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Replacing Shielded Wires with EMI Output Filters on VSD

Proper shielding of output wires on Variable Speed Drives will prevent radiation emitted by these wires from bypassing the powerline filter, resulting in pick-up by the input wires. The output wires can be fully shielded using a cable with a braided or foil shield. They can also be properly shielded by running them through solid metal conduit, which turns out to be the least expensive approach.

However, there are applications where shielding these wires is impractical, such as for an overhead crane. Using a different approach, the high frequency content in the output waveform can be minimized with an output EMI filter. We have provided motor drive output EMI filters for many years, but only for OEM applications. The reason is that the output filter must be positioned, grounded, and wired in a specific way. Done incorrectly, the output filter can cause more conducted EMI on the powerline than originally present.

The data below was taken using a 250 VAC, 3 phase 10 HP drive. The output was a 7.5 HP motor loaded to 20 Amps. A Hoffman type enclosure was mounted directly beneath the motor drive and two short conduit stubs were used to connect the enclosure to the drive housing. The input filter and the output filter were both mounted to the sub-chassis along with a vertical metal plate that ran the length of the sub-chassis. This plate divided the enclosure into two sections, isolating both filters and their associated wiring, from each other. Power from the AC mains entered through conduit at the bottom left side, connected to the input filter's line terminals, ran from the filter's load terminals output through one conduit stub, and ended at the drive's input terminals. Output wires from the drive ran through the other conduit stub, connected to the output filter's drive terminals, ran from the filter's motor terminals, and exited the lower right side of the enclosure.

The well shielded input wiring prevented a large amount of radiated pick-up from occurring and as shown in Fig. # 1 the DT40 filter easily met CISPR 14 Class B limits. When the VHL25 output filter was installed, there was considerable reduction in conducted EMI above 1 MHz. as shown in Fig. # 2.

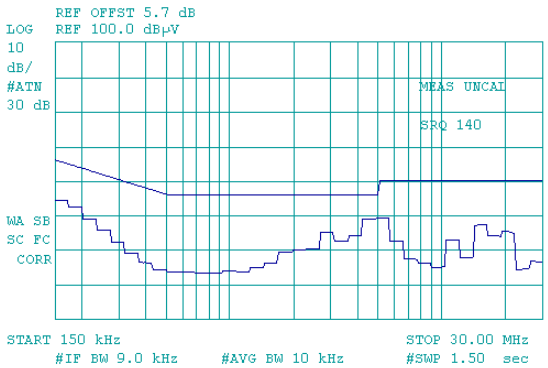

Fig. # 1 DT40 Input Filter with Shielded Input Wires & Unshielded Output Wires

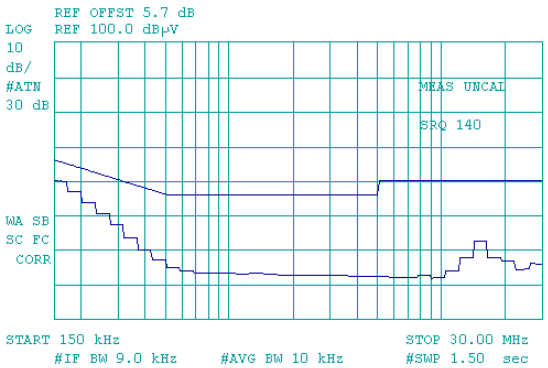

Fig. # 2 DT40 Input Filter with Shielded Input Wires & VHL25 Output Filter with Unshielded Output Wires

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This reduction did not occur without a penalty. Comparing Fig # 1 to Fig. # 2 in the 150 kHz. to 700 kHz. frequency range, there is an increased level of EMI, by as much as 6 dB at 150 kHz.

The output filter is bypassing a large amount of high frequency energy to ground. This reduces the RF energy on the output wires but increases the RF on the ground plane and hence somewhat increases the conducted noise present on the powerline. This is the main reason that we recommend going to a higher performance input powerline filter whenever an output filter is used in the system. If an “L” section input filter (eg. DL40) was being used to meet the Class B emission limit, adding an output filter could easily raise emission levels above that specification. It would be necessary to switch to a “T” section input filter (eg. DT40) if compliance must be maintained.

The design of an output filter is a fine balancing act in the selection of the filter’s cutoff frequency. Too low a cutoff frequency will waste valuable power, which should be going to the motor. Too high a cutoff frequency and there will be insufficient attenuation in the lower RF spectrum which is usually considered the AM broadcast band. The filter must be properly mounted not only for RF grounding but also for proper heat sinking to maintain case temperatures.

In another experiment, the DT40 filter was swapped for a special custom filter. Shown in Fig. # 3 and # 4, the extremely low cutoff frequency of this input powerline filter was able to provide sufficient attenuation so that the low frequencies were unaffected with the addition of the output filter to the system.

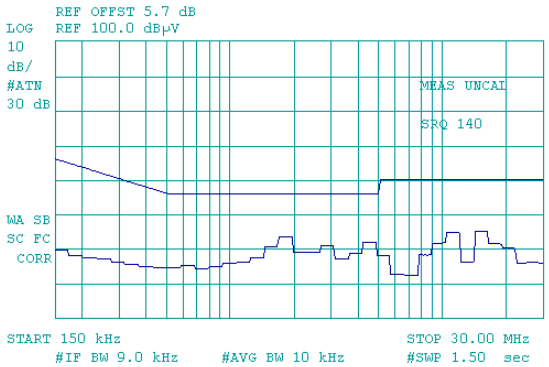

Fig. # 3 Custom EMI Filter w / Shielded Input Wires & Unshielded Output Wires

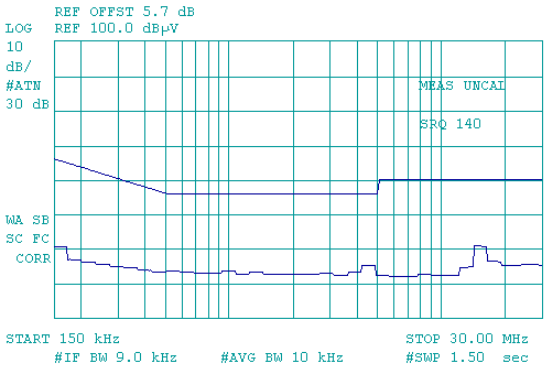

Fig. # 4 Custom EMI Filter w / Shielded Input Wires & VHL25 Output Filter w / Unshielded Output Wires

Test results were excellent, but the more expensive custom filter was really overkill for this application. Since the specification limit was already met using a catalog filter, there was no need to go with a custom filter.

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In Fig. # 5 the output filter was removed and all of the output wiring replaced with shielded wires. Comparing Fig. # 5 to Fig. # 4 shows marginally less improvement for considerably less than the cost of an output filter.

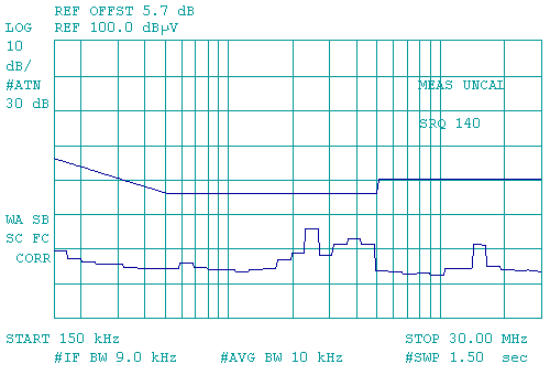

Fig. # 5 Custom EMI Filter with Shielded Input & Output Wiring

Summarizing key points:

1.) The most cost effective approach is to shield both input and output wiring. The least expensive way to shield this wiring is to run it through solid metal conduit.
2.) The addition of an output filter to the VSD can reduce the radiation emitted from the wiring to the motor and eliminate the need to shield these wires.
3.) The low frequency conducted EMI will increase with the addition of the output filter and may require an input filter with higher attenuation to maintain the same level of compliance.

Emission Control, Ltd. is dedicated to providing “EMC Solutions for Conducted EMI”. Since 1984, we have been focused on the design and manufacturing of the highest quality and most effective line of EMI filters available. We have no other objectives.

If you have a special product or application, which requires EMI filtering; we can supply our experience and expertise early in your planning, so as to achieve the most efficient and cost effective filter solution. Our in-house test facilities are available to guarantee your product will meet the applicable emission standards. We maintain a complete quality control system from design, through all phases of production, and to final delivery. We remain committed to our goal of providing a defect free product on which you can depend.

Whether you require a standard catalog filter, a modified standard, a full custom designed unit, or a short delivery cycle; we are determined to provide the individual level of service needed to meet your satisfaction.