Lightning Retardant Cable
Communication Cable Tests

Technical Report

September 28, 2004

SPAWAR Systems Center
Tactical Communications Division
Charleston, SC

Introduction

The Navy's tactical Communication Division of the SPAWAR System Center Charleston, SC has an interest in testing the effects of Lightning Retardant Cable (LRC) technology on coaxial transmission cable, specifically RG-214.

LRC's lightning deterrent capabilities have been previously tested and documented by both the FAA and Lightning Technologies, Inc. in Pittsfield, MA. A summary of these two reports are attached for the reader's review. The Navy does not wish to duplicate these tests but instead focus its efforts of the additional effects the technology may have upon coax cable.

Background

LRC is a new technology that reduces the effects of lightning on wires and cables.
It has been issued 6 US patents and is patented and patent pending in various foreign countries. The technology has won numerous engineering awards and has been featured in several NASA articles.

The technology has evolved over the years and is under its fifth version.

Technology

LRC's main purpose is to keep lightning on the outside of wire and cable thus encouraging it to travel down proper ground paths.

It accomplishes this by establishing a high impedance path to ground and applying a 100% helical wrapped foil tape to take advantage of the "skin effect". Also, it uses an insulated conductor applied in the opposite direction and the foil to establish a counter magnetic field for maximum cancellation.

Version I cable, tested by Lightning Technologies, Inc., resulted in a 780% improvement in lightning protection over standard coax. The "LRC Plus Design" tested is similar to current Version 5 technology as far as the foil thickness is concerned.

More detailed information can be obtained by visiting the vendors web site at http://www.lrccable.com.

Tests

The tests conducted by the Tactical Communication Division were specifically chosen to give a performance overview of LRC RG-214. The results should give us an indication of the overall performance of the technology.

TEST ONE – Phase Stabilization Characteristics

The first test performed was to observe Phase Stabilization Characteristics of a 200 foot length of military grade RG-214.

Figure One, pictured on a network analyzer, is a representative of 1 to 30 mhz (hf).

Figure 1

Note the wavy lines around a poorly defined center. This illustrates Mil-Spec acceptable phase stabilization characteristics.

Figure 2 illustrates an identical length of military grade RG-214 with Lightning Retardant Cable Technology applied.

Figure 2

The display indicates excellent phase stabilization characteristics. Note the defined center and symmetry of the display. Similar data was taken at VHF-UHF frequencies up to 1.8 GHz.

The results indicate LRC RG-214 offers an added advantage of superior Phase Stabilization Characteristics over standard military grade RG-214.

In addition, the LRC technology's effect on coaxial cable VSWR and characteristic impedance is nil.

TEST TWO - Local Interference Test

The display pictured in Figure 3 below of the E4402B Spectrum Analyzer show a display of the AM Broadcast band, centered on 1.250 Mhz, which is a local 50,000 watt broadcast station. Interference from this station into our RF lab is always a problem.

The test setup: a 25 foot length of RG-214, and a similar length of LRC-configured RG-214 were connected to the spectrum analyzer as a loop. The ends of the cables were terminated with Type-N connectors and connected to a T-connector. The Output of the Tee went to the analyzer input, one cable at a time.

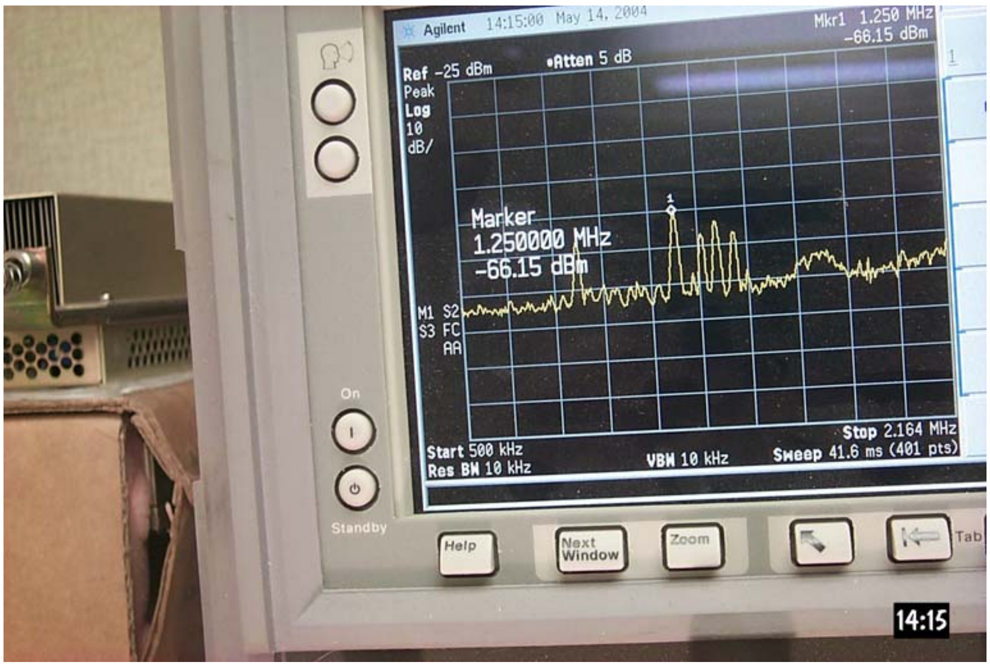

Figure 3

The spectrum analyzer display of military grade RG-214 clearly shows the nearby 1.25 MHz local am radio broadcast station. Note the entire waveform and other three nearby radio stations to the right of the 1.25 MHz marker.

The interfering signals, which must penetrate through the dual “silver” braid shield shows a –66.15 dBm level.

The display pictured in Figure 4 is LRC RG-214 cable. Note the 1.25 MHz signal has been lowered by 10.67 dB. Also, note the drastic reduction of adjacent signals on the display. This test is a true representation of outside interference on LRC Cable versus standard military grade cable.

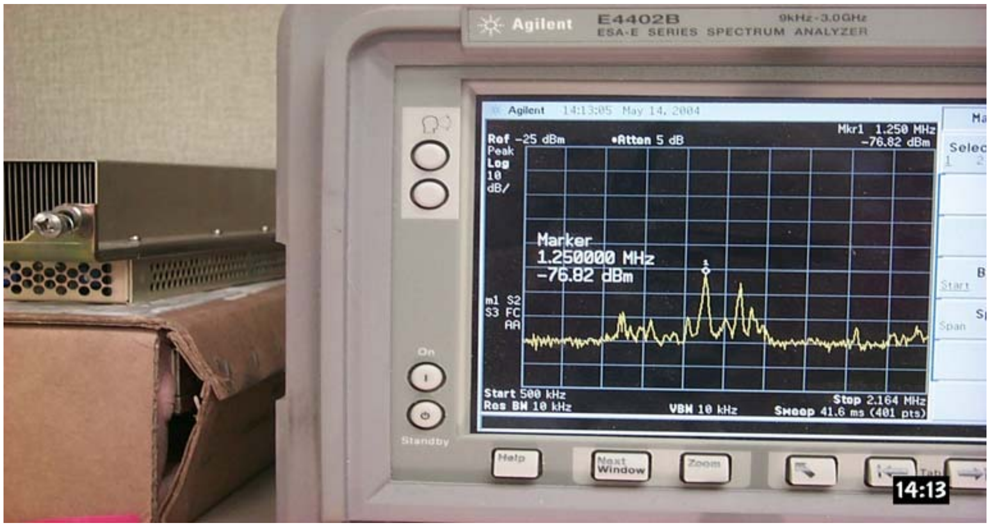

Figure 4

The results indicate LRC technology applied to military grade RG-214 offers an added benefit of 10dB improvement in shielding of outside interference.

Note: The connection of the LRC choke conductors were “shorted together” at the T-connectors.

TEST THREE - Signal to Noise

The third test performed was to measure signal to noise on both Transmit and Receive.

Conditions of testing: RG-214 and LRC-configured RG-214 laid out in a 200 foot circumference loop, laying on an asphalt parking lot, 6" spacing between the cables. A B&W HF transmit dipole antenna is situated 30 feet above the center of the loops.

Transmit level was CW at 10 watts. Simultaneous measurements of background noise and then high level RF were taken on two spectrum analyzers, the HP-8562C and E-4402C, which were calibrated and normalized to make sure they had similar sensitivity and signal to noise. Connection to the two loops were via 2 identical conduit fed cable trunk lines underground. Preliminary measurements were made with these trunk lines terminated with dummy loads to make sure they had similar RF isolation from above ground wires.

The LRC counter-wound copper foil field-canceling coils were shorted together across the type N “T” connectors for the testing. Essentially, the center conductor of the coax cables under test was connected to the RF input of the spectrum analyzers.

The graphical display of these data points show an average of 10 dB improved isolation from outside noise and RF fields upon the coax cable electrodes.

Test	Frequency MHz	dBm Noise Level RG-214	dBm Noise Level LRC-style RG-214	10watt CW Sig. RG-214	10watt CW Sig. LRC-style RG-214
A	1.890	-100.3	-113.0	-80.8	-82.6
B	7.00	-101.0	-113.3	-69.2	-74.2
C	10.10	-102.0 -105.0	-114.3 -115.3	-76.0 -75.8	-94.1 -92.9
D	14.00	-100.8 -103.7	-112.2 -114.5	No data Taken	No data Taken
E	18.10	-103.8	-113.9	-83.5 -83.7	-95.8 -96.9
F	21.00	-102.5 -93.8 -93.0	-112.7 -100.4 -101.1	-78.5 -105.0 -91.3	-89.5 -114.8 -98.8
G	24.9	-105.0 -101.8 -103.3	-116.5 -115.1 -113.2	-96.0 -93.0	-105.0 -105.0
H	29.64	-103.5	-115.2	-76.7	-84.3

The chart above is a true representation of results from 1.890 MHz to 29.64 MHz.

The results indicate that LRC RG-214, on average, provided a 13db better signal to noise floor than standard military grade RG-214.

Test Four
Unbalanced RF Currents

A test to see if the LRC double helix windings affect unbalanced RF currents riding on the outside of the cable were made. What we were hoping to see was that the windings would act like an RF Choke, preventing the currents from propagating back along the cable. Three methods are typically employed to minimize RF currents on the shield, they are: BALUN transformer at the antenna feedpoint, a Ferrite sleeve attached on the outside of the cable, and a "choke coil" made up of ten to twenty coils of coax cable, taped together.

We found the windings to offer no reduction in currents. These currents were measured by three means:

1. A fluorescent tube "wand" passed over the two cables. The brightness was identical.
2. A Gaussian probe, attached to a HP-3561A Dynamic Signal Analyzer
3. A Gaussian probe, attached to a spectrum analyzer.

LRC

RG-214

Intermodulation Distortion

Although an Intermodulation Distortion Test was not specifically performed, the tests that were performed indicate a pattern of much greater performance than standard military grade RG-214. Therefore, certain assumptions can be made as to the results of related tests.

Testing of coax cable treated with the LRC (lightning retardant cable) double helix configuration has shown measurable shielding effects from LF through UHF frequencies. As this technology uses copper foil there should be measurable reduction in the generation of IMD (intermodulation distortion products) which are created by external RF transmit sources coupling energy onto the shields of the subject coax. Shield materials which exhibit nonlinearities at RF frequencies produce the IMD products. With the LRC shield added to the coax system, the coupled energy level onto the coax shield is reduced by greater than 10 dB (measured in the lab). This reduction in energy should translate in significantly lower IMD susceptibility.

Conclusion:

The original purpose to add LRC double helix technology to RF Coaxial Cable is to prevent lightning surge energy from coupling onto the cable. The technology can not be claimed to stop lightning energy from coming into the system from the antenna elements. The benefits of this technology should be observed for long runs down towers and for rejecting energy away from lines which are buried. It is over the longer cable runs that more energy is coupled onto the cable than by the antenna alone.

Phase stability appears to be improved on cable thus treated.

Shielding effectiveness is improved at all RF frequencies. The improvement is exhibited by improved Signal to Noise numbers with both large signal and low level signal measurements.

Intermodulation Distortion testing should be performed at a later date. The lower level of interfering signal getting through the LRC windings to the coaxial braid implies less energy available to generate spurious signals.

LRC-enhanced coax cable offers benefits above and beyond lightning protection. No negative effects were noted in any tests performed.

Exhibit A – Lightning Technologies Test Report

TEST SUMMARY

LIGHTNING TECHNOLOGIES, INC., 10 Downing Parkway, Pittsfield, Massachusetts 01201 • (413) 499-2135
FAX (413) 499-2503

IMPROVEMENT OFFERED BY LIGHTNING RETARDANT CABLE (LRC)

A series of tests were performed at Lightning Technologies Inc. for Sam Gasque/Vantage, Inc. to determine what degree of improvement might be offered to satellite receiving systems by using a new Lightning Retardant Cable, as compared with the industry standard ribbon cable.

LOW CURRENT TESTS

Low current tests (120 amperes peak were performed to explore how the cables responded to surge voltages and to determine the improvement offered by the Lightning Retardant Cable (LRC).

LRC Standard Design

In round numbers, there was an improvement over the standard ribbon cable of about 195% for the coaxial cable and 370% for the control conductors. The exact improvement depends on the particular conductor under discussion, but these numbers are reasonable averages.

LRC Plus Design

Compared to the standard ribbon cable, the improvement was about 700 % for the RF coaxial cable and 1500 % for the control wires. Again the exact improvement would depend on which particular wire was under discussion and upon the waveshape of the surge current.

HIGH CURRENT TESTS

High current tests were done for three reasons; to confirm the conclusions reached during the low current testing, to determine if there were any non-linear effects of current and to determine if the cables could carry high currents without physical damage.

LRC Standard Design

The improvement depends on the waveshape, but for the unidirectional current was about 350 %, for both the RF coaxial cable and for the control wires. The absolute magnitude of voltage was of course larger on the control wires.

LRC Plus Design

The improvement over the standard ribbon cable ranged from 780 % for the RF coaxial cable, to 1480 % for one of the control wires.

Exhibit B – FAA Test Report Conclusion

CONCLUSION

Lightning Retardant Cable has performed perfectly after four years of infield testing in the nation's most severe lightning area. The test was a true "side-by-side" comparison of Lightning Retardant Cable's L-824C versus standard L824C. All circuits were powered from the same source.

During this four year test there has been no down time on Bartow's 9L-27R runway, nor has there been any maintenance costs whatsoever. This has resulted in a very high safety factor even under the most severe thunderstorms.

The technology not only retards or eliminates lightning but keeps any strike localized to an individual component instead of running down the cable. This should also minimize maintenance costs and down time.

The manufacturing process has been perfected since Phase 1 at Bartow. Current LRC has a smooth outer jacket for maximum connector sealing and is impervious to de-icing chemicals.

Connector issues have been resolved with the recommendation of shrink tubing with additional sealant on the rear of the connector. Installation of the connector, once mastered, takes about the same time to install as standard connectors.

This test has been a success after four years of testing. The untreated airport lighting circuits have had numerous outages and the LRC circuits have had none. A direct strike to one of the LRC circuit landing lights only damaged the light fixture, not the cable. There have been no outages to the LRC circuits. Monitoring of the airport lighting circuits at Bartow Airport will continue.