CHAPTER 3 - LORAN-C SYSTEM INFORMATION

This chapter is intended not as a binding specification on Loran-C transmissions, but as an information document on the many details which relate to Loran-C calibration, Loran-C control procedures and Loran-C services from the various chains.

A. System Calibration Procedures:

1. Discussion

The primary purpose of a Loran-C chain calibration is to ensure that the Emission Delay (ED) of each secondary station is set to the value published by the U.S. Coast Guard. This is accomplished using an equipment suite which directly measures the Time of Transmission (TOT) of each station in the chain. The ED is then calculated using the procedures discussed in Chapter 3.A.3.b. During the calibration, the approximate UTC position of the master's transmission in time is determined and a crude UTC synchronization can be achieved.

2. Equipment

The time standard for the ED equipment suite (designated the Emission Delay Measurement Equipment Suite) is a Hewlett-Packard Model 5061A Cesium Beam Frequency Standard with option 001 Time Standard. This device is used with a Hewlett-Packard Model K02-5060A Standby Power Supply making it a portable "Hot Clock". The 5 MHZ signal from the standard is used (with a rate generator) to generate a reference Group Repetition Interval (GRI) for the ED measurements. The 1 PPS from the standard is used to synchronize the reference GRI to its UTC Time of Coincidence (TOC). The reference GRI is the time standard against which all TOT measurements are made. TOC is defined as the UT second where the standard zero crossing of the master station's first pulse (phase code group A) is coincident with the occurrence of the UT second. The TOT measurements are made with respect to the Standard Zero Crossing, (SZC), 30 microseconds after the beginning of the pulse.

The antenna current waveform is sensed by a clamp-on, current transformer installed on the transmitting antenna ground return line. The transformer is marked to ensure correct phasing of its output. The actual TOT measurement is made using a Hewlett-Packard Model 5360 or 5370 Time Interval Counter (there are two systems in use). These units measure the time difference between the beginning of the reference GRI and the SZC on the transmitting antenna current pulse. The TOTs for all sixteen pulses in one phase code interval (PCI) are measured.

Auxiliary equipment included in the suite perform common mode interference rejection, signal attenuation, oscilloscope trigger generation, oscilloscope monitoring, and signal phase inversion (switch controlled) to permit the operator to determine the presence of and subsequently take corrective action to eliminate common mode interference within the equipment.

3. Technique

a. Data Collection

Data is collected at each secondary station once, and at the master station twice. The collection is performed at the base of the transmitting antenna. The clamp-on current transformer is installed and the signal is coupled through the common mode rejection filter to the coupler unit. The coupler unit contains the attenuator and the phase inverter. The attenuator is adjusted such that no half-cycle amplitude BEFORE the SZC exceeds the maximum input level of the Computing Counter (any half-cycle after the SZC which exceeds the input level limitation of the counter will not affect the measurement). The signal is then fed to the oscilloscope and the computing counter.

The TOC for the GRI being measured is calculated and the reference GRI is synchronized to it. A pulse corresponding to the beginning of the reference GRI is coupled to the computing counter. A Gate waveform, 10 microseconds in duration, is generated. Its delay from the start of the reference GRI is switch selectable and is positioned so it straddles the SZC of the pulse being measured. This Gate waveform is also used for oscilloscope triggering.

TOT readings (three with the inverter phasing of 0° and three with 180° phasing) are recorded for each pulse. Each TOT is the mean value of 100 separate samples of the time difference between the beginning of the reference GRI and the SZC of the pulse being measured. Then the TOT of the next pulse is measured. When completed, there will be 6 recorded mean TOTs for each pulse in phase group A and phase group B or a total of 96 TOTs.

b. Data Reduction

The purpose of the two visits to the master station is to set a start time for the calibration and to determine the frequency offset between the master operate oscillator and the "Hot Clock". The Clock Error Rate, the rate in nanoseconds per hour at which the Hot Clock 1PPS output is shifting in time with respect to that of the master operate oscillator, is calculated by measuring the timing offset between the two visits and dividing by the time from the first to the second measurement.

Using the Clock Error Rate and the period of time between the first master data collection and the data collection at the secondaries, a correction to the secondary TOTs is determined and applied. The effect of this correction is to get an actual TOT which has been corrected for "hot clock" drift.

The Controlling Standard Time Difference (CSTD) offset for the baseline, as seen at the monitor site in control of the pair, is algebraically subtracted from the secondary TOTs to correlate the measured TOT with the assigned Controlling Standard Time Differences. Then, the individual pulse TOTs for each station are adjusted (by subtracting multiples of 1 millisecond) to the first pulse of the respective phase code groups (the result of this adjustment is that all TOTs have the same milliseconds digits). The mean is taken of the adjusted TOTs yielding the final TOT for the station.

The Emission Delay of each secondary is calculated as follows:

$$ED_S = TOT_S - TOT_M \qquad (3.1)$$

The CSTD correction is determined as

$$COR = ED_P - ED_S \qquad (3.2)$$

where
ED_P is the published ED for the baseline. The correction is added algebraically to the presently assigned CSTD to arrive at the value for the new CSTD.

4. Chart Verification

The U.S. Coast Guard cooperates with the Defense Mapping Agency and the National Ocean Survey in the preparation and verification of Loran-C charts. The Defense Mapping Agency, with the cooperation of the USCG, prepares predicted Loran-C time differences for a given coverage area. When selected portions of the coverage area have been surveyed by the U.S. Coast Guard or National Ocean Survey, the measured points are adaptively correlated to the predicted values using force-fit techniques. This ongoing process provides feedback to ensure that predicted (charted) and measured time differences agree closely throughout the coverage area.

B. Loran-C Chain Control Procedures

1. Purpose

The purpose of Loran-C chain control is to maximize the usability of available signals within the defined service area. Therefore, a fundamental requirement of control is the measurement of selected parameters to ensure that the values established and assigned as a result of the chain calibration are maintained. The following three basic parameters are measured:

- Phase time difference (TD)
- Envelope-to-cycle difference (ECD)
- Peak radiated power

2. Procedures

The procedures utilized for control of these parameters are as specified below:

a. Phase Time Difference (TD)

Continuous measurement of the TD of each respective master-secondary pair is made at a monitor location, or locations, within the defined service area. This TD is maintained at the controlling standard time difference (CSTD) (established during the calibration) by the insertion of local phase adjustments (LPA). In general, the hourly average of TD is held to within ±50 nanoseconds of the CSTD. Blink tolerances are shown on the chain data sheets of appendix (A).

b. Envelope-to-Cycle Difference (ECD)

Continuous measurements of ECD are made in the far field at the same location(s) described in 3.B.2.a above. Additionally, each transmitting station continuously measures its transmitted ECD and monitors its pulse shape through the i(t) waveform (antenna ground current). The far field Controlling Standard ECD (CSECD) and the associated Nominal ECD (NECD) at the transmitter are assigned by the program manager at the time of baseline or monitor certification. Assignment of these parameters takes into account the transmitted pulse shape and the annual cyclical propagation effects. Typically, the procedures used to assign the CSECD include a period of data collection, i.e., an average of 30 days of far-field data. During this period of data collection, the NECD is monitored to ensure it remains stable. In most cases, the NECD is maintained at 0.0 microseconds. This results in far field ECD values that ensure proper user receiver cycle selection within the prescribed coverage area. NECD assignments take into account the phase differences (+2.5 microseconds) between the antenna current waveform and the ECD observed in the far field (which is influenced in addition by the propagation path). See Chapter 4 for definitions which apply to ECD control.

c. Peak Radiated Power

Peak radiated power is monitored at each transmitting station by measurement of the zero-to-peak current in the Loran-C antenna ground return.

3. User Notification

User notification of unusable signals is accomplished by blinking initiated under the following circumstances:

- Off-air or peak radiated power less than one half of that specified
- TD out of tolerance

- ECD out of tolerance
- Improper phase code or GRI.

C. Specific Loran-C Chain Information

Specific Loran-C chain information is contained in three appendices to this document. An outline of each of the three appendices follows:

1. Loran-C Chain Data Sheets, appendix (A), contain a separate data sheet for each Loran-C chain. Each data sheet lists all Loran-C stations of a chain by name and includes the following information (where applicable): station function, location, emission delay, radiated power, control parameters (e.g., CSTD with tolerance), and other general notes of interest.

2. Predicted Loran-C Groundwave Coverage, appendix (B), contains a separate chartlet for each Loran-C chain. The predicted coverage contour for the chain is drawn on the chartlet. An explanation of the constraints and procedures used to generate the contours is provided in the introduction of appendix (B) along with a sample predicted-noise-level computation.

3. Contours which show the 2 DRMS (95%) limits with accuracies of 500, 1000, and 1500 feet are provided in appendix (C). These contours do not account for the effects of signal attenuation or noise.