BENCHMARK MEDIA SYSTEMS, INC.

CMF-1, Common-Mode Filter Instructions

Introduction

The common-mode filter is a very helpful but little known audio device used to reduce, or even eliminate, RFI (radio frequency interference). The filter consists of a common-mode choke, having two highly symmetrical windings on a single toroid core, two 1000 pF capacitors, and two termination resistors, chosen so that the total termination impedance is 10 kΩ. The filter has a differential bandwidth of greater than 200 kHz when driven from a low impedance source (200 Ω or less), but a common-mode bandwidth of only 26 kHz. The filter is designed to be used at the input of an amplifier or processing package, and can be used with both microphone and line level signals.

How It Works

The differential bandwidth is primarily a function of the common-mode choke. When the choke sees a differential signal (equal amplitude and opposite polarity), the magnetic fields created in the core cancel and the inductor effectively disappears from the circuit. However, when a signal is of equal amplitude and of the same polarity, as is the case with interference we wish to remove, both lines see an L-C low pass filter. As a two pole device with a cutoff rate of 12 dB per octave, the filter is down 60 dB at 1 MHz and thus prevents most RF from reaching the active electronics. (See CMF-1 schematic.)

Proper Termination

For the filter to have its desired (common-mode) Butterworth response, it must be terminated in 10 kΩ per leg. As shipped, the CMF-1 has 10.0 kΩ termination resistors installed. However, we do not know the input impedance of the device in which it will be installed. You must determine the input impedance of the device into which you are planning to install the CMF-1 and change the termination resistors, if necessary, to the appropriate value to bring the total impedance down to 10 kΩ. This is easily calculated using Ohm's law. For instance, if the input impedance (each leg to ground) of the amplifier or console is 50 kΩ (100 kΩ balanced input), then the required value of the termination resistors, in parallel with the input resistance, is:

$$R_p = \frac{1}{\frac{1}{10\ k\Omega} - \frac{1}{R_{in}}} \qquad [1.0]$$

$$R_p = 12.5\ k\Omega \qquad [1.1]$$

We suggest that for equipment input impedances of 100 kΩ or above, the response degradation is insignificant and that no resistor change is necessary.

Installation and Use - Input Connections

The CMF-1 is available with or without a universal XLR type (D3F style) Neutrik connector; therefore the input to the unit is made either through the input connector or by way of the solder pads.

!!! Warning!!!

Do not attempt to pass microphone phantom power through the CMF-1.

The CMF-1 was not designed to pass a steady state common-mode DC current, such as 48 volt phantom power for microphone circuits. Passing 10 mA will reduce the designed 38 mH inductance to less than 4 mH and negate the effect of the inductor.

!!! Warning!!!

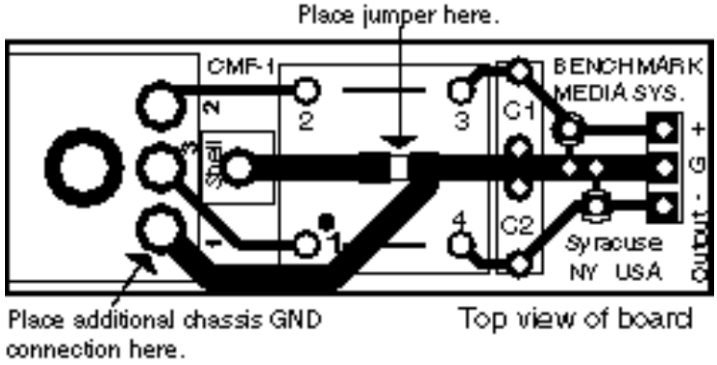
To be effective the CMF-1 must be mounted at, or extremely close to, the input connector and have the input cable's Pin 1 (shield) and the ground of the CMF-1 tied to the chassis *at the point of entry!*

!!! Warning!!!

To be effective, the CMF-1 must be driven from a *balanced* (or differential) output, since this is the only way to ensure that the audio signal currents flowing in the inductor will be equal and of opposite polarity. Attempting to use the CMF-1 when feeding from an unbalanced output will result in significant audio distortion from the inductor.

Every piece of professional audio equipment should have two "ground" circuits designed into the equipment. The first ground is the chassis. This assumes that your equipment has a metallic chassis or that it has a deposited metallic coating on the inside of a plastic chassis. The second "ground" is the internal analog signal reference (the common of the bipolar power supply).

Tying pin 1 and the "ground" line of the PCB to the *chassis* is very important for the proper performance of the filter. This is because the shield of an audio pair is an extension of the shielding capability of the chassis, and therefore it *must* be tied to the chassis *at* the connector. This chassis grounding is important to prevent currents, that are being directly induced into the shield magnetically, or by way of two or more chassis being at differing potentials, from being sent through the internal analog signal reference and adding hum, RF, and noise to it.



Additional Jumpers Locations

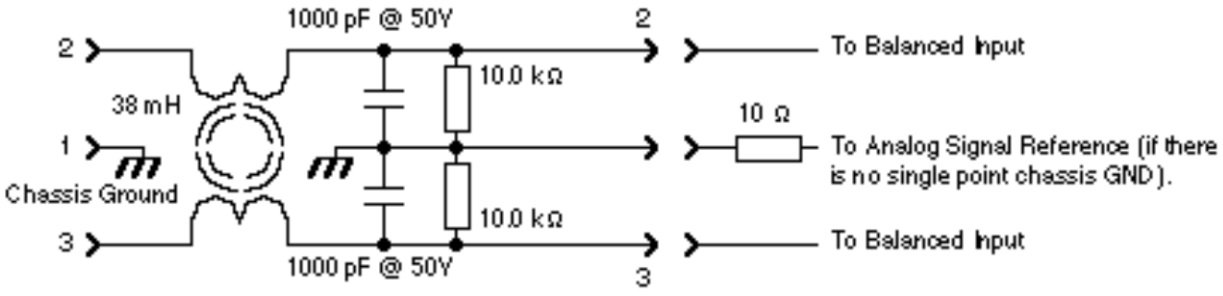
If you purchased the CMF-1 with the XLR type connector, Pin 1 needs to be directly connected to the shell of the connector and to the chassis of the equipment. With the current style of printed circuit boards, a jumper must be added across the surface mount pads underneath the PCB, if there isn't one already there. It is very advisable to add a ground lug to the mounting hole of the bottom XLR screw mount, and run a short piece of #12 or #14 bus wire to the Pin 1 pad of the circuit board to provide a better connection to the chassis than by that of the connector shell wire. This is desirable because the connector shell isn't a reliable chassis connection, depending as it does upon the internal locking mechanism of the connector to make its electrical connection. One consultant has, in fact, reported that the small wire tying the connector shell to the PCB plane is resonant at cell telephone frequencies.

In all equipment, tying the internal analog signal reference to the chassis should be done at *only one point* to prevent an internal ground loop. This may be done at the place where the third wire power ground is connected to the chassis. A small resistor may be used, such as a 10 Ω 1/4 watt type, instead of a direct short, to tie the two ground systems together, providing further isolation of the two "grounds".

If you are not using the CMF-1 mounted to an XLR type connector, place the device directly at the input connector inside the chassis. Be sure to wire the equivalent of Pin 1 (shield) to the chassis for both the incoming audio pair at the connector, and the Pin 1 position of the filter, as noted above. Remember, the filter depends upon this connection for proper operation. Make sure that the printed circuit board is as close as is physically possible to the input connector and that the wire leads are as short as possible.

Installation and Use - Output Connections

The output of the device is taken from the three pin connector at the rear of the PC board. Remember that the center of the three pins is *Chassis Ground*, and tying it to the internal analog signal reference is not advisable, since the piece of equipment probably already has a single tie of the analog signal reference to the chassis. Therefore, the center pin of the three will usually be left without a connection.



Possible Output Connection Installation

A mating solder tab female header is provided to make the output connection. Additionally, a 10' pigtail, the PL-10 (available from Benchmark), will plug directly to the three pins and eliminate soldering at one end; however, when using the PL-10 the center connector position should be cut to prevent inadvertently tying the two ground systems together.

This completes the CMF-1 instructions. 110194

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