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Model DA-01

Differential Amplifier

Instruction Manual

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Introduction

The Model DA-01 Differential Amplifier is a two-stage differential amplifier with a gain of 10 followed by a differentiator (time derivative). The DA-01 is used to eliminate common-mode signals that arise due to differing ground potentials in a remote measurement system. In addition, the DA-01 provides a differentiated output that facilitates time-of-arrival measurements for such applications as jet engine blade vibration monitoring.

A typical measurement system is illustrated in Figure 1, in which a capacitive probe is mounted in a jet engine compressor in a test cell and is connected to a preamp. The output of the preamp is passed to a data acquisition system through a coaxial cable. Because of the nature of the capacitance probe, one lead is automatically tied to the engine, which is at ground potential. As a result, the shield of the coaxial cable is also tied to the same ground as the engine. Generally speaking, the data acquisition system may be some distance away from the test cell, so that data acquisition ground potential may be quite different from that of the test cell. Power line currents can easily generate tens to hundreds of millivolts in difference in ground potentials with most of the signals being at frequencies that are multiples of the line frequency. Large differences in ground potentials can occur even over short distances if high-power equipment is involved.

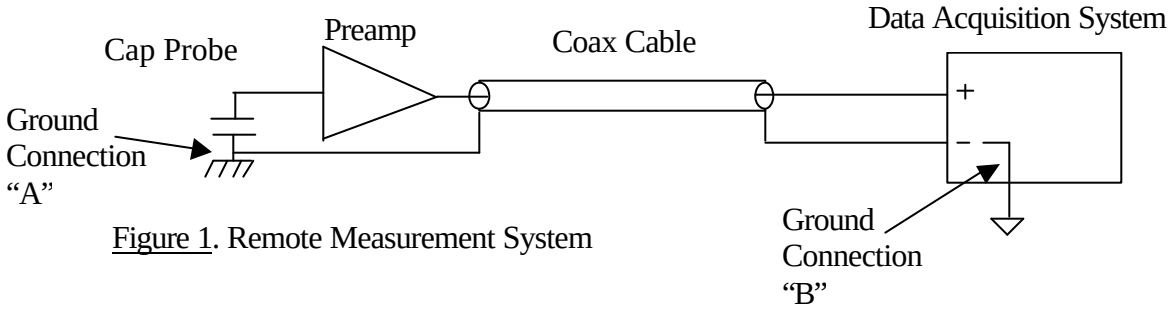

Figure 1. Remote Measurement System

If the data acquisition system input is fully differential – that is, the negative input is floating relative to the local ground -- then no problems will occur due to the differing ground potentials. However, as is often the case, the negative side of the data acquisition system may be internally connected to the local ground, shown as Ground Connection "B" in Figure 1. In this case, the voltage difference between the two grounds will appear as a signal on top of the regular preamp output. Thus the output signal of the preamp will be corrupted by the ground signals. In many cases, the desired signal may be considerably smaller than that of the ground signals.

In order to eliminate the effect of the differing ground potential, a differential amplifier, such as the DA-01, must be placed between the output of the coaxial cable and the input to the data acquisition system, as shown in Figure 2.

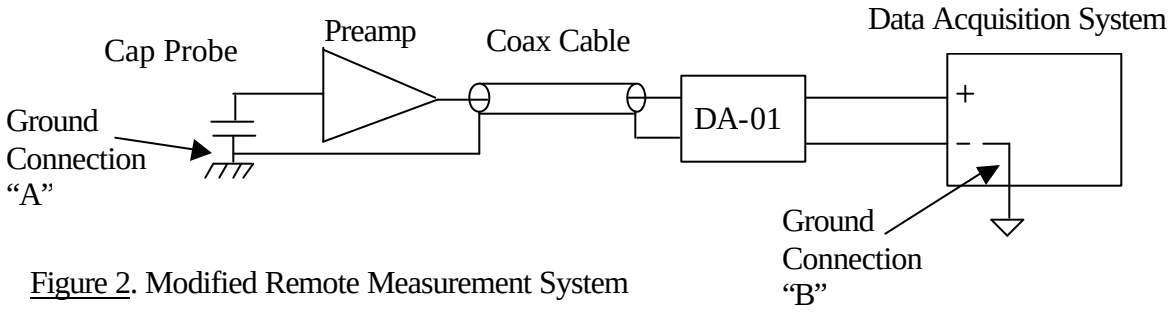

Figure 2. Modified Remote Measurement System

The DA-01 inserts a resistance of approximately 6.6 K ohms in series with the negative (shield) side of the coaxial cable, and only amplifies the signal on the coaxial cable. As a result, the signal presented to the data acquisition system is simply an amplified version (gain = 10) of the output of the preamp.

The DA-01 provides an additional output which is the time derivative of the amplified preamp signal. If a single-electrode capacitive sensor is used with a PW-03 HiBand Preamp to measure tip clearance of jet engine blades, then the preamp output signals would be individual pulses, as shown in Figure 3.

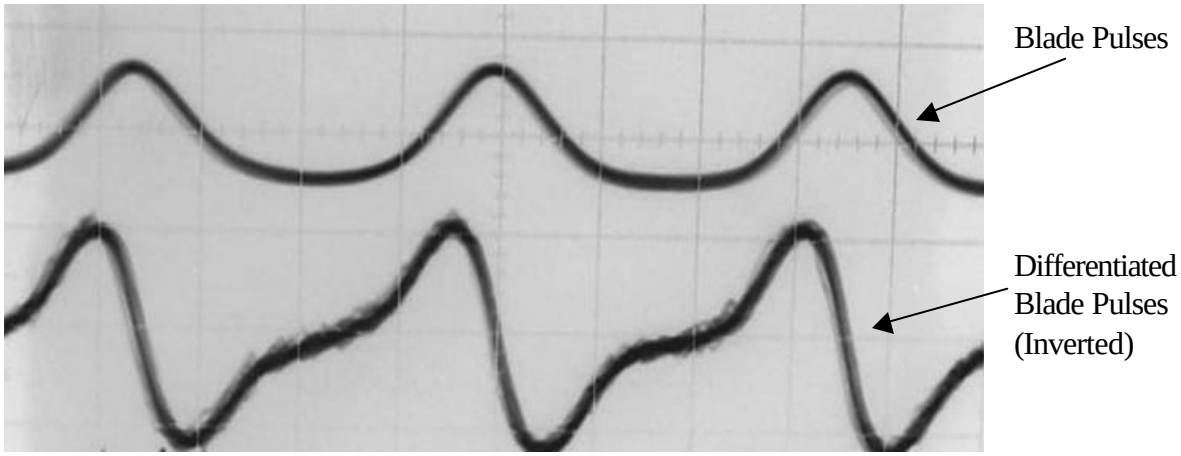

Figure 3. Amplifier and Differentiator Outputs of DA-01

The differentiator output from the DA-01, shown in Figure 3, allows accurate time-of-arrival measurements to be made for the blades by detecting the time at which the differentiated output crosses zero. The DA-01 uses a classic inverting differentiator circuit with an operational amplifier, an input capacitor (150 pF) and a feedback resistor (4.99K). An additional capacitor (33 pF) is in parallel with the feedback resistor and a resistor (1K) is in series with the input capacitor to provide two poles at approximately 1 MHz to reduce the effects of high frequency noise.

Figure 4 shows the input and output connections for the DA-01.

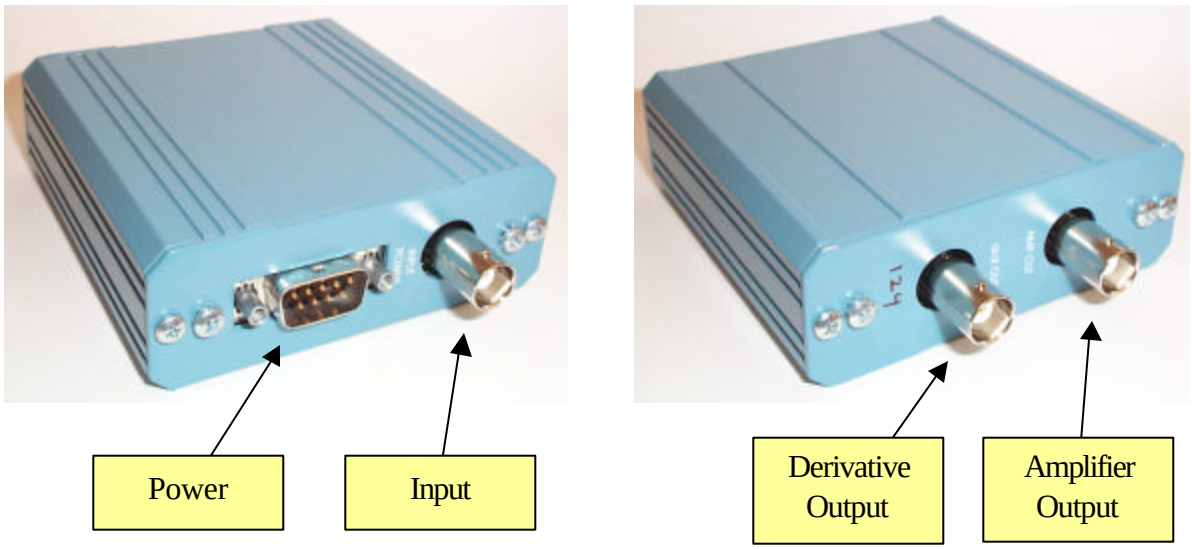

Figure 4. Input/Output Connections for the DA-01

The power connections for the 9-pin D connector are:

Pin Number	Voltage
1	No Connection
2	No Connection
3	-12 volts to –15 volts
4	Analog Ground
5	+12 volts to +15 volts
6	Chassis Ground (tied to the box)
7	-12 volts to –15 volts
8	Analog Ground
9	+12 volts to +15 volts

Pins 3 and 7 are connected internally, pins 4 and 8 are connected internally, and pins 5 and 9 are connected internally.

An optional internal connection between Analog Ground (pins 4 and 8) and the Chassis Ground (tied to the box and to pin 6) is shown in Figure 5. This connection is normally factory installed, but is available should the user want to keep the two ground connections separated.

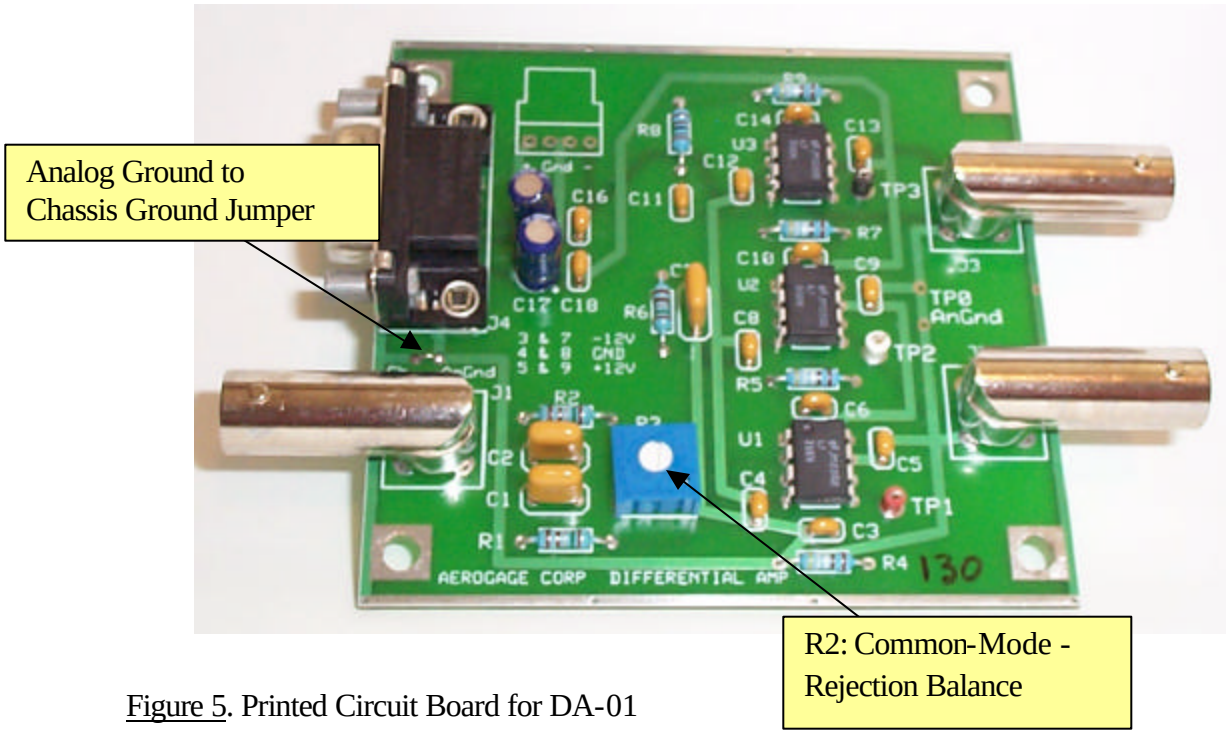

Figure 5. Printed Circuit Board for DA-01

Adjustments and Calibration

Only one adjustment is available to the user. Resistor R2 is a 100 ohm, single-turn pot that allows the common-mode rejection of the DA-01 to be optimized. The pot compensates for the output impedance of the preamp. For the case of a PW-03 HiBand preamp, as illustrated in Figures 1 and 2, the output impedance is 50 ohms, so resistor R2 would be set to the half-way point (50 ohms). If the preamp impedance were zero ohms, then R2 should be set to zero ohms (full counter-clockwise).