ARC SUPPRESSION TECHNOLOGIES

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EMI Reduction

Unsuppressed vs. Suppressed Arcing

Lab Note #104 — rev B

ABSTRACT

Electric contact current arcing in electromechanical relays and contactors generates electromagnetic emissions and resultant electromagnetic interference (EMI). EMI can be detrimental to the workings of adjacent equipment, radio receivers and automation controls in industrial and military environments. In fact, managing electromagnetic emissions and EMI profiles is imperative to the safety and security of armed forces equipment and personnel. Product designers, technicians and engineers are taught that snubbers are a reasonable solution for arc reduction. Unfortunately, snubbers do not address suppression at its source ... and in fact, when improperly applied, will actually make the problem worse. Addressing EMI from relays and contactors requires source suppression of the electric contact current arc.

PROBLEM

Contrary to the training of designers, technicians and engineers, adding a snubber across the contacts of a relay or contactor does not significantly reduce switching EMI as it does not address the electric contact current arcing that is the actual root cause of this EMI.

TESTS

Operate a Tyco T9A open-frame relay switching a resistive load at 120Vac, 1.5kW, 0.125 second cycle time (an insane speed! ... running a relay at this speed without an arc suppressor will create a fire hazard!), 50% duty cycle, under three separate test conditions:

- I. With no suppression element
- II. With a typical RC Snubber (ITW QuenchArc, 0.1μF+200Ω) connected across the relay contacts
- III. With a NOsparc MMXac™ arc suppressor connected across the relay contacts

The high operation speed allows the relay to act as a spark gap transmitter, facilitating emissions data capture. Emissions yielding arcing occurs as the relay contacts cycle through the four distinct states (shown in Fig. 1):

1. **CLOSED**
2. **BREAK** (transition state from closed to open)
3. **OPEN**
4. **MAKE** (transition state with “bounce” from open to closed state)

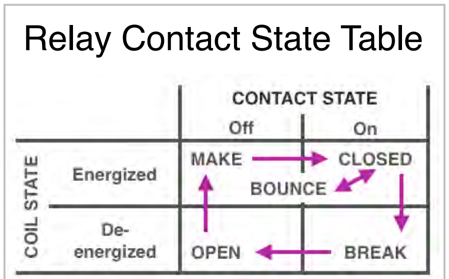

Fig. 1

There are two distinct arcs during the MAKE state: the first is the initial dielectric breakdown (Make Arc), followed-by one or more Bounce arcs until the contacts come to rest in the CLOSED state. The most damaging arc occurs during the contact BREAK state, as it is akin to the process of arc welding.

Test Procedure:
Measure radiated emissions from the arc using broadband linearly polarized antennas positioned 2 meters horizontally from the Equipment Under Test (EUT).

Conduct a continuous max hold peak detection sweep to make measurements with an A.H. Systems SAS-542 Biconical antenna from 30MHz to 300MHz and an EMCO 3146 Log Periodic antenna from 300MHz to 1GHz. Have total sweep time for each antenna range be 60 seconds with each individual sweep approximately 700ms. Set the RBW and VBW to 10kHz, and use a preamp to improve the sensitivity of the test system.

Use an N1996A Agilent CSA spectrum analyzer to measure the signal strength of the Arc Spectral Emissions between a range of 30MHz and 1GHz.

WARNING: Tests use high electrical power, therefore only qualified personnel should attempt to recreate them.

Fig. 2

MINNESOTA WIRE

EMI testing was performed in Minnesota Wire’s 3 meter compact EMC chamber shown in Fig. 2. Additional information on Minnesota Wire may be found at their website: www.mnwire.com.

To learn more about Arc Suppression Technologies tests and findings, as well as additional information on the relative effectiveness of snubbers vs. true arc suppression please refer to previous lab notes posted on our website at: www.arcsuppressiontechnologies.com/LabNotes.aspx

RESULTS

Results are shown in graphs created from data recorded by the spectrum analyzer during each of the tests. Each graph shows the relay arc's ("spark gap transmitter's") spectral emissions field strength measured in µV/m at various frequencies across the 30MHZ to 1GHZ range. (Note: The results are best seen when this document is either printed in color or viewed online at www.ArcSuppressionTechnologies.com/LabNotes.aspx.)

Test I

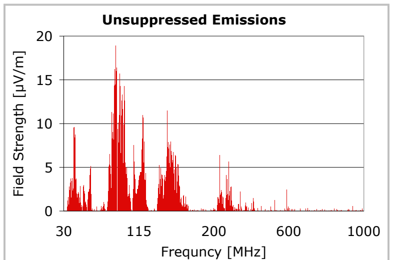

Fig. 3

Fig. 3 shows the spectral emissions for the unsuppressed arcs. This graph is used as a reference spectrum for comparison with subsequent tests.

ITW QuenchArc (bottom) and NOsparc arc suppressor (top), each shown with 12" wires and IEC power connector for attaching to test equipment. Fig. 6

Test II

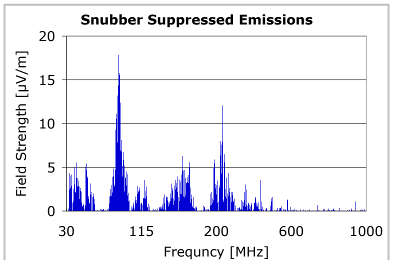

Fig. 4

Fig. 4 shows the spectral emissions for the RC snubber suppressed arcs.

Note that at some specific lower range frequencies EMI reduction by the snubber is measurably better than with unsuppressed arcing. For example:

Frequency of 41.730MHz
Unsuppressed Emissions 9.803µV/m
Snubber Suppressed Emissions 4.006µV/m

Snubber yields a **reduction factor of 2.44**, or **7.77dB**.

At higher frequencies, in contrast, the snubber can actually increase EMI due to the 12" wire connecting the snubber to the relay (see Fig. 6) acting as a transmission antenna loop. For example:

Frequency of 223.200MHz
Unsuppressed Emissions 0.744µV/m
Snubber Suppressed Emissions 8.213µV/m

Snubber yields an **increase factor of 11.04**, or **20.85dB**.

Across the entire range of 30MHz to 1GHz, the overall broadband EMI from the snubber yielded an average **reduction factor of 1.30**, or **2.26dB** compared to unsuppressed arcing.

Test III

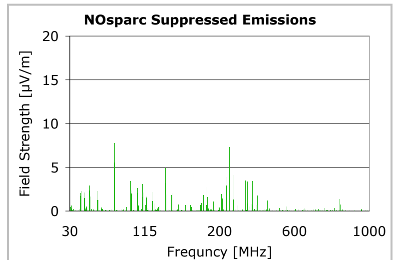

Fig. 5

Fig. 5 shows the spectral emissions for the NOsparc suppressed arcs. The NOsparc suppressor significantly reduces EMI across the full range of 30MHz to 1GHz. The same examples from the snubber results show:

Frequency of 41.730MHz
Unsuppressed Emissions 9.803µV/m
NOsparc Suppressed Emissions 0.030µV/m

NOsparc yields a **reduction factor of 326.7**, or **50.28dB**.

Likewise at higher frequencies (even with the same 12" wire leads), the NOsparc suppressor greatly reduces EMI:

Frequency of 223.200MHz
Unsuppressed Emissions 0.744µV/m
NOsparc Suppressed Emissions 0.066µV/m

NOsparc yields a **reduction factor of 11.27**, or **21.04dB**.

Across the entire range of 30MHz to 1GHz, the overall broadband EMI from the NOsparc arc suppressor yielded an average **reduction factor of 5.62**, or **14.99dB** compared to unsuppressed arcing.

DISCUSSION

Every device creating EMI modulates or varies it in some way. Similar to the spectra of most broadband EMI sources, the emissions from the test relay tends to be stronger at lower frequencies and diminish at frequencies increase (see Fig. 7).

Because broad-band EMI occurs virtually anywhere that electrical power is being turned off and on, it can be a significant issue in many business operations. In addition, the armed forces constantly worry about the EMI profile of their equipment, and its susceptibility to enemy Electronic Support (ES) assets.

In this test, the snubber yielded an average reduction factor of 1.30, or 2.26dB across the range of 30MHz to 1GHz. The tests also showed that while the snubber was modestly effective at reducing EMI from relays at some specific frequencies in the lower end of this range it also increased EMI at some specific frequencies in the mid to higher end of the range of 30MHz to 1GHz.

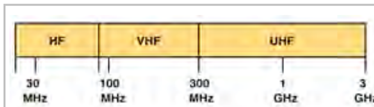

Fig. 7

In contrast, the NOsparc arc suppressor in this test reduced overall broadband EMI spectral emissions consistently across the full range of 30MHz to 1GHz. The NOsparc arc yielded an average suppression factor of 5.62, or 14.99dB.

CONCLUSION

Product designers, technicians and engineers are all taught that a reasonable solution to address EMI from relays and contactors is to add snubbers connected across contacts. This does not address the electrical current arcing that is the actual root cause of EMI.

The source suppression provided by NOsparc arc suppression technology yields measurably superior EMI reduction across the range of 30MHz to 1GHz when compared to snubbers.