October 2012

Potential Navy Mast Light EMI/EMC Issues

Jeff McFadden, Director of Engineering, RSL Fiber Systems LLC and

Ed Nakauchi, *NARTE Certified EMC/ESD Engineer*

Technical Paper

Introduction - Why the concern?

In today's modern Navy, there is an increasing use and deployment of more and more sophisticated digital/RF type systems for electronic warfare, communications (SATCOM, Line-Of-Sight, etc.), and radar. Along with all this potential new hardware come more complex antenna array systems with their increased sensitivity. This increase use of digital/RF hardware results in the greater potential of having electromagnetic interference/compatibility (EMI/EMC) issues that can degrade or damage overall system performance. In addition, there is a concerted effort by the Navy in reducing their ship's overall RF signature and radar cross section (RCS) in an attempt to become more stealthy. So, it is important to minimize RF signatures and reduce noise sources. Even more importantly, the increase use of digital/RF hardware is increasing space, weight, and power demands on the mast. Increasing power capacity means increased weight and higher costs as well, so the need is present for reducing weight and power in other areas as well as reducing potential noise sources. A new approach in mast lighting technology may provide an alternative to achieve these goals.

Mast Lights as a Potential Noise Source

Lights used on masts are typically incandescent, carbon arc lamps, or gaseous lamp types which require voltage conversions to specific light operating voltage/power levels. Generally, incandescent lights are not a major source of noise, but their power level can be as high as several hundreds of watts. The higher the power level, the higher the potential noise level. Also, lights can be switching or blinking on and off which will create broadband noise. Carbon arc lamps and gaseous tube lamps are notorious generators of broadband noise leading to the increased potential of EMI/EMC issues since they are basically an arcing noise generator. Conversion to modern LED type lights can have their own issue in that typically these LED lights require DC power and so, again a voltage converter (AC-DC or DC-DC converters) is integral to their operation which is also potential broadband noise sources. Usually, when these voltage conversions are necessary, added filtering is necessary to prevent any noise generated by the conversion process from being "transmitted" (i.e. conducted and radiated) to the main power grid and to other potential susceptible hardware with increased cost, space, and weight.

Figure 1 shows the typical noise coupling paths that could occur.

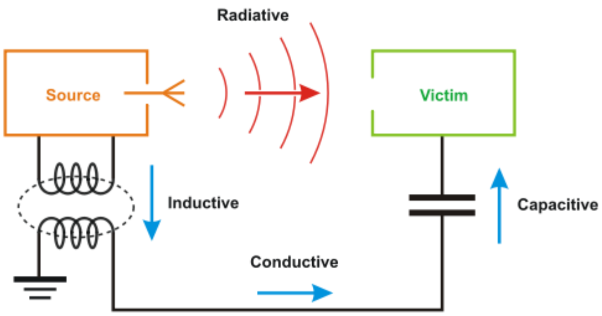

Figure 1. Typical EMI coupling mechanisms with source being a "noisy" mast light and victim being a nearby sensitive digital/RF hardware or antenna.

In MIL-HDBK-1195, it is even stated that a major source of potential EMI is "…high intensity discharge (HID) lighting systems…".[2] So, potentially these types of lights add to potential EMI sources that must be considered and designed for through increased filtering and/or shielding. Broadband noise source are particularly of concern since their energy is spread across a wide frequency range (reference Figure 2), with no particular frequency accentuated. So, any time a new piece of hardware is added or an existing piece of hardware is modified, a system that did not previously have an EMI problem since it was not susceptible originally may have one due to the new or modified circuitry. The possibilities are very likely with a broadband noise source since it emanates a wide range of frequencies. Eliminating these types of broadband noise sources makes achieving electromagnetic compatibility less of a concern especially as systems keep getting modified and/or upgraded constantly. Reducing broadband noise sources also, of course, improves the RF stealth signature of the ship.

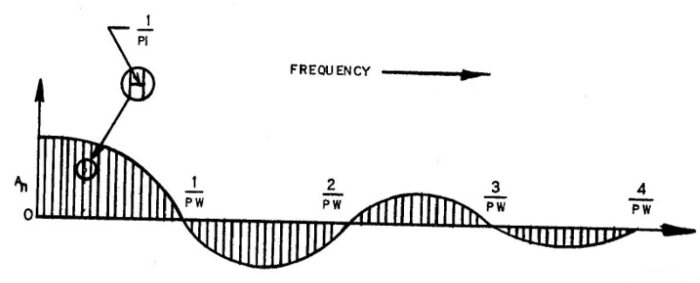

Figure 2. Typical broadband signature.

Intermodulation Effects

A method of designing for minimizing EMI is to have good RF grounding of all nearby metal structures. However, in joining separate structures, corrosion becomes a possibility. Corrosion is the natural oxidation of metal. Corrosion in metals may appear in several distinct forms, but corrosion is most prevalent in a salt water environment. The sea and the salty atmosphere are saline media that are highly aggressive to metals. Marine structures such as ships, bridges, and drilling rigs and platforms usually show signs of severe corrosion unless they have been properly protected. Figures 3 are some examples of the effects of corrosion.

Figure 3. Examples of the effects of corrosion (i.e. rust)

One phenomenon caused by the build-up of corrosion/rust deposits in a RF joint is intermodulation, also known as the 'rusty bolt effect'. In this case, the corrosion deposits are 'nonlinear semiconductors' and cause signal mixing. The end result is interference from frequencies not knowingly transmitted at the joint, but created from the mixing of multiple signals received by the joint. The joint, in turn, acts like an electronic circuit which mixes signals. This problem is common whenever multiple electronic devices are used in close proximity. The shielding effectiveness of a non-linear joint cannot be measured using DC measurements or standard RF test methods. So, if broadband noise sources are present, this “rusty bolt” phenomenon increases even more the potential number of possible potential frequencies that could cause susceptibility issues.

A Practical Solution

An alternative to the lighting systems described above is a remote source fiber optic system. In this system the light engine is placed in an interior space such as an equipment room, passageway, bridge or enclosed mast. The system component that actually emits and distributes the light specific to the required application (masthead, task light, running light, etc.) is a passive composite luminaire. Connecting the light engine and luminaire is a non-metallic fiber optic cable that transmits the light from the light engine to the luminaire. Since all components outside of the light engine are of non-metallic or composite construction, corrosion issues are effectively eliminated. Similarly, with no electricity (and no conductive components) in the system outside of the light engine, EMI/EMC issues are also effectively eliminated. Additional benefits of the remote source solution include reduction in topside weight of 80-90%, and reduction and simplification of maintenance (all components requiring preventative maintenance reside in the light engine), as well as the ability to dramatically reduce RCS with embedded and reduced size luminaires.

References:

1. Naval Research Laboratory, Washington, **DC, Integrated Topside (In Top) Joint Navy-Industry Open Architecture Study**, NRL/FR/5008-10-10, 198.
2. **MIL-HDBK-1195 Radio Frequency Shielded Enclosures**, dated 30 September 1988.
3. Naval Postgraduate School in Monterey, CA, **An Arsenal Ship Design Report**, December 1996.

Ed Nakauchi

Mr. Nakauchi holds a BSEE and MSEE from Northrop University and Columbia Pacific University, respectively. He has over forty years of engineering experience beginning with analog, power, and digital design. For the last thirty years, he has spent a majority of his time in the EMI/EMC/EMP and ESD areas for both military/aerospace companies and commercial audio/computer/medical companies. He has written numerous technical papers and magazine articles as well as presented seminars on EMI/EMC/EMP/ESD topics for many companies. He has taught EMI and electrical engineering courses through the University of California Irvine Extension program, was the primary author of a shielding design guideline for the Army and was an EMI consultant to the Air Force's Space and Missile Command on their COTS program. He has also worked on several RF projects including the CASSPER system that is an innovative correlation analyzer. He is a NARTE Certified EMC/ESD Engineer with senior membership in the IEEE and currently the Director of EMC for G&M Compliance as well as an independent consultant.

Jeff McFadden

Mr. McFadden is the Director of Engineering for RSL Fiber Systems headquartered in Hartford, Ct. He holds a master of science in engineering from the New Jersey Institute of Technology and completed post-graduate studies at Brooklyn Polytechnic University and Texas Tech. He obtained his Bachelor of Science degree from Northeastern State University (Oklahoma). He has worked in a variety of Senior Technical positions in Aerospace, Defense, and commercial markets. He served as an adjunct faculty member at New Jersey Institute of Technology. A registered Professional Engineer and a Certified Manufacturing Engineer, Mr. McFadden holds 29 United States and foreign patents.