



DXC100A PROBE MANUAL

DXC100A PROBE INFORMATION & CALIBRATION PROCEDURE



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A Word about Differential Amplifiers and Probes

When using a differential amplifier it is very important to understand the role probes play in the overall measurement system performance. Probes not only make attachment to the circuit under test more convenient, 10X and 100X attenuating probes also extend the common mode range of the differential amplifier. For example, the DA1855A amplifier has a common mode range of ± 15.5 volts when the internal attenuators are set to $\div 1$ and 155 volts when set to $\div 10$. The addition of a probe with an attenuation factor of ten extends the common mode range to 1550 volts or the rating of the probe, whichever is less.

However there is a trade-off in that the Common Mode Rejection Ratio (CMRR) capability of even highly matched differential probe pairs seldom matches that of the amplifier. In order to preserve the amplifier's performance at the probe tips, it is important to use probes designed for differential performance. Attempting to use normal 10X or 100X attenuating oscilloscope probes, even high quality probes, results in very poor CMRR performance. Nominally matching X1 probes, however, provide excellent common mode rejection and are recommended.

When making differential measurements, probe compensation is just as important as it is for single-ended measurements. While probe compensation is important, how well the probes are matched is essential. Most probes depend on the accuracy of the oscilloscope's 1 M Ω input resistor to determine the accuracy of the probe's attenuation factor. Two probes with a 1% accuracy specification can yield a CMRR as low as 50 to 1 at DC while the amplifier CMRR may be higher than 100,000 to 1. At high frequencies, the CMRR is worse.

A differential probe pair must allow for matching at DC as well as over their useful frequency range. Changing the compensation of a differentially matched probe set without following the proper compensation procedure can result in a significant decrease in the CMRR capability of any differential probe pair.

It is considered good practice to compensate a probe pair for a given amplifier and then keep the probe pair and amplifier together as a system. Similarly, it is important that once a probe is compensated for a given amplifier, the respective probe always is used on the same input (meaning, one probe always used on the +INPUT and the other always on the -INPUT).

The DXC100A Differential Probe Pair

The DXC100A is a high performance matched passive differential probe pair designed for use with LeCroy differential amplifiers. The probe pair consists of two well-matched individual probes sharing a common compensation box allowing the attenuation factor on both probes to be simultaneously switched between 10X and 100X. When used with the LeCroy Model DA1855A Differential Amplifier, the probe's attenuation factor is automatically incorporated into the effective gain display and the decimal properly located in the Precision Voltage Generator (PVG) display. Although primarily designed for use with LeCroy amplifiers, the DXC100A Differential Probe pair can be used with any oscilloscope or plug-in unit with an input impedance of 1 M Ω /15-26pF and one inch (25.4 mm) spacing between connectors.

Probe Grounding

The DXC100A Probe Pair is supplied with accessories allowing for three probe ground connection methods. In most cases, when the common mode portion of the signal consists mainly of low frequencies (1 MHz and below), the probe ground leads **should not** be connected to the ground of the circuit under test. Instead, they should be connected to each other to minimize the effects of ground loop currents. The signal corruption caused by not having the probes connected to the ground of the circuit under test is common to both inputs and rejected by the differential amplifier.

However, when working in an environment with high RF ambient noise, it is best to connect the probe ground leads to a good RF ground near the point where the signal is being measured.

The best way to determine which probe grounding technique should be used is to try both methods and use the one that provides the least corruption of the differential signal. Probe tip to BNC adapters are required when adjusting the compensation and probe CMRR as they provide the best performance of the three grounding methods.

DXC100A Probe Short Calibration Procedure

Important Notes:

There are two situations where the DXC100A Probe Short Calibration Procedure is appropriate:

1. When the DXC100A probe calibration status is unknown or it has been a long time since the probe has been calibrated. A small difference between the two probes can result in a significant CMRR loss, even though the error may be so small that it's irrelevant to transient response. This makes it rather important to occasionally check the CMRR performance of the probes. This can be done by performing **Part 1** (as follows) and adjusting as needed.
2. When critical measurements are required, checking the DXC100A CMRR by performing at least **Part 1** of the short procedure is recommended. When very high slew rate signals ($>1\text{V/ns}$) are encountered, performance can be enhanced over that of a full calibration procedure done with commonly available pulse generators. Notice that the DXC100A Probe Short Calibration Procedure is the last step in the DXC100A Probe Full Calibration Procedure.

Once you are accustomed to making these adjustments, they become quick and easy. **Part 2** can be attempted when high slew rates ($>1\text{V/ns}$) are encountered, and/or when high frequency (time constraints less than 20ns and frequencies greater than 1MHz) CMRR is especially important.

Note: Do not change any of the adjustments associated with the +INPUT. Doing so requires checking the changed adjustment, and perhaps doing the entire DXC100A Probe Full Calibration Procedure.

Refer to Figure 1.1 for the location of adjustments, and to the schematic diagram in Figure 1.2 for guidance. Both figures can be found at the end of this manual.

Part 1

1. Set the oscilloscope sweep speed to $10\mu\text{s/div}$. Connect both probe tips to the same point in the circuit where a measurement is to be made, and set the DA1855A GAIN, ATTENUATOR and INPUT COUPLING controls to the same settings to be used in the measurement. Be sure the signal used does not exceed the maximum common mode voltage allowed: e.g. 155 volts with 10X and DA1855A ATTENUATOR set to X1.
2. Set the DXC100A to 10X. Adjust C8 (-X10 LF) so as to minimize the total deflection.
3. Set the DXC100A to 100X. Adjust C18 (-X100 LF1) so as to minimize the total deflection.

Part 2

4. Set the oscilloscope sweep speed to 20ns/div . Now, set the DXC100A ATTENUATION to X10. Adjust R2 (-X10 HF1) and R8 (-X10 HF2) so as to minimize the total deflection.
5. Set the DX100A ATTENUATION to 100X. Adjust R18 (-X100 HF1) so as to minimize the total deflection.

DXC100A Probe Full Calibration Procedure

If the probe pair has been repaired or is to be used on a DA1855A other than the one it was originally calibrated with, the probe pair should be calibrated using the following DXC100A Probe Full Calibration Procedure. The last step is to perform the DXC100A Probe Short Calibration Procedure as needed for high slew rate signals.

Required Equipment

Equipment:	Description:
Differential Amplifier	LeCroy Model DA1855A or Equivalent
Oscilloscopes	150 MHz Minimum Bandwidth
Calibration Generator	Tektronix PG506A or Equivalent
DVM	HP 34401A or Equivalent
DC Voltage Generator	HP 6209B or other stable source of 150V and 300V
Probe Tip to BNC Adaptor (2)	Supplied with probes
BNC T Adaptor	Two female and one male BNC connector, no resistors
COAX Cables (2)	50 ohm
Termination, 50 ohm	If oscilloscope has no 50 ohm input impedance
Termination, 75 ohm	50 ohm may be substituted
Trimmer Tool	Not supplied with probes

Refer to Figure 1.1 for the location of adjustments, and to the schematic diagram in Figure 1.2 for guidance. Both figures can be found at the end of this manual.

1. DA1855A and Oscilloscope Setup

Follow the sequence shown in the previous DXC100A Probe Short Calibration Procedure topic to set up the DA1855A amplifier with your oscilloscope. Remove the probe's bottom cover and attach the probe to the DA1855A.

Note: Do not attach the probe upside down and then reverse the probes after they are compensated.

Reversing the probes after they have been compensated results in degradation of the CMRR performance. Turn the entire DA1855A and probe to gain access to the adjustments. Set the probes to X10 attenuation. Initialize the DA1855A to its power-up reset state by turning its power off and then back on.

At this point, the DA1855A is in the following state:

Setting:	Status:
+Input	Off
-Input	Off
BW Limit	Full
Gain	X1
Attenuator	$\div 1$
Input Resistance	1M
Precision Voltage Generator	+000.00
Comparison or Differential	Comparison
Effective Gain	$\div 100$

Press the $\div 1$ Attenuator button on the DA1855A. The $\div 1$ Attenuator light is now on.

Check: The DA1855A Effective Gain indicators change when the probe is switched from 10X to 100X.

Note: The DXC100A provides probe attenuation factor information to the DA1855A through an 11" black wire which should be plugged into the DA1855A Probe Coding Input jack on the DA1855A rear panel. If the DA1855A has no probe coding input, and the wire is not used. Skip to Step 2.

Note: It is both important and convenient to use the right hardware to connect the probes to the test signals. In all cases, the BNC to probe tip adapters are helpful. For the high frequency adjustments, they are required.

CMRR (common mode rejection ratio) adjustments should be done with both probes connected to a BNC T (two female BNC and one male BNC connected together without any matching resistors).

Note: With the DXC100A connected, let 20 minutes pass to allow the DA1855A to warm up before performing the calibration procedure.

2. +Input X10 DC Attenuation

Setup: Set the probe to the 10X position. Connect both probes to the BNC T, the BNC T and the DVM to the dc voltage source. Set the voltage source to 150 volts. Press the V_{Comp} button. Measure the dc source with DVM and note the actual voltage (e.g. 149.821 volts). Set the Precision Voltage Generator to equal the noted voltage (e.g. 149.821 volts).¹ Set the oscilloscope to 10mV/div. Press the +Input DC button. Set the BW Limit to 20MHz. Press the X10 Gain Button (to invoke AUTOBALANCE).

Adjust: R5 (+X10 DC) to bring the DA1855A output to center screen (0 volts) on the oscilloscope. A 1 division error is equivalent to 10mV out of 150 volts, or 0.0067%, or 67 ppm.

3. X10 DC CMRR

Setup: Continuing from the previous step, press the -Input DC button.

Adjust: R6 (-X10 DC) to bring the DA1855A output to center screen (0 volts) on the oscilloscope. This is a very critical adjustment, and it is desirable to disconnect both probes from the source simultaneously (by removing the BNC T) and observe that the trace stays within 0.25 div (60,000:1 CMRR) between the two conditions.

4. +Input X100 DC Attenuation

Setup: Continuing from the previous step, set the probe to the 100X position. Set the voltage source to 300 volts. Press the V_{Comp} button. Measure DC source with DVM and note the actual voltage (e.g. 302,617). Set the Precision Voltage Generator to equal the noted voltage (see footnote). Set the oscilloscope to 10mV/div and 10 μ s/div. Press the +Input DC button. Press the X10 Gain button (to invoke AUTOBALANCE).

¹ When a large voltage is not available, or when extra precision is desired, monitor the PVG output on the DA1855A rear panel and set the PVG to exactly one tenth the voltage applied to the probe. As little as 32 volts may be used to calibrate the +probe using this method. For CMRR, 32 volts is inadequate and a 50 or 60Hz signal of 30 to 90 Vrms is recommended.

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Adjust: R23 (+X100 DC) to bring the DA1855A output to center screen (0 volts) on the oscilloscope. A 1 division error is equivalent to 100mV out of 300 V, or 0.03%, OR 330 ppm.

5. X100 DC CMRR

Setup: Continuing from the previous step, press the –Input DC button. Set the oscilloscope to 2mV/div. Press X10 Gain to invoke AUTOBALANCE.

Adjust: R24 (-X100 DC) to bring the DA1855A output to center screen (0 volts) on the oscilloscope. This is a very critical adjustment, and it is desirable to disconnect both probes from the source simultaneously and observe that the trace stays within 0.5 div between the two conditions. 0.5 divisions is equivalent to a CMRR of 30,000:1 (300V/10mV).

Setup: Press the +Input Off button. Press the –Input Off button. Disconnect both probes and the DVM from the voltage source.

6. +Input X10 LF Compensation

Note: Low frequency compensation of the DXC100A probe attached to the +Input is done by observing a small portion of the large amplitude step. With this magnification, the waveform shows considerable deviation from flat. What is important is that the front (1 μ s) and rear (about 10ms) of the waveform are at the same level.

Setup: Set the probe to the 10X position. Set the oscilloscope to 10mV/div and 10 μ s/div. Terminate the pulse generator's high amplitude output in 50 or (preferable) 75 ohms, producing approximately a 5 to 8 volt step. Connect the +probe to the pulse generator's high amplitude output using the probe tip to BNC adaptor. Press the X10 Gain button (to invoke AUTOBALANCE). Now, press the +Input DC button. Connect the pulse generator's trigger output to the oscilloscope's external trigger input and then trigger the oscilloscope on its external trigger input.

Adjust: C7 (+X10LF) so the amplitude at the front of the waveform (1 μ s) matches the amplitude at the rear of the waveform (10ms using 1ms/div).

7. X10 LF CMRR

Setup: Continue from the previous step, (using BW Limit set to 20MHz, and the oscilloscope set to 10mV/div and 10 μ s/div) and connect the +probe and –probe to the pulse generator output. Press the –Input DC button.

Adjust: C8 (-X10 LF) capacitor for a minimum amplitude display. The residual displayed amplitude should be less than 5mV peak (10mV p-p at slower sweep speeds where the entire waveform is visible). Ignore the first 1 μ s after the step (this is adjusted later).

8. +Input X10 HF Transient Response

Setup: Press the –Input Off button. Set the BW Limit to Full. Press the X1 Gain button. Set the oscilloscope to 20mV/div. Connect the +probe to the pulse generator's fast rise output using a 50 ohm termination and the BNC to probe tip adaptor. Press the V_{Diff} button to enable V_{Diff} mode. Position the trace 2½ divisions above the centerline using the PVG (-00.500). Press the +Input DC button. Set the oscilloscope sweep speed to 10ns/div. Adjust pulse generator for 5 divisions of a 100kHz signal.

Adjust: R1 (+X10 HF1) and R7 (+X10 HF2) for minimum aberrations at the top of the waveform and a system rise time of less than 3.5ns.

9. X10 HF CMRR

Setup: Continuing from the previous step, disconnect the probe from the pulse generator. Connect both probes to the pulse generator's fast rise output using a 50 ohm termination, the BNC T, and two probe tip to BNC adapters. Disable V_{Diff} mode by pressing the V_{Diff} button. Set the oscilloscope to 5mV/div. Press the –Input DC button.

Adjust: R2 (-X10 HF1) and R8 (-X10 HF2) for minimum displayed signal. The residual displayed amplitude should be less than 15mV (3.0 divisions) peak to peak.

10. +Input X100 LF Compensation

Note: Low frequency compensation of the DXC100A probe attached to the +Input is done by observing a small portion of a large amplitude step. For the 100X probe attenuation, the oscilloscope transient response plays an important part in determining the correct LF compensation adjustment. The oscilloscope response should be measured at this point and recorded as a reference waveform.

The oscilloscope's transient response error may be determined by connecting the oscilloscope to a known flat pulse generator (i.e., Tektronix PG506 fast rise output). Since the DA1855A produces a maximum output of 0.5 volts, apply a waveform that is stepped from -0.5 volts to 0 volts to the oscilloscope. Oscilloscope response is recorded at 10mV/div, 10 μ s/div. The correct adjustment of the DA1855A produces a waveform most like the recorded reference waveform, and not necessarily the flattest waveform.

Digital oscilloscopes record and store waveforms nicely. Some users of analog oscilloscopes mark waveforms on the CRT face using a grease pencil.

Setup: Set the oscilloscope to 10 μ s/div and 10mV/div. Press the –Input DC Off button. Set the probe to the 100X position. Connect the +probe to the high amplitude output of the pulse generator using a 50 ohm or (preferably) 75 ohm termination and the BNC to probe tip adaptor. Press the X10 Gain button. Set the pulse generator amplitude to maximums (5-8V peak). Set the BW Limit to 20 MHz.

Adjust: C17 (+X100 LF1) and C11 (+X100 LF2) for a response that matches the oscilloscope response noted earlier. Ignoring any DC offset, the recorded waveform and this displayed trace should match within 0.1 div.

11. X100 LF CMRR

Setup: Continuing from the previous step, disconnect the probe from the pulse generator. Connect both probes to the pulse generator's high amplitude output using a 50 ohm or (preferably) 75 ohm termination, the BNC T, and two BNC to probe tip adapters. Press the –Input DC button.

Adjust: C18 (-X100 LF1) and C12 (-X100 LF2) for minimum displayed signal. Ignoring the first 1 μ s (0.1div), the residual displayed amplitude should be less than 2mV (0.2div) peak to peak.

12. +Input X100 HF Transient Response

Setup: Press the –Input Off button. Press the X10 Gain button. Set BW Limit to Full. Set the oscilloscope to 20mV/div. Connect the +probe to the pulse generator's fast rise output using a 50 ohm termination and the BNC to probe tip adaptor. Press the VDiff button to enable VDiff mode. Position the trace 2.5 divisions above the centerline using the PVG (-00.500). Press the +Input DC button. Set the oscilloscope sweep speed to 10ns/div. Adjust pulse generator for 5 divisions of a 100 kHz signal.

Adjust: R17 (X100 HF) for minimum aberrations at the top of the waveform and a system rise time of less than 3.5ns.

13. X100 HF CMRR

Setup: Continuing from the previous step, disconnect the probe from the pulse generator. Connect both probes to the pulse generator's fast rise output using a 50 ohm termination, the BNC T, and two probe tips to BNC adapters. Disable V_{Diff} mode by pressing the V_{Diff} button. Set the oscilloscope to 5mV/div.

Adjust: R18 (-X100 HF1) for minimum displayed signal. The residual displayed amplitude should be less than 8mV peak to peak (1.6 div).

14. Final Adjustments and Notes

Setup: Now, replace probe cover. Replacing the probe cover disturbs the X10 LF and X100 LF compensations for CMRR very slightly. These fine adjustments need to be made now.

Set the BW Limit to 20MHz. Now, set the oscilloscope to 10mV/div and 10 μ s/div, and the probe attenuation to 10X. Terminate the pulse generator's high amplitude output in 50 or (preferably) 75 ohms, producing approximately a 5 to 8 volt step. Connect both probes to the pulse generator's high amplitude output using the BNC T and two probe tips to BNC adaptors. Press the X1 Gain button. Now, press the +Input and –Input DC buttons.

DXC100A Probe

Adjust: C8 (-X10 LF) capacitor for a minimum amplitude display. Ignoring the first 1 μ s, the residual displayed amplitude should be less than 5mV peak to peak.

Setup: Continuing from the previous step now set the probe attenuation to 100X.

Adjust: C18 (-X100 LF1) capacitor for a minimum amplitude display.

Note: Pulse generators such as the Tektronix PG506 (ones that do not have a high enough slew rate) may be encountered in some measurement situations. Therefore it is reasonable to make minor adjustments to the -probe compensation to improve the CMRR using a specific source. Do this by connecting both probes to a suitable test point in the circuit under test and adjusting the C8 (-X10 LF), R2 (-X10 HF1), R8 (-X10 HF2) or C18 (-X100 LF1), and R18 (-X100 HF1) as needed. This is the same as performing the DXC100A Probe Short Calibration Procedure.

When the +probe has been properly adjusted it should be used as a reference. CMRR adjustments made to the probe in the future should be done to the -probe.

At this point, do not change any of the +Input X10 or +Input X100 Adjustments, as doing so may require repeating the entire probe calibration procedure.

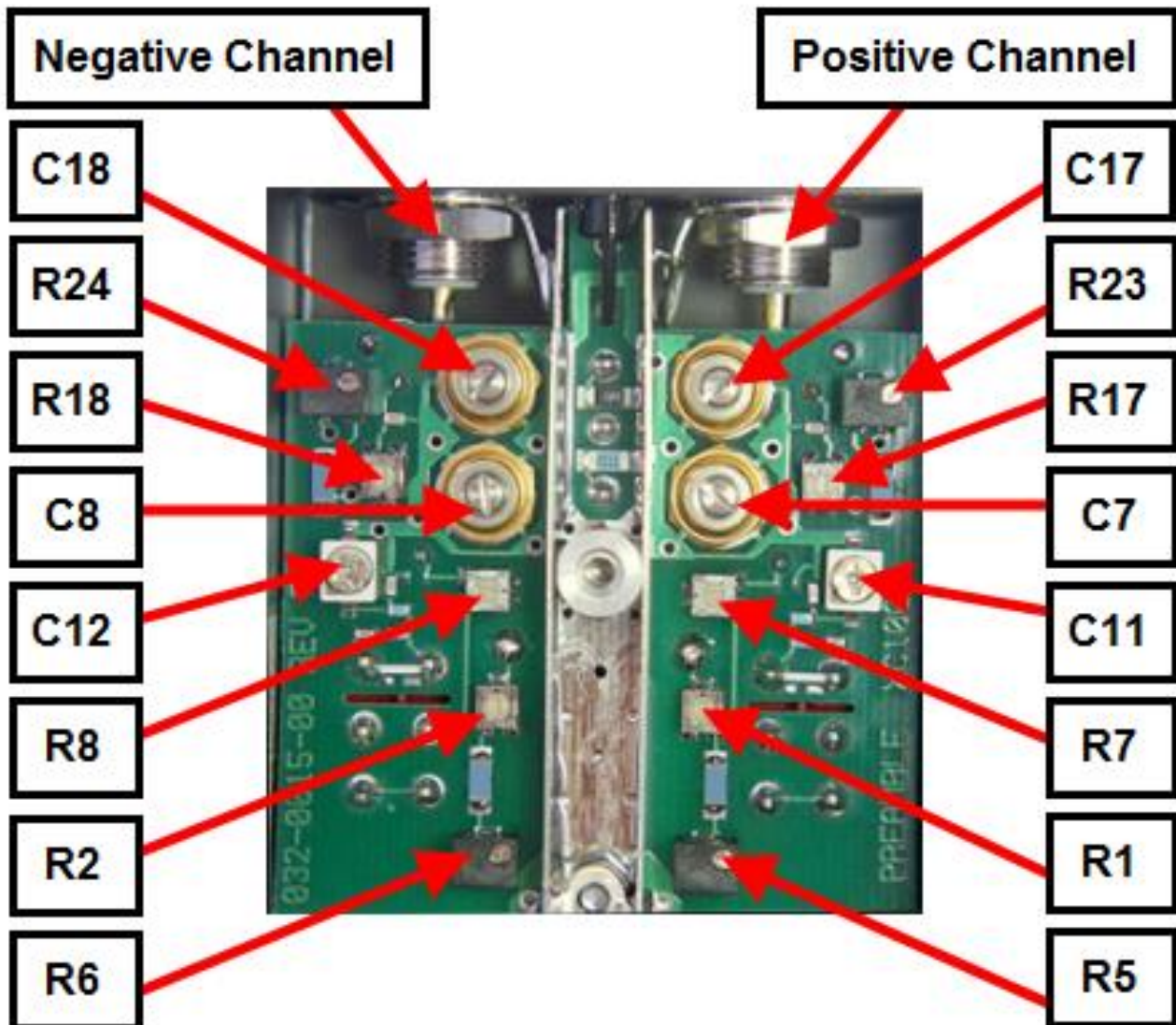
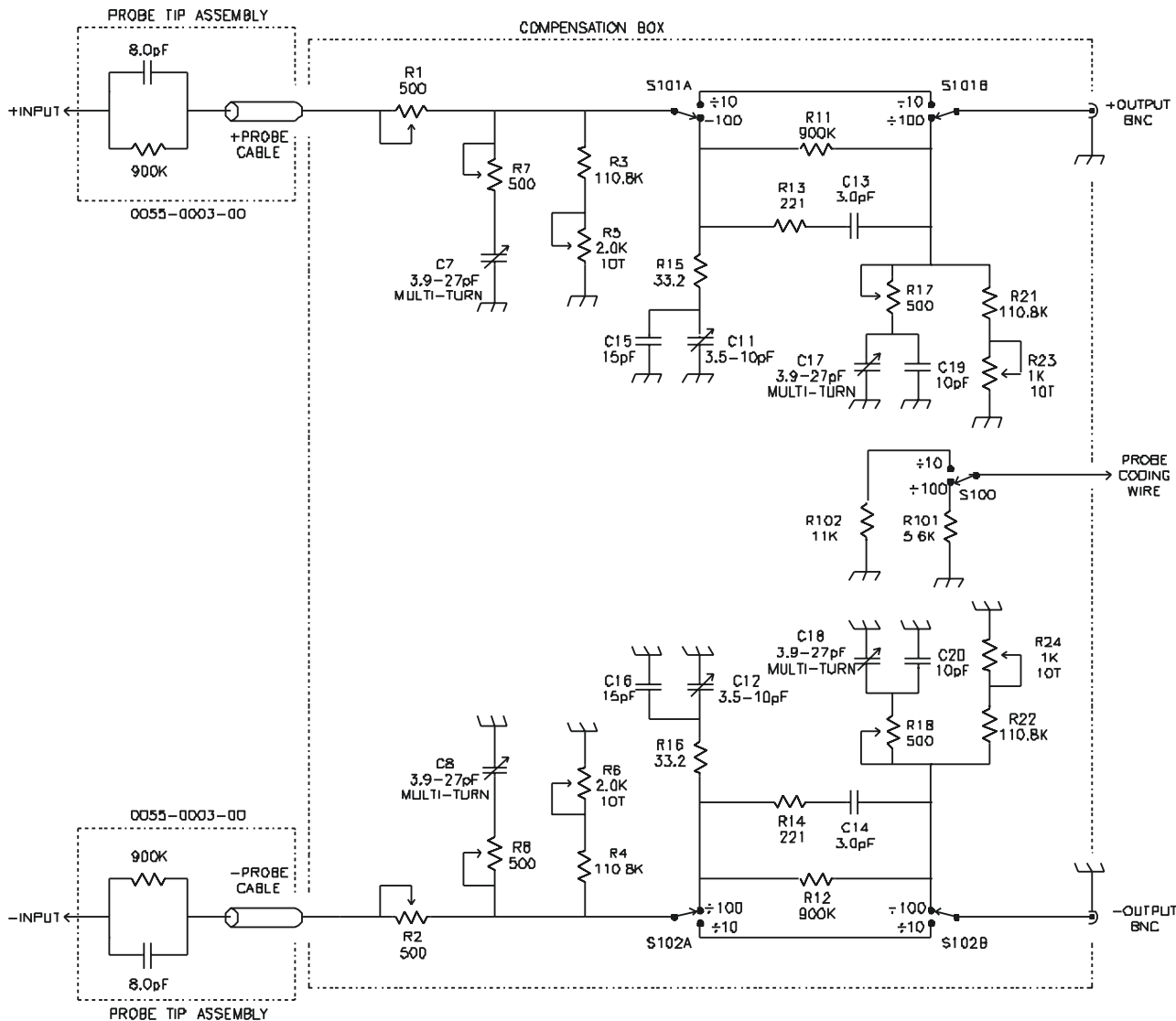


Figure 1-1. The DXC100A Board Layout.

DXC100A Probe

DXC100A $\div 10/\div 100$ DIFFERENTIAL PROBE

0032-0015-00 BOARD



JUNE 8, 2001

Figure 1-2. The DXC100A Schematic.

Operating Environment

Before using your accessory, ensure that its operating environment will be maintained within these parameters:

- **Temperature:** 0 to 50 °C.
- **Humidity:** ≤ 80% RH (non-condensing).
- **Altitude:** 2000 meters Max.

Safety Precautions



Avoid personal injury or damage to your accessory or any equipment connected to it by reviewing and complying with the following safety precautions:

- **Use only as intended.** The accessory is intended to be used only with the compatible LeCroy instruments. Use of the accessory and/or the equipment it is connected to in a manner other than specified may impair the protection mechanisms.
- **Connect and disconnect properly.** Avoid damage through excessive bending.
- **Do not use in wet/damp or explosive atmospheres.**
- **For indoor use only.** The accessory is intended for indoor use and should be operated in a clean, dry, environment.
- **Do not operate with suspected failures.** Do not use the product if any part is damaged. All maintenance should be referred to qualified service personnel.
- **Keep product surfaces clean and dry.**
- Connect probe to the measurement instrument before connecting the probe test leads to a circuit/signal being tested.
- **Do not apply a voltage to any input that exceeds the maximum rating of that input.** Refer to the Specifications on LeCroy website at www.lecroy.com for detailed information.
- **Be careful with sharp tips.** Handle the probe with care as it has sharp tips that may cause bodily injury if not handled properly.

CERTIFICATIONS

CE Compliant

CE Declaration of Conformity

The accessory meets requirements of EMC Directive 2004/108/EC for Electromagnetic Compatibility and Low Voltage Directive 2006/95/EC for Product Safety.

EMC Directive

- EN 61326-1:2006
- EMC requirements for electrical equipment for measurement, control, and laboratory use.

Electromagnetic Emissions:

- EN 55011/A2:2002, Radiated and conducted emissions (Class A)*

DXC100A Probe

Electromagnetic Immunity:

- EN 61000-4-2:2001 Electrostatic Discharge.
(4 kV contact, 8 kV air, 4 kV vertical/horizontal coupling planes)
- EN 61000-4-3:2006 RF Radiated Electromagnetic Field.
(3 V/m, 80-1000 MHz; 3 V/m, 1400 MHz - 2 GHz; 1 V/m, 2 GHz - 2.7 GHz)

* This is a Class A product. In a domestic environment this product may cause radio interference, in which case the user may be required to take appropriate measures.

Low-Voltage Directive

EN 61010-031:2002

Safety requirements for electrical equipment for measurement, control, and laboratory use –

Part 031: Safety requirements for the hand-held probe assemblies for electrical measurement and test.

The design of the differential probe has been verified to conform to EN 61010-031 safety standard per the following limits:

- Installation (Overvoltage) Category I: Refers to signal level which is applicable for equipment measuring terminals that are connected to source circuits in which measures are taken to limit transient voltages to an appropriate low level.
- Pollution Degree 2: Refers to an operating environment where normally only dry non-conductive pollution occurs. Occasionally a temporary conductivity caused by condensation must be expected.