U.S. Department of Transportation
United States Coast Guard

DOT/TSC LORSTA GRANGEVILLE TEST REPORT

Project Memorandum
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Center for Navigation

Approved for Distribution:

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PREFACE

A field test team from the U.S. Department of Transportation, Transportation Systems Center (TSC) made a series of measurements on the signal being radiated by the U.S. Coast Guard LORAN-C Station (LORSTA) Grangeville, Louisiana on 14 to 16 May 1985. The measurements were made with a set of computer controlled test equipment, which was designed and integrated specifically to measure LORAN-C signal parameters.

These signal measurements determined the following:

A. Frequency Domain Measurements

1. Spectrum of the transmitters contained slightly under 99 percent (98.82 percent) radiated energy in the 90 to 110 kHz band.

2. Radiated harmonics were over 80 dB below peak signal levels at all harmonics except the third. The third harmonic measured 63.7 and 64.3 dB down for Coupler 1 and Coupler 2 respectively.

3. Continuous LORAN-C emissions were observed at Ring Road approximately 90 dB below pulse peak. It was highly concentrated at 300 kHz. There were also sporadic emissions at Site 4, most being at least 95 dB below pulse peak.

B. Time Domain Measurements

1. The signals being radiated by LORSTA Grangeville met or exceeded Coast Guard specifications with the exception of some half-cycle zero crossings, one pulse trailing edge and pulse to pulse timing tolerances. The half-cycle zero crossing at the 10 μsec crossing was slightly out of tolerance for all transmitter/coupler combinations. The trailing edge of Pulse 2 of Pulse Amplitude Timing Controller (PATCO) 1/Coupler 1 (P1/C1) measured just above the 0.0014 limit. Pulse 1 was offset for both PATCOs, therefore all combinations failed the specification that Pulses 2 through 8 must satisfy the relationship (N-1) 1000 sec $\pm$ 25 nsec, where N is the pulse number.

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1. INTRODUCTION

A series of detailed signal measurements were taken at U.S. Coast Guard LORAN-C Station (LORSTA) Grangeville, Louisiana by an engineering field test team from the U.S. Department of Transportation, Transportation Systems Center (TSC). These measurements were made with an instrumentation van designed for measuring LORAN-C signals. All data were collected from 14 to 16 May 1985.

Signal measurements included both frequency and time domain signatures at several field sites near the transmitting station as well as data from the station's internal signal sensors.

This report documents the data obtained and presents a discusion of the results.

2. STATION DESCRIPTION

LORSTA Grangeville is a single rated station operating on a GRI of 7980. It is equipped with an AN/FPN 64-56 solid-state LORAN-C transmitter. The antenna is a 700-foot top loaded monopole. The station transmitter has two separate antenna couplers for redundancy.

The combination FPN 64-56 transmitter and 700-foot antenna is rated to deliver a peak output power of 800 kw. Operation of the station was reported to be normal during the data collection period.

3. OBSERVATION SITES

Measurements were made and data were recorded in the LORAN-C station Operations Building and at 7 field sites shown in Figure 3-1. The remote sites chosen were to the north, southeast, south, southwest and northwest of the station and represented excellent choices for obtaining an accurate data set. The off-station sites were not symmetrically located because of the presence of power lines southeast of the station. Sites ranged from 0.1 mile to approximately 4.5 miles from the transmitting antenna and none were near power lines.

For data reporting purposes, the site designations (indicated in Figure 3-1) were:

Site 1 - 0.1 mile east of station

2 - 0.4 mile southeast of station

3 - 1.5 miles south of station

4 - 2.0 miles south of station

5 - 4.3 miles southwest of station

6 - 4.5 miles north of station

7 - 1.3 miles northwest of station

Frequency spectrum measurements were taken at 4 sites while time domain pulse waveforms were recorded at the station and at Site 1. The sensor for the measurement made on-station was the "operate" Pearson current transformer located on the antenna ground return.

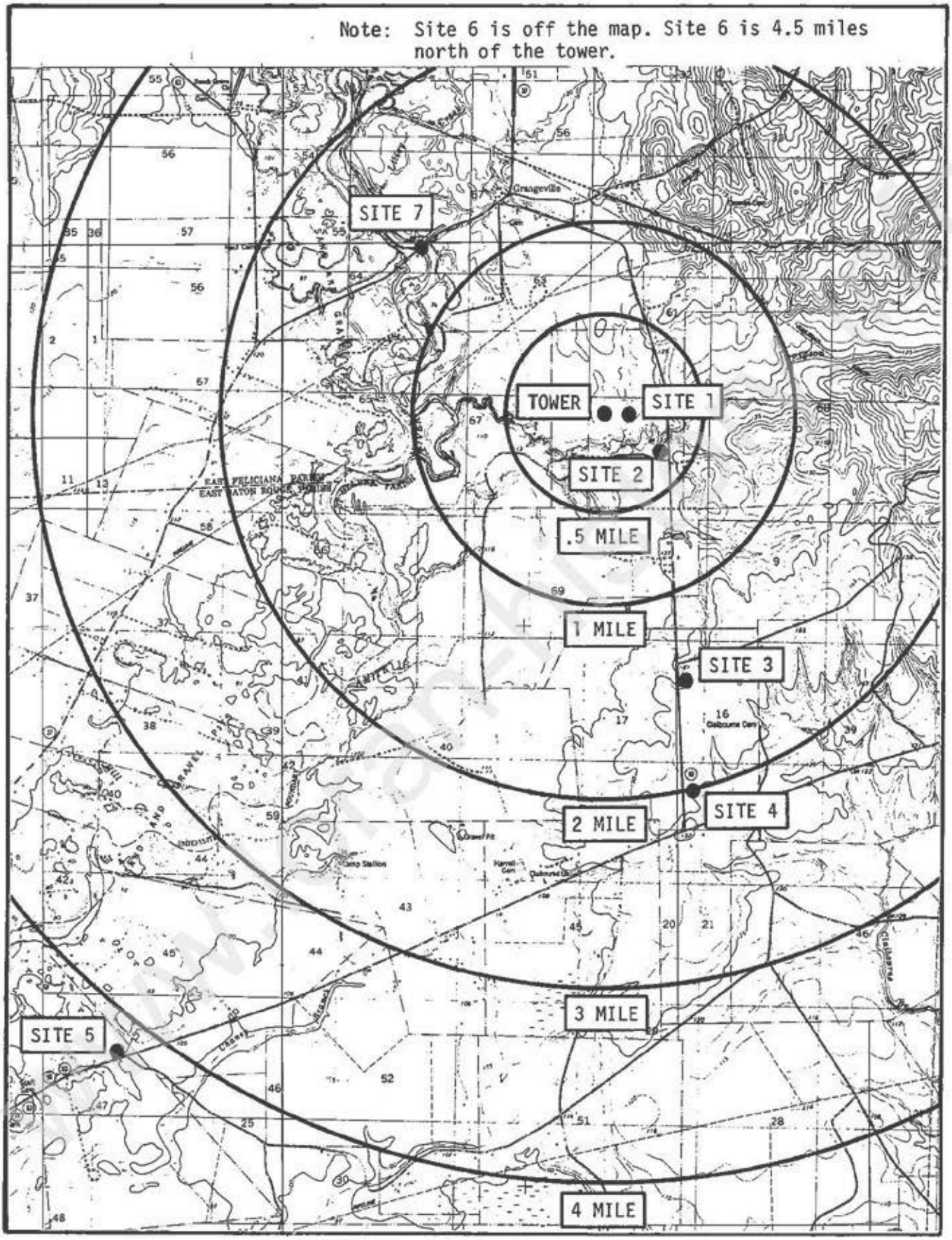


FIGURE 3-1. TEST SITE LOCATIONS

4. FREQUENCY DOMAIN MEASUREMENTS

4.1 MEASUREMENT TECHNIQUES

All frequency domain measurements were made with a van mounted instrumentation package designed for collecting this type of data. The major components of the system are shown in Figure 4-1.

Signals were sampled at 1 kHz increments in the range from 70 to 130 kHz by a Hewlett Packard (HP) 3585A spectrum analyzer. The spectrum analyzer was controlled by a HP86B computer with graphics capability. The computer calculated in-band and out-of-band radiated power percentages after sampling the spectrum.

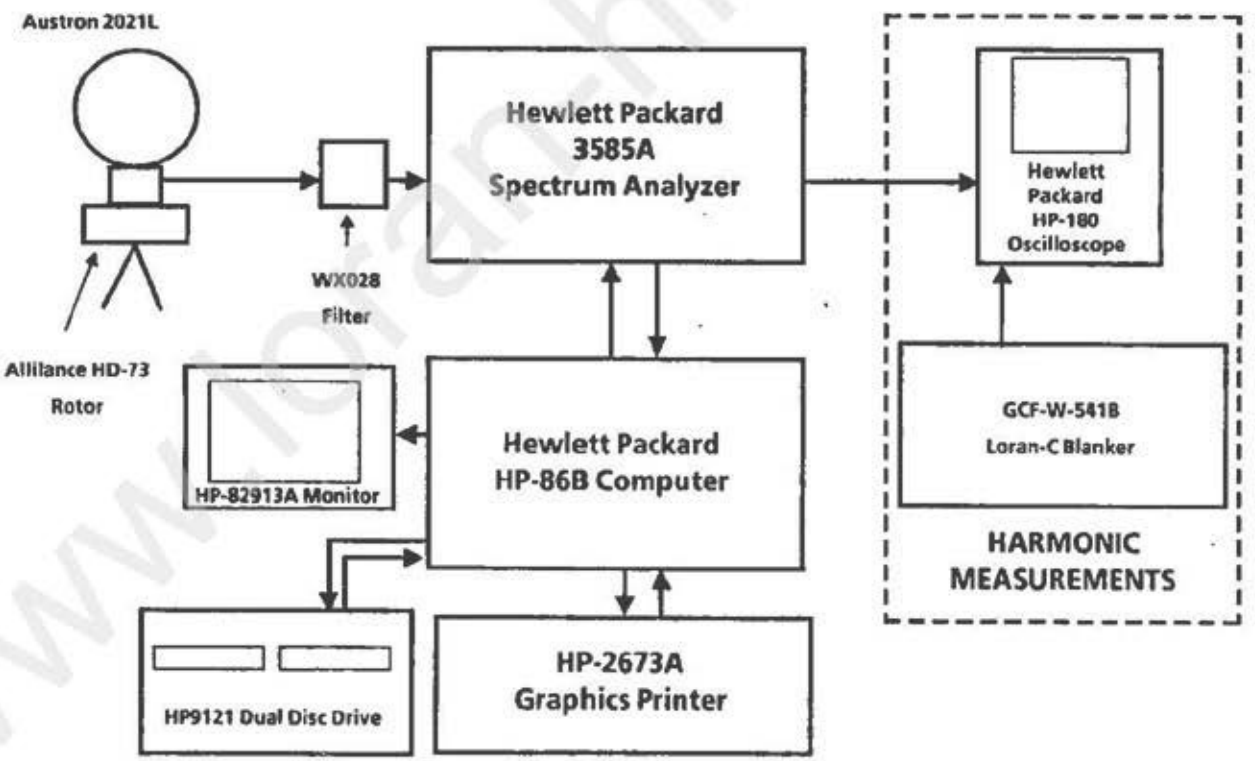


FIGURE 4-1. EQUIPMENT CONFIGURATION FOR MEASUREMENT OF FREQUENCY DOMAIN DATA

Harmonic radiation measurements were made by placing the spectrum analyzer in the manual mode and examining the intermediate frequency (IF) output for evidence of radiated LORAN-C energy at all harmonic frequencies. The IF output was analyzed by observing the energy present at each harmonic frequency on an oscilloscope triggered with the group repetition interval (GRI) of the station. Harmonic energy could be seen as characteristic LORAN-C pulse group patterns. A 100 kHz notch filter was inserted in the signal line from the antenna during harmonic measurements to prevent dynamic range signal overload in the spectrum analyzer circuitry from affecting the obtained data. Measurements of any extant near-band signals were also made and documented. The procedure for making these measurements is detailed in the DOT/LORSTA Seneca Test Report (DOT-TSC-CG337-PM-83-29).

4.2 LORAN-C SPECTRUM EVALUATION

The radiated spectrum from LORSTA Grangeville was slightly below the requirement for 99 percent of radiated energy to be contained in the 90 to 110 kHz band. Table 4-1 shows that the average in-band energy for Coupler 1 was 98.88 percent while that of Coupler 2 was 98.77 percent. The measurements for Coupler 1 were averaged over three remote sites and the Operations Building while those for Coupler 2 were averaged from three measurements, two with PATCO 2 and one with PATCO 1. The out-of-band radiated energy was balanced for Coupler 1 with 0.57 percent below 90 kHz and 0.56 percent above 100 kHz. Coupler 2 was unbalanced with most of the out-of-band energy below 90 kHz. Averaging all three measurements with Coupler 2 yields 0.73 percent below 90 kHz and 0.50 percent above 100 kHz. Examination of the data and spectrum photographs in Figures 4-2 through 4-9 shows good correlation between the data from all field sites. Comparison of the spectrum exhibited by Coupler 1 to Coupler 2 shows Coupler 2 slightly unbalanced.

RF spectrum measurements were recorded by the HP86B computer in the Operations Building and at Sites 1, 2 and 4. These data are presented in Figure 4-10 and the tabular data are contained in Table 4-2. Frequency domain data for all sites mentioned above are contained in Appendix A.

TABLE 4-1. LORSTA GRANGEVILLE SPECTRUM MEASUREMENTS, SIGNAL POWER DISTRIBUTION IN RANGE FROM 76 TO 124 kHz (C1P1, C2/P1, C2/P2)

Measurement Site	Date	COUPLER C1/P1 % of total power				COUPLER C2/P1 % of total power				COUPLER C2/P2 % of total power			
		Time	IN-BAND	Below 90 kHz	Above 110 kHz	Time	IN-BAND	Below 90 kHz	Above 110 kHz	Time	IN-BAND	Below 90 kHz	Above 110 kHz
Operations Building	05/14/85	12:50	98.77	0.78	0.45	13:29	98.76	0.78	0.46	16:58	98.73	0.80	0.47
0 1 Mile Site	05/15/85	15:34	98.87	0.57	0.56					14:09	98.82	0.58	0.60
Map Site 2	05/16/85	11:03	98.92	0.47	0.61								
Map Site 4	05/16/85	12:46	98.94	0.45	0.61								
Average			98.88	0.57	0.56		98.76	0.78	0.46		98.78	0.69	0.54

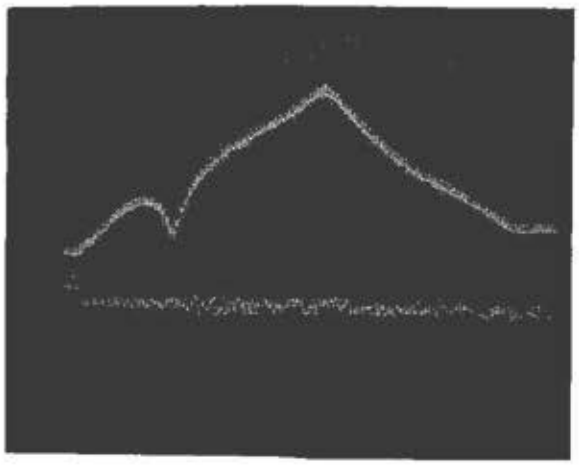


FIGURE 4-2. RF SPECTRUM FROM LORSTA GRANGEVILLE COUPLER 1 AT SITE 1, HORIZONTAL SCALE - 6 kHz/DIV

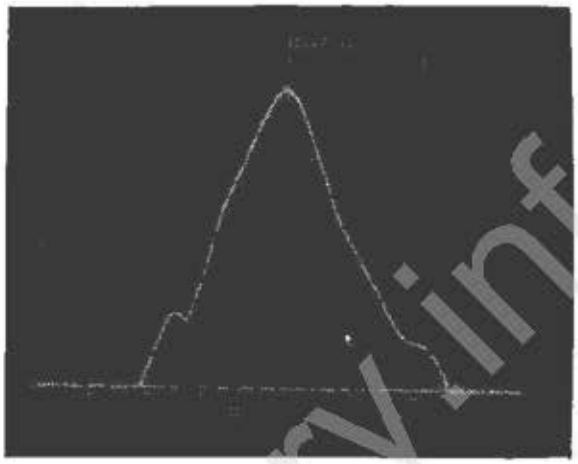


FIGURE 4-3. RF SPECTRUM FROM LORSTA GRANGEVILLE COUPLER 1 AT SITE 1, HORIZONTAL SCALE - 10 kHz/DIV

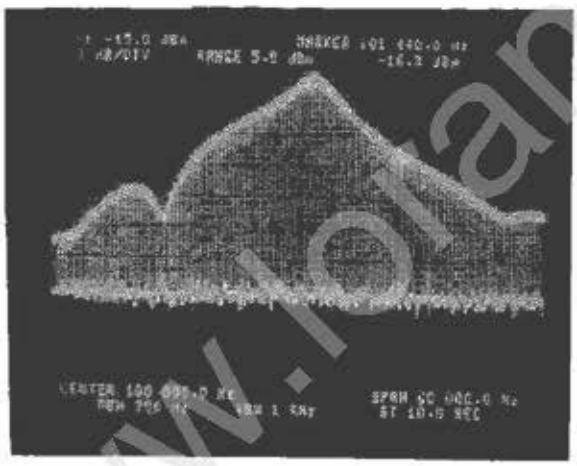


FIGURE 4-4. RF SPECTRUM FROM LORSTA GRANGEVILLE COUPLER 2 AT SITE 1, HORIZONTAL SCALE - 6 kHz/DIV

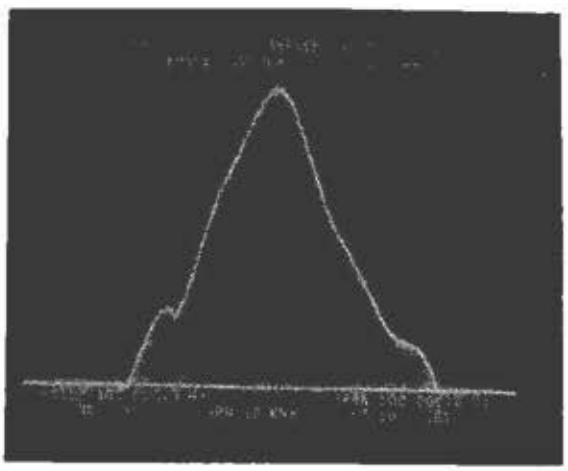


FIGURE 4-5. RF SPECTRUM FROM LORSTA GRANGEVILLE COUPLER 2 AT SITE 1, HORIZONTAL SCALE - 10 kHz/DIV

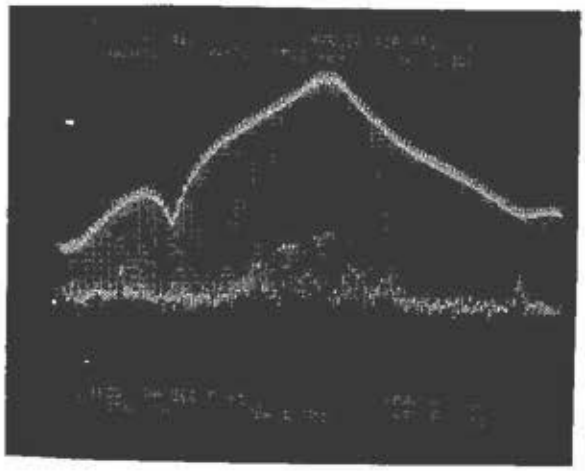


FIGURE 4-6. RF SPECTRUM FROM LORSTA GRANGEVILLE COUPLER 1 AT SITE 4, HORIZONTAL SCALE - 6 kHz/DIV

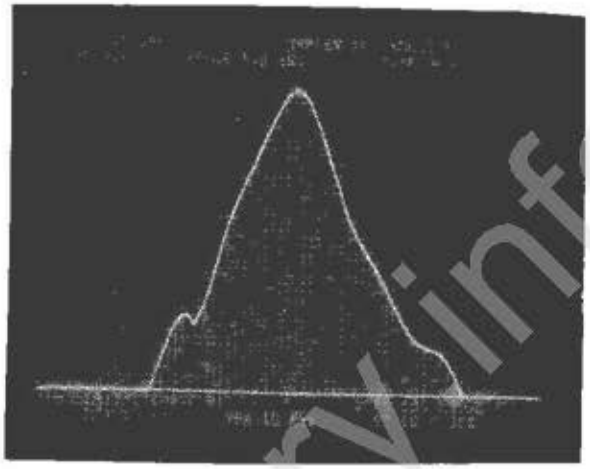


FIGURE 4-7. RF SPECTRUM FROM LORSTA GRANGEVILLE COUPLER 1 AT SITE 4, HORIZONTAL SCALE - 10 kHz/DIV

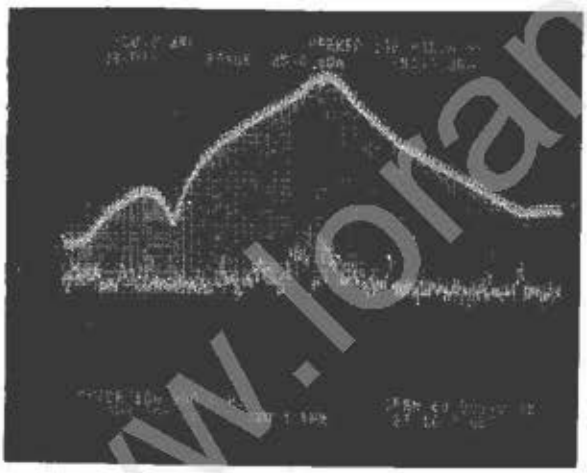


FIGURE 4-8. RF SPECTRUM FROM LORSTA GRANGEVILLE COUPLER 1 AT SITE 5, HORIZONTAL SCALE - 6 kHz/DIV

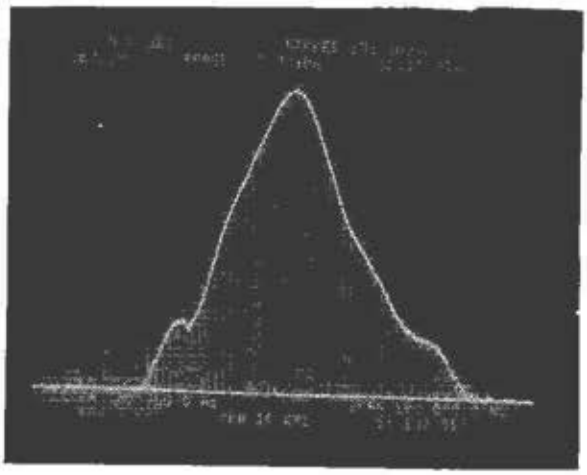


FIGURE 4-9. RF SPECTRUM FROM LORSTA GRANGEVILLE COUPLER 1 AT SITE 5, HORIZONTAL SCALE 10 - kHz/DIV

DOT/TSC SIGNAL SPECTRUM ANALYSIS

START TIME 15:35:44	END TIME 15:45:37	
MEASUREMENT ID	GC1/P1(5)15:34 MAY 15 1985	
IN-BAND POWER		98.87%
OUT-OF BAND POWER	(HIGH SIDE)	.56:
OUT-OF-BAND POWER	(LOW SIDE)	.57%

RF SIGNAL POWER (76 TO 124 kHz)
MEDIAN FREQUENCY 100.6240 KILOCYCLES

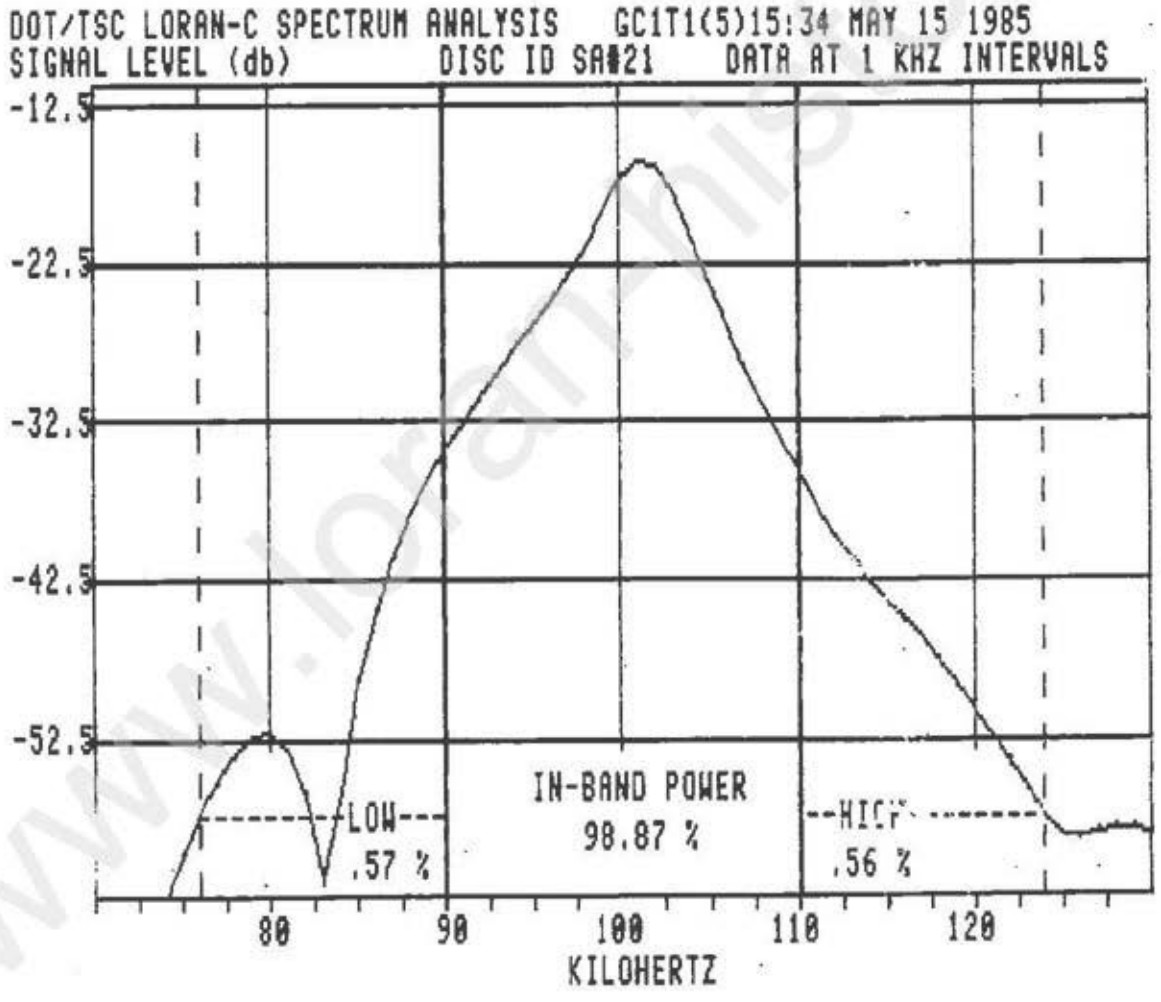


FIGURE 4-10. RF SPECTRUM FROM LORSTA GRANGEVILLE COUPLER 1 SITE 1 AS RECORDED BY HP86B COMPUTER

TABLE 4-2. RF SPECTRUM FROM LORSTA GRANGEVILLE COUPLER 1 ON STATION

DOT/TSC SIGNAL SPECTRUM ANALYSIS 86/19

DISC ID SA#21

FILE NO 5

MEASUREMENT ID GC1/P1(5)15:34 MAY 15 1985

MEASUREMENT AT SITE 1

SIGNAL SOURCE LOOP

OBSERVED DATA

CTR. FREQ. (kHz)	CTR. SAMPLE VALUE	FREQ. (kHz)	SAMPLE VALUE	FREQ. (kHz)	SAMPLE VALUE	START TIME
100	-17.10	101	-16.15	99	-19.26	15:35:44
		102	-16.43	98	-21.46	
		103	-18.15	97	-23.23	
		104	-21.06	96	-24.77	
		105	-23.87	95	-26.37	
		106	-26.37	94	-27.78	
		107	-28.92	93	-29.36	
		108	-31.29	92	-30.97	
		109	-33.41	91	-32.57	
		110	-35.60	90	-34.25	
		111	-37.50	89	-36.10	
		112	-39.31	88	-38.38	
		113	-41.01	87	-41.11	
		114	-42.42	86	-44.46	
		115	-43.74	85	-48.91	
		116	-44.94	84	-55.63	
		117	-46.19	83	-61.32	
		118	-47.59	82	-55.85	
		119	-49.07	81	-53.06	
		120	-50.82	80	-52.20	
		121	-52.34	79	-52.44	
		122	-53.90	78	-53.46	
		123	-55.57	77	-54.97	
		124	-57.21	76	-57.11	
		125	-58.52	75	-59.74	
		126	-58.66	74	-62.58	
		127	-58.22	73	-65.27	
		128	-57.92	72	-67.60	
		129	-57.97	71	-68.44	
100	-17.25	130	-58.30	70	-68.75	

STOP TIME 15:45:37

4.3 RADIATED HARMONIC SIGNALS

Radiated harmonic frequency levels were measured at Site 1. The results are tabulated in Table 4-4. The tabulated results indicate that the harmonics were, in general, more than 80 dB below the signal level at 100 kHz. The one notable exception was the third harmonic which measured 63.7 and 64.3 dB down for Coupler 1 and Coupler 2, respectively.

4.4 BROADBAND SPECTRUM EVALUATION

The frequency band from 200 to 1200 kHz was examined to determine if spurious LORAN-C transmissions were present. LORAN-C spurious signals are identified by using rapid scan rates of 5 to 10 seconds. At these scan rates, LORAN-C energy appears as a "comb" signal rather than as a single envelope as AM radio stations do. At Ring Road, continuous LORAN-C emissions were observed throughout this band, at a level approximately 90 dB down. There was a higher concentration at 300 kHz. There also were sporadic LORAN-C emissions at Site 4, most of them being at least 95 dB below peak pulse. Examples of the spectrum at Ring Road and at Site 4 are presented in Figures 4-11 and 4-12.

4.5 INTERFERENCE

In the 70 to 130 kHz band RF interference in or near the LORAN-C band is detected by using fast scan rates between 5 and 10 seconds on the spectrum analyzer. No interfering frequencies were detected.

TABLE 4-3. LORSTA GRANGEVILLE RADIATED HARMONIC SIGNAL LEVELS

HARMONIC FREQUENCY (kHz)	0.1 MILE SITE COUPLER 1 (dB)	0.1 MILE SITE COUPLER 2 (dB)
200	-84.10	-84.50
300	-63.70	-64.30
400	-92.35	-90.60
500	-81.55	-84.20
600	-91.60	-89.55
700	-89.75	-92.60
800	-94.00	-92.30
900	-92.00	-94.20
1000	-87.75	-90.10

Harmonic signal levels are referenced to the fundamental at 100 kHz

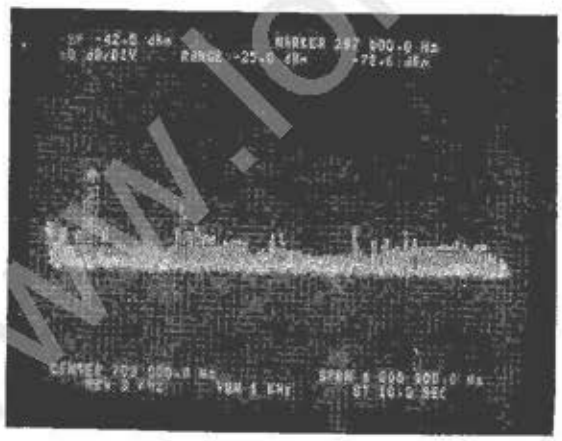


FIGURE 4-11. BROADBAND RF SPECTRUM FROM LORSTA GRANGEVILLE COUPLER 2 AT SITE 1

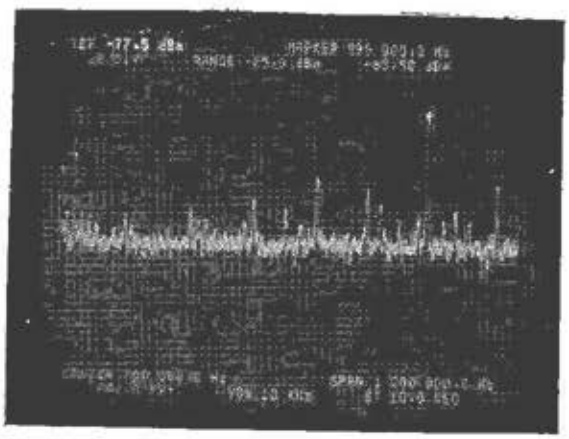


FIGURE 4-12. BROADBAND RF SPECTRUM FROM LORSTA GRANGEVILLE COUPLER 1 AT SITE 4

5. TIME DOMAIN MEASUREMENTS

5.1 MEASUREMENT TECHNIQUES

5.1.1 Equipment Description

The equipment configuration used to measure the time domain parameters of the radiated LORAN-C pulses is illustrated in Figure 5-1. The HP5180A waveform recorder is the primary equipment in this setup and is used to sample, digitize and store data on input analog signals. The sample window of the HP5180A is 10 nsec wide and the minimum sample spacing is 50 nsec. At LORSTA Grangeville, a sample interval of 200 nsec was used. This sample rate provides 25 samples per half-cycle and provides an accurate reconstruction of the LORAN-C pulse for analysis.

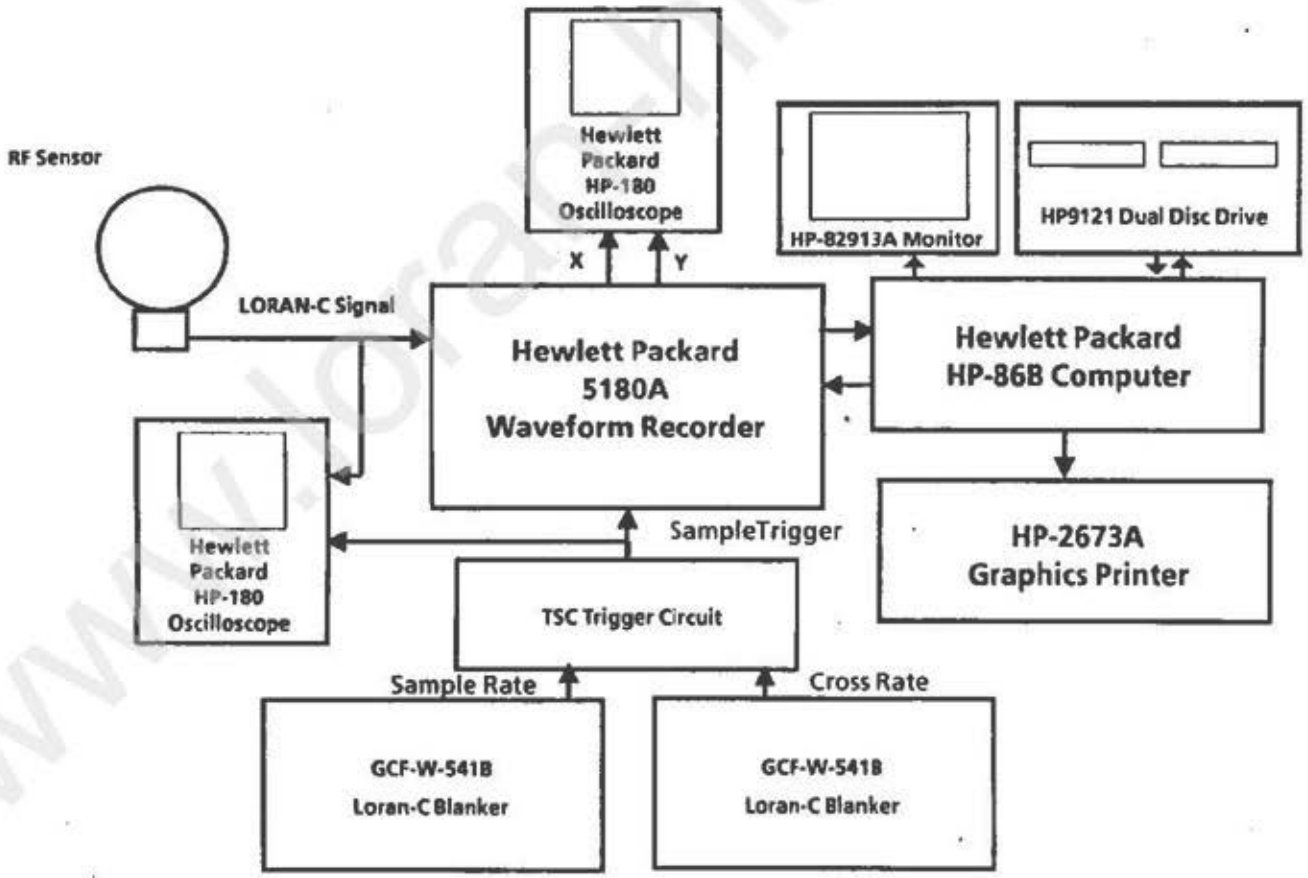


FIGURE 5-1. EQUIPMENT CONFIGURATION FOR MEASUREMENT OF TIME DOMAIN DATA

A stable sampling trigger is generated by one Coast Guard-provided cross rate blanker (LORAN-C rate generators). This trigger can be adjusted in time to allow sampling to begin on any pulse for either phase code interval. The data are then transferred to tape storage by the HP86B computer.

5.1.2 Data Collected

Pulse waveform data collected at LORSTA Grangeville are listed in Table 5-1. Data were collected from the antenna current transformer in the Operations Building and with a loop antenna at Site 1. Since U.S. Coast Guard Commandant's Instruction "Specification of the Transmitted LORAN-C Signal" (COMDTINST M16562.4) states that station performance is measured using the antenna current waveform, all analysis was done using this signal.

5.1.3 Data Analysis and Display

The pulse samples were analyzed by a special processing program written for the HP86B computer. After data has been collected on a pulse, the program first estimates a zero signal level, adjusts all values to this reference, converts stored digital values to volts, and provides a plot similar to that shown in Figure 5-2. The program then identifies the cycle zero crossing at 30 μsec, locates 5 cycle-zero crossings before this point and 6 cycle zero crossings after it, establishes the exact relative time of each zero crossing and displays the results in tabular form similar to that shown in Figure 5-3. The zero crossing data are then reformatted into graphical form in a curve similar to Figure 5-4. The zero-crossing tolerance established by the Coast Guard for LORSTA Grangeville are superimposed on the graphs.

The analysis program then computes an effective Envelope-to-Cycle Difference (ECD) using a standard Coast Guard algorithm published in Coast Guard Electronic Engineering Center (EECEN) project W08990-A4 -- Interim Report 1. The ECD value is used to compute the expected peak pulse value and the RMS ensemble error of the individual half-cycle peak values compared to the calculated half-cycle peak values. All of this data, as well as effective pulse carrier frequency and pulse-to-pulse offset values, are summarized in tables similar to Table 5-2, which shows results for Coupler 1.

TABLE 5-1. PULSE WAVEFORM RECORDS COLLECTED AT LORSTA GRANGEVILLE FOR TIME DOMAIN ANALYSIS

SITE	SIGNAL SOURCE	TRANSMITTER	GRI	INTERVAL	PULSE #
ON STATION	PEARSON CURRENT TRANSFORMER	C1P1	7980	A	12345678
			7980	B	12345678
			7980		16 GRI, PULSE 2
		C1P2	7880	A	12345678
			7980	B	12345678
		C2P2	7980	A	12345678
			7980	B	12345678
			7980		16GRI, PULSE8
0.1 MILE	AUSTRON 2041 LOOP ANTENNA	C2P2	7980	A	12345678
			7980		
			7980	B	12345678
			7980		16GRI, PULSE7
		C1P1	7980	A	12345678
			7980	B	12345678
			7980		16 GRI, PULSE 8

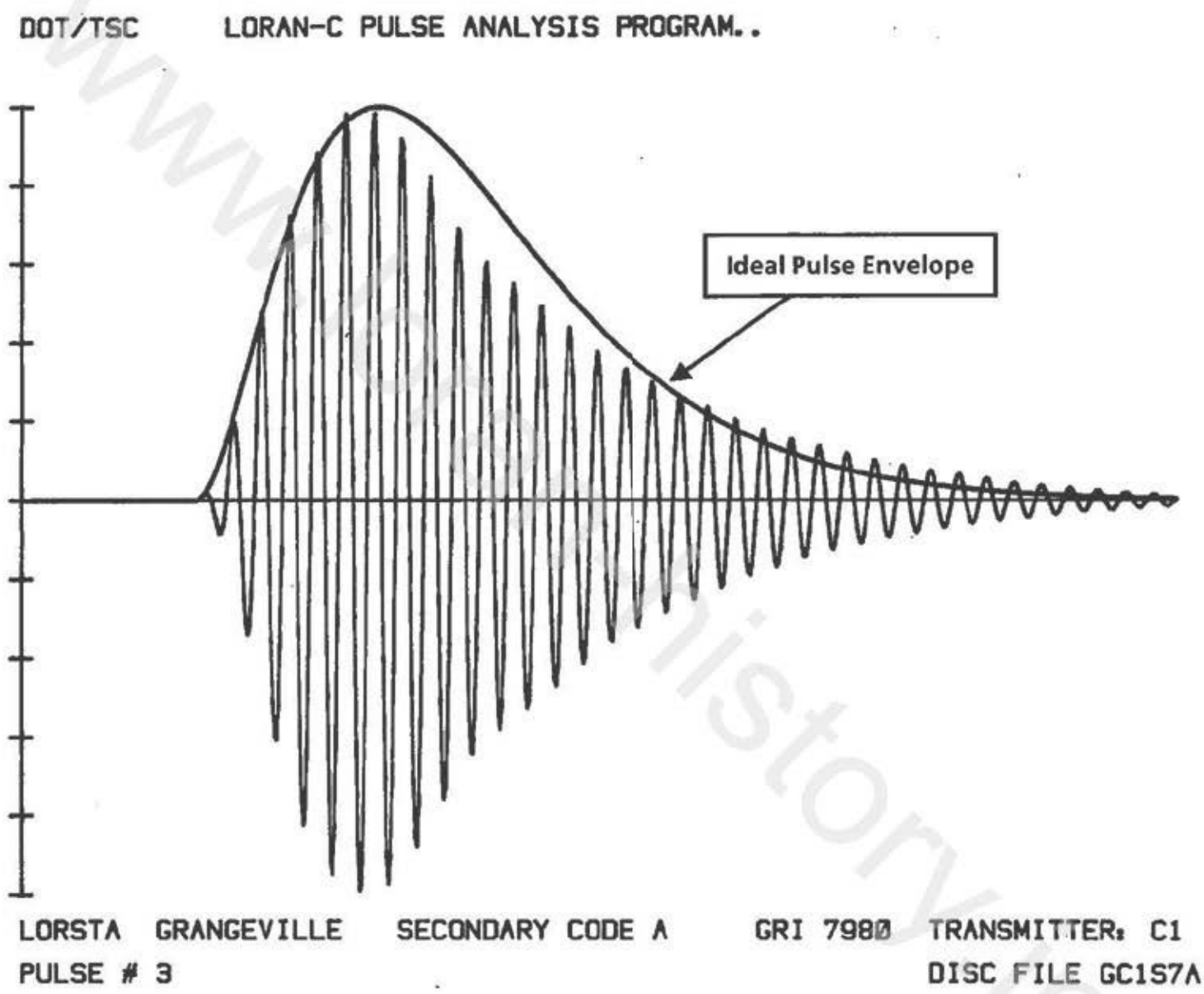


FIGURE 5-2. COMPUTER GENERATED PLOT OF DIGITIZED LORAN-C PULSE

TABLE 5-2. TABULATED HALF ZERO CROSSING TIMES FOR C2/P2 ON STATION

ZERO CROSSINGS LOCATION	TIME(MICROSECONDS)	DIF(nanosec.)
525.69	4.68	324.64
551.57	9.85	149.05
576.97	14.93	69.02
602.18	19.97	26.96
627.28	24.99	6.84
652.31	30.00	0.00
677.31	35.00	-.77
702.33	40.00	-2.86
727.28	44.99	5.42
752.30	50.00	3.10
777.27	54.99	9.08
802.27	59.99	8.76
827.27	64.99	9.11
852.30	70.00	2.01
877.28	74.99	5.49
902.23	79.98	17.09
926.97	84.93	68.41

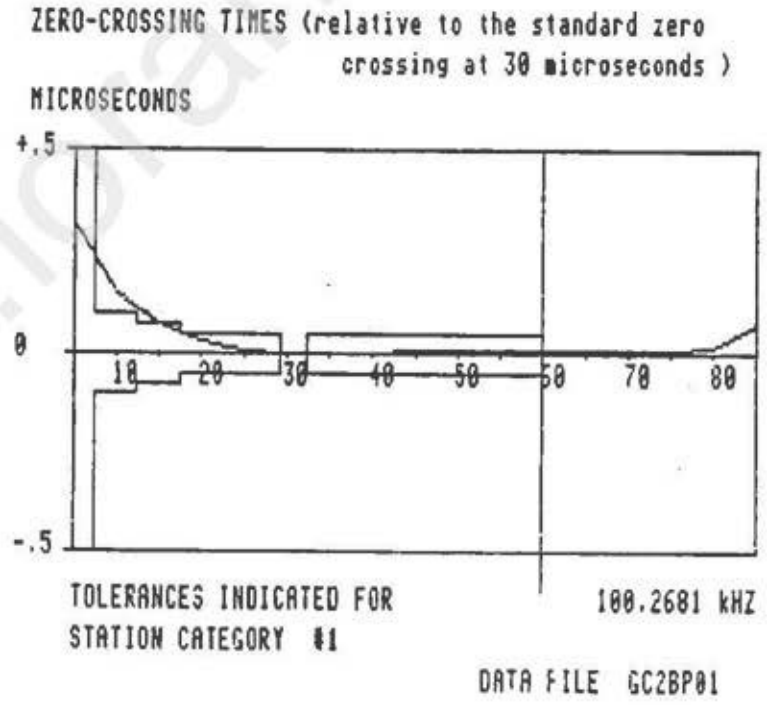


FIGURE 5-3. LORAN-C PULSE ZERO CROSSING ERRORS PLOTTED BY THE HP86B COMPUTER FOR THE SAMPLED RF SIGNAL

TABLE 5-3. REPRESENTATIVE PULSE WAVEFORM RESULTS FOR LORSTA GRANGEVILLE COUPLER 1

SITE	SIGNAL SOURCE	TRANSMITTER	GRI	INTERVAL
STATION	Current Transformer	C1/P1	7890	A

PULSE #	PHASE CODE	ECD microseconds	PULSE PEAK		Half Cycle Peak Errors in %			EFFECTIVE CARRIER FREQUENCY kHZ	PULSE to PULSE OFFSET nanoseconds	N*
			Measured	Computed	Ens	1-8	9-13			
1	+	-0.057	0.962	1.025	0.33	0.6≤	5.8≤	100.181	0.0	*
2	+	-0.104	0.978	1.038	0.36	0.6≤	5.7≤	100.163	-105.55	*
3	+	-0.080	0.978	1.040	0.34	0.5≤	5.6≤	100.165	-122.45	*
4	+	-0.012	0.980	1.043	0.38	0.7≤	5.9≤	100.178	-131.87	*
5	+	-0.073	0.979	1.042	0.35	0.6≤	5.7≤	100.151	0.00	*
6	-	-0.054	0.979	1.043	0.50	0.8≤	4.8≤	100.156	-2.67	85
7	-	-0.017	0.978	1.044	0.37	0.5≤	5.0≤	100.151	-12.93	85
8	+	-0.002	0.981	1.046	0.28	0.5≤	6.1≤	100.160	-26.02	*
	Overall Avg:	0.065								
	+ Code	-0.067								
	-Code	-0.059	Droop = 1.990%							

N is defined as the nominal zero crossing interval (in microseconds) after which pulse zero crossings exceed the 50 nsec limit.
* = WITHIN TOLERANCES

TABLE 5-4. PULSE WAVEFORM RESULTS FOR 16 CONSECUTIVE PULSE OBSERVATIONS COUPLER 1

SITE	SIGNAL SOURCE	TRANSMITTER	GRI	PULSE #
Station	Pearson Current Transformer	Coupler 1	7980	2

PULSE #	PHASE CODE	ECD microseconds	PULSE PEAK		Half Cycle Peak Errors in %			EFFECTIVE CARRIER FREQUENCY kHZ
			measured	computed	Ens	1-8	9-13	
1	+	-0.023	0.977	1.040	0.36	0.5≤	5.7≤	100.15
2	-	-0.044	-0.967	1.031	0.41	0.6≤	5.0≤	100.14
3	+	-0.017	0.978	1.042	0.33	0.6≤	6.0≤	100.16
4	-	-0.077	0.967	1.031	0.45	0.7≤	4.9≤	100.15
5	+	-0.050	0.977	1.040	0.37	0.5≤	5.7≤	100.15
6	-	-0.073	0.967	1.030	0.42	0.6≤	4.9≤	100.14
7	+	-0.053	0.977	1.041	0.34	0.7≤	5.9≤	100.15
8	-	-0.047	-0.965	1.033	0.43	0.7≤	5.3≤	100.15
9	+	-0.037	0.975	1.041	0.39	0.7≤	5.9≤	100.14
10	-	-0.062	0.965	1.032	0.43	0.7≤	5.2≤	100.14
11	+	0.035	0.977	1.040	0.31	0.6≤	6.0≤	100.15
12	-	-0.076	0.965	1.031	0.44	0.7≤	5.2≤	100.16
13	+	-0.008	0.977	1.042	0.35	0.5≤	6.0≤	100.16
14	-	-0.084	0.967	1.032	.0.40	0.6≤	5.0≤	100.15
15	+	-0.075	0.977	1.038	0.35	0.6≤	5.6≤	100.16
16	-	-0.110	0.969	1.028	0.47	0.7≤	4.5≤	100.16
	Overall Avg:	-0.545	0.7305					100.149
	+ Code Avg:			Droop = 1.33%				

N* is defined as the nominal zero crossing interval (in microseconds) after which pulse zero crossings exceed the 100 nanosecond limit.

5.1.4 Radiated Signal Standards

All data collected at LORSTA Grangeville were compared to the standards established by the U.S. Coast Guard for that station. These standards are contained in COMDTINST M16562.4.

5.2 MEASUREMENT RESULTS

5.2.1 General

The time domain data measured at LORSTA Grangeville are presented in the order in which the data standards are published in COMDINST M16562.4. Significant variations from the specified values are noted. Individual tables for each data set are contained in Appendix B.

5.2.2 Half-Cycle Peak Amplitude

5.2.2.1 Ensemble Tolerance - (Standard requires RMS ensemble errors of the radiated pulse to be less than or equal to 1 percent.)

All pulses measured were well within the specified tolerance.

5.2.2.2 Individual Half Cycle Tolerance - (Standard requires halfcycles 1 through 8 of the radiated pulses to be less than or equal to 3 percent and half cycles 9 through 13 to less than or equal to 10 percent.)

The transmitter was well within the 3 percent specification on the first 8 half-cycles and the 10 percent specification on half-cycles 9 through 13.

5.2.2.3 Pulse Trailing Edge - (Standard requires pulse trailing edge to be less than or equal to .0014A for all pulse times greater than 500 μsec, where A is the peak-pulse value.)

Examination of the trailing edge of the pulse for the combinations P1/C1 and P2/C2 were made at Site 1. Pulse 2, for P1/C1 measured 0.00142 while all others were in tolerance.

5.2.2.4 Zero Crossing Times and Tolerances - (Specification requires different error values for each half-cycle from 30 μsec to 60 μsec. Beyond 60 μsec, the zero crossings are required to conform to 100 kHz $\pm$ 1 kHz.)

The half-cycle zero crossings at 10 μsec were above the specified 100 nsec for all combinations. All pulses for C2/P2 were out of specification an average of 37.93 nsec. C1/P1 had pulses 1, 2, 4 and 7 offset from the specification by an average of 18.33 nsec. C2/P1 was the combination closest to the specified limits with pulses 1, 2, 5 and 7 out of specification an average of 5.73 nsec. The frequency of the zero crossings beyond 60 sec was well within the 1 kHz specification limit.

5.2.3 Uniformity of Pulses within a Group

5.2.3.1 Pulse-to-Pulse Amplitude Tolerance - (The Specification calls for the amplitude of the smallest pulse to be within 5 percent of the amplitude of the largest pulse within a group.)

The transmitter was well within the specified 5 percent with the largest difference being less that 2.26 percent in any one group.

5.2.3.2 Pulse-to-Pulse ECD Tolerance - (The specification calls for each pulse within a group to be within 0.5 sec of all pulses in group A and group B.)

All pulses measured were within 0.147 sec of all pulses in group A and group B.

5.2.3.3 Pulse-to-Pulse Timing Tolerance - (Pulse 2 through 8 must satisfy the relationship (N-1) 1000 sec $\pm$ 25 nsec, where N is the pulse number.)

Pulses 2 through 4 for all combinations failed this specification. They were offset by a mean value of 117.22 nsec. Pulse 8 also failed for all combinations. It was offset by a mean value of 44.86 nsec. Pulse 7 of C1/P1 measured 75.98 nsec, 50.98 nsec above the allowed offset.

5.2.4 Uniformity of Pulses within Different GRI

Measurements were made of 3 different 16 pulse sequences to observe what variations were exhibited by the Couplers in successive GRI. The result for P2/C1 as observed at the Operations Building are shown in Table 5-3. Over the 16 GRI sample, ECD varied within a range of 0.102 μsec, with an average of -0.0545 μsec. Droop was 1.33 percent for the same sample. Variations of all pulses were within established specifications. Similar results were obtained with Coupler 2.

6. DISCUSSION OF OBSERVATION AND SUMMARY OF RESULTS

6.1 FREQUENCY DOMAIN RESULTS

6.1.1 General

Data of excellent quality were obtained at the Operations Building and at seven field sites, where the data collected were generally well correlated. All of the equipment functioned normally and the results obtained represent a good picture of the signal being radiated by LORSTA Grangeville. The frequency data are contained in Appendix B.

6.1.2 Radiated Spectrum

The radiated spectrum at LORSTA Grangeville was slightly below the requirement for maintaining 99 percent of the radiated energy in the 90 to 100 kHz band. Computations of in-band power produced a seven site average of 98.83 percent in-band for both Couplers. Out-of-band components for Coupler 1 were balanced below 90 and above 110 kHz and exceeded the 0.5 percent limit. Coupler 2 was unbalanced with most of the out-of-band energy below 90 kHz. The out of band energy below 90 kHz for Coupler 2 also exceeded the 0.5 percent limit. The radiated spectrum was centered slightly above 100 kHz.

6.1.3 Harmonics

The harmonic content of the radiated signal was very low. Harmonics from both Couplers were similar, with the third harmonic under 60 dB down from the peak. All other harmonics were at least 80 dB below the pulse peak.

6.1.4 Spurious Emissions

The broadband spectrum measurements from 200 to 1200 kHz showed continuous LORAN-C emissions 90 dB down at Ring Road with a high concentration at 300 kHz. There were also sporadic emissions at Site 4, all of them being at least 95 db below the pulse peak.

6.2 TIME DOMAIN MEASUREMENTS

6.2.1 General

Measurement of all eight pulses for sufficient combinations of the two Couplers and the two PATCOs was necessary because change of either a PATCO or a Coupler can affect time domain data. The complete set required sampling 24 pulses.

The time domain measurements at LORSTA Grangeville did not produce any surprises. With the exception of some cycle zero crossings and one pulse trailing edge, all data was within specification.

6.2.2 Pulse Waveform Evaluation

6.2.2.1 Pulse trailing edge - The pulse trailing edge for C1/P2 measured 0.00002 above the 0.0014 limit. All other pulses were within specification.

6.2.2.2 Half-Cycles within a Pulse - The data show the transmitter to be within tolerance for all half-cycles except for those at 10 μ sec which exceeded the 100 nsec offset allowance by a mean error of 10 nsec.

6.2.2.3 Pulses within a group - All measured pulses were well within the specified tolerance for pulse-to-pulse amplitude and ECD. Pulses 2 through 4 did not meet the timing tolerance specifications for all combinations. They were offset by an mean value of 117.22 nsec.

APPENDIX A
FREQUENCY DOMAIN DATA COLLECTED AT LORSTA GRANGEVILLE FROM 14 TO 16 MAY 1985

DOT/TSC SIGNAL SPECTRUM ANALYSIS 86/19

DISC ID SA#21

FILE NO 1

MEASUREMENT ID GC1/P1(1) 12:49 MAY 14 1985

MEASUREMENT AT STATION

SIGNAL SOURCE DIRECT

OBSERVED DATA

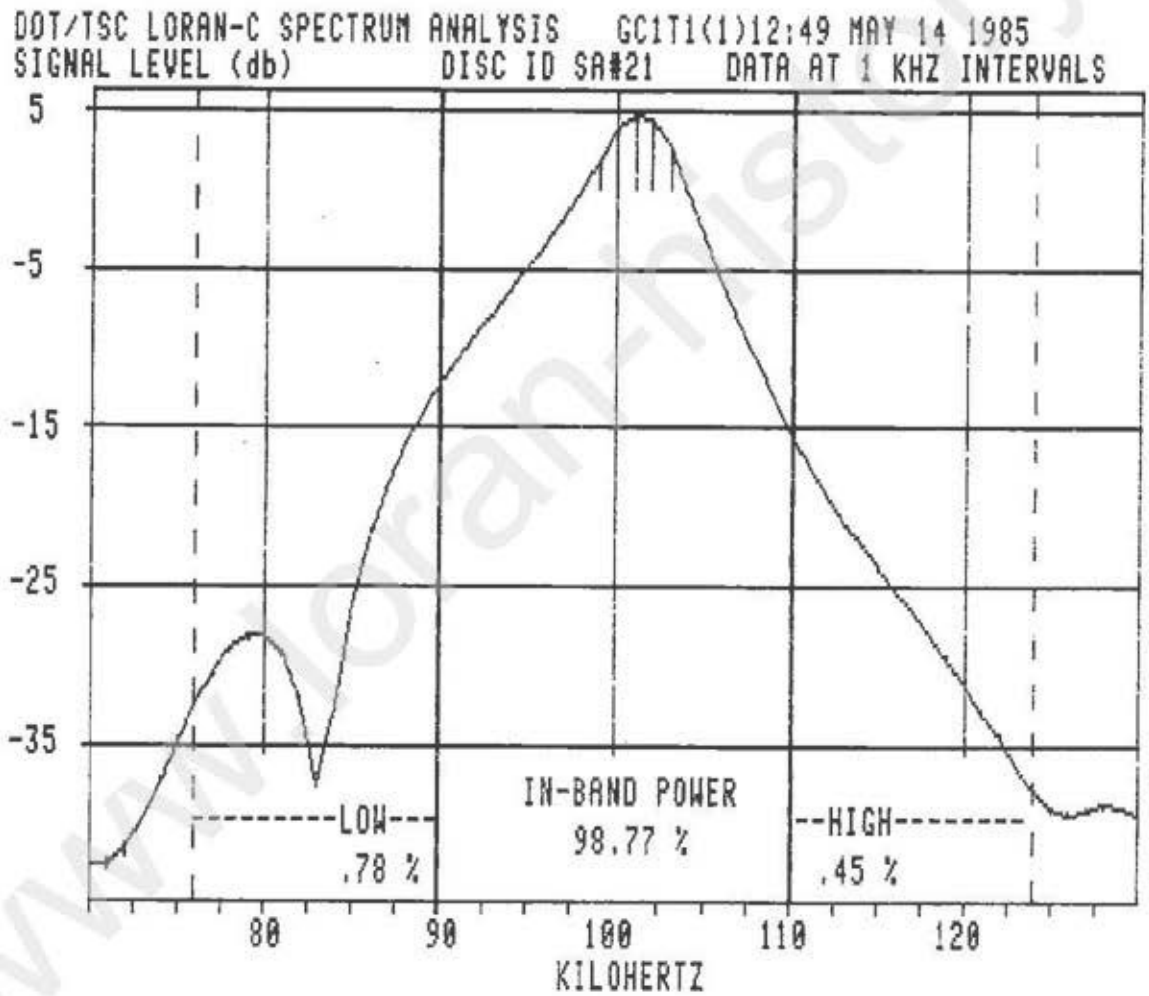
CTR. FREQ. (kHz)	CTR. SAMPLE VALUE	FREQ. (kHz)	SAMPLE VALUE	FREQ. (kHz)	SAMPLE VALUE	START TIME
100	3.89	101	4.81	99	2.00	12:50:57
		102	4.41	98	0.00	
		103	2.60	97	-1.71	
		104	-.21	96	-3.21	
		105	-3.21	95	-4.72	
		106	-5.92	94	-6.12	
		107	-8.47	93	-7.52	
		108	-10.83	92	-8.93	
		109	-13.10	91	-10.43	
		110	-15.34	90	-12.04	
		111	-17.27	89	-13.94	
		112	-19.15	88	-16.01	
		113	-20.84	87	-18.45	
		114	-22.26	86	-21.54	
		115	-23.81	85	-25.97	
		116	-25.17	84	-32.63	
		117	-26.51	83	-37.64	
		118	-28.06	82	-32.21	
		119	-29.54	81	-29.22	
		120	-31.23	80	-28.20	
		121	-32.93	79	-28.20	
		122	-34.53	78	-29.00	
		123	-36.32	77	-30.50	
		124	-37.84	76	-32.47	
		125	-39.11	75	-34.76	
		126	-39.39	74	-37.30	
		127	-39.15	73	-39.77	
		128	-38.82	72	-41.69	
		129	-38.97	71	-42.59	
100	3.80	130	-39.43	70	-42.55	

STOP TIME 13:00:51

DOT/TSC SIGNAL SPECTRUM ANALYSIS

START TIME 12:50:57	END TIME 13:00:51	
MEASUREMENT ID	GC1/P1(1)12:50 MAY 14 1985	
IN-BAND POWER		98.77%
OUT-OF BAND POWER	(HIGH SIDE)	.45%
OUT-OF-BAND POWER	(LOW SIDE)	.78%

RF SIGNAL POWER (76 TO 124 kHz)
MEDIAN FREQUENCY 100.5117 KILOCYCLES



DOT/TSC SIGNAL SPECTRUM ANALYSIS 86/19

DISC ID SA#21

FILE NO 5

MEASUREMENT ID GCI/P1(5)15:34 MAY 15 1985

MEASUREMENT AT SITE 1

SIGNAL SOURCE LOOP

OBSERVED DATA

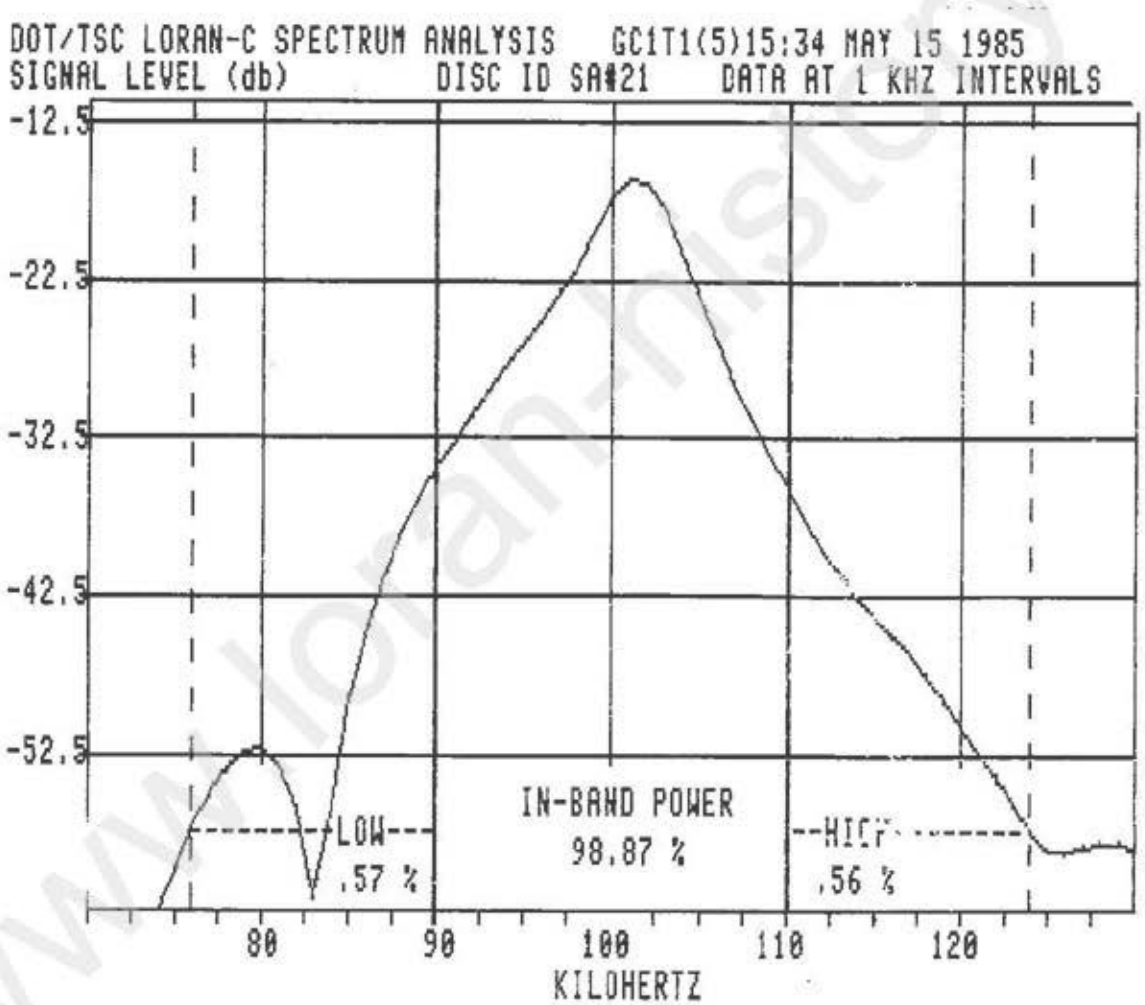
CTR. FREQ. (kHz)	CTR. SAMPLE VALUE	FREQ. (kHz)	SAMPLE VALUE	FREQ. (kHz)	SAMPLE VALUE	START TIME
100	-17.10	101	-16.15	99	-19.26	15:35:44
		102	-16.43	98	-21.46	
		103	-18.15	97	-23.23	
		104	-21.06	96	-24.77	
		105	-23.87	95	-26.37	
		106	-26.37	94	-27.78	
		107	-28.92	93	-29.36	
		108	-31.29	92	-30.97	
		109	-33.41	91	-32.57	
		110	-35.60	90	-34.25	
		111	-37.50	89	-36.10	
		112	-39.31	88	-38.38	
		113	-41.01	87	-41.11	
		114	-42.42	86	-44.46	
		115	-43.74	85	-48.91	
		116	-44.94	84	-55.63	
		117	-46.19	83	-61.32	
		118	-47.59	82	-55.85	
		119	-49.07	81	-53.06	
		120	-50.82	80	-52.2(	
		121	-52.34	79	-52.44	
		122	-53.90	78	-53.46	
		123	-55.57	77	-54.97	
		124	-57.21	76	-57.11	
		125	-58.52	75	-59.74	
		126	-58.66	74	-62.58	
		127	-58.22	73	-65.27	
		128	-57.92	72	-67.60	
		129	-57.97	71	-68.44	
100	-17.25	130	-58.30	70	-68.75	

STOP TIME 15:45:37

DOT/TSC SIGNAL SPECTRUM ANALYSIS

START TIME 15:35:44	END TIME 15:45:37	
MEASUREMENT ID	GC1/P1(5)15:34 MAY 15 1985	
IN-BAND POWER		98.87%
OUT-OF BAND POWER	(HIGH SIDE)	.56:
OUT-OF-BAND POWER	(LOW SIDE)	.57%

RF SIGNAL POWER (76 TO 124 kHz)
MEDIAN FREQUENCY 100.6240 KILOCYCLES



DOT/TSC SIGNAL SPECTRUM ANALYSIS 86/19

DISC ID SA#21

FILE NO 6

MEASUREMENT ID GC1/P1(6)11:03 MAY 16 1985

MEASUREMENT AT SITE 2

SIGNAL SOURCE LOOP

OBSERVED DATA

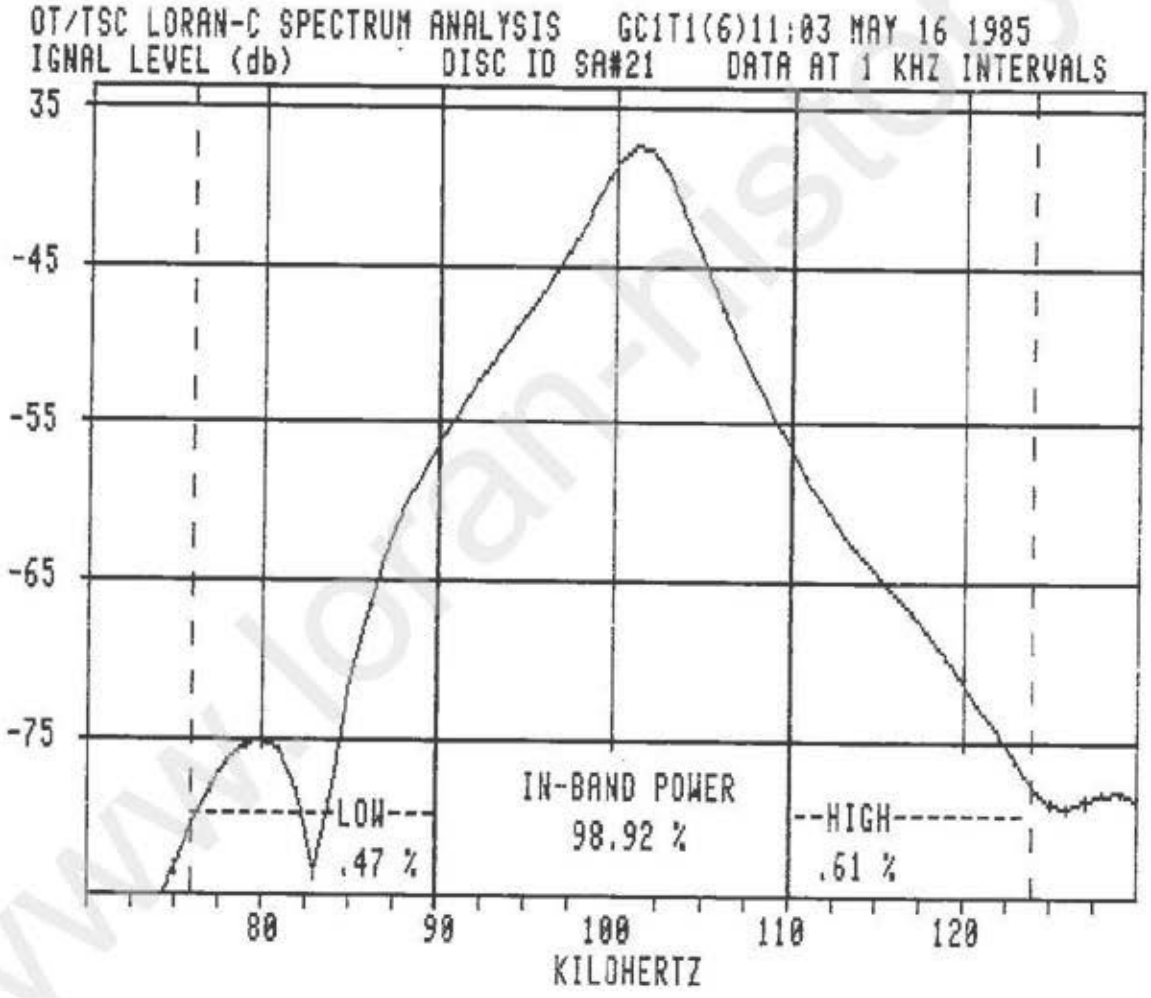
CTR. FREQ. (kHz)	CTR. SAMPLE VALUE	FREQ. (kHz)	SAMPLE VALUE	FREQ. (kHz)	SAMPLE VALUE	START TIME
100	-38.51	101	-37.40	99	-40.51	11:04:40
		102	-37.60	98	-42.82	
		103	-39.31	97	-44.62	
		104	-42.01	96	-46.33	
		105	-44.92	95	-47.93	
		106	-47.45	94	-49.43	
		107	-49.94	93	-51.02	
		108	-52.30	92	-52.64	
		109	-54.45	91	-54.37	
		110	-56.55	90	-56.21	
		111	-58.44	89	-58.16	
		112	-60.14	88	-60.46	
		113	-61.77	87	-63.27	
		114	-63.17	86	-66.70	
		115	-64.55	85	-71.27	
		116	-65.72	84	-77.91	
		117	-66.94	83	-83.69	
		118	-68.42	82	-78.43	
		119	-69.79	81	-75.74	
		120	-71.41	80	-74.98	
		121	-73.06	79	-75.38	
		122	-74.68	78	-76.50	
		123	-76.22	77	-78.21	
		124	-77.91	76	-80.45	
		125	-78.97	75	-83.15	
		126	-79.21	74	-85.60	
		127	-78.77	73	-88.50	
		128	-78.41	72	-90.95	
		129	-78.31	71	-92.33	
100	-38.51	130	-78.71	70	-91.40	

STOP TIME 11:14:45

DOT/TSC SIGNAL SPECTRUM ANALYSIS

START TIME 11:04:40	END TIME 11:14:45	
MEASUREMENT ID	GC1/P1(6)11:03 MAY 16 1985	
IN-BAND POWER		98.92%
OUT-OF BAND POWER	(HIGH SIDE)	.61%
OUT-OF-BAND POWER	(LOW SIDE)	.47%

RF SIGNAL POWER (76 TO 124 kHz)
MEDIAN FREQUENCY 100.6700 KILOCYCLES



DOT/TSC SIGNAL SPECTRUM ANALYSIS 86/19

DISC ID SA#21

FILE NO 7

MEASUREMENT ID GCI/PI(7)12:46 MAY 16 1985

MEASUREMENT AT SITE 4

SIGNAL SOURCE LOOP

OBSERVED DATA

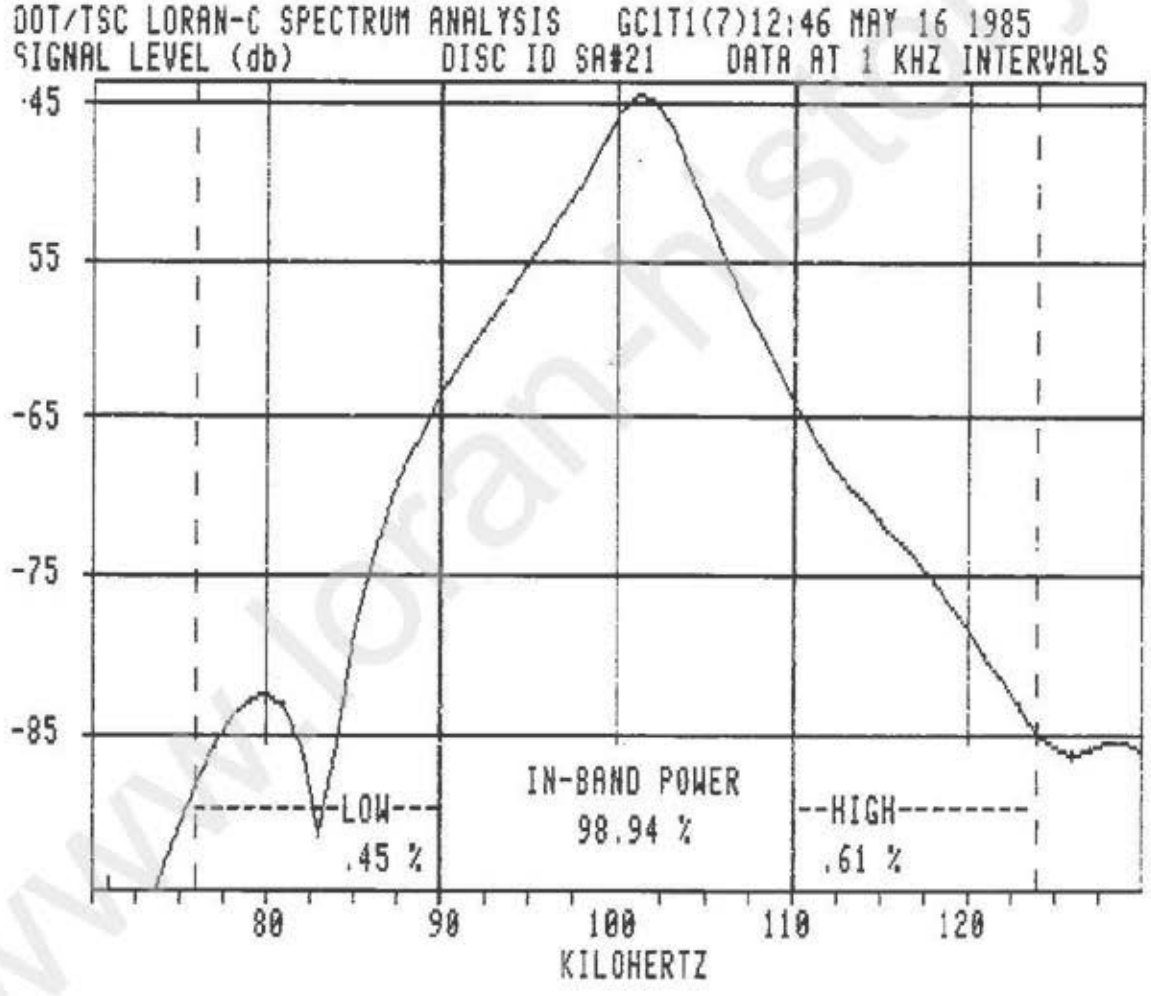
CTR. FREQ. (kHz)	CTR. SAMPLE VALUE	FREQ. (kHz)	SAMPLE VALUE	FREQ. (kHz)	SAMPLE VALUE	START TIME
00	-45.72	101	-44.52	99	-47.73	12:47:36
		102	-44.82	98	-49.94	
		103	-46.53	97	-51.74	
		104	-49.23	96	-53.34	
		105	-52.04	95	-55.09	
		106	-54.65	94	-56.65	
		107	-57.15	93	-58.26	
		108	-59.46	92	-59.86	
		109	-61.57	91	-61.61	
		110	-63.77	90	-63.47	
		111	-65.68	89	-65.58	
		112	-67.38	88	-67.78	
		113	-68.98	87	-70.49	
		114	-70.19	86	-73.90	
		115	-71.51	85	-78.55	
		116	-72.69	84	-85.49	
		117	-73.90	83	-91.26	
		118	-75.38	82	-85.93	
		119	-76.78	81	-83.20	
		120	-78.41	80	-82.52	
		121	-80.05	79	-82.88	
		122	-81.64	78	-84.12	
		123	-83.34	77	-85.71	
		124	-85.03	76	-88.19	
		125	-85.89	75	-90.78	
		126	-86.41	74	-93.69	
		127	-86.07	73	-96.58	
		128	-85.69	72	-98.74	
		129	-85.59	71	-97.96	
100	-45.80	130	-86.11	70	.	

STOP TIME 12:57:35

DOT/TSC SIGNAL SPECTRUM ANALYSIS

START TIME 12:47:36	END TIME 12:57:35	
MEASUREMENT ID	GC1/P1(7)12:46 MAY 16 1985	
IN-BAND POWER		98.94%
OUT-OF BAND POWER	(HIGH SIDE)	.61%
OUT-OF-BAND POWER	(LOW SIDE)	.45%

RF SIGNAL POWER (76 TO 124 kHz)
MEDIAN FREQUENCY 100.6642 KILOCYCLES



DOT/TSC SIGNAL SPECTRUM ANALYSIS 86/19

DISC ID SA#21

FILE NO

MEASUREMENT ID GC2/P1(2) 13:29 MAY 14 1985

MEASUREMENT AT STATION

SIGNAL SOURCE DIRECT

OBSERVED DATA

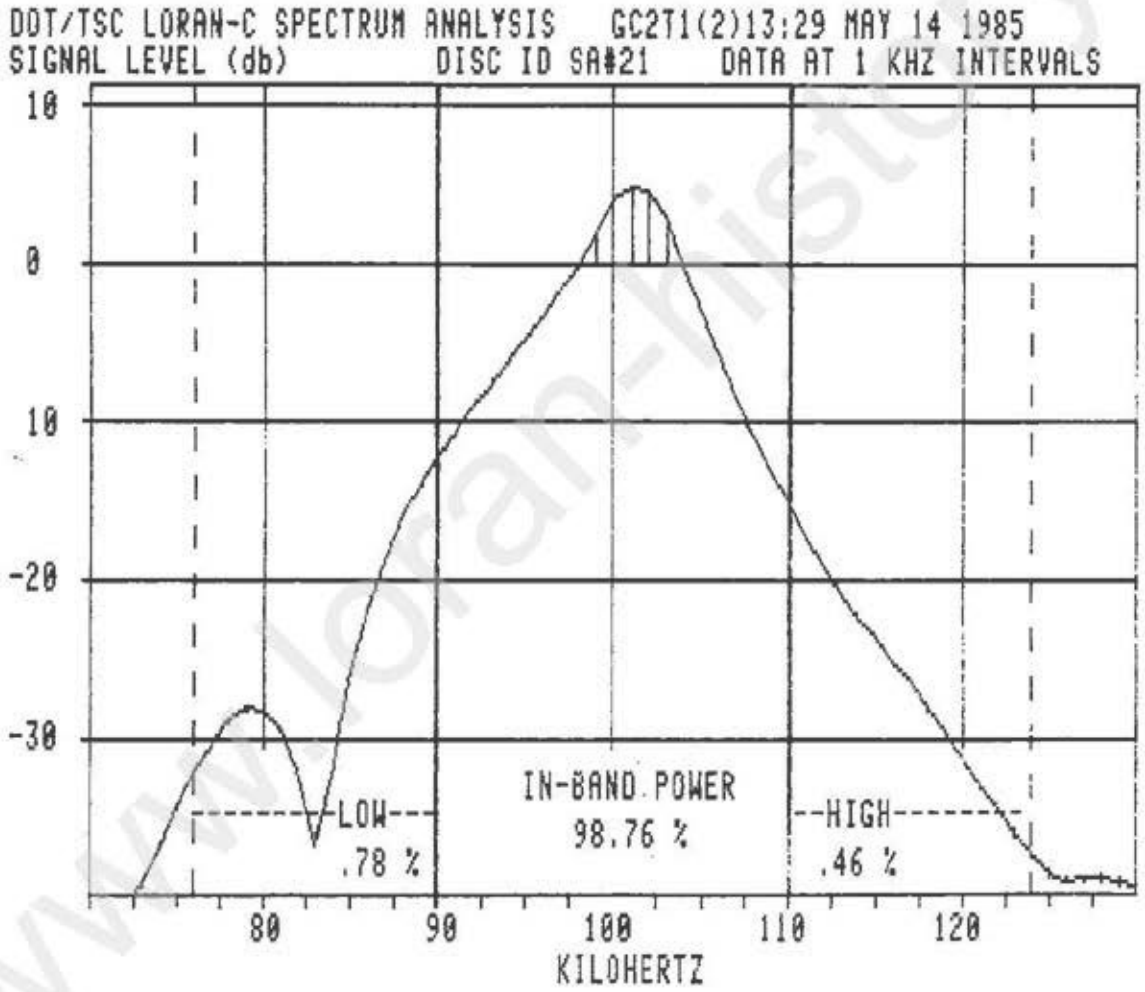
CTR. FREQ. (kHz)	CTR. SAMPLE VALUE	FREQ. (kHz)	SAMPLE VALUE	FREQ. (kHz)	SAMPLE VALUE	START TIME
100	4.01	101	4.91	99	2.10	13:31:07
		102	4.61	98	-.11	
		103	2.70	97	-1.71	
		104	-.25	96	-3.17	
		105	-3.21	95	-4.64	
		106	-5.82	94	-6.12	
		107	-8.43	93	-7.46	
		108	-10.83	92	-8.93	
		109	-12.94	91	-10.43	
		110	-15.04	90	-12.14	
		111	-17.05	89	-13.88	
		112	-18.85	88	-15.85	
		113	-20.68	87	-18.35	
		114	-22.22	86	-21.54	
		115	-23.65	85	-25.61	
		116	-25.15	84	-31.75	
		117	-26.53	83	-36.80	
		118	-28.12	82	-32.51	
		119	-29.66	81	-29.44	
		120	-31.35	80	-28.20	
		121	-33.03	79	-28.12	
		122	-34.45	78	-28.90	
		123	-36.00	77	-30.32	
		124	-37.42	76	-32.15	
		125	-38.60	75	-34.33	
		126	-39.05	74	-36.76	
		127	-38.97	73	-39.21	
		128	-38.86	72	-41.01	
		129	-39.06	71	-42.03	
00	4.01	130	-39.47	70	-42.11	

STOP TIME 13:40:55

DOT/TSC SIGNAL SPECTRUM ANALYSIS

START TIME 13:31:07	END TIME 13:40:55	
MEASUREMENT ID	GC2/P1(2) 13:29 MAY 14 1985	
IN-BAND POWER		98.76%
OUT-OF BAND POWER	(HIGH SIDE)	.46%
OUT-OF-BAND POWER	(LOW SIDE)	.78%

RF SIGNAL POWER (76 TO 124 kHz)
MEDIAN FREQUENCY 100.5199 KILOCYCLES



DOT/TSC SIGNAL SPECTRUM ANALYSIS 86/19

DISC ID SA#21

FILE NO 3

MEASUREMENT ID GC2/P2(3)16:58 MAY 14 1985

MEASUREMENT AT STATION

SIGNAL SOURCE DIRECT

OBSERVED DATA

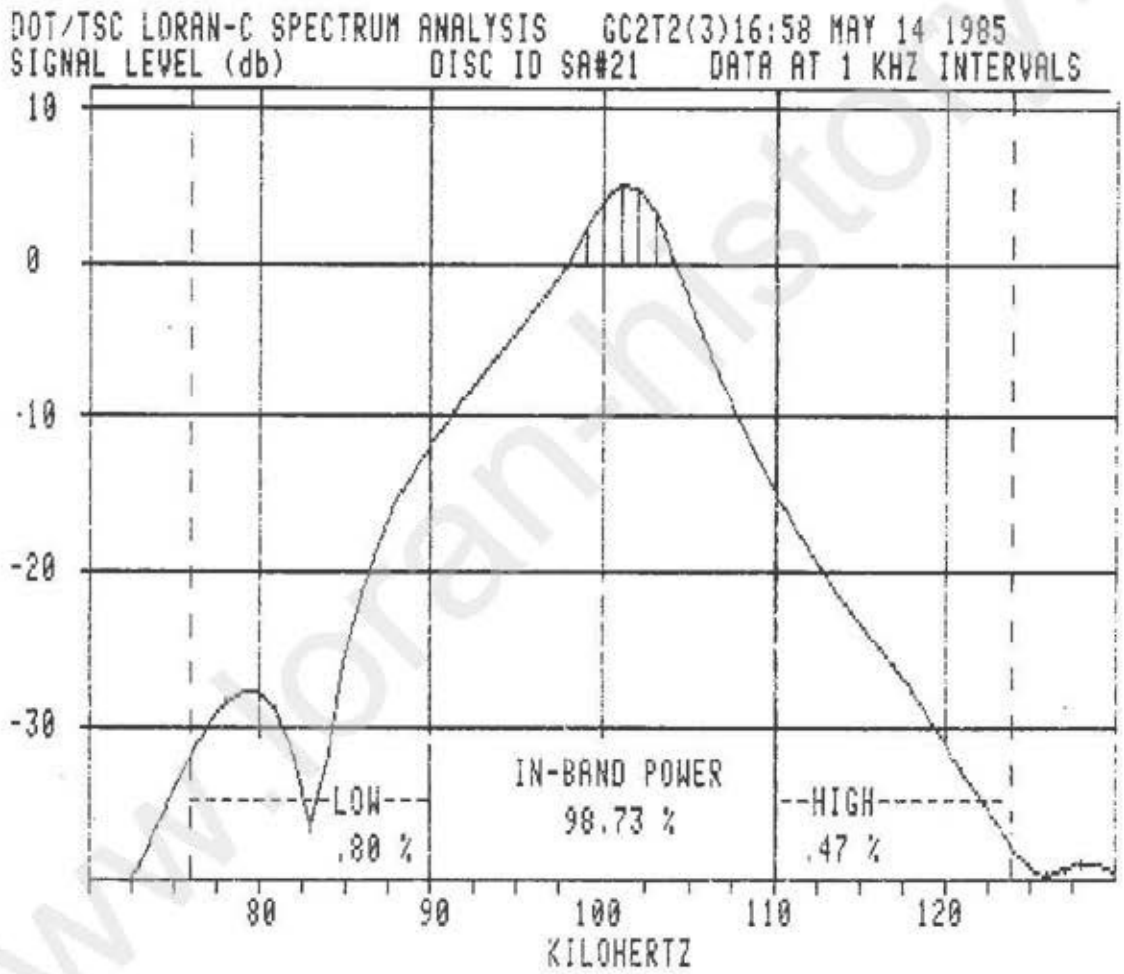
CTR. FREQ. (kHz)	CTR. SAMPLE VALUE	FREQ. (kHz)	SAMPLE VALUE	FREQ. (kHz)	SAMPLE VALUE	START TIME
100	4.11	101	5.11	99	2.20	17:09:21
		102	4.91	98	.10	
		103	3.20	97	-1.51	
		104	.38	96	-3.01	
		105	-2.71	95	-4.42	
		106	-5.32	94	-5.72	
		107	-7.83	93	-7.12	
		108	-10.33	92	-8.53	
		109	-12.54	91	-10.05	
		110	-14.74	90	-11.74	
		111	-16.65	89	-13.48	
		112	-18.53	88	-15.45	
		113	-20.36	87	-17.87	
		114	-21.86	86	-21.12	
		115	-23.35	85	-25.29	
		116	-24.75	84	-31.59	
		117	-26.09	83	-36.48	
		118	-27.64	82	-31.99	
		119	-29.30	81	-28.96	
		120	-31.05	80	-27.78	
		121	-32.89	79	-27.72	
		122	-34.45	78	-28.48	
		123	-36.10	77	-29.90	
		124	-37.80	76	-31.79	
		125	-39.09	75	-33.99	
		126	-39.61	74	-36.36	
		127	-39.25	73	-38.90	
		128	-38.94	72	-40.77	
		129	-38.99	71	-41.65	
100	4.11	130	-39.45	70	-41.67	

STOP TIME 17:19:16

DOT/TSC SIGNAL SPECTRUM ANALYSIS

START TIME 17:09:21	END TIME 17:19:16	
MEASUREMENT ID	GC2/P2(3)16:58 MAY 14 1985	
IN-BAND POWER		98.73%
OUT-OF BAND POWER	(HIGH SIDE)	.47%
OUT-OF-BAND POWER	(LOW SIDE)	.80%

RF SIGNAL POWER (76 TO 124 kHz)
MEDIAN FREQUENCY 100.5697 KILOCYCLES



DOT/TSC SIGNAL SPECTRUM ANALYSIS 86/19

DISC ID SA#21

FILE NO 4

MEASUREMENT ID GC2/P2(4)14:09 MAY 14 1985

MEASUREMENT AT SITE 1

SIGNAL SOURCE LOOP

OBSERVED DATA

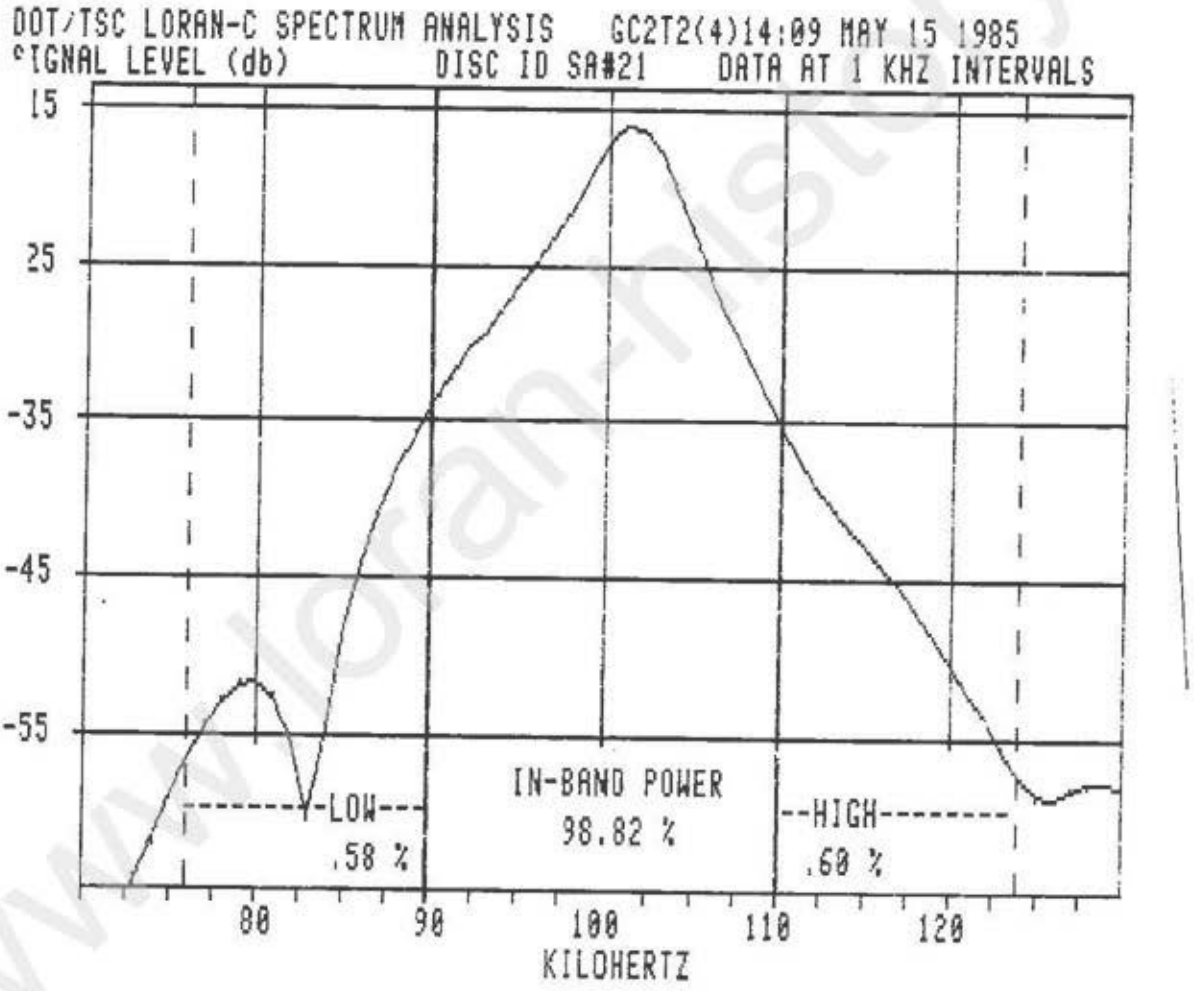
CTR. FREQ. (kHz)	CTR. SAMPLE VALUE	FREQ. (kHz)	SAMPLE VALUE	FREQ. (kHz)	SAMPLE VALUE	START TIME
100	-17.05	101	-16.05	99	-19.15	14:11:12
		102	-16.15	98	-21.26	
		103	-17.75	97	-22.96	
		104	-20.36	96	-24.57	
		105	-23.27	95	-26.17	
		106	-25.97	94	-27.58	
		107	-28.46	93	-29.08	
		108	-30.79	92	-30.58	
		109	-32.89	91	-32.13	
		110	-35.10	90	-33.89	
		111	-37.00	89	-35.88	
		112	-38.71	88	-38.00	
		113	-40.31	87	-40.51	
		114	-41.67	86	-43.80	
		115	-42.94	85	-48.23	
		116	-44.32	84	-54.71	
		117	-45.62	83	-60.40	
		118	-47.11	82	-55.71	
		119	-48.71	81	-52.70	
		120	-50.40	80	-51.74	
		121	-52.24	79	-51.92	
		122	-53.93	78	-52.94	
		123	-55.75	77	-54.55	
		124	-57.49	76	-56.59	
		125	-58.80	75	-59.02	
		126	-58.98	74	-61.68	
		127	-58.40	73	-64.53	
		128	-58.02	72	-66.53	
		129	-57.98	71	-68.13	
00	-17.25	130	-58.28	70	-68.20	

STOP TIME 14:21:08

DOT/TSC SIGNAL SPECTRUM ANALYSIS

START TIME 14:11:11	END TIME 14:21:08	
MEASUREMENT ID	GC2/P2(4)14:09 MAY 14 1985	
IN-BAND POWER		98.82%
OUT-OF BAND POWER	(HIGH SIDE)	.60%
OUT-OF-BAND POWER	(LOW SIDE)	.58%

RF SIGNAL POWER (76 TO 124 kHz)
MEDIAN FREQUENCY 100.6766 KILOCYCLES



APPENDIX B
TIME DOMAIN DATA COLLECTED AT LORSTA GRANGEVILLE FROM 14 TO 16 MAY 1985

See page B-2 for explanation of formats for 8 and 16 pulse analysis data printouts.

DOT/TSC LORAN-C PULSE ANALYSIS 8 PULSE GROUP
STATION NAME - LORSTA GRANGEVILLE
LORAN-C RATE - GRI 7980
TRANSMITTER COMBINATION - C2/P2
MEAUSREMENT AT- SITE 1
FILE IDENTIFIER - DISC GC2A7

START TIME 12:06:50 MAY 15 1985
STOP TIME 12:37:45 MAY 15 1985

ANALYSIS RESULTS

PULSE #	PHASE CODE	ECD	PULSE PEAK (VOLTS) measured	PULSE PEAK (VOLTS) computed	HALF-CYCLE % ERRORS ave	HALF-CYCLE % ERRORS 1-8	HALF-CYCLE % ERRORS 9-13	FREQ kHZ.	PULSE TO PULSE OFFSET NS.	N
1	1	-.032	-.873	.918	.61	1.3	4.1	100.371	0.00	*
2	1	-.031	-.884	.930	.65	1.6	4.0	100.350	-99.61	*
:	:	:	:	:	:	:	:	:	:	:
7	-1	-.071	.895	.937	.51	1.0	4.2	100.344	-30.04	*
8	1	-.093	-.894	.935	.66	1.5	3.6	100.340	-24.26	*

DOT/TSC LORAN-C PULSE ANALYSIS 16 PULSE GROUP
FILE IDENTIFIER - DISC ID GC2A7
STATION NAME - LORSTA GRANGEVILLE
LORAN-C RATE - GRI 7980
MEAUSREMENT AT- SITE 1
TRANSMITTER COMBINATION - C2/P2

ANALYSIS RESULTS

PULSE #	PHASE CODE	ECD	PULSE PEAK (VOLTS) measured	PULSE PEAK (VOLTS) computed	HALF-CYCLE % ERRORS ave	HALF-CYCLE % ERRORS 1-8	HALF-CYCLE % ERRORS 9-13	FREQ kHZ.	PULSE TO PULSE OFFSET NS.	N
1	1	-.064	.888	.933	.58	1.3	4.3	100.35	368.87	*
2	1	-.078	.889	.932	.56	1.3	4.2	100.36	368.00	*
:	:	:	:	:	:	:	:	:	:	:
15	1	-.060	.888	.933	.58	1.3	4.3	100.34	368.73	*
16	1	-.098	.889	.933	.66	1.4	4.1	100.34	367.86	*

DOT/TSC LORAN-C PULSE ANALYSIS 8 PULSE GROUP

LORSTA GRANGEVILLE
GRI 7980

TRANSMITTER C2 P2
MEASUREMENT AT SITE 1
DISC GC2A7A

12:06:50 MAY 15 1985
12:37:45 MAY 15 1985

		ECD	PULSE PEAK (VOLTS)		HALF-CYCLE % ERRORS ave	1-8	9-13	FREQ kHZ.	OFFSET NS.		N
1	1	-.032	-.873	.918	.61	1.3	4.1	100.371	0.00	*	
2	1	-.031	-.884	.930	.65	1.6	4.0	100.350	-99.61	*	
3	1	-.104	.887	.929	.71	1.7	3.3	100.347	-120.39	*	
4	1	-.075	-.889	.931	.65	1.5	3.9	100.365	-133.92	*	
5	1	-.090	-.890	.934	.64	1.5	3.5	100.341	0.00	*	
6	-1	-.072	.896	.937	.61	1.4	3.9	100.347	-25.29	*	
7	-1	-.071	.895	.937	.51	1.0	4.2	100.344	-30.04	*	
8	1	-.093	-.894	.935	.66	1.5	3.6	100.340	-24.26	*	
			measured								
			computed								

[N] is defined as the nominal zero crossing interval in microsconds after which pulse zero crossings exceed the 50 nanosecond limit * - WITHIN TOLERANCES

SECONDARY CODE A

USCG ECD

OVERALL AVERAGE	-.071 MICROSECONDS
+ CODE AVERAGE	-.072
- CODE AVERAGE	-.071

AVERAGE PULSE PEAK MAGNITUDE .888 VOLTS (MEASURED)

HALF CYCLE PEAK ERRORS
OVERALL AVERAGE .630 %

EFFECTIVE CARRIER FREQUENCY

OVERALL AVERAGE	100.351 KILOHERTZ
+ CODE AVERAGE	100.345
- CODE AVERAGE	100.352

PULSE TO PULSE OFFSET (NANOSECONDS)

+ CODE AVERAGE	-27.666
- CODE AVERAGE	-63.031

PEAK DROOP 2.544 %

DOT/TSC LORAN-C PULSE ANALYSIS 8 PULSE GROUP

LORSTA GRANGEVILLE
GRI 7980

TRANSMITTER C2 P2
MEASUREMENT AT SITE 1
DISC GC2A7A 12:06:50 MAY 15 1985
12:37:45 MAY 15 1985

	ECD	PULSE PEAK (VOLTS) measured	PULSE PEAK (VOLTS) computed	HALF-CYCLE % ERRORS ave	1-8	9-13	FREQ kHZ.	OFFSET NS.	N
1	1 -.076	-.873	.918	.65	1.6	4.0	100.346	0.00	*
2	-1 -.101	.888	.929	.55	1.2	4.0	100.341	-106.42	*
3	1 -.093	-.890	.931	.65	1.4	3.8	100.343	-112.87	*
4	-1 -.082	.890	.934	.54	1.1	4.3	100.326	-140.26	*
5	1 -.092	-.890	.934	.65	1.5	3.7	100.361	0.00	*
6	1 -.079	-.893	.933	.62	1.5	3.7	100.353	-5.12	*
7	-1 -.116	.890	.934	.62	1.5	3.9	100.348	-21.45	*
8	-1 -.032	.889	.937	.63	1.4	4.3	100.365	-30.25	*

[N] is defined as the nominal zero crossing interval in microsconds after which pulse zero crossings exceed the 50 nanosecond limit * = WITHIN TOLERANCES

SECONDARY CODE B

USCG ECD

OVERALL AVERAGE	-.084 MICROSECONDS
+ CODE AVERAGE	-.083
- CODE AVERAGE	-.085

AVERAGE PULSE PEAK MAGNITUDE .888 VOLTS (MEASURED)

HALF CYCLE PEAK ERRORS
OVERALL AVERAGE .612 %

EFFECTIVE CARRIER FREQUENCY

OVERALL AVERAGE	100.348 KILOHERTZ
+ CODE AVERAGE	100.345
- CODE AVERAGE	100.351

PULSE TO PULSE OFFSET (NANOSECONDS)

+ CODE AVERAGE	-74.596
- CODE AVERAGE	-29.499

PEAK DROOP 2.278 %

DOT/TSC 16 PULSE ANALYSIS

DISC ID GZG2A7
LORSTA GRANGEVILLE
GRI 7980
SITE SITE 1

COUPLER 2, PATCO 2
PULSE #7

PULSE CODE		ECD	PULSE PEAK (VOLTS)		HALF-CYCLE % ERRORS ave 1%	1-8 3%	9-13 10%	FREQ. kHZ. 1kHZ.		N
TOLERANCES----------										
1	1	-.064	.888	.933	.58	1.3	4.3	100.35	368.87	*
2	1	-.078	.889	.932	.56	1.3	4.2	100.36	368.00	*
3	1	-.060	.889	.934	.61	1.3	4.4	100.37	368.13	*
4	1	-.057	.889	.934	.56	1.3	4.4	100.37	368.24	*
5	1	-.089	.888	.932	.60	1.3	3.9	100.35	368.38	*
6	1	-.075	.888	.932	.61	1.3	4.2	100.35	368.55	*
7	1	-.110	.889	.931	.58	1.3	4.3	100.35	368.67	*
8	1	-.038	.887	.934	.58	1.3	4.4	100.37	368.79	*
9	1	-.088	.889	.932	.55	1.2	4.2	100.36	367.95	*
10	1	-.011	.889	.935	.60	1.3	4.2	100.35	368.11	*
11	1	-.075	.888	.932	.61	1.3	4.2	100.36	368.20	*
12	1	-.074	.889	.934	.60	1.3	4.2	100.36	368.35	*
13	1	-.060	.887	.934	.56	1.3	4.4	100.36	368.50	*
14	1	-.076	.887	.933	.57	1.3	4.1	100.36	368.62	*
15	1	-.060	.888	.933	.58	1.3	4.3	100.34	368.73	*
16	1	-.098	.889	.933	.66	1.4	4.1	100.34	367.86	*
			measured							
				computed						

AVERAGE OF ECD (+ CODE) -.070
AVERAGE MEASURED PEAK (+ CODE) .888
AVERAGE MEASURED PEAK (- CODE) .

EFFECTIVE CARRIER FREQUENCY
OVERALL AVERAGE100.356
+CODE AVERAGE100.356

PEAK DROOP .26 %

DOT/TSC LORAN-C PULSE ANALYSIS 8 PULSE GROUP

LORSTA GRANGEVILLE
GRI 7980

TRANSMITTER C1 P1
MEASUREMENT AT SITE 1
DISC GC1A7A 16:14:02 MAY 15 1985
- 16:43:37 MAY 15 1985

		ECD	PULSE PEAK (VOLTS) measured	PULSE PEAK (VOLTS) computed	HALF-CYCLE % ERRORS ave	1-8	9-13	FREQ kHZ.	OFFSET NS.	N
1	1	-.128	-.841	.876	.58	1.4	3.2	100.241	0.00	*
2	1	-.139	-.855	.889	.59	1.5	2.9	100.257	-98.64	*
3	1	-.143	-.855	.890	.64	1.5	2.7	100.246	-117.83	*
4	1	-.163	-.857	.889	.55	1.3	2.6	100.252	-130.50	*
5	1	-.143	.858	.891	.66	1.6	2.5	100.265	0.00	*
6	-1	-.138	.859	.893	.60	1.3	2.9	100.276	-18.82	*
7	-1	-.122	.859	.892	.64	1.5	3.0	100.271	-25.24	*
8	1	-.120	.857	.892	.57	1.3	2.7	100.288	-20.96	*

[N] is defined as the nominal zero crossing interval in microsconds after which pulse zero crossings exceed the 50 nanosecond limit * = WITHIN TOLERANCES

SECONDARY CODE A

USCG ECD

OVERALL AVERAGE	-.137 MICROSECONDS
+ CODE AVERAGE	-.130
- CODE AVERAGE	-.139

AVERAGE PULSE PEAK MAGNITUDE .855 VOLTS (MEASURED)

HALF CYCLE PEAK ERRORS
OVERALL AVERAGE .603 %

EFFECTIVE CARRIER FREQUENCY

OVERALL AVERAGE	100.262 KILOHERTZ
+ CODE AVERAGE	100.274
- CODE AVERAGE	100.258

PULSE TO PULSE OFFSET (NANOSECONDS)

+ CODE AVERAGE	-22.029
- CODE AVERAGE	-61.322

PEAK DROOP 2.134 %

DOT/TSC LORAN-C PULSE ANALYSIS 8 PULSE GROUP

LORSTA GRANGEVILLE
GRI 7980

TRANSMITTER C1 P1
MEASUREMENT AT SITE 1
DISC GC1A7A

16:14:02 MAY 15 1985
16:43:37 MAY 15 1985

	ECD	PULSE PEAK (VOLTS) measured	PULSE PEAK (VOLTS) computed	HALF-CYCLE % ERRORS ave	1-8	9-13	FREQ kHZ.	OFFSET NS.	N
1	1 -.151	-.841	.874	.63	1.6	2.5	100.260	0.00	*
2	-1 -.126	.853	.887	.63	1.4	3.3	100.240	-108.87	*
3	1 -.101	-.857	.892	.67	1.6	3.1	100.253	-116.12	*
4	-1 -.137	.857	.889	.60	1.4	2.8	100.240	-137.29	*
5	1 -.154	-.857	.892	.62	1.5	2.7	100.274	0.00	*
6	1 -.122	-.857	.892	.64	1.5	2.7	100.286	189.07	*
7	-1 -.114	.863	.894	.62	1.1	3.5	100.279	207.71	*
8	-1 -.099	.861	.893	.62	1.4	2.9	100.286	195.12.	*

[N] is defined as the nominal zero crossing interval in microsconds after which pulse zero crossings exceed the 50 nanosecond limit * = WITHIN TOLERANCES

SECONDARY CODE B

USCG ECD

OVERALL AVERAGE	-.126 MICROSECONDS
+ CODE AVERAGE	-.119
- CODE AVERAGE	-.132

AVERAGE PULSE PEAK MAGNITUDE .856 VOLTS (MEASURED)

HALF CYCLE PEAK ERRORS
OVERALL AVERAGE .631 %

EFFECTIVE CARRIER FREQUENCY

OVERALL AVERAGE	100.265 KILOHERTZ
+ CODE AVERAGE	100.262
- CODE AVERAGE	100.268

PULSE TO PULSE OFFSET (NANOSECONDS)

+ CODE AVERAGE	39.169
- CODE AVERAGE	18.235

PEAK DROOP 2.476 %

DOT/TSC 16 PULSE ANALYSIS

DISC ID GYG1A7
LORSTA GRANGEVILLE
GRI 7980
SITE SITE 1

COUPLER 1, PATCO 1
PULSE #2

PULSE CODE	ECD	PULSE PEAK (VOLTS)		HALF-CYCLE % ERRORS			FREQ. kHZ.		
TOLERANCES----------				ave 1%	1-8 3%	9-13 10%	1kHZ.		N
1 -1	-.128	.838	.876	.63	1.5	3.0	100.26	299.37	*
2 -1	-.144	.841	.875	.73	1.8	2.7	100.28	300.21	*
3 -1	-.132	.841	.875	.69	1.6	2.7	100.26	300.10	*
4 -1	-.183	.840	.873	.61	1.5	2.5	100.27	299.94	*
5 -1	-.209	.843	.872	.69	1.5	2.1	100.27	299.81	*
6 -1	-.225	.840	.872	.69	1.7	2.4	100.28	299.69	*
7 -1	-.114	.839	.876	.72	1.6	3.0	100.26	299.53	*
8 -1	-.164	.841	.876	.72	1.8	2.7	100.28	299.42	*
9 -1	-.197	.841	.873	.76	1.8	2.4	100.27	299.26	*
10 -1	-.134	.841	.877	.73	1.8	2.9	100.26	300.13	*
11 -1	-.125	.841	.876	.67	1.6	2.8	100.26	299.98	*
12 -1	-.162	.842	.875	.75	1.7	2.5	100.27	299.86	*
13 -1	-.226	.841	.872	.73	1.8	2.2	100.26	299.68	*
14 -1	-.164	-.839	.875	.75	1.8	2.9	100.27	299.57	*
15 -1	-.259	.841	.871	.72	1.7	2.2	100.26	299.42	*
16 -1	-.143	.843	.875	.72	1.8	2.5	100.28	299.26	*
		measured							
			computed						

AVERAGE OF ECD (- CODE) -.169

AVERAGE MEASURED PEAK (- CODE) .736

EFFECTIVE CARRIER FREQUENCY
OVERALL AVERAGE100.267
-CODE AVERAGE100.267

PEAK DROOP .51 %

DOT/TSC LORAN-C PULSE ANALYSIS 8 PULSE GROUP

LORSTA GRANGEVILLE
GRI 7980

TRANSMITTER C2 P2
MEASUREMENT AT STATION
DISC GC2B7X 15:32:42 MAY 14 1985
- 15:57:08 MAY 14 1985

	ECD		PULSE PEAK (VOLTS)		HALF-CYCLE % ERRORS ave	1-8	9-13	FREQ kHZ.	OFFSET NS.	N
1	1	-.142	.995	1.065	.41	.6	6.4	100.252	0.00	*
2	1	-.029	1.011	1.084	.40	.6	6.8	100.253	-100.46	*
3	1	-.069	1.011	1.086	.43	.7	6.7	100.246	-123.94	*
4	1	-.057	1.015	1.086	.40	.7	6.5	100.238	-141.55	*
5	1	-.081	1.017	1.089	.40	.7	6.6	100.249	0.00	*
6	-1	-.106	-1.009	1.086	.45	.7	6.0	100.245	-13.58	*
7	-1	-.125	-1.009	1.086	.52	.8	6.0	100.232	-23.31	*
8	1	-.042	1.018	1.091	.37	.7	6.8	100.254	-25.20	*
			measured							
			computed							

[N] is defined as the nominal zero crossing interval in microsconds after which pulse zero crossings exceed the 50 nanosecond limit * = WITHIN TOLERANCES

SECONDARY CODE A

USCG ECD

OVERALL AVERAGE	-.081 MICROSECONDS
+ CODE AVERAGE	-.070
- CODE AVERAGE	-.116

AVERAGE PULSE PEAK MAGNITUDE 1.011 VOLTS (MEASURED)

HALF CYCLE PEAK ERRORS
OVERALL AVERAGE .422 %

EFFECTIVE CARRIER FREQUENCY

OVERALL AVERAGE	100.246 KILOHERTZ
+ CODE AVERAGE	100.249
- CODE AVERAGE	100.238

PULSE TO PULSE OFFSET (NANOSECONDS)

+ CODE AVERAGE	-65.191
- CODE AVERAGE	-18.446

PEAK DROOP 2.258 %

DOT/TSC LORAN-C PULSE ANALYSIS 8 PULSE GROUP

LORSTA GRANGEVILLE
GRI 7980

TRANSMITTER C2 P2
MEASUREMENT AT STATION
DISC GC2B7X

15:32:42 MAY 14 1985
15:57:08 MAY 14 1985

	ECD	PULSE PEAK (VOLTS)		HALF-CYCLE % ERRORS ave	1-8	9-13	FREQ kHZ.	OFFSET NS.	N
1	1 -.077	.995	1.067	.40	.7	6.8	100.268	0.00	*
2	-1 -.147	1.002	1.079	.49	.7	5.9	100.246	-117.65	*
3	1 -.051	1.013	1.086	.44	.7	6.6	100.262	-122.42	*
4	-1 -.147	-1.005	1.082	.45	.7	5.9	100.252	-154.26	*
5	1 -.043	1.015	1.089	.43	.7	6.6	100.261	0.00	*
6	1 -.092	1.017	1.087	.41	.7	6.7	100.275	-14.00	*
7	-1 -.121	1.009	1.087	.45	.7	5.9	100.268	-44.05	*
8	-1 -.091	-1.011	1.087	.52	.8	6.0	100.274	-54.37	*
		measured							
			computed						

[N] is defined as the nominal zero crossing interval in microsconds after which pulse zero crossings exceed the 50 nanosecond limit * = WITHIN TOLERANCES

SECONDARY CODE B

USCG ECD

OVERALL AVERAGE	-.096 MICROSECONDS
+ CODE AVERAGE	-.066
- CODE AVERAGE	-.127

AVERAGE PULSE PEAK MAGNITUDE 1.008 VOLTS (MEASURED)

HALF CYCLE PEAK ERRORS

OVERALL AVERAGE	.450 %

EFFECTIVE CARRIER FREQUENCY

OVERALL AVERAGE	100.263 KILOHERTZ
+ CODE AVERAGE	100.266
- CODE AVERAGE	100.260

PULSE TO PULSE OFFSET (NANOSECONDS)

+ CODE AVERAGE	-34.105
- CODE AVERAGE	-92.580

PEAK DROOP 2.178 %

DOT/TSC 16 PULSE ANALYSIS

DISC ID GXG2S7
LORSTA GRANGEVILLE
GRI 7980
SITE STATION

COUPLER 2, PATCO 2
PULSE #8

PULSE CODE	ECD	PULSE PEAK (VOLTS)		HALF-CYCLE % ERRORS			FREQ. kHZ.		
				ave	1-8	9-13			N
TOLERANCES----------				1%	3%	10%	1kHZ.		
1 -1	-.104	-1.011	1.087	.47	.7	6.1	100.22	337.26	*
2 1	-.058	1.017	1.091	.38	.6	6.6	100.26	336.97	*
3 -1	-.087	-1.011	1.087	.43	.7	5.9	100.25	337.46	*
4 1	-.089	1.018	1.090	.39	.8	6.6	100.25	337.16	*
5 -1	-.092	1.012	1.088	.49	.8	5.8	100.24	336.63	*
6 1	-.043	1.018	1.091	.36	.7	6.7	100.25	337.37	*
7 -1	-.080	-1.010	1.089	.55	.8	6.2	100.24	336.87	*
8 1	-.070	1.018	1.091	.40	.6	6.5	100.27	337.54	*
9 -1	-.067	1.010	1.090	.54	.9	6.1	100.23	337.06	*
10 1	-.081	1.017	1.089	.40	.7	6.5	100.26	336.78	*
11 -1	-.077	-1.010	1.088	.46	.7	6.0	100.25	337.27	*
12 1	-.077	1.018	1.091	.43	.7	6.7	100.26	336.96	*
13 -1	-.103	-1.010	1.087	.46	.7	5.9	100.23	337.47	*
14 1	-.010	1.017	1.094	.41	.7	6.9	100.25	337.18	*
15 -1	-.092	1.009	1.088	.47	.7	6.0	100.24	336.68	*
16 1	-.063	1.017	1.091	.41	.7	6.6	100.25	337.36	*
		measured							
		computed							

AVERAGE OF ECD (+ CODE) -.061
AVERAGE OF ECD (- CODE) -.088

AVERAGE MEASURED PEAK (+ CODE) 1.017
AVERAGE MEASURED PEAK (- CODE) -.253

EFFECTIVE CARRIER FREQUENCY
OVERALL AVERAGE100.247
+CODE AVERAGE100.257
-CODE AVERAGE100.238

PEAK DROOP 1.35 %

DOT/TSC LORAN-C PULSE ANALYSIS 8 PULSE GROUP

LORSTA GRANGEVILLE
GRI 7980

TRANSMITTER C2 P1
MEASUREMENT AT STATION
DISC GC2S7A 13:55:45 MAY 14 1985
14:32:19 MAY 14 1985

		ECD	PULSE PEAK (VOLTS)		HALF-CYCLE % ERRORS ave	1-8	9-13	FREQ kHZ.	OFFSET NS.	N
1	1	-.215	.966	1.032	.41	.7	6.3	100.162	0.00	*
2	1	-.137	.979	1.051	.47	.9	6.8	100.169	-100.38	*
3	1	-.193	.981	1.050	.45	.8	6.4	100.173	-124.05	*
4	1	-.154	.984	1.053	.41	.8	6.8	100.161	-134.78	*
5	1	-.202	.985	1.052	.39	.7	6.3	100.165	0.00	*
6	-1	-.169	-.981	1.051	.53	.8	5.6	100.163	-7.15	*
7	-1	-.146	.982	1.051	.51	.8	5.4	100.164	-18.26	*
8	1	-.148	.985	1.054	.41	.7	6.3	100.162	-28.92	*
			measured							
			computed							

[N] is defined as the nominal zero crossing interval in microsconds after which pulse zero crossings exceed the 50 nanosecond limit * - WITHIN TOLERANCES

SECONDARY CODE A

USCG ECD

OVERALL AVERAGE	-.171	MICROSECONDS
+ CODE AVERAGE	-.175	
- CODE AVERAGE	-.158	

AVERAGE PULSE PEAK MAGNITUDE .980 VOLTS (MEASURED)

HALF CYCLE PEAK ERRORS
OVERALL AVERAGE .447 %

EFFECTIVE CARRIER FREQUENCY

OVERALL AVERAGE	100.165	KILOHERTZ
+ CODE AVERAGE	100.165	
- CODE AVERAGE	100.164	

PULSE TO PULSE OFFSET (NANOSECONDS)

+ CODE AVERAGE	-64.689
- CODE AVERAGE	-12.703

PEAK DROOP 1.995 %

DOT/TSC LORAN-C PULSE ANALYSIS 8 PULSE GROUP

LORSTA GRANGEVILLE
GRI 7980

TRANSMITTER C2 P1
MEASUREMENT AT STATION
DISC GC2S7A 13:55:45 MAY 14 1985
14:32:19 MAY 14 1985

	ECD	PULSE PEAK (VOLTS)		HALF-CYCLE % ERRORS ave	1-8	9-13	FREQ kHZ.	OFFSET NS.	N
1	1 -.191	.966	1.034	.38	.6	6.4	100.176	0.00	*
2	-1 -.179	.974	1.047	.51	.8	5.7	100.171	-113.91	*
3	1 -.184	.984	1.050	.46	.9	6.6	100.171	-125.02	*
4	-1 -.197	-.978	1.048	.51	.8	5.6	100.157	-150.35	*
5	1 -.133	.985	1.055	.40	.7	6.8	100.169	0.00	*
6	1 -.119	.985	1.055	.43	.7	6.5	100.178	-12.00	*
7	-1 -.171	.978	1.050	.51	.7	5.6	100.187	-13.03	*
8	-1 -.152	-.979	1.051	.47	.7	5.7	100.179	-20.29	*
		measured	computed						

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SECONDARY CODE B

USCG ECD

OVERALL AVERAGE	-.166 MICROSECONDS
+ CODE AVERAGE	-.157
- CODE AVERAGE	-.175

AVERAGE PULSE PEAK MAGNITUDE .979 VOLTS (MEASURED)

HALF CYCLE PEAK ERRORS
OVERALL AVERAGE .459 %

EFFECTIVE CARRIER FREQUENCY

OVERALL AVERAGE	100.173 KILOHERTZ
+ CODE AVERAGE	100.173
- CODE AVERAGE	100.173

PULSE TO PULSE OFFSET (NANOSECONDS)

+ CODE AVERAGE	-34.257
- CODE AVERAGE	-74.396

PEAK DROOP 1.989 %

DOT/TSC LORAN-C PULSE ANALYSIS 8 PULSE GROUP

LORSTA GRANGEVILLE
GRI 7980

TRANSMITTER C1 P1
MEASUREMENT AT STATION
DISC GC1S7A 11:15:35 MAY 14 1985
11:44:20 MAY 14 1985

	ECD	PULSE PEAK (VOLTS)		HALF-CYCLE % ERRORS ave	1-8	9-13	FREQ kHZ.	OFFSET NS.	N
1	1 -.081	.963	1.025	.33	.5	5.7	100.157	0.00	*
2	-1 -.021	.977	1.042	.45	.7	5.0	100.178	-43.71	*
3	1 -.025	.979	1.043	.33	.6	6.0	100.167	-125.18	*
4	-1 -.085	.977	1.042	.48	.8	5.0	100.187	-72.60	*
5	1 -.080	.979	1.042	.31	.5	5.7	100.157	0.00	*
6	1 -.046	.981	1.043	.34	.6	5.8	100.155	-5.76	*
7	-1 -.065	-.975	1.040	.44	.7	5.0	100.149	-75.98	*
8	-1 -.044	.977	1.041	.41	.6	4.9	100.135	-89.78	*
		measured							
		computed							

[N] is defined as the nominal zero crossing interval in microsconds after which pulse zero crossings exceed the 50 nanosecond limit * = WITHIN TOLERANCES

SECONDARY CODE B

USCG ECD

OVERALL AVERAGE	-.056 MICROSECONDS
+ CODE AVERAGE	-.058
- CODE AVERAGE	-.054

AVERAGE PULSE PEAK MAGNITUDE .976 VOLTS (MEASURED)

HALF CYCLE PEAK ERRORS
OVERALL AVERAGE .386 %

EFFECTIVE CARRIER FREQUENCY

OVERALL AVERAGE	100.161 KILOHERTZ
+ CODE AVERAGE	100.159
- CODE AVERAGE	100.162

PULSE TO PULSE OFFSET (NANOSECONDS)

+ CODE AVERAGE	-32.735
- CODE AVERAGE	-70.517

PEAK DROOP 1.893 %

DOT/TSC 16 PULSE ANALYSIS

DISC ID GWG1S7
LORSTA GRANGEVILLE
GRI 7980
SITE STATION

COUPLER 1, PATCO 1
PULSE #2

PULSE CODE	ECD	PULSE PEAK (VOLTS)		HALF-CYCLE % ERRORS		
TOLERANCES----------				ave 1%	1-8 3%	9-13 10%
1	1	-.023	.977 1.040	.36	.5	5.7
2	-1	-.044	-.967 1.031	.41	.6	5.0
3	1	-.017	.978 1.042	.33	.6	6.0
4	-1	-.077	.967 1.031	.45	.7	4.9
5	1	-.050	.977 1.040	.37	.5	5.7
6	-1	-.073	.967 1.030	.42	.6	4.9
7	1	-.053	.977 1.041	.34	.7	5.9
8	-1	-.047	-.965 1.033	.43	.7	5.3
9	1	-.037	.975 1.041	.39	.7	5.9
10	-1	-.062	.965 1.032	.43	.7	5.2
11	1	-.035	.977 1.040	.31	.6	6.0
12	-1	-.076	.965 1.031	.44	.7	5.2
13	1	-.008	.977 1.042	.35	.5	6.0
14	-1	-.084	.967 1.032	.40	.6	5.0
15	1	-.075	.977 1.038	.35	.6	5.6
16	-1	-.110	.969 1.028	.47	.7	4.5
		measured	computed			

AVERAGE OF ECD (+ CODE) -.037
AVERAGE OF ECD (- CODE) -.072

AVERAGE MEASURED PEAK (+ CODE) .97
AVERAGE MEASURED PEAK (- CODE) .484

EFFECTIVE CARRIER FREQUENCY
OVERALL AVERAGE100.149
+CODE AVERAGE100.152
-CODE AVERAGE100.145

PEAK DROOP **1.33** %