

TRF8010 RF Power Amplifier S-Parameter Board

APPLICATION BRIEF: SWRA011

Wireless Communications Business Unit

*Digital Signal Processing Solutions
November 97*



IMPORTANT NOTICE

Texas Instruments (TI) reserves the right to make changes to its products or to discontinue any semiconductor product or service without notice, and advises its customers to obtain the latest version of relevant information to verify, before placing orders, that the information being relied on is current.

TI warrants performance of its semiconductor products and related software to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are utilized to the extent TI deems necessary to support this warranty. Specific testing of all parameters of each device is not necessarily performed, except those mandated by government requirements.

Certain application using semiconductor products may involve potential risks of death, personal injury, or severe property or environmental damage ("Critical Applications").

TI SEMICONDUCTOR PRODUCTS ARE NOT DESIGNED, INTENDED, AUTHORIZED, OR WARRANTED TO BE SUITABLE FOR USE IN LIFE-SUPPORT APPLICATIONS, DEVICES OR SYSTEMS OR OTHER CRITICAL APPLICATIONS.

Inclusion of TI products in such applications is understood to be fully at the risk of the customer. Use of TI products in such applications requires the written approval of an appropriate TI officer. Questions concerning potential risk applications should be directed to TI through a local SC sales office.

In order to minimize risks associated with the customer's applications, adequate design and operating safeguards should be provided by the customer to minimize inherent or procedural hazards.

TI assumes no liability for applications assistance, customer product design, software performance, or infringement of patents or services described herein. Nor does TI warrant or represent that any license, either express or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right of TI covering or relating to any combination, machine, or process in which such semiconductor products or services might be or are used.

TRADEMARKS

TI is a trademark of Texas Instruments Incorporated.

Other brands and names are the property of their respective owners.

CONTACT INFORMATION

PIC TELEPHONE	(972) 644-5580
PIC FAX	(972) 480-7800
HP SUPPORT LINE	(972) 480-7872
PIC email	sc-infomaster@ti.com

Contents

Abstract	7
Product Support	8
The TI Advantage Extends Beyond RF to Every Other Major Wireless System Block.....	8
Related Documentation	9
World Wide Web.....	9
Email	9
S-Parameter Board Assembly	10
Calibration Structures	13
Calibration Kit Definition	15
Evaluation Board Disclaimer	17
References	18

Figures

Figure 1. TRF8010 S-Parameter Test Board.....	10
Figure 2. Placement of the Resistor at the end of the Transmission Line	11
Figure 3. Solder Connections (Top View).....	12
Figure 4. Solder Connections (Bottom View).....	12

Tables

Table 1. TRF8010 S-Parameter Board Values	16
---	----

TRF8010 RF Power Amplifier S-Parameter Board

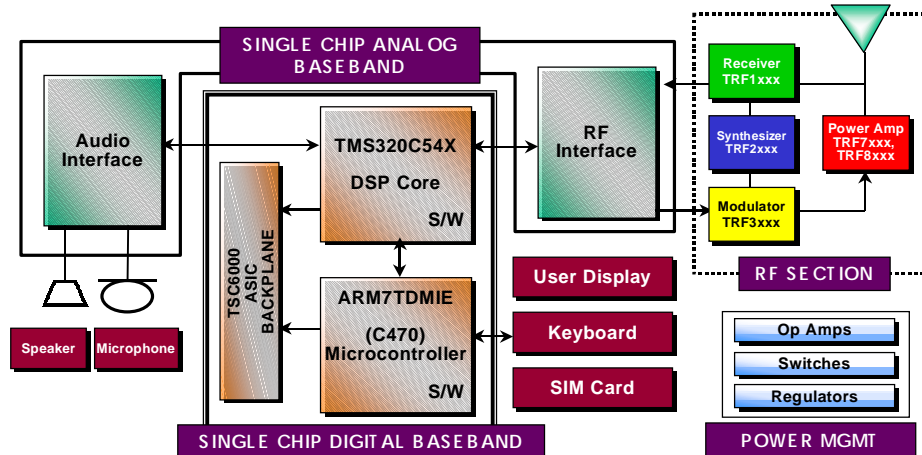
Abstract

The TRF8010 RF Power Amplifier S-Parameter Board documentation explains in detailed instructions the procedure for the S-Parameter board assembly. The PCB includes all necessary structures for a standard TRL calibration; including the 50 Ohm through line, short circuit, open circuit, and 50 Ohm load.

The calibration structures and the items on the test board are explained to ensure accurate calibration and measurements. To accurately characterize the TRF8010, the calibration kit must be defined in the network analyzer. A step-by-step process illustrates how the calibration kit is defined in the network analyzer using the HP8753 or other network analyzers such as the HP8510.

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.

Analog Baseband

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.

- *TRF8010 900-MHz RF Transmit Driver*, Literature number SLWS031B
- *TRF8010 Product Bulletin*, Literature Number SLWT003

World Wide Web

Our World Wide Web site at www.ti.com contains the most up to date product information, revisions, and additions. Users registering with TI&ME can build custom information pages and receive new product updates automatically via email.

Email

For technical issues or clarification on switching products, please send a detailed email to sc-infomaster@ti.com. Questions receive prompt attention and are usually answered within one business day.

S-Parameter Board Assembly

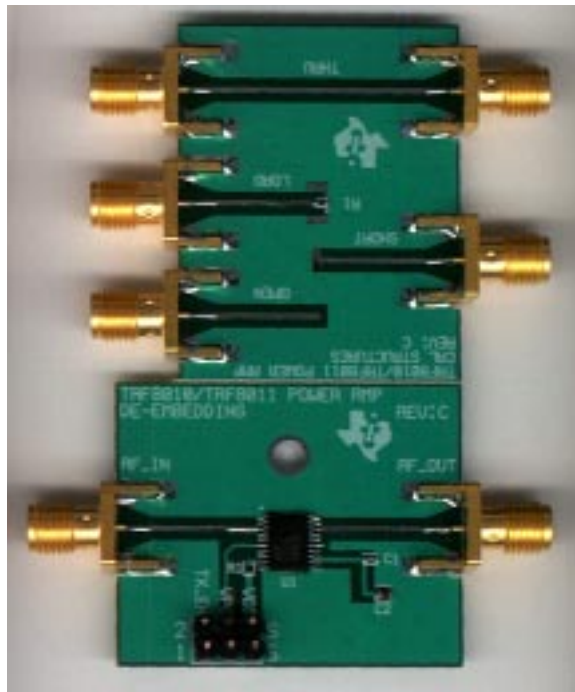
Figure 1 illustrates the TRF8010 S-parameter test board. As illustrated, the assembly consists of one printed circuit board, seven 3.5mm SMA/PCB connectors, one 51 ohm 0402-size resistor, one 1uF 0603-size capacitor, one 100pF 0402-size capacitor, and one 82ohm 0402-size resistor, one six-pin connector, and one TRF8010 RF IC in a TSSOP-20 package. 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.

- C1 100pF
- C2 1uF
- R1 82 ohms
- R1(load) 51 ohms

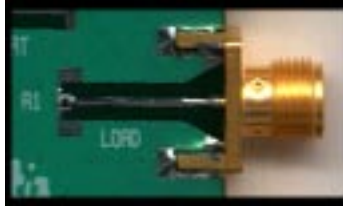
Figure 1. TRF8010 S-Parameter Test Board



The first step in assembly is mounting the TRF8010 to the PCB. 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. C1, C2, and R1 should then be installed on the de-embedding board. Following the device installations, the six-pin power connectors should be installed by soldering the connector to the back side via. **Caution: The TRF8010 is an ESD sensitive device. Please follow proper ESD procedures.**

The 51 ohm resistor (R1 load) should be installed following the TRF8010 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 topside 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)





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 TRF8010, 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 TRF8010 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. Please note that the open-circuit capacitance measured by the user can vary plus or minus 50 fF due to PC board manufacturing tolerances.



Calibration Kit Definition

In order to accurately characterize the TRF8010, 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.

- Enter the menu on the spectrum analyzer that accesses the calibration kit. On the HP8753, this is a key titled CAL KIT.
- Under the calibration menu, select the calibration kit that is to be modified. It will then be underlined.
- On the HP8753, select MORE, MODIFY [cal kit], and DEFINE STANDARD.
- 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

- 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.
- 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 TRF8010 S-parameter board are listed below. Press C1 and enter the value for the TRF8010 board listed in Table 1. 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. TRF8010 S-Parameter Board Values

C0 (fF)
100

- 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.
- 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.
- The calibration kit may be saved to disk by selecting the kit at the same time that a measurement is saved to disk.
- The network analyzer can be calibrated for S-parameter measurements on the TRF8010 by using the user-defined calibration kit and the standards on the TRF8010 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.

We would like to draw your attention to the fact that these boards have been processed through one or more of Texas Instruments' external subcontractors which have not been production qualified.

Device parameters measured, using these boards, are not representative of any final data sheet or of a final production version. Texas Instruments does not represent or guarantee that a final version will be made available after device evaluation.

THE EVALUATION BOARDS ARE SUPPLIED WITHOUT WARRANTY OF ANY KIND, EXPRESSED, IMPLIED OR STATUTORY, INCLUDING BUT NOT LIMITED TO, ANY IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE.

TEXAS INSTRUMENTS ACCEPTS NO LIABILITY WHATSOEVER ARISING AS A RESULT OF THE USE OF THESE BOARDS.



References

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

Hewlett Packard Company. "RF Design and Measurement Seminar" Pgs. 149-158.