TRF7003 RF Power Mosfet S-Parameter Board

Wireless Communications Business Unit

Digital Signal Processing Solutions
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TEXAS INSTRUMENTS

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Abstract

The TRF7003 RF Power MOSFET S-Parameter Board documentation explains in detailed instructions the procedure for the S-Parameter Board Assembly. The test board includes: the 50 Ohm through line, short circuit, open circuit, 50 Ohm load.

The calibration structures and items on the test board are explained to ensure accurate calibration and measurements. To accurately characterize the TRF7003, the calibration kit must be defined in the network analyzer. A step-by-step procedure illustrates how the calibration kit is defined in the network analyzer using the HP8753, HP8510, or other network analyzers used by TI in characterizing cellular-frequency parts.

Product Support

The TI Advantage Extends Beyond RF to Every Other Major Wireless System Block
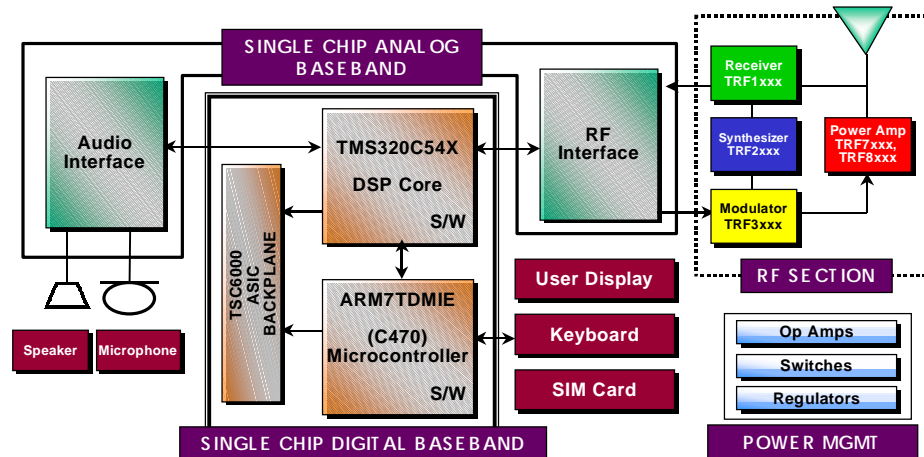
Digital Baseband

TI's single-chip Digital Baseband Platform, combines two high-performance core processors – a digital signal processor tailored for digital wireless applications and a microcontroller designed specifically for low-power embedded systems. The customizable platform helps wireless digital telephone manufacturers lower component counts, save board space, reduce power consumption, introduce new features, save development costs and achieve faster time to market, at the same time giving them flexibility and performance to support any standard worldwide.

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TI analog baseband components provide a Mixed-signal bridge between the real world of analog signals and digital signal processors, the key enabling technology of the digital wireless industry. Using a seamless architecture for wireless communications technology, TI matches its baseband interfaces, radio frequency ICs and power management ICs to digital signal processing engines to create complete DSP Solutions for digital wireless systems.

Power Management

TI provides power management solutions with integration levels designed to meet the needs of a range of wireless applications. From discrete LDOs and voltage supervisors to complete power supplies for the baseband section, TI power management solutions play an important role in increasing wireless battery life, time-to-market and system functionality.

For more information visit the Wireless Communications web site at www.ti.com/sc/docs/wireless/home.htm.

Related Documentation

The following list specifies product names, part numbers, and literature numbers of corresponding TI documentation.

❑ *MOSFET POWER AMPLIFIER*, Literature number SLWS058A

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S-Parameter Board Assembly

Figure 1 illustrates the TRF7003 S-parameter test board. As illustrated, the assembly consists of one printed circuit board, nine 3.5mm SMA/PCB connectors, one 51 ohm 0402-size resistor, and two TRF7003 RF ICs in SOT-89 packages. The PCB includes all necessary structures for a standard TRL calibration:

❑ Through Line

❑ Short Circuit

❑ Open Circuit

❑ 50 Ohm Load

All of the structures are properly labeled for ease of identification.

Figure 1. TRF7003 S-Parameter Test Board
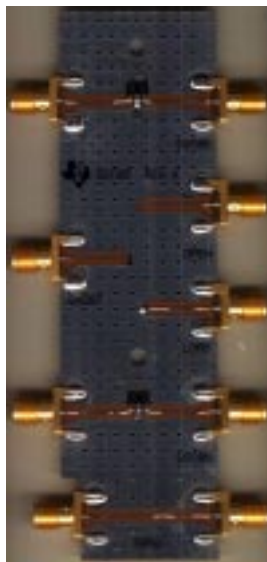
The first step in assembly is mounting the TRF7003 to the SOT89 labeled structures. To maintain good electrical and thermal performance, the devices must be soldered on the backside of the package. TI suggests pre-tinning the device prior to mounting. A poor backside connection will cause device failure due to thermal heating and / or poor RF performance due to poor source grounding. **Caution: The TRF7003 is an ESD sensitive device. Please follow proper ESD precautions.**

The 51 ohm resistor should be installed following the TRF7003 devices. Figure 2 illustrates the placement of the resistor at the end of the transmission line. The resistor should span from the end of the transmission line to the top-side ground at the end of the transmission line. The single 51 ohm resistor can be replaced by two parallel 100 ohm resistors attached at the same location. TI has found that a single resistor yields acceptable results (-30 dB return loss at 900 MHz.)

Figure 2. Placement of the Resistor at the end of the Transmission Line

3.5mm SMA connectors should be attached to the PCB at the designated locations. Figure 3 and Figure 4 illustrate the top and bottom solder connections needed to successfully mount the connectors. The gap between the connector and the PCB should be minimized to reduce any stray capacitance. The center pin of the connector should be short, as shown in the illustration. TI has found that long center pins prevent a good connection between the ground plane of the PCB and the connector thus, causing excess capacitance to be included in the measurement.

Figure 3. Solder Connections (Top View)

Figure 4. Solder Connections (Bottom View)

Lastly, heat sinks should be connected to the backside of the PCB so that they are in good thermal contact with the SOT-89 packages. The hardware used to attach each heat sink consists of one 6-32 x 1/5 inch screw, one flat washer, and one locking washer. Thermal compound is not needed if the TRF7003 and heat sink are mounted appropriately.

Calibration Structures

The calibration structures are typical of any TRL calibration kit. The test board includes a 50 ohm through line, short circuit, open circuit, and fifty ohm load. In testing the TRF7003, it is recommended that a full TRL 2-port calibration be performed. This takes into account all of the provided calibration structures and yields accurate calibration and measurements.

The thru transmission line is simply a low loss fifty ohm transmission line. This structure is used to calibrate for any line losses occurring from the 3.5mm connector to the measurement reference plane. This transmission line is exactly twice the length of the open circuit and short circuit calibration structures.

The short circuit transmission line provides a calibration structure that measures a unity reflection and 180 degree phase shift. To minimize stray capacitance, the structure is grounded to the top and bottom ground planes through a single, large via. This provides an accurate reflection standard. The length of the short circuit line determines the measurement reference plane. The length of the short circuit line is exactly half the length of the thru line and exactly the length of the input and output transmission lines to which the TRF7003 is attached. This provides accurate measurement reference planes at the input and output of the device under test.

The load standard consists of a fifty ohm transmission line equal in length to the open and short circuit standards that is terminated in fifty ohms. This provides a zero reflection calibration standard that is used to normalize the system impedance.

The open circuit transmission line standard provides a calibration structure of unity reflection and zero degree phase shift. The length of the transmission line, along with the accompanying short circuit calibration standard, also determines the measurement reference plane. Thus it is equal in length to the load and short circuit standards and half the length of the thru standard. The open circuit transmission line must be measured, however, to account for any fringing capacitance. The value of fringing capacitance must be programmed into the network analyzer.

The fringing capacitance of the open circuit transmission line is measured in the following manner.

❑ Perform a one-port calibration using 3.5mm SMA calibration standards.

❑ Measure the fifty ohm load standard and store that value in memory.

❑ Program the display function to display data - memory.

❑ Measure the short circuit standard and adjust the port extension to yield a 180 degree phase response over the frequency band of interest. (TI calibrated from 10 MHz to 6 GHz.)

❑ Measure the open circuit standard and display the results on an admittance smith chart. Fit the capacitance curve to the polynomial $C_0+C_1f+C_2f^2+C_3f^3$ (TI used only the first two terms, C_0 and C_1f to calibrate up to 1 GHz.) The coefficients are provided in a following section.

Calibration Kit Definition

In order to accurately characterize the TRF7003, a calibration kit must be defined in the network analyzer. TI employs a HP8753 network analyzer in characterizing cellular-frequency parts, however the following procedure applies for other network analyzers such as the HP8510.

1) Enter the menu on the spectrum analyzer that accesses the calibration kit. On the HP8753, this is a key titled CAL KIT.

2) Under the calibration menu, select the calibration kit that is to be modified. It will then be underlined.

3) On the HP8753, select MORE, MODIFY [cal kit], and DEFINE STANDARD.

4) The standard types are now listed on the softkey menu display. To select the standard to define, the following buttons apply. The x1 button is the located on the right side of the number key pad. After pressing one of the following sequences of keystrokes, press the calibration standard that is underlined.

Short	1 and x1
Open	2 and x1
Load	3 and x1
Thru	4 and x1

5) Select the short circuit standard by pressing 1 and x1. Press the softkey that corresponds to SHORT. Select SPECIFY OFFSET. Ensure that the OFFSET DELAY is 0 Sec. and the COAX selection is highlighted. If it is not highlighted, press the softkey corresponding to COAX. Press STD OFFSET DONE. Press STD DONE (DEFINED) to exit back to the calibration standard selection menu.

6) Press DEFINE STANDARD then 2 and x1. This underlines the OPEN standard. Select OPEN. Press C0 and enter the value of the C0 coefficient in fF. The values for the TRF7003 S-parameter board are listed in Table 1. Press C1 and enter the value for the TRF7003 board listed below. Ensure that the C2 and C3 values are both set to zero. Press SPECIFY OFFSET. Ensure that the OFFSET DELAY is 0 Sec. and the COAX selection is highlighted. If it is not highlighted, press the softkey corresponding to COAX. Press STD OFFSET DONE. Press STD DONE (DEFINED) to exit back to the calibration standard selection menu.

Table 1. Values for the TRF7003 S-Parameter Board

C0 (fF)	C1 (fF)
39	135

7) Press DEFINE STANDARD then 3 and x1. This underlines the LOAD standard. Select LOAD. Ensure that FIXED is underlined. Press SPECIFY OFFSET. Ensure that the OFFSET DELAY is 0 Sec. and the COAX selection is highlighted. If it is not highlighted, press the softkey corresponding to COAX. Press STD OFFSET DONE. Press STD DONE (DEFINED) to exit back to the calibration standard selection menu.

8) Press DEFINE STANDARD then 4 and x1. Select DELAY/THRU then SPECIFY OFFSET. Ensure that the OFFSET DELAY is 0 Sec. and the COAX selection is highlighted. If it is not highlighted, press the softkey corresponding to COAX. Press STD OFFSET DONE. Press STD DONE (DEFINED) to exit back to the calibration standard selection menu. Press LABEL KIT then ERASE TITLE. Enter a new title using the select wheel and SELECT LETTER softkey. Press DONE when finished labeling the cal kit. Press KIT DONE then SAVE USER KIT.

9) The calibration kit may be saved to disk by selecting the kit at the same time that a measurement is saved to disk.

10) The network analyzer can be calibrated for S-parameter measurements on the TRF7003 by using the user-defined calibration kit and the standards on the SOT-89 S-parameter board.

Evaluation Board Disclaimer

Please note that the enclosed evaluation boards are experimental Printed Circuit Boards and are therefore only intended for device evaluation.

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References

Hewlett Packard Company. "HP 8753D Network Analyzer User's Guide" 1994, 1995, Hewlett Packard Company. Pgs. 5-24 through 5-26.

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