

# LeCroy

## DA18000

### Differential Amplifier



## Instruction Manual

December 2006



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### Warranty

LeCroy warrants this oscilloscope accessory for normal use and operation within specification for a period of one year from the date of shipment. Spare parts, replacement parts and repairs are warranted for 90 days.



In exercising its warranty, LeCroy, at its option, will either repair or replace any assembly returned within its warranty period to the Customer Service Department or an authorized service center. However, this will be done only if the product is determined by LeCroy's examination to be defective due to workmanship or materials, and the defect is not caused by misuse, neglect, accident, abnormal conditions of operation, or damage resulting from attempted repair or modifications by a non-authorized service facility.

The customer will be responsible for the transportation and insurance charges for the return of products to the service facility. LeCroy will return all products under warranty with transportation charges prepaid.

This warranty replaces all other warranties, expressed or implied, including but not limited to any implied warranty of merchantability, fitness or adequacy for any particular purposes or use. LeCroy shall not be liable for any special, incidental, or consequential damages, whether in contract or otherwise.

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DA18000-OM-E Rev A  
914715-00 Rev A



## DECLARATION OF CONFORMITY

according to ISO/IEC Guide 22 and EN 45014:1998

**Manufacturer's Name:** LeCroy Corporation

**Manufacturer's Address:** 700 Chestnut Ridge Road  
Chestnut Ridge, NY 10977  
USA

herewith declare that

**Product(s) Name:** Differential Amplifier

**Model Number(s):** DA18000

including all their options are in conformity with the provisions of the following EC directive(s), including the latest amendments, and with national legislation implementing these directives:

**73/23/EEC Low Voltage Directive**  
**89/336/EEC EMC Directive**

and that conformity with Council Directive 73/23/EEC is based on

EN 61010-031: 2002 Safety requirements for electrical equipment for measurement, control and laboratory use  
Part 031: Safety requirements for hand-held amplifier assemblies for electrical measurement and test

and that conformity with Council Directive 89/336/EEC is based on

EN 61326/A3:2003 EMC requirements for electrical equipment for measurement, control and laboratory use

Emissions	EN 55011/A2:2002	Radiated Emissions
Immunity:	EN 61000-4-2/A2:2001 EN 61000-4-3/A1:2003	Electrostatic Discharge RF Radiated Electromagnetic Field



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**Warning:** 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 adequate measures.

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### Safety Information

#### SAFETY SYMBOLS

The following symbols appear on the DA18000 Differential Amplifier or in this manual and alert the customer to important safety considerations.



Refer to the accompanying information or document to protect against personal injury or damage to the instrument.



CAUTION

The CAUTION sign indicates a potential hazard. It calls attention to a procedure, practice or condition, which, if not followed, could possibly cause damage to the equipment. If a CAUTION is indicated, do not proceed until its conditions are fully understood and met.



WARNING

The WARNING sign indicates a potential hazard. It calls attention to a procedure, practice or condition which, if not followed, could possibly cause bodily injury or death. If a WARNING is indicated, do not proceed until its conditions are fully understood and met.



The ESD sign indicates a potential hazard. It calls attention to the susceptibility of the equipment to Electrostatic Discharge (ESD) induced damage if anti-static measures are not taken.

#### OPERATOR SAFETY

To avoid personal injury and to prevent damage to the probe or any products connected to it, review the following safety precautions. To avoid potential hazards, use the probe only as specified.

*To avoid damage to the amplifier or personal injury, comply with the following:*



**ESD Sensitive:** The amplifier tips of the DA18000 amplifier are sensitive to electrostatic discharge (ESD). To avoid causing damage to the amplifier, always follow anti-static procedures (wear wrist strap, etc.) when using or handling the amplifier.



CAUTION

Connect amplifier to the measurement instrument before connecting the probe test leads to a circuit/signal being tested.



CAUTION

Using the amplifier and/or the oscilloscope it is connected to in a manner other than that specified may impair their protection mechanisms.



WARNING

Do not apply a voltage to any input that exceeds the maximum rating of that input. (Section 9, Specifications).

## DA18000 Differential Amplifier

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WARNING

Handle the probe with care as it has sharp tips that may cause bodily injury if not handled properly.



WARNING

Do not use the amplifier in wet or explosive atmospheres.



CAUTION

Do not use the amplifier if any part is damaged. All maintenance should be referred to qualified service personnel.

### OPERATING ENVIRONMENT

The DA18000 Differential Amplifier is intended for indoor use and should be operated in a clean, dry environment.

The design of the differential amplifier 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.

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### Overview

#### DESCRIPTION

The DA18000 Differential Amplifier is a very high bandwidth differential amplifier with 50  $\Omega$  inputs and high common mode rejection, and is designed to be used exclusively with the SDA 18000 Serial Data Analyzer.

The amplifier contains common circuitry such as power supply, communication and control and AutoColor ID. The DA18000 amplifier utilizes digital filtering to improve the system frequency response. The response is corrected through the use of digital filters which are specifically tailored through calibration to optimize the frequency flatness of the amplifier. This provides the highest fidelity in eye pattern measurements.

Certificate of Calibration is supplied with each amplifier indicating that the system will meet the specifications with those components listed in the Certificate.



**ESD Sensitive:** The inputs of the DA18000 amplifier are sensitive to Electrostatic Discharge (ESD). To avoid causing damage to the amplifier, always follow anti-static procedures (wear wrist strap, etc.) when using or handling the 2.92 mm connectors.

#### APPLICATIONS

The DA18000 amplifier is ideally suited for acquiring differential signals common in high speed serial data applications with fine pitch ICs and high lead count where high speed, minimal loading and accurate jitter measurement are required.

- System Designers:  
Designing systems using standard and ASIC components Use simulators and correlate with lab measurements
- IC Designers:  
Characterize new chip design
- Manufacturers of servers, PC Motherboards, Data routers, Disk drives
- High-speed SERDES

#### STANDARD ACCESSORIES

- Matched 2.92 mm Input Cables (1 pair)
- 2.92 mm 6 dB attenuators (2)
- SAC-01 Soft Accessory Case with insert
- ESD Dissipating Wrist Strap
- DA18000 Instruction Manual
- Certificate of Calibration

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## DA18000 Differential Amplifier

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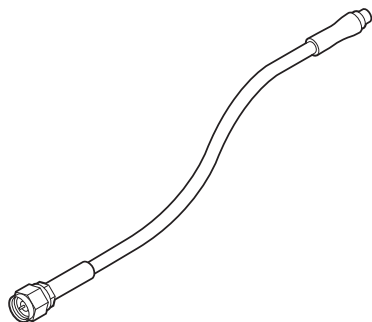
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## Components and Accessories

### Components and Accessories

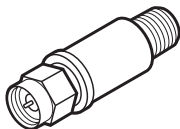
#### STANDARD ACCESSORIES

##### 2.92 mm Input Cables



A matched pair of 50  $\Omega$  2.92 mm Input Cable is provided for direct cable connection to female 2.92 mm connectors of the amplifier.

##### 2.92 mm $\div 2$ Attenuator



The 2.92 mm attenuator can be used to extend the differential mode range or to improve the VSWR by reducing reflections.

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## DA18000 Differential Amplifier

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## Operation

### HANDLING THE AMPLIFIER

The DA18000 Differential Amplifier is a precision test instrument; exercise care when handling and storing the amplifier. Always handle the amplifier by the body. Avoid putting excessive strain on the attached cables or exposing the cables to sharp bends.



**ESD Sensitive:** The inputs of the DA18000 amplifier are sensitive to Electrostatic Discharge (ESD). To avoid causing damage to the amplifier, always follow anti-static procedures (wear wrist strap, etc.) when connecting cables to the input.

### 2.92 MM CONNECTORS

The 2.92 mm connector of the DA18000 amplifier is a precision coaxial connector that operates up to 40 GHz. It is compatible with SMA, WSMA and 3.5 mm connectors.

To avoid misalignment of the male pin to the female contact, the male pin of the 2.92 mm connector is made shorter than the SMA or 3.5 mm connector pins. This way the outer housing is properly aligned prior to mating of the center conductors. Because of the new design, the insertion force has been reduced from about 27 N in SMA and 3.5 mm connectors to about 2.3 N with the 2.92 mm design. 2.92 mm connectors can be tightened to the same torque specification as is used for type SMA, without damage.

#### Note

*When connecting SMA or 3.5 mm connectors, always align the male and female parts before insertion to prevent damage to the female center connector.*

2.92 mm connectors use air for the dielectric, as opposed to PTFE resin in type SMA. Foreign material such as excessive dust can enter the dielectric pocket and degrade the high frequency performance. Should this occur, remove the foreign material, using a jet of compressed air or gas. Disposable cans of compressed gas for dusting purposes are readily available from photo or electronic equipment suppliers.



CAUTION

Never insert an object into the connector in attempting to clean it. The center contact can be easily bent out of position, destroying the connector.

### COMPATIBILITY

The DA18000 Differential Amplifier is designed to be used exclusively with the SDA 18000 Serial data Analyzer. However it includes frequency compensation data compatible with lower BW WaveMaster, SDA, and DDA 5005 oscilloscopes.

### CONNECTING THE AMPLIFIER TO A LECROY SERIAL DATA ANALYZER

The DA18000 amplifier has been designed for exclusive use with the SDA 18000 Serial Data Analyzer.

For optimum performance and full bandwidth always connect the amplifier only to channel 1 of the SDA 18000 analyzer.

## DA18000 Differential Amplifier

To attach the amplifier to the LeCroy oscilloscope, align the interface connector with the input connector and push the interface toward the oscilloscope.

A click will be heard when the amplifier's interface latches to the oscilloscope. This amplifier also uses the thumb screws to secure the interface to the oscilloscope.



Thumb screws should be tightened finger tight only. Use of pliers or another tool may overtighten the screws, resulting in damage to the oscilloscope.

To remove the DA18000 from the LeCroy oscilloscope, move the amplifier up and down while pulling gently till a loud snap is heard indicating that the amplifier is unlatched from the oscilloscope.

### AUTOCOLOR ID

When the amplifier is connected to a SDA 18000, the LED will illuminate in the default color of the channel to which the amplifier is connected.

### OPERATION WITH THE SDA 18000

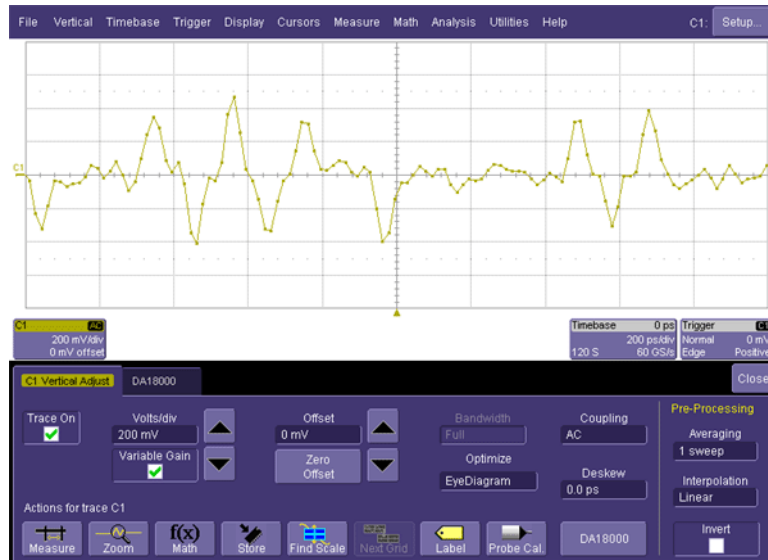


Figure 4-1. Vertical Menu

When the amplifier's output connector is attached to the SDA 18000 oscilloscope's input connector, the oscilloscope will recognize the amplifier and activate the vertical channel functions in the user interface. Figure 4-4. Refer to your oscilloscope's instruction manual for operations of the oscilloscope.

## Operation

Control through the oscilloscope's interface can be found in the screen menu of the channel to which the amplifier is connected.

Touching the tab indicating the attached amplifier (in this case DA18000) will activate the amplifier menu screen. Figure 4-5.

The amplifier information frame shows the characteristics of the amplifier only.

In some applications it may be desirable to turn the amplifier's AutoColor ID OFF or ON with touching the Led On frame.

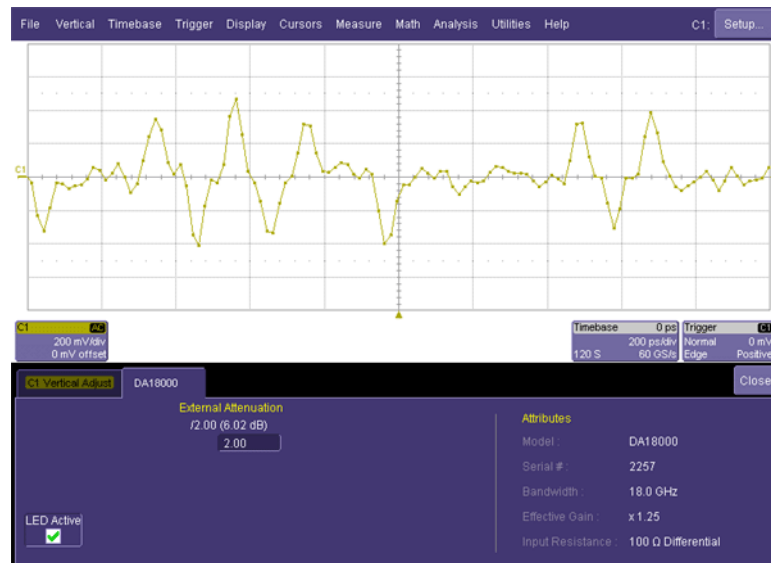


Figure 4-2. Probe menu

### CONNECTING THE AMPLIFIER TO THE TEST CIRCUIT

For all modules and interconnect leads, positive voltages applied to the + input relative to the – input will deflect the oscilloscope trace towards the top of the screen.

#### 2.92 mm Input Cables

The 2.92 mm Interconnect System has been designed to connect directly to female 2.92 mm connectors as well as to the higher performance 3.5 mm and 2.92 mm female connectors.

The Interconnect Cable connects to the amplifier and the matched pair of SMA Cable connect to the Interconnect Lead.

The connector should be tightened to a torque of 0.06 Nm (8 in.-oz.).

#### Note

*The 2.92 mm Input Cables are supplied as a matched pair. Individual cables should not be interchanged between amplifiers.*

## DA18000 Differential Amplifier

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### USE OF DC $\div 2$ ATTENUATOR

The  $\div 2$  attenuator should be used when the common mode or differential voltage of the circuit under test is unknown or exceeds the maximum voltage specified. (See section 9, Specifications). The use of the attenuator will also reduce the reflections, thus improving the VSWR.

The DA18000 amplifier has no method to detect the presence or absence of the attenuator. To maintain correct vertical scale factor and amplitude measurement results, you must inform the oscilloscope when the attenuator is being used. This is done in the **Vertical Adjust** → **DA18000** control dialog for the channel that the amplifier is connected to.

### DYNAMIC RANGE

The DA18000 amplifier has no gain or attenuation control. The system gain is fixed at x1.

Exceeding the common mode range may introduce distortion to the output signal. Use of the  $\div 2$  attenuators will increase the differential mode range; however, due to power limitations, they will not increase the common mode range.

There are two common mode voltages:

- $\pm 10$  V without a  $\div 2$  attenuator
- 7 V<sub>rms</sub> with a  $\div 2$  attenuator

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### Care and Maintenance

#### CLEANING

The exterior of the amplifier and cable should be cleaned using a soft cloth only moistened with water or isopropyl alcohol. The use of abrasive agents, strong detergents or other solvents may damage the exterior of the amplifier.



#### CAUTION

The amplifier case is not sealed and should never be immersed in any fluid.

#### SERVICE STRATEGY

Defective amplifiers must be returned to a LeCroy service facility for diagnosis and repair or replacement. A defective product under warranty will be repaired or replaced.

#### RETURNING AN AMPLIFIER FOR CALIBRATION OR SERVICE

Procedure for returning a product for calibration or service:

Contact your local LeCroy sales representative to find out where to return the product. All returned products should be identified by model number and serial number. Provide your name and contact number and if possible describe the defect or failure. In case of products returned to the factory, a Return Authorization Number (RAN) should be used. The RAN can be established by contacting your nearest LeCroy sales office, representative, or the North America Customer Care Center.

Return shipment should be prepaid. LeCroy cannot accept COD or Collect Return shipments. We recommend air-freighting.

#### Note

*It is important that the RAN be clearly shown on the outside of the shipping package for prompt redirection to the appropriate department.*

1. Contact your local LeCroy sales or service representative to obtain a Return Authorization Number.
2. Remove all accessories from the amplifier. Do not include the manual. If you need to return a DA18000 system, do include all Interconnect Leads.
3. Pack the probe in its case, surrounded by the original packing material (or equivalent) and box.
4. Label the case with a tag containing:
  - RAN
  - Name and address of the owner
  - Product model and serial number
  - Description of failure
5. Package the probe case in a cardboard shipping box with adequate padding to avoid damage in transit.

## DA18000 Differential Amplifier

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6. Mark the outside of the box with the shipping address given to you by the LeCroy representative; be sure to add the following:
  - ATTN: <RAN assigned by the LeCroy representative>
  - FRAGILE
7. Insure the item for the replacement cost of the product.
8. Ship the package to the appropriate address.

### RETURNING AN AMPLIFIER TO A DIFFERENT COUNTRY

In order to avoid customs duty for purchase price of a new amplifier or accessory, when your probe is returned for service, please use the following procedure.

In addition to the items mentioned above in 'Returning a probe for calibration or service', you'll need to mark shipments returned for service as a 'Return of US manufactured goods for warranty repair/recalibration'. If there is a cost involved in the service, put the cost of the service in the value column and the original value of the product at time of purchase in the body of the invoice marked 'For insurance purposes only'. Be very specific as to the reason for shipment. Duties may have to be paid on the value of the service.

### REPLACEMENT PARTS

The amplifier accessories and other common parts can be ordered through the regional customer care centers. Refer to table 5-1 for LeCroy part numbers.

**Table 5-1. Replaceable Parts List**

Item	LeCroy P/N	Replacement Quantity
Type 'K' Lead	PK18000-1	1
÷2 Attenuator		1
DA18000 Instruction Manual	DA18000-OM-E	1

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### Reference Information

#### DIFFERENTIAL MODE AND COMMON MODE

Differential amplifiers sense the voltage difference which appears between the + input and – input. This voltage is referred to as the Differential Mode or Normal Mode voltage. The voltage component which is referenced to earth and is identical on both inputs is rejected by the amplifier. This voltage is referred to as the Common Mode voltage and can be expressed as:

$$V_{CM} = \frac{V_{+input} + V_{-input}}{2}$$

#### DIFFERENTIAL MODE RANGE AND COMMON MODE RANGE

Differential Mode range is the maximum signal which can be applied between the + and - inputs without overloading the amplifier/amplifier, which otherwise would result in clipping or distorting of the waveform measured by the oscilloscope.

The Common Mode Range is the maximum voltage with respect to earth ground which can be applied to either input. Exceeding the common mode range can result in unpredictable measurements. Because the Common Mode signal is normally rejected and not displayed on the oscilloscope, the user needs to be careful to avoid accidentally exceeding the common mode range.

Because the input signal of a differential amplifier is not referenced to ground, the concept of "V<sub>peak</sub>" versus "V<sub>peak-peak</sub>" may be confusing.

With a ground referenced signal, V<sub>peak</sub> is the maximum instantaneous voltage amplitude the signal will have with respect to ground. In a differential system, there is no ground reference. Therefore the Differential Mode Range refers to the maximum instantaneous amplitude of the signal difference between the positive input and the negative input. Since most amplifiers have symmetrical bipolar inputs, the value is generally expressed as an absolute value, and can have either polarity.

For example, an amplifier with a differential mode rating of ±1 V can have a maximum voltage difference appearing at any instant in time of 1 V between the inputs. The polarity could be either positive or negative. This does not imply that the number can be doubled to 2 volts, however. For clarity, consider the following table of absolute voltages applied to the inputs of a differential amplifier that has a differential mode range of ±1 V and a common mode range of ±5 V:

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Voltage on + input to ground	Voltage on - input to ground	Difference	Comment
+1.5 V	+0.8 V	+0.7 V	OK: within $\pm 1$ V range
-1.5 V	-0.8 V	-0.7 V	OK: within $\pm 1$ V range
+0.8 V	-0.1 V	+0.9 V	OK: within $\pm 1$ V range
+1.0 V	-1.0 V	+2.0 V	Out of range: exceeds $\pm 1$ V
+6.5 V	+6.0 V	0.5 V	Exceeds $\pm 5$ V common mode range
1.5 V <sub>pk-pk</sub> sine	Ground	0.75 V <sub>peak</sub>	OK: within $\pm 1$ V range

Some amplitudes are specified as "peak to peak." The differential amplifier peak-to-peak range will be twice the peak differential mode range specification as, at any instant in time, the maximum voltage amplitude signal would be one-half of the peak-to-peak value.

In a balanced differential system, the signal on each output will be an inverted copy of the other input. For example, an LVDS system may have a pair of outputs, each of which has a voltage swing of 0 to +370 mV. A logic 1 would be represented when the + output is at +370 mV, while the - output is at 0 V. A logic zero would be the opposite polarity: the + output at 0 V and the - output at +370 mV. Note that even though both outputs swing 370 mV, the maximum difference voltage between them at any instant is still within  $\pm 370$  mV. So this signal could be measured with a differential amplifier that has a differential mode range of  $\pm 400$  mV.

### COMMON MODE REJECTION RATIO

The ideal differential amplifier/amplifier would sense and amplify only the differential mode voltage component and reject all of the common mode voltage component. Real differential amplifiers are not perfect and a small portion of the common mode voltage component appears at the output. Common Mode Rejection Ratio (CMRR) is the measure of how much the amplifier rejects the common mode voltage component. CMRR is equal to the differential mode gain (or normal gain) divided by the common mode gain. Common mode gain is equal to the output voltage divided by the input voltage when both inputs are driven by only the common mode signal. CMRR can be expressed as a ratio (e.g. 10,000:1) or implicitly in dB (e.g. 80 dB). Higher numbers indicate greater rejection (better performance).

The first order term which determines the CMRR is the relative gain matching between the + and - input paths. To obtain high CMRR values, the input attenuators in a differential amplifier are precisely matched to each other. The matching includes the DC attenuation as well as the capacitance which determines the AC attenuation. As the frequency of the common

## Reference Information

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mode component increases, the effects of stray parasitic capacitance and inductance in determining the AC component becomes more pronounced. The CMRR becomes smaller as the frequency increases. Hence the CMRR is usually specified in a graph of CMRR versus common mode frequency.

The common mode frequency in these graphs is assumed to be sinusoidal. In real life applications, the common mode signal is seldom a pure sine wave. Signals with pulse wave shapes contain frequency components much higher than the repetition rate may suggests. As such, it is very difficult to predict actual performance in the application for CMRR versus frequency graphs. The practical application of these graphs is to compare the relative common mode rejection performance between different probes and amplifiers.

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## DA18000 Differential Amplifier

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## Performance Verification

### Performance Verification

#### INTRODUCTION

This procedure can be used to verify the warranted characteristics of the DA18000 Differential Amplifier.

The recommended calibration interval for this amplifier is one year. Test results can be recorded on a photocopy of the Test Record provided in Appendix A.

Performance Verification can be completed without removing any covers or exposing the user to hazardous voltages. No adjustments are provided.

In the unlikely event that the amplifier should fail the performance verification, it can be sent back to the local service center or the factory. For information on returning the amplifier refer to Section 5, Care and Maintenance.

This procedure tests the DA18000 for the following warranted specification:

- Rise time
- Voltage Gain Accuracy

#### TEST EQUIPMENT REQUIRED

Table 7-1 lists the test equipment and accessories, or their equivalents, that are required for performance verification of the DA18000 Differential Amplifier.

This procedure has been developed to minimize the number of parameters required to be calibrated in the test instrumentation.

Only the parameters listed in **boldface** in the "Minimum Requirements" column must be calibrated to the accuracy indicated.

Because the input and output connector types may vary on different brands and models of test instruments, additional adapters or cables may be required.

**Table 7-1. List of Required Equipment**

Description	Minimum Requirements	Test Equipment Examples
Oscilloscope, High BW	<b>SDA 18000</b>	LeCroy: SDA 18000
Step Generator, Differential	Differential output with deskew capability $T_r \leq 20$ ps $V_{out} \approx 200$ mV	LeCroy WaveExpert oscilloscope with two ST-20 TDR sampling modules
Attenuator, 2 ea.	6 dB, female-female, 2.92 mm	Supplied with DA18000
2.92 mm coaxial cable, 2 ea.	male-male, 2.92 mm, 50 $\Omega$	Supplied with DA18000
Connector Saver	female-female, 2.92 mm	Supplied with ST-20

## DA18000 Differential Amplifier

Table 7-1. List of Required Equipment (Continued)

Description	Minimum Requirements	Test Equipment Examples
Torque Wrench	8 in.-lbs.	LeCroy: TW-8

### PRELIMINARY PROCEDURE

1. Allow at least 20 minutes warm-up time for the DA18000 Differential Amplifier and test equipment before performing the Verification Procedure.
2. Turn on the other test equipment and allow these to warm up for the time recommended by the manufacturer.
3. While the instruments are reaching operating temperature, make a photocopy of the Performance Verification Test Record (located in Appendix A), and fill in the necessary data.

The warranted characteristics of the DA18000 Differential Amplifier are valid at any temperature within the Environmental Characteristics listed in "Specifications." However, some of the other test equipment used to verify the performance may have environmental limitations required to meet the accuracy requirements needed for the procedure. Be sure that the ambient conditions meet the requirements of all the test instruments used in the procedure.

### VERIFICATION PROCEDURE

#### 1. Rise Time (20-80%)

Measuring the amplifier's rise time cannot be done directly; it has to be performed in an indirect way. First you have to measure the rise time of the source, i.e., the rise time of the pulse generator (TDRs) and the oscilloscope. Second, measure the rise time of the system: pulse generator, amplifier, and oscilloscope. The rise time of the amplifier alone can then be determined from these two measurements.



**ESD Sensitive:** The inputs of the DA18000 amplifier as well as those of the oscilloscopes are sensitive to Electrostatic Discharge (ESD). To avoid causing damage to the equipment, always follow anti-static procedures (wear wrist strap, etc.) when working with these instruments.

- a. Install the two ST-20 TDRs in Ch 1 and Ch 2 of the WE 9000 oscilloscope.
- b. To prevent accidental discharge of any accumulated charge in the coaxial cables, attach a  $\div 2$  attenuator to one end of each of the two 2.92 mm coaxial cables before connecting the cables to the oscilloscope. This will provide a discharge path.
- c. Then connect the other end of each cable to the connector saver at the outputs of the ST-20 TDRs.



When fastening an SMA or 2.92 mm connector, always use the torque wrench to tighten the connector.



## Performance Verification

- d. Remove the  $\div 2$  attenuator from the coaxial cables.
- e. From the menu bar, select **Timebase** (Figure 7-1).
- f. Set the WE 9000 to output a differential step. This sampling oscilloscope is only used to provide power to the ST-20 TDR pulse generators
- g. Initialize the TDR by touching the **TDR Main** tab.



Figure 7-1. Timebase Menu

- h. Connect the ST-20 TDR coaxial cable from Channel 1 of the WE 9000 via the LPA-K adapter to Channel 1 of the SDA 18000. Be sure to properly torque all connectors (8 in.-lbs.).
- i. Set the SDA 18000 to Channel 1 and the timebase to 500 ps/div and 60 GS/s. Set the scope to trigger on Channel 1, and edge triggering to positive slope.
- j. Set math trace F1 to the **Ptrace mean** of Channel 1 (Figure 7-2).

## DA18000 Differential Amplifier

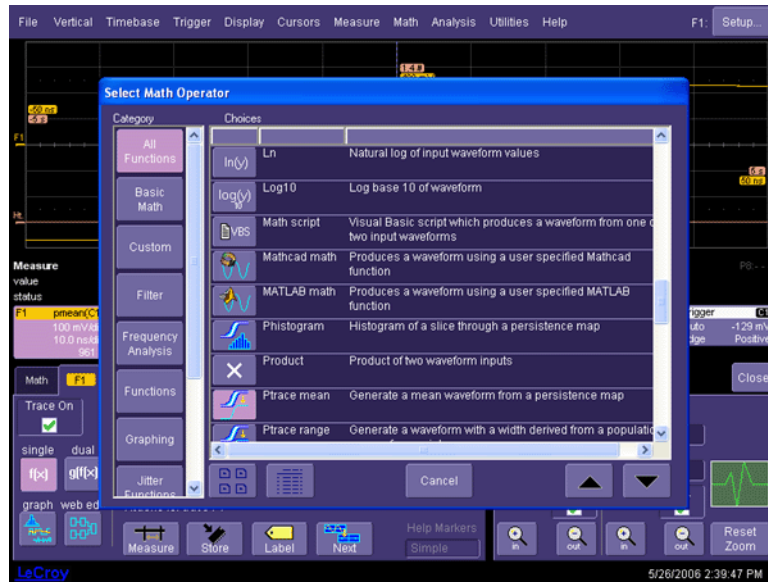


Figure 7-2. Math Menu Setup

- k. Set a measurement function to measure **Rise 20-80%** (Figure 7-3).

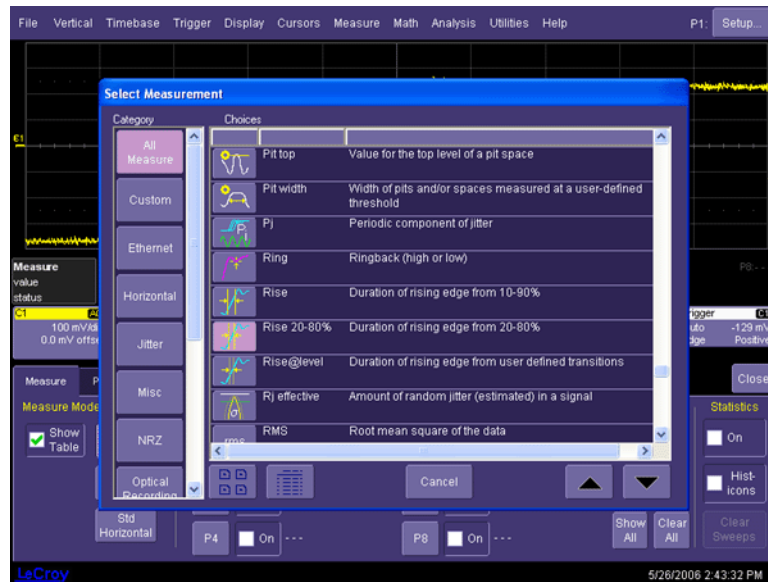


Figure 7-3. Measure Menu Setup

## Performance Verification

- I. Record the measured 20-80% rise time as “Source rise time” ( $t_{source}$ ) in the Test Record (Figure 7-4).

Only the positive edge is measured. The difference in rise time between the positive edge and the negative edge of the STD-20 TDR is less than 1 ps.

- m. To measure the amplifier’s rise time, disconnect the coaxial cable and PLPA-K adapter from Channel 1 of the SDA 18000 and connect the cable only to the + input of the DA18000 amplifier. Connect the cable from Channel 2 TDR to the – input of the amplifier.
- n. Measure the 20-80% rise time and record the measurement as “System rise time” ( $t_{system}$ ) in the Test Record.
- o. Calculate the amplifier’s rise time:

$$\text{Amplifier Rise Time, } t_r = \sqrt{(t_{system})^2 - (t_{source})^2}$$

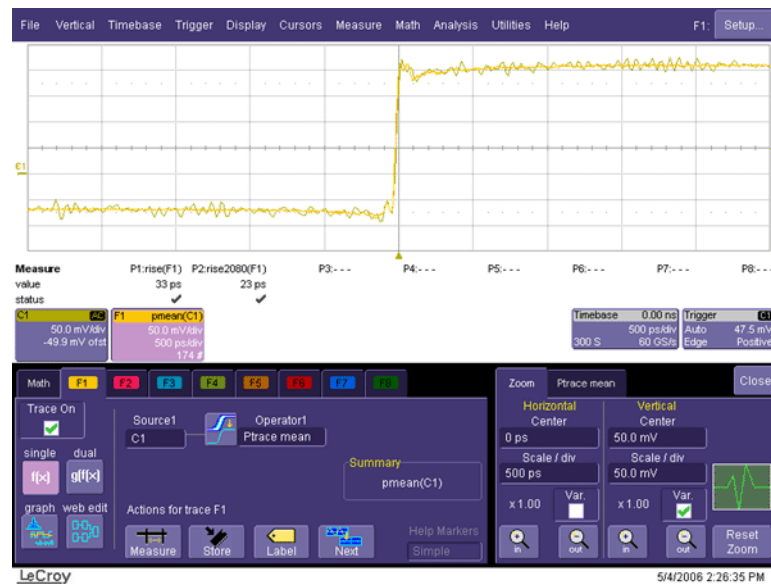


Figure 7-4. Rise Time Measurement

- p. Record the calculated rise time as “Amplifier Rise Time” in the Test Record.
- q. Verify that the calculated rise time for the DA18000 is less than 19 ps.

This concludes the Performance Verification Procedure.

## 2. Voltage Gain Accuracy

- a. Set the scope Aux output equal to a 50 Hz, 250 mV.
- b. Connect the Aux output to a scope channel through an adapter that allows the voltage to be simultaneously measured with a DMM.

## DA18000 Differential Amplifier

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- c. Measure the rms voltage with the scope (using SDEV function), as well as the AC rms voltage at the scope input using the DMM. Record these values.
- d. Calculate and record the scope accuracy:  $(V_{\text{scope}} - V_{\text{DMM}}) / V_{\text{DMM}}$  expressed in percent.
- e. Measure the channel input resistance of the scope using the DMM. Record the resistance accuracy (should be 50 ohms) in percent.
- f. Connect the DA18000 to the channel previously measured.
- g. Connect the Aux output to the positive input of the DA18000 using the same DMM adapter. Connect a short to the negative input of the DA18000.
- h. Measure the rms voltage with the scope, as well as the rms voltage at the probe positive input. Record these values.
- i. Calculate and record the system accuracy:  $(V_{\text{scope}} - V_{\text{DMM}}) / V_{\text{DMM}}$ , expressed in percent.
- j. Calculate the probe accuracy:

$(\text{system accuracy}) - (\text{scope accuracy}) - (\text{resistance accuracy} / 2)$ .

Ensure that this value is less than 2%.

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### Specifications


The specifications are valid for probes when the following conditions have been met:

- The probe has been operating for at least 30 minutes in an environment, which is within the operating environmental specifications.
- The probe has been calibrated within the last 12 months. Calibration was performed in a controlled environment of 25 °C  $\pm$ 5 °C.

### NOMINAL CHARACTERISTICS

Nominal characteristics describe parameters and attributes that are guaranteed by design, but do not have associated tolerances.

#### General

Input Configuration	True differential, + and – Inputs
Input Connectors	2.92 mm
	The 2.92 mm input leads will connect directly to female 2.92 mm connectors on the system under test.
Maximum Non-Destruct Input Voltage, continuous	10 V <sub>peak</sub>
Amplifier Gain	~ 1.2
 Oscilloscope display factor is calibrated to actual amplifier gain	
Input Impedance	100 $\Omega$ , true differential
Max Input: Differential Mode	
Without $\div$ 2 attenuators	$\pm$ 400 mV, 800 mV <sub>p-p</sub>
With $\div$ 2 attenuators	$\pm$ 800 mV, 1.6 V <sub>p-p</sub>
Max Input: Common Mode	
Without $\div$ 2 attenuators	10 mV <sub>p-p</sub>
With $\div$ 2 attenuators	7 V <sub>rms</sub>

### WARRANTED CHARACTERISTICS

Warranted characteristics describe parameters that have guaranteed performance. Unless otherwise noted, tests are provided in Section 8, Performance Verification, for all warranted specifications.

Rise Time (Amplifier only) <sup>1</sup> (20-80%)	19 ps
Voltage Gain Accuracy	> 2%

1. Measured with an SDA 18000 oscilloscope. Rise time of oscilloscope and source subtracted (rms).

## DA18000 Differential Amplifier

### TYPICAL CHARACTERISTICS

Typical characteristics are parameters with no guaranteed performance. Tests for typical characteristics are not provided in the Performance Verification Procedure.

Bandwidth (System) <sup>1</sup>	100 kHz to 18 GHz (with SDA 18000)
Rise Time (System) <sup>2</sup> (20-80%)	< 24 ps
Propagation Delay	7.3 ns
Gain Variation with Temperature	0.1% / °C
Noise, System <sup>3</sup>	1 mV <sub>rms</sub> (Referred to amplifier input)
Noise, Amplifier only	0.5 V <sub>rms</sub>
CMRR	
100 kHz to 18 GHz	> 16 dB (See Figure 8-1.)
Input Match Differential Mode	
Without ÷2 attenuators	–14 dB (VSWR 1.5:1)
With ÷2 attenuators	–19 dB (VSWR 1.25:1)
Input Match Common Mode	
Without ÷2 attenuators	–6 dB (VSWR 3:1)
With ÷2 attenuators	–12 dB (VSWR 1.7:1)
Total Harmonic Distortion (Amplifier only)	2.5% (at maximum input)

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1. Measured with an swept sine wave source or step with FFT. Frequency of oscilloscope channel subtracted from the measurement.
  2. Measured with an SDA 18000 oscilloscope. Step optimized for eye diagram.
  3. Measured with an SDA 18000 oscilloscope using SDEV function to remove offset.

## Specifications

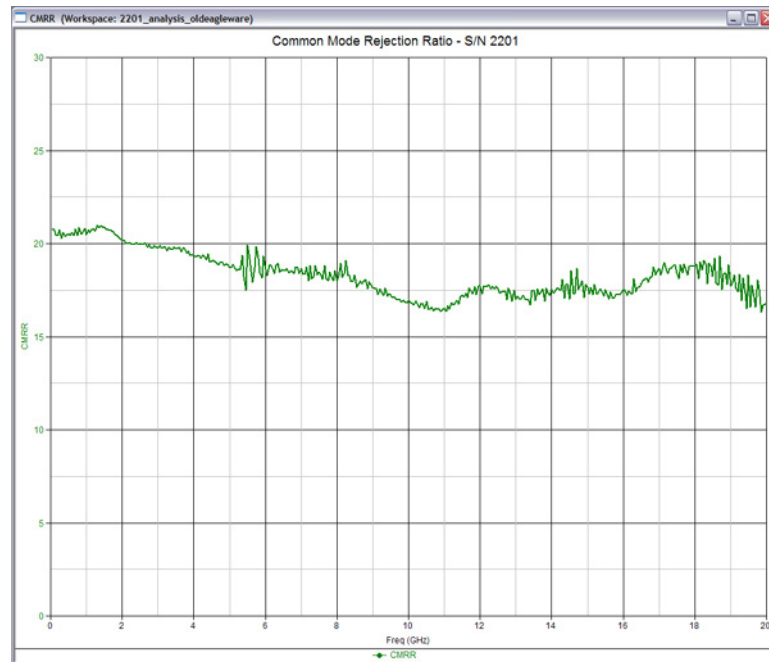


Figure 8-1. Typical DA18000 CMRR

### ENVIRONMENTAL CHARACTERISTICS

The Environmental Characteristics are tested to specification MIL-PRF-28800F Class 4

Temperature (Operating)	0 °C to 40 °C
Temperature (Non-operating)	-40 °C to 71 °C
Humidity (Operating)	5% to 80% RH (Non-condensing) 50% RH above 30 °C
Humidity (Non-operating)	5% to 95% RH (Non-condensing) 75% RH above 30 °C and 45% RH above 40 °C

### PHYSICAL CHARACTERISTICS

Cable Length	1.3 m (4 ft. 3 in.)
Weight:	400 g
Amplifier only	385 g (13.5 oz.)
Shipping	1.36 kg (3 lbs. 0 oz.)

## DA18000 Differential Amplifier

### COMPLIANCE AND CERTIFICATIONS



CE Compliant

#### EC Declaration of Conformity

The DA18000 meets the intent of the European Council Directive 73/23/EEC for Product Safety and 89/336/EEC for Electromagnetic Compatibility. This declaration is based upon compliance of the product to the following standards:

*Low Voltage Directive:*      *EN 61010-031:2002*  
*Safety requirements for electrical equipment for measurement, control and laboratory use.*  
*Part 031: Safety requirements for hand-held probe assemblies for electrical measurements and test.*

*EMC Directive:*              *EN 61326/A3:2003 EMC requirements for electrical equipment for measurement, control and laboratory use.*

EN 55011/A2:2001 Radiated Emissions (Class A)

EN 61000-4-2:1995+Amd2:2001<sup>1</sup> Electrostatic Discharge Immunity ( $\pm 4$  kV contact discharge,  $\pm 8$  kV air discharge)

EN 61000-4-3/A1:2003<sup>1</sup> RF Radiated Electromagnetic Field Immunity (3 V/m, 30 MHz to 1 GHz, 80% amplitude modulated with 1 kHz sine wave)



#### Caution

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.

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1. Meets Performance Criteria "B" limits – temporary, self-recoverable degradation or loss of performance is allowed, but no change of actual operating state or loss of stored data is allowed.



## Appendix A

### PERFORMANCE VERIFICATION TEST RECORD

This record can be used to record the results of measurements made during the performance verification of the DA18000 Differential Amplifier.

Photocopy this page and record the results on the copy. File the completed record as required by applicable internal quality procedures.

The section in the test record corresponds to the parameters tested in the performance verification procedure. The numbers preceding the individual data records correspond to the steps in the procedure that require the recording of data. Results to be recorded in the column labeled "Test Result" are the actual specification limit check. The test limits are included in all of these steps. Other measurements and the results of intermediate calculations that support the limit check are to be recorded in the column labeled "Intermediate Results".

Permission is granted to reproduce these pages for the purpose of recording test results.

### ITEMS TESTED

Item	Serial Number
DA18000	

### EQUIPMENT USED

	Model	Serial Number	Calibration Due Date
OSCILLOSCOPE			
OSCILLOSCOPE			
ST-20 TDR			
ST-20 TDR			

### TEST RECORD

Step	Description	Intermediate data	Test Result
<b>1. Rise Time</b>			
1-m	Source rise time, $t_{\text{source}}$	_____ ps	
1-o	System rise time, $t_{\text{system}}$	_____ ps	
1-q	<b>Probe Rise Time, <math>t_r</math> (&lt; 19 ps)</b>		_____ ps
<b>2. Voltage Gain Accuracy</b>			
2-d	Scope Accuracy	_____ V	
2-i	System Accuracy	_____ V	
2-j	<b>Probe Accuracy (&lt; 2%)</b>		_____ %
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## DA18000 Differential Amplifier

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