixed rate.

The components that are used to create this system are an impedance tuner (either active or passive) and an equipment/test set. The impedance tuner is used to control and set our DUT to preferred impedance while the test/equipment set is used to measure the signals at the input and output ports of it.

* Passive vs. Active Load-Pull

When it comes to the types of techniques that can be used in a load-pull system, it depends on the impedance tuner being used. If the tuner is passive, then that would mean that the devices it is being applied to would have to be measured at high speeds, hence passive load-pull. If the tuner is active, then that would mean that we would be dealing with applications that have high reflection coefficients.

The benefits of passive load-pull are that they are inexpensive to install and maintain and are also easy to use. It is also able to handle and measure high powered devices with no non-linearization. The lone major disadvantage is that impedance is limited because the maximum reflection coefficient is limited. What that means is that when using a Smith chart, it’s difficult, if not impossible to be able to find the matching impedance for a DUT with low output impedance.

Active load-pull is more related to the signal coming from the load port of the DUT. Like operational amplifiers, they can operate either in open-loop and closed-loop settings. They are also similar to passive load-pull systems as they synthesize low impedances. In an open-loop active load-pull, the reflection coefficient inside of the load gets synthesized to a certain extent depending on the variable attenuator, phase-shifter and radio frequency generator. The reason why is because the attenuator and phase-shifter adjust the magnitude and phase of the wave inside of the transmission line by the load. This method of active load-pull calls for special algorithms so that it can achieve certain coefficients to keep the output of a DUT functioning properly. Due to the DUT’s dependency on these algorithms, it causes this method to be inadequate when it comes to making high measurements in applications. Closed loop active load-pull, on the other hand, is a counter to open-loop method because the reflective wave coming from the DUT output is only a modified version. This as a result means that whatever happens in one traveling wave at the output is going to affect the other. This particular for of active load-pull needs an amplifier with high gain and linearity for it to work because it is prone to oscillation.

* Transmission line, load-pull and applications of load pull

After all of this information, those who study or have an interest in telecommunications may wonder “how are load-pull systems and transmission lines related?” How is it possible that what a student learns in a classroom can be applied to what Hashni and Ghannouchi are explaining in their article? The connection that this article has to transmission lines is that load-pull is dependent on reflection coefficient and impedance. When it comes to applications of the Smith Chart, load-pull systems would fall under the category of matching impedances. It doesn’t matter if we are determining the load impedance from input impedance or vice versa, both of these require the ability to find a normalized impedance value based on whatever impedance is given as well as the voltage standing wave ratio (VSWR) and the reflection coefficient (Γ).

Another piece of information that was interesting also came from an online article written by Steve Dudkiewicz on <http://mwrf.com/test-and-measurement/tracing-evolution-load-pull-methods> as he explains how the relationship between amplifiers and load-pull systems because of its impedance matching capabilities. The way he generalizes the various techniques used in transmission lines is that engineers use them to study the response inside of a device, such as changes in power, resistance and voltage

In conclusion, there are a plethora of capabilities of a load-pull system. There are many different ways they can be implemented on transmission lines and various devices. The common denominator between all of the techniques that have been implemented and studied is that they are used to measure impedance, frequency and biasing to figure out when exactly is a device performing at its peak. The perfect analogy to load-pull systems are basketball players and teams. Those who watch and follow basketball heavily learn to analyze various players and teams by noticing things like which situations do players perform their best, when are teams playing at their best, or which coach is the best fit for a certain team. No matter which technique is used in either basketball, or in load-pull systems, we all are looking for the same results.