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RESCUE MICROVOLTS FROM VOLTS OF NOISE

Is your data acquisition system being confused by high-frequency common-mode noise? After hooking up your system do you find excessive noise and dc drift on the output? You improve shielding and eliminate ground loops but the noise is still too high. You then carefully look at the input signal and discover that there is a high-frequency common-mode* component.

What to do? The Ectron Model 778 may well be the answer.

This unique bridge conditioning amplifier has high-frequency common-mode rejection (CMR) as well as a wide frequency response and fast rise time.

Obviously applications that need a dc to over 200 kHz response are candidates for using the Model 778. However, many other uses for this amplifier involve reducing the high-frequency common-mode noise,* and frequently this noise is well over the 60 Hz CMR specification of the typical conditioner amplifier. Sources of high-frequency noise include fluorescent lights (the new RF excited types including most compact fluorescent lights are the worst), nearby radio stations, switching power supplies, motor noise, etc.

The original circuit design was developed for use in underground nuclear testing (the Ectron Model 776).

* Common-mode signals are those common to both input leads of an amplifier as opposed to differential (normal mode) signals that are the desired signal. Picture a thermocouple welded to the heating coil of an electric heater. The differential signal is the output of the thermocouple and the common-mode signal is the power line. Common-mode rejection is the ability of the amplifier to reject the power line signal and amplify only the thermocouple signal. A typical high-performance amplifier specification is that common-mode rejection is 120 dB from dc to 60 Hz. 120 dB equates to 1,000,000 to one so if the power line signal is 50 V then the amplifier will see a 50 µV signal equivalent at its input. The Model 778 raises the bar so that CM signals up to 100 kHz are attenuated by 120 dB and signals of 1 MHz are attenuated by 100 dB or 100,000 to one.

The Model 778 includes some of this earlier product's design features along with an extended bandwidth. The result is an amplifier and bridge conditioner that has a frequency response from dc to 3 MHz with a rise time of 150 ns as well as a unique wide band CMR specification.

For very good high-frequency common-mode rejection the amplifier's input, including excitation supply and completion circuitry, must be totally isolated from case or output grounds. Whereas the usual high-performance amplifier specification is 120 dB at 60 Hz, the specification for the Model 778 is >120 dB for frequencies from dc to 100 kHz and 100 dB to 1 MHz.

What this means is that when SCR or fluorescent light noise is picked up as common-mode signals by the input signal leads of the instrumentation amplifier much of this noise will be rejected before it is mixed with the desired signal.

What applications need the 778?

1. Hopkinson bar testing that involves high strain rates. Reflections in the bars are measured to determine the magnitude of the impact. Many times the environment includes high-frequency noise.

2. Gun barrel tests involving high-frequency materials analysis. Strain gages are used to determine stresses in the barrel of the gun. Again, the environment usually includes many sources of high-frequency noise.
3. Rail Gun testing. Huge current pulses are used to energize the rail gun. Similar to applications involving underground nuclear tests, these pulses generate high-frequency CM voltages. As in nuclear test applications, the desired signals frequently require measurements immediately following the impulse.
4. Amplifiers operating near AM band radio stations or high-frequency generators, such as SCR power supplies, RF fluorescent lights including CFL types, computer equipment, etc.
5. Current pulse measurements involving high-frequency memory chips.
6. New EMALS aircraft carrier launch systems. Using a linear motor design the Electromagnetic Aircraft Launch System is under development by the U. S. Navy for use on the latest carriers. Again, high-power currents are involved thus high-voltage common-mode signals as well as high-frequency signals are usually involved. The 778 is a natural answer for instrumentation for these launch systems.

To take advantage of the Model 778's CMR requires good shielding of the input signal so that conversion from CM to NM (normal-mode signals) in the cabling is minimized.

For example, what if the CM signal is just 1 V at 1 MHz, from a nearby SCR power supply? The typical amplifier in a data system will have a rejection of perhaps 10 dB at this frequency so the 1 V "noise" is reduced to 0.3 V; thus the output will include 0.3 V times gain. If the desired signal level requires a gain of ×100 this amount of "noise" will completely mask the desired signal. The average amplifier will also convert some amount of this CM signal to dc causing an offset in addition to the added noise at the output. A pre-filter causes problems of added input impedance, distortion of the desired signal, etc. The Model 778 is the answer, providing over 100 dB attenuation of the CM signal at 1 MHz thus reducing a 1 V interference signal to 10 µV or 0.0001 V.

When looking at the input of the Model 778 its input isolation specification has a resistive component of >10 GΩ (10×10^9 Ω). The capacitive component of input isolation must also be extremely small. The specification here is <10 fF (10×10^{-15} F). This isolation demands the use of total internal shielding which in effect serves as a Faraday shield separating the input, excitation supply, and completion components from case, power, or output grounds. Even the power transformer must have "box shielded windings" that involve totally shielded sections.

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