Proper Use of RF Coaxial Connections at LIGO
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1. Overview

It has been noted that the demodulation phase angle of RF detection chains within the ISC subsystem can change when the RF cables within a rack are physically disturbed. In response to Bugzilla bug number 332 "RF phase shifts when cables moved," engineering guidelines and maintenance practices must be documented to minimize the chance that workmanship and commissioning activities can cause significant inadvertent phase shifts within the RF systems. Normally there is no significant phase sensitivity (at typical LIGO modulation frequencies up to 150MHz) for an RF cable/connector combination that is properly torqued, and has been assembled according to the manufacturer's guidelines.

This note will document reasonable practices for use and manufacture of RF coaxial cable terminations (connectors) specifically focusing on SMA, Type-N, and TNC.

2. Attachment of RF Connectors to Coaxial Cable

For any given RF coaxial connector in use at LIGO, there are specific manufacturer's instructions detailing proper attachment. Rather than duplicate these instructions, it is good engineering practice to read, understand, and follow these instructions. A conversation with one of the site electrical engineering staff will certainly aid in finding such instructions and gaining proficiency. A representative summary for an Amphenol SMA connector is given below.

Figure 1, SMA Connector

The connector shown above (DigiKey Part Number ACX1192-ND, Amphenol Part Number 132113) comes with a datasheet that is available on the DigiKey and Amphenol website. The datasheet has several key pieces of information. Among these are the dimensions of a properly prepared coaxial cable, and the recommended die size for the crimping tool. Below are snippets from the data sheet for this SMA connector.
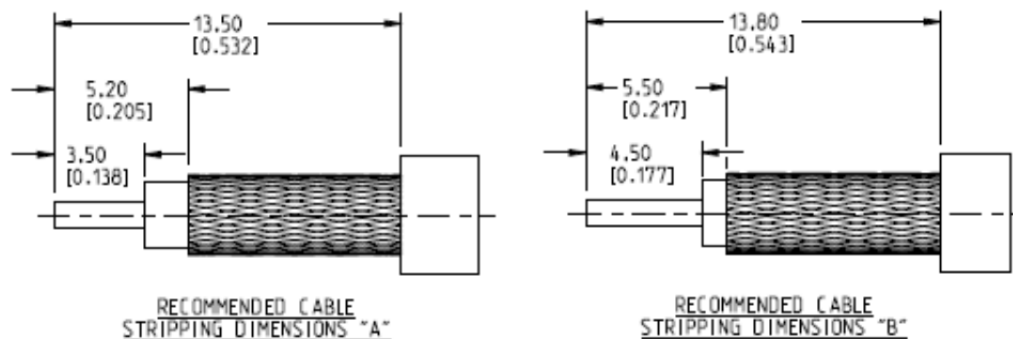
Figure 2, Cable Stripping Dimensions

NOTES:

1. IMPEDANCE: 50 OHM

2. FREQUENCY RANGE: DC-12.4 GHZ

3. ELECTRICAL PERFORMANCE MAY VARY DEPENDING
   ON THE TYPE OF CABLE BEING USED

4. DIELECTRIC WITHSTANDING VOLTAGE: 1000 VRMS. MIN.

5. DURABILITY: 500 CYCLES MIN.

6. TEMPERATURE RANGE: -65°C TO +165°C

7. CRIMPED FERRULE HEX CRIMP SIZE 0.213".

8. CONTACT PIN TO SOLDER.

9. WHEN USING WITH RG-58 CABLE.DISCARD THE
   PTFE SPACER AND USE STRIPPING DIMENSIONS "A".

10. WHEN USING WITH LMR-195 CABLE.ADD THE
    PTFE SPACER AND USE STRIPPING DIMENSIONS "B".

Figure 3, Example Notes for Tooling

In closing, there is no substitute for practice when it comes to terminating cables. All connections MUST be tested after fabrication. The testing should typically be done by measuring the RF loss of the cable section which should reveal flaws such as poor workmanship if one physically stresses the cable during the test.

3. **Maintenance of Installed RF Cabling**

After a subsystem is installed, it is possible that threaded RF coaxial connectors may not be tightly attached leading to intermittent connections. All RF coaxial connectors MUST be periodically checked to be sure they have not been compromised during testing or commissioning. Specifically, the connector must be torqued in the case of an SMA connector, or manually tightened in the case of either Type N, or TNC. The large connector body size of Type N and TNC connectors renders them suitable for hand tightening with reasonable finger strength. SMA connectors should be tightened to 8 inch-pounds.

Preset SMA torque wrenches are available from many vendors, and typically cost around $400. An excellent tool has been created by MiniCircuits Inc. that allows easy access to high density SMA connectors. The MiniCircuits tool has flat surfaces between the knurled finger grips that permit use of a torque wrench. These should be standard fare for LIGO maintenance. Shown below are images of a typical SMA torque wrench, and ordering details for the MiniCircuits extension tool.

Figure 4, SMA Torque Wrench, DigiKey Part Number A99929-ND

HT-2-SMA   HT-4-SMA

CASE STYLE: MY-1E

Model	Price	Qty.
HT-2-SMA	$24.95 ea.	(1-9)
HT-4-SMA	$29.95 ea.	(1-9)

Figure 5, MiniCircuits HT-Series SMA Wrench