Automatic Load-pull Tuner

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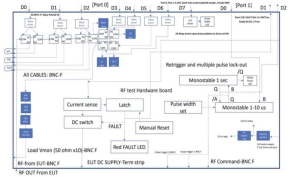
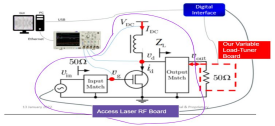
Problem Statement

- Customers who use Access Laser RF circuits face the following problems:
  - Have various cable types and these are not always compatible.
  - Access Laser RF engineers had to manually test multiple different loads.
  - Sometimes customers fry the circuit with their improper loads.
- Our project goal is to design and create a circuit that will simulate various loads and a GUI to control this circuit and save associated oscilloscope waveform data that will contain the necessary data for the RF engineers at Access Laser.

Requirements

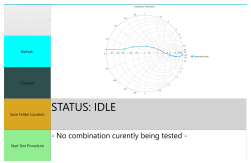
- This board design will develop 72 different combinations which are created by 3 cables and 4 load resistance on the Smith chart.
- We need to create a variable load circuit and a software program to control:
  - The digital interface (sets the different load combinations).
  - GUI displaying Smith Chart information for various loads.
  - Gathering and saving voltage/current data for each load from an oscilloscope using ethernet communication.





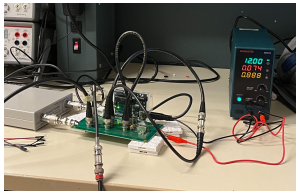
GUI

- Allows user to select serial port for digital interface communications.
- Allows user to select location to save waveform data.
- Displays impedance information for 72 loads through Smith Chart.
- Allows user to start automatic load testing while showing status of test and the current load being tested.



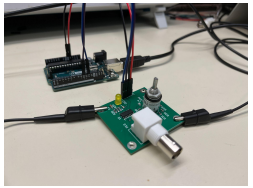
Core Circuit

- The purpose is to switch the relay between two positions via digital inputs from the digital interface to configure the resistance/impedance combination loads to the RF output.
- It can also trigger the RF amplifier to output a signal through the BNC connector.
- Another accomplishment is to attenuate the load voltage through load capacitor and load resistors.



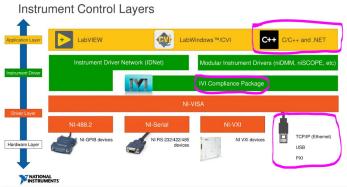
Pulse Limit Circuit

- The purpose is to limit the incoming pulse from the digital interface to have 1 second between each pulse with 1-10 µs pulses. In the case of reading a constant high signal from the digital interface, the pulse width circuit will fix the signal to a pulse.
- Without the pulse limit board, the triggering signal is not monitored and will potentially burn the RF amplifier.



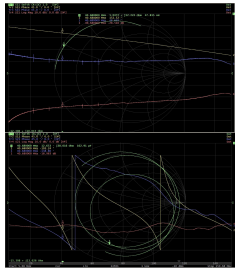
Oscilloscope Ethernet Communications

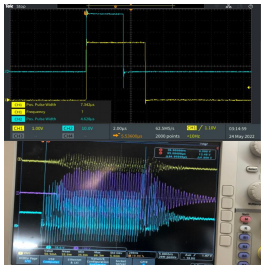
- Connect to Tektronix oscilloscope using a National Instruments remote ethernet communications driver called NI-VISA.
- Voltage/Current data is returned in a raw format known as "digitizing levels" and must be translated using a formula.
- 1000 record length of data



Results

- PCBs printed and assembled for Core Circuit and Pulse Limit circuit
- The relays were able to switch with the digital input from an arduino.
- Transferred raw data from oscilloscope measuring Access Laser's RF board to software program using ethernet.
- Successfully measured the RF signal using a network analyzer through various load configurations.
- Pulse Limit circuit was able to output a pulse width of 1.5µs to 12.92µs by rotating the switch.





Future Work and Acknowledgments

- Development of a current sense circuit to shut off power to the RF amplifier in case of overcurrent.
  - Less than 100ns response time to prevent damage to amplifier circuit.
  - Latch at 1A overcurrent and remain latched until a button press delatches.
- Further development of oscilloscope triggering.
  - Making sure acquisition of data is synchronized with the trigger signal sent by the digital interface every time a load is changed (RF_Start signal that triggers the RF board).
  - Confirm translated data from waveform transfer matches actual data
- Record length of 20M waveform points.

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Industry Advisors: Iris Tsai, Gordon Wood, Shahab Shahdoost

References

"Software required for Instrument Control (GPIB, serial, Visa, USB, etc)," *NI*. [Online]. Available: https://knowledge.ni.com/KnowledgeArticleDetails?id=kA00Z0000019XKkSAM&l=en-US. [Accessed: 24-May-2022].

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