TESTING OF THE TRNG9880

The TRNG9880 is a hardware SMT module for random number generation. We describe how to test that the unit works, using various electrical testing tools.

Identification of Product:

This test description refer to all TRNG9880 units, including older units produced under the old brand-name. Units with production date of 0745 and higher carry the updated software, that is recommended.

This report describe various electrical tests that can be applied to a test unit.

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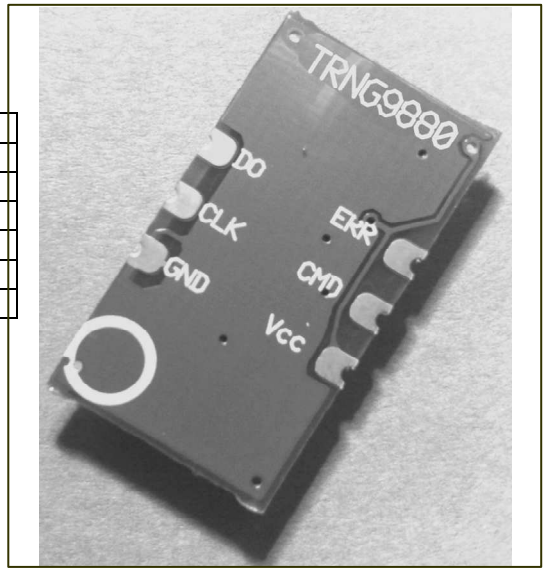
TRNG9880 Test Pads

There are 6 bottom electrical connections:

PAD NO	NAME	CONNECTION	FUNCTION
1	GND	IN	Ground connection
2	CLK	IN	Input serial clock
3	DO	OUT	Data Out
4	ERR	IN/OUT	Device Error Signal
5	CMD	IN/OUT	Device Command
6	Vcc	IN	Power Supply



In addition to these, there are 6 top side test pads:

NAME	DIR	FUNCTION
PRG_DATA	IN/OUT	Reserved for special purpose
RESET	IN/OUT	Reset detect or reset control pad
HEARTBEAT	OUT	Heartbeat signal from digital block
ANALOG	OUT	Analogue noise signal
DIGITEST	OUT	Raw digital stream after sampling
PRG_CLK	Reserved	Reserved for production

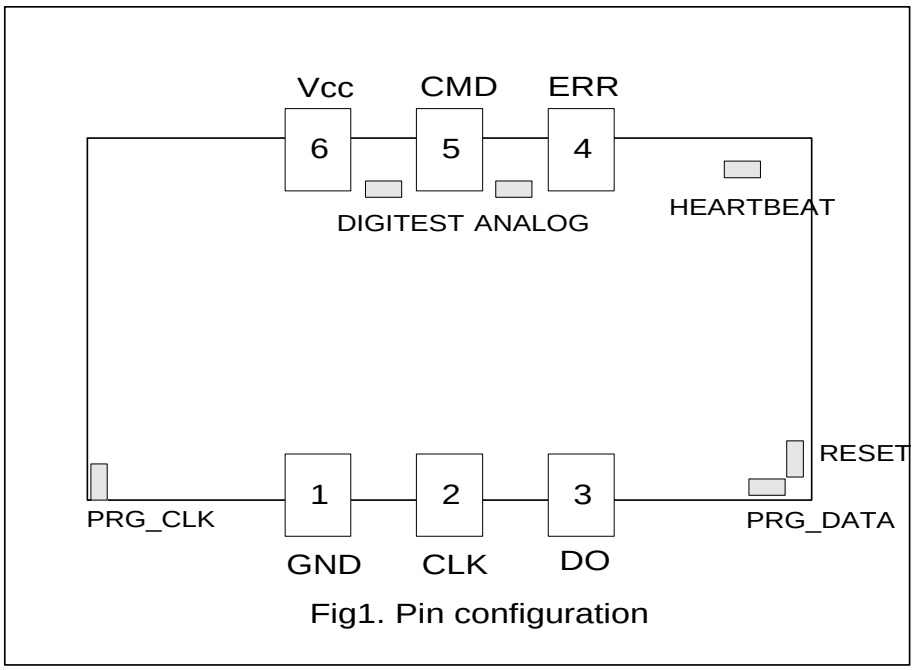


Fig1. Pin configuration

Test Set-Up, Tools and Instrumentation

We assume that ordinary laboratory equipment is available, and also an TRNG9880-unit that shall be tested.
In addition it is recommended to arrange several of the instruments listed:

- Attach a signal light on a high-impedance probe to the ERR pad. Emit a red light when the pad is low. Check that the open pad voltage (no test unit mounted) remain low (light on).
- Measurement of the current consumption on the Vcc pad; 0-50mA range with 0.1mA resolution.
- An AC square-wave to provide test-input to the CLK pad. The signal generator should have a current limiting resistor to allow the signal source to be connected directly to ground or Vcc (to protect the signal generator). Output frequency set to 50k cycles/s and using Low 0V, High 2.6V; or Amplitude = 2.6V, Offset = 1.3V.
  If this cannot be obtained some other square-wave signal should be obtained to allow at least a simpler functional testing of the pad.
- A digital oscilloscope channel to monitor the DO pad.
- A digital oscilloscope channel to test the ANALOG and DIGITEST test pads as well as other test pads.
- An analogue oscilloscope to monitor the ANALOG test pad.
- A spectrum analyser to check the frequencies in the signal from the ANALOG test pad.
- A DC power supply at 2.85V, where it is preferred if the supply can also switch to 5.2V. If an analogue supply is used, check the voltages using a voltmeter.
- A computer/signal amplifier to allow the computer to print the CMD serial signal as plain text. Connection shall be half duplex to allow commands to be sent to the test unit. An optical isolated TRNG9880-EVM module is available for the electrical amplification and optical isolation, that is practical for this test.
- If your application generate or provide some disturbance during normal operation, some means to provide a normal or elevated disturbance level should be provided. Do not put an antenna from a cell phone right nest to the unit, as the near-field of an antenna can be very strong. If your application have a transmitter, this shall be considered during the test.

Basic Test Set-Up

Arrange so that the current consumed on the Vcc pad can be observed at all times. If a unit show any abnormal high or low current consumption anywhere during the test, this unit shall be selected for additional testing. Note that individual units may consume slightly different currents, so some experience might be needed to decide on this.

Some kind of socket is needed to connect the TRNG9880 to the test set-up. We are aware of this issue and please contact us if there is a problem.

To mount a test unit, note the white printed line close to pin 1 "GND". Do not mount the unit wrong, so that the Vcc drive voltage enters a signal pin.

Test Summary

We normally run the tests in this order:

1. We check the HEARTBEAT test pad for the 32Hz signal.
   We check that the ERR pin go high to indicate an OK self-test.
2. We check that the RESET is low, using the digital oscilloscope.
3. We ground the HEARTBEAT and check that the analogue reset is working.
4. We check the software revision on the attached computer, reading from the CMD-pad.
5. We start a test signal on CLK, and check the DO output
6. We look at the signal on ANALOG and DIGTEST pins using the digital oscilloscope
7. We check the signal density on the ANALOG pad using an analogue oscilloscope.
8. The analogue signal is feed to a HP 8568B spectrum analyser, that is used to check for any frequency drop-out.
9. We stop the CLK input and issue a 0B boot command from the computer. We sii if the module can read commands from the CMD pin. We monitor that the unit boots and that the ERR signal toggles.
10. We check the current consumption of the unit during normal operation.
11. We issue a 0L low-power command from the computer, and monitor the current consumption of the unit in low-power mode.
12. We rise the Vcc voltage to 5.2V , and check that the unit boot and start at this voltage.
13. The unit is accepted.

Reset and Watch-Dog Circuits

The TRNG9880 have an analogue external watch-dog circuit, that is needed for continuous operation of the unit. The circuit issue a hard reset, that is as good as a power-cycle reset.

1. Mount the test unit into the test set-up.
2. Check that a proper connection is made to the bottom pads. This might well be the most difficult part of the test procedure.
3. Apply a Vcc voltage of 2.85V. This voltage is outside the operating range in the datasheet. If the source is difficult to adjust, use 2.85V-2.95V. Do not go below 2.80V.
4. Check that the unit starts, and that the ERR pad is high; red light shall go off.
5. Monitor a 32 Hz AC square-wave on the HEARTBEAT pad. Use an oscilloscope probe. This indicates that the unit is operating the analogue reset unit.
6. Move the oscilloscope probe to the RESET pad.
7. Check to see that the RESET pad is low with no glitches.
8. Take a cable, ground the cable at the GND pad, and short-circuit the HEARTBEAT pad to ground. Do not ground the wrong pad. It is OK to hold the HEARTBEAT to ground for extensive periods of time.
9. There should be a slow square-wave signal on the RESET pad. The test is OK if the RESET pad go above 2.2V at least occasionally. The frequency is about 2Hz-5Hz, so a voltmeter will likely work to measure the RESET pulse.

The module also have a microcontroller internal watch dog circuit that, as usual, is implemented using digital electronics, and as a result of this, as usual, may block or lock, and thus do not guarantee a reset. The circuit is used to monitor the operation of the unit, and if there is a software problem, or some format problem in input, or other issue that may occur, run a reset from the internal software. This is implemented by stopping the external signal to the analogue watch dog circuit, that will then hard-reset the chip.

For correct operation the customer's application must accept an occasional TRNG9880 reset cycle.
Note that the unit is expected to run for a minimum of several months without any reset at all, internal or external.

The reset circuit is there to help.

Analogue Signal Testing

The unit use a Johnson noise source. The randomness originates at a high input resistance of an operational amplifier. The noise signal is amplified using both external amplifiers, and also analogue amplifies inside the microcontroller. The resulting analogue signal is export by a buffer amplifier to the ANALOG test pad, where it can be measured. If a disturbance is intentionally injected, on the power line, a correlation between the disturbance and the noise signal may be observed.

The noise signal is sampled into 8-bit bytes using a serial-to-parallel converter. The output of this register is available at the DIGTEST test pad. Note that there is an 8 bit delay between the ANALOG test pad and the DIGTEST pad.

The microcontroller is configured to generate a varying comparison level for the input noise signal. This will provide a greater resistance against low frequency Vcc voltage disturbances. This is important in case the drive voltage at the Vcc input pin is not stabile, but is subject to some low frequency disturbance. A residue of this compensation circuit is present on the ANALOG test pad.

To test the analogue noise source:

1. Start the unit.
2. Check that the unit pass the internal tests; the ERR pin shall go high (the red light shall go off).
3. Measure a random analogue signal on the ANALOG test pad.
4. Attach an analogue oscilloscope using a slow sweep and check the signal's voltage density. Use some experience to evaluate the signal.
5. You may additionally apply a disturbance either by electrostatic coupling, inductive coupling or by some input or output lines to the unit. You can check if the ANALOG output signal catch the disturbance, or is correlated to the disturbance.
6. Attach a digital oscilloscope to the DIGITEST test pad, and check the analogue noise signal after sampling.
7. Check that the DIGITEST signal is a square-wave with low at GND level and high at Vcc level. The sampling frequency shall be 50 kbit/s approximately.
8. Note that, during disturbance testing, a long Hi-level or long Low-level blocking of the DIGITEST signal is not serious, as this is catched by the sampling software. The result will only be a lower random number production rate.

Output Port I/O Testing

Apply an AC square-wave signal to the CLK pad, and check that the unit respond with bits on the DO pad.

1. Start the unit.
2. Check that the unit pass the internal tests; the ERR pin shall go high (the red light shall go off).
3. Check to see that there is no short-circuit to GND/Vcc on either input pad CLK or DO output pad.
4. Check that the output on the DO pad has low at the GND level and high at the Vcc level.
5. Check to see that the DO signal is synchronised to the CLK input signal.
6. If it is easy to modify the input CLK frequency, raise frequency and check that the ERR pin drops low when the unit is overrun. If you have a computer attached to the CMD pin, various error messages will be printed.
7. Check that the output DO voltage is GND when the unit is overrun.
8. If it is important to your application, check that the unit accepts high speed CLK signals, as described in the datasheet. One byte shall be available at 10 Mbit/s; 240 bits at 450 kbit/s; and continuous operation at 50 kbit/s. You may test each condition individually or all conditions simultaneously. You may test on bit-rates a bit higher compared to the datasheet.

Identification of the Software

A connection is made to the CMD serial port. The recommended method is to obtain an old PC, with a working serial port, where the operating system allow the PC to run at non-standard bit rates.

It is to be expected that various test units run at different bit rates, and some experimenting might be necessary to get the communication right. At room temperature, most TRNG9880 units seems to like a 9500 b/s bit rate.

All PC serial ports don't work. Some PC:s was equipped with a non-standard and essentially broken serial decoder, that could hang the decoder chip. This cannot be fixed by an/any operating system upgrade.

An opto-coupled test board TRNG9880-EVM is available that change and amplify the serial port signal from the test-unit levels of 0V and Vcc volts, to the serial port voltage of +5V and -5V. You can not attatch the TRNG9880 directly to a serial port.

Output from the unit:

TRNG9880T-1319
CMD_3R.
STAT_OK_1936
OK19CA OK19A2

Brand-name
"TRNG9880" is the brand-name identifier

Hardware revision code
"T" is the hardware revision code (example character):
"A" used on previously produced units. Some of these units hold the older software.
"T" (Test-Units) used on TRNG9880 produced using the older yellow can with round corners.
"H" (RoHS-units) Lead-free production.

Production year
"13" is the production year, 2013

Production week
"19" is the production week of the year.

The ID code is terminated by a CR-LF, ASCII (decimal) 13,10.
We plan to expand the ID code in future products, where the ID code may appear on two lines. The second line will be used for a serial number.

Hardware test OK
"STAT_OK_1936" is the hardware test OK message. It is issued when the module pass the first statistical test, and the output buffer is full. The number 1936, which is in hex, is the test level, a higher value is better.

Runtime test OK
"OK19CA" is the runtime hardware test message. The number that follows is the test level.