UTEX Scientific Instruments Inc.

UT340 Calibration Procedure for End Users

Rev 1.0

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Scope

This procedure provides instructions for verifying the calibration of a UTEX UT340 pulser receiver using readily available equipment. The scope of the calibration is limited to amplifier gain calibration across a user-defined bandwidth, verifying that the instrument remains within stated capabilities of the UT340 pulser receiver.

This document reflects the requirements of ASTM E 1324 and ASTM E 317 for gain accuracy and amplifier linearity.

Introduction

This procedure provides two methods for performing calibrations:

1. In-system calibrations using Winspect or InspectionWare software and the RF digitizer.
2. Laboratory calibration using a digital oscilloscope.

The in-system calibration method allows the calibration procedure to be integrated as a part of the entire inspection system.

The laboratory calibration should not be needed unless absolute calibrations are required.

General Considerations:

This procedure suggests that tests be performed at frequencies relevant to the intended application since the bandwidth of the UT340 exceeds 150 MHz.

It is important to stabilize the coupling to the test piece (water path or contact) so that constant amplitude signals are maintained.

In-System Calibration using a Step Attenuator

Through-transmission calibration

The following "in-system" calibration using an attenuator is an acceptable method of calibrating the UT340 when configured for through-transmission inspection.

Pulse-echo calibration

"In-system" calibration using an attenuator is possible but not recommended for pulse-echo mode because the very high peak power generated by the UT340 square wave pulser can easily damage most attenuators. Calibration using the through-transmission channel is sufficient since both channels share amplifier components.

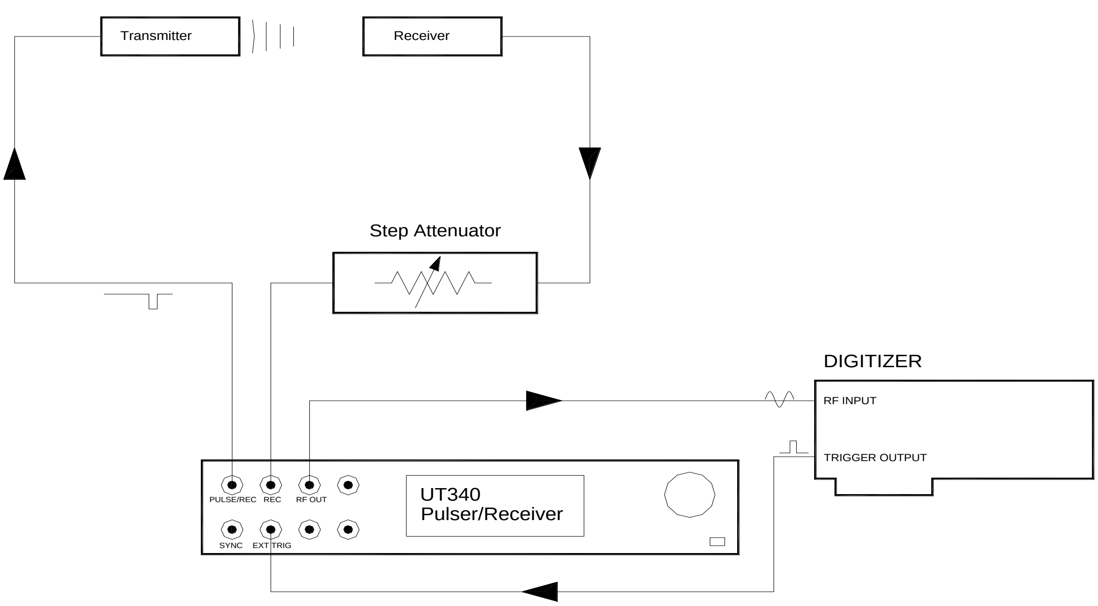
In-system Calibration Diagram

As illustrated below, the recommended calibration set-up uses a precision step attenuator in the receive path of this through-transmission configuration. The RF digitizer, as part of the existing inspection system, is used to make relative amplitude measurements when adjusting the UT340 gain setting concurrently with that of the attenuator.

In the configuration diagram shown, the UT340 receiver gain can be adjusted to compensate for the loss of signal reductions imposed by the attenuator. If the UT340 does this precisely, it can be said that the gain accuracy of the UT340 matches the calibrated accuracy of the attenuator. Accuracy of the calibration is therefore limited to the accuracy of the calibrated attenuator.

For example, if 40 dB of gain on the UT340 precisely compensated for a 40 dB of loss imposed by the attenuator, it can be said that the UT340 is precisely calibrated.

Having a calibrated step attenuator with a 60 dB range in 1dB steps allows the user to test the accuracy of the UT340 over the same 60 dB range in 1 dB steps.



The digitizer is used for comparative measurement only when attenuation is introduced and additional gain of the UT340 is added to compensate. There is very little dependency on the accuracy of the digitizer to accurately verify gain calibration of the UT340. If this is of concern, the results of measurements made with the digitizer can be compared with those of a calibrated oscilloscope.

In-system Procedure

This calibration uses the ultrasonic signal as a calibration reference and therefore the resulting measurements are based on the frequency of that ultrasonic signal. If you need to perform a calibration over a wider frequency range, you would require a number of transducers at different frequencies.

The specified gain accuracy and linearity of the UT340 is +/- 5% of Full Scale.

Initial setup

Verify that the system is configured according to the "in-system" configuration diagram.

1. Set the UT340 Pitch-Catch gain to 0 dB.
2. Set the Step Attenuator to 0 dB.
3. If the filter option is installed, make sure that the high-pass and low-pass filters are turned off
4. Align the transducers and adjust the water pressure (if a squirter system) to maximize the signal in the A-scan viewer to a maximum of 90% of full scale to allow for 10 % headroom. If you need to trim the amplitude, the UT340 pulse voltage and pulse width can be used to adjust the amplitude of the received signal. If possible, we want to conserve the majority of the attenuator's range for calibration.
5. Set up an amplitude gate to measure the peak amplitude of the reflected signal.
6. Set signal averaging to eight or higher to improve the SN ratio during the calibration.

Taking Measurements

Do not take measurements until a stable signal is present on the A-scan viewer.

1. With a stable signal in the gate, record the current value of the amplitude. This will be our Reference Level. This level in percentage of full scale can be converted to dB using the following formula.

   20 Log(% Amplitude/100)

   For example:

   An Amplitude of 76% in dB = 20Log(76/100)

   = 20Log(.76)

   = -2.38 dB

3. Switch the attenuator to 1 dB (impose a 1 dB loss)
4. Increase the UT340 gain to 1 dB (compensate for 1 dB loss by adding 1 dB gain)
5. Record the value in % amplitude of the signal in the gate. If the UT340 gain step matches that of the attenuator, then this amplitude should equal the REFERENCE LEVEL within a tolerance.
6. Continue to add more attenuation and corresponding gain in 1 dB steps and record the percentage amplitude into the table.
7. Table 1 shows an example of collected data and the calculated gain deviation of the UT340 against that of the calibrated step attenuator.
8. Summary of conditions for the sample measurements recorded in Table 1:

9. Measurements start with the UT340 PC (Pitch-Catch) gain set to zero
10. The step attenuator is also set to 0 dB
11. An amplitude of 44.3% amplitude was measured (this is an example) with the transducers adjusted for maximum signal in a through-transmission configuration
12. 44.3% of full-scale represents a –7.07 dB signal level when 0 dB=100% amplitude using the formula dB=20Log(% ampliude/100)
13. The gain deviation is based on subtracting the amplitude for each dB step from the -7.07 dB reference level representing the deviation in the UT340 gain from that of the precision attenuator

Table 1: Example of Record for Gain Linearity Measurements

UT340 Gain in dB	Attenuator setting in dB	GA (Winspect Gated Amplitude collected in % of full scale for each dB setting)	GA dB (Calculated amplitude of gated signal in dB) =Absolute value of: 20 Log(GA/100)	UT340 Gain Deviation in dB (REF Level dB-GAdB)
0 (REF Gain)	0 (REF ATT)	44.3 (REF Level in % FS)	7.07 dB (REF Level in dB)	0.00 dB e.g. (7.07-7.07)
1	1	44	7.13	-0.06 dB e.g. (7.07-7.13)
2	2	45.1	6.91	+0.16 dB e.g. (7.07-6.91)
3	3	47.9	6.39	+0.68 dB
4	4	42.7	7.39	-0.32 dB
5	5	44.5	7.03	+0.04 dB
6	6	45%	6.93	+0.14 dB
7	7	46%	6.74	+0.33 dB
8	8	44%	7.13	-0.06 dB
9	9	21%	13.55	-6.48 dB
10	10	.etc	etc.	etc.
11	11	.etc	etc.	etc.
…	…			
…	…			
44	44			
45	45			
46	46			
47	47			
48	48			
49	49			
50	50			
51	51			
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57	57			
58	58			
59	59			

Laboratory Calibration

The Laboratory procedure does not require the use of any inspection system related hardware to acquire and measure the amplified output signal of the UT340 instrument.

Required equipment

This procedure requires a digital sampling oscilloscope, an external attenuator, and an RF signal generator, or a function generator of suitable capability.

DSO (Digital Sampling Oscilloscope)

A DSO is recommended because of the ease and accuracy of measurements although a calibrated general-purpose analog scope is acceptable.

50 OHM input impedance

Bandwidth = 2 x UT Signal bandwidth requirements

RF Signal Generator

Input/Output Impedance: 50 OHMS

Bandwidth (calibrated): User bandwidth requirements

Output power: 0 dBm or greater into 50 Ohms

Note:

If the above requirements can be met with a suitable function generator, then a function generator can be used instead of an RF Signal Generator.

Step Attenuator

Input/Output Impedance: 50 OHMS

Bandwidth: 2 x user bandwidth requirements

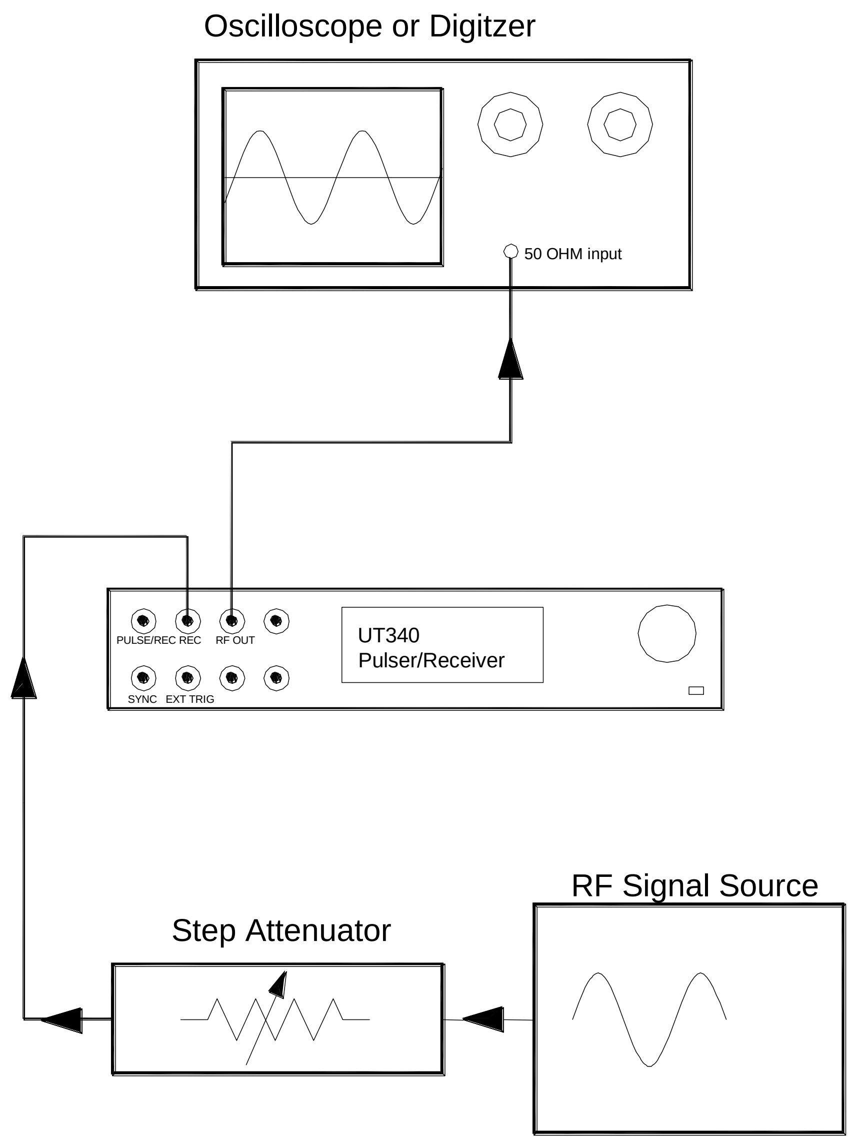
Step size: 1 dB

Recommended Accuracy: +/- .25 dB over user bandwidth.

Power rating: 0 dBm or greater

Cable: 50 Ohm coax, 6ft. maximum length per ASTM E1324.

Laboratory Setup Configuration Diagram



Laboratory Procedure

The specified gain accuracy and linearity of the UT340 is +/- 5%.

1. Connect the UT340 as shown in the laboratory setup configuration diagram.
2. Set the amplitude of the RF signal generator to one of the following equivalent levels:
3. .255 Volts RMS
4. .360 Volts Peak
5. .720 Volts Peak to Peak
6. 0 dBm if the RF generator has a dB power entry feature
7. Set the RF generator to the lowest frequency of the frequency range intended for the calibration.
8. Set the UT340 gain to 0 dB
9. Make sure that the UT340 high-pass and low-pass filters are OFF, if the filter option is installed
10. Set the step attenuator to 0 dB
11. Ensure that the input impedance of the scope is set to 50 OHMS. If the scope doesn't have this feature then use a Coaxial Tee with a 50-OHM RF coaxial termination.
12. For ease of measurement, set the oscilloscope coupling to AC
13. Adjust the oscilloscope vertical gain to .5 volts/division
14. Set the oscilloscope trigger system to internal "AUTO" on the required channel and adjust the trig level to zero
15. Adjust the vertical position to the center of the display. If using a digitizer or DSO, the offset can be precisely set to zero.
16. Set the scope's time base in us/div to approximately 1/Frequency in Hz in order to visualize the RF waveform/signal. For example; 1 us/div for a frequency of 1 MHz (1/1x10-6). Reduce this value accordingly for higher frequencies in order to visualize the RF waveform.
17. With everything operating, the scope should be displaying a sine wave with an amplitude of .360 Volts or greater and a period equal to 1/frequency of the RF source.
18. Once you have a valid signal, experiment adding some attenuation and then some corresponding gain to the UT340 in order to verify the test setup is operational. Adding attenuation will reduce the signal amplitude seen on the scope and will eventually cause the signal to disappear. Increasing the gain of the UT340 should restore the amplitude to its original value before attenuation was added.
19. Keep in mind that noise will be introduced into the signal when high levels of gain are applied. DSO's usually have digital averaging that can be enabled to decrease noise when making measurements in the presence of noise.

20. Align the transducers and adjust the water pressure (if a squirter system) to maximize the signal in the A-scan viewer to a maximum of 90% of full scale to allow for 10 % headroom. If necessary, the UT340 pulse voltage can be reduced to 100 Volts in an effort to prevent the received signal from clipping. If possible, we want to conserve the majority of the attenuator's range for calibration.

Taking Measurements

Do not take measurements until a stable signal is present on the oscilloscope.

1. Record the current value of the amplitude. This will be our Reference Level. This level in percentage of full scale can be converted to dB using the following formula

   20 log(% Amplitude/100)

   For example:

   An Amplitude of 76% in dB = 20Log(76/100)

   = 20Log(.76)

   = -2.38 dB

2. Switch the attenuator to 1 dB (introduce a loss of 1 dB)
3. Increase the UT340 gain to 1 dB (compensate for the 1 dB loss by adding 1 dB gain)
4. Record the value in % amplitude of the signal on the scope. If the UT340 gain step matches that of the attenuator, then this amplitude should equal the REFERENCE LEVEL within a tolerance.
5. Continue to add more attenuation and corresponding gain in 1 dB steps and record the percentage amplitude into the table.

6. Use Table 1 as presented for In System calibrations to record the data.
7. Summary of conditions for the sample measurements recorded in Table 1
8. Measurements start with the UT340 PC (Pitch-Catch) gain set to zero
9. The step attenuator is also set to 0 dB
10. An amplitude of 44.3% amplitude was measured (this is an example) with the transducers adjusted for maximum signal in a through-transmission configuration
11. 44.3% of full-scale represents a –7.07 dB signal level when 0 dB=100% amplitude using the formula dB=20Log(% ampliude/100)
12. The gain deviation is based on subtracting the amplitude for each dB step from the -7.07 dB reference level representing the deviation in the UT340 gain from that of the precision attenuator

Revisions

Revision	Date	Author	Revision Notes
-	April 11, 2001	D. Chapman	Initial Release
1.0	March 02, 2010	D. Seto	Amended specification to explicitly state measurement requirement as : ± 5% of Full Scale Corrected typos in example table Assigned new document number. TP10-340-100 Original No.:F434866