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SECTION 1. EXECUTIVE DIGEST

1.1 EXECUTIVE SUMMARY

This document represents the results of a type approval certification test of a Personal Location Beacon, Model MicroPLB (No. MBT-040600), manufactured by Microwave Monolithics, Incorporated. The tests were conducted at the Electronic Proving Ground's Environmental Test Facility (ETF) and Antenna Test Facility (ATF) at Fort Huachuca, Arizona. The test period was from 8 to 23 February and 20 to 21 April 1999.

Electrical and Functional Tests at Constant Temperature

The following electrical and functional tests were conducted at ambient temperature [25° Celsius (C)], minimum temperature (-20° C), and maximum temperature (55° C) conditions:

a. Transmitter power output.

b. Message format and structure.

c. Modulation.

d. Transmitted frequency.

e. Spurious output.

f. Voltage standing wave ratio (VSWR) check.

g. Self-test mode.

Test Results at Ambient Temperature (25° C)

The unit under test (UUT) passed all ambient temperature tests.

Test Results at Minimum Temperature (-20° C)

The UUT passed all minimum temperature tests.

Test Results at Maximum Temperature (55° C)

The UUT passed all maximum temperature tests.

Thermal Shock Test

The following electrical and functional tests were conducted during the thermal shock test:

a. Transmitted frequency.

b. Transmitted power output.

c. Message format and structure.

Test Results

The UUT passed all thermal shock tests.

Operating Lifetime at Minimum Temperature

Test Results

The UUT passed the operating lifetime test.

Frequency Stability Test with Temperature Gradient

The following electrical and functional tests were conducted during the frequency stability test with temperature gradient:

a. Transmitted frequency.

b. Transmitted power output.

c. Message format and structure.

Test Results

The UUT met all frequency stability test requirements with temperature gradient.

Satellite Qualitative Tests

Test Results

The UUT met all requirements for the satellite qualitative tests.

Beacon Antenna Test

Test Results

The calibration signal level was -60.50 decibel with reference to 1 milliwatt (dBm). The calibration effective radiated power (ERP) level was -6.90 dBm.

The received signal levels (in dBm) for vertical and horizontal polarization of the probe antenna are tabulated in Appendix B, Table B-1 and Table B-2.

a. Beacon ERP measurement.

Range calibration factor. The range calibration factor (in dB) was calculated to be

-6.90 - (-60.50) = 53.60 dB.

Total ERP calculation. The total beacon ERP was determined by combining the vertical and horizontal polarization received signal levels using the following equation:

Total ERP (in dBm) =

$$10\, log_{10} \left[\, 10^{Pv\text{(in dBm)}/10} + 10^{Ph\text{(in dBm)}/10} \right] \quad + \text{ Range Calibration Factor}$$

This equation converted the vertical and horizontal received signal power levels (Pv and Ph, in dBm) into milliwatts (mW), added the two components together, and then converted the total power in mW to a power level in dBm. The range calibration factor (in dB) was added to this value to yield total ERP (in dBm). These values were calculated and tabulated for every 30 degrees of azimuth from 0 to 330 degrees, and for every 10 degrees of elevation from 10 to 50 degrees (see Appendix B, Table B-3).

Antenna range instrumentation accuracy. The measurement accuracy of the arc test range is ±2.45 dB. This root-sum-squared value (rss) is determined from the following range instrumentation accuracies:

±0.02 dB	Hewlett-Packard 438A Power Meter
±0.13 dB	Hewlett-Packard 8481A Power Sensor
±1.00 dB	Hewlett-Packard 8562A Spectrum Analyzer
±2.00 dB	Antenna gain standard calibration accuracy
±1.00 dB	Allowance for environmental variations

$$\text{rss accuracy} = \pm\sqrt{(0.02)^2 + (0.13)^2 + (1.00)^2 + (2.00)^2 + (1.00)^2} = \pm 2.45 \text{ dB}$$

The percentage of ERP values ranging from 1.6 to 20 watts (32.0 to 43.0 dBm), allowing for antenna range instrumentation accuracy, was 100% (see Appendix B, Table B-3).

The beacon antenna is considered to be vertically polarized.

Navigation System Test

Test Results

The UUT met all requirements for the navigation system test.

Beacon Self-Test Mode

Test Results

The UUT met the requirements for the beacon self-test mode.

Conclusion

The UUT met the certification requirements for type approval.

Beacon Antenna Test

Test Results

The calibration signal level was -60.50 decibel with reference to 1 milliwatt (dBm). The calibration effective radiated power (ERP) level was -6.90 dBm.

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-6.90 - (-60.50) = 53.60 dB.

Total ERP calculation. The total beacon ERP was determined by combining the vertical and horizontal polarization received signal levels using the following equation:

$$\text{Total ERP (in dBm)} = 10\,log_{10}\left[\,10^{Pv\text{(in dBm)}/10} + 10^{Ph\text{(in dBm)}/10}\right] + \text{Range Calibration Factor}$$

This equation converted the vertical and horizontal received signal power levels (Pv and Ph, in dBm) into milliwatts (mW), added the two components together, and then converted the total power in mW to a power level in dBm. The range calibration factor (in dB) was added to this value to yield total ERP (in dBm). These values were calculated and tabulated for every 30 degrees of azimuth from 0 to 330 degrees, and for every 10 degrees of elevation from 10 to 50 degrees (see Appendix B, Table B-3).

Antenna range instrumentation accuracy. The measurement accuracy of the arc test range is ±2.45 dB. This root-sum-squared value (rss) is determined from the following range instrumentation accuracies:

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±0.13 dB	Hewlett-Packard 8481A Power Sensor
±1.00 dB	Hewlett-Packard 8562A Spectrum Analyzer
±2.00 dB	Antenna gain standard calibration accuracy
±1.00 dB	Allowance for environmental variations

$$\text{rss accuracy} = \pm\sqrt{(0.02)^2 + (0.13)^2 + (1.00)^2 + (2.00)^2 + (1.00)^2} = \pm\ 2.45\ \text{dB}$$

The percentage of ERP values ranging from 1.6 to 20 watts (32.0 to 43.0 dBm), allowing for antenna range instrumentation accuracy, was 100% (see Appendix B, Table B-3).

The beacon antenna is considered to be vertically polarized.

Navigation System Test

Test Results

The UUT met all requirements for the navigation system test.

Beacon Self-Test Mode

Test Results

The UUT met the requirements for the beacon self-test mode.

Conclusion

The UUT met the certification requirements for type approval.

SUPPORTING TEST DATA

1. Electrical and Functional Tests at Constant Temperature

   a. Ambient Temperature (See Annex I of Appendix A, page A-I-1.)

   b. Minimum Temperature: -20° C (See Annex I of Appendix A, page A-I-15.)

   c. Maximum Temperature: 55° C (See Annex I of Appendix A, page A-I-23.)

2. Thermal Shock Test (See Annex II of Appendix A.)

3. Operating Lifetime at Minimum Temperature (See Annex III of Appendix A.)

4. Frequency Stability Test with Temperature Gradient (See Annex IV of Appendix A.)

5. Satellite Qualitative Tests (See Annex V of Appendix A.)

6. Navigation System (See Annex VI of Appendix A.)

7. Self-Test Mode (See Annex VII of Appendix A.)

8. Antenna Characteristics (See Appendix B.)

9. Table C2. Summary of 406 MHz Beacon Test results (See Appendix C.)

1.2 REFERENCE DOCUMENTS

- Cospas-Sarsat Document C/S T.001, Specification for Cospas-Sarsat 406 MHz Distress Beacon, Issue 3, Revision 2, October 1998.

- Cospas-Sarsat Document C/S T.007, Cospas-Sarsat 406 MHz Distress Beacon Type Approval standard, Issue 3, Revision 5, October 1998.

- EPG Document, Cospas-Sarsat 406 MHz Distress Beacon Type Approval Certification Detailed Test Procedures.

1.3 PURPOSE

The purpose of this document is to present detailed test procedures to implement type approval test methods delineated in C/S T.007.

1.4 SCOPE

The detailed test procedures for the following tests are presented in Section 2:

a. Electrical and Functional Tests at Constant Temperature.

b. Thermal Shock Test.

c. Operating Lifetime at Minimum Temperature.

d. Frequency Stability Test with Temperature Gradient.

e. Satellite Qualitative Tests.

f. Antenna Characteristics.

g. Navigation System.

h. Self-Test Mode.

A distribution list is provided in Appendix D.

SECTION 2. TESTS REQUIRED

2.1 ELECTRICAL AND FUNCTIONAL TESTS AT CONSTANT TEMPERATURE

The following electrical and functional tests were conducted at ambient temperature, minimum temperature, and maximum temperature conditions. The UUT, while turned off, was allowed to stabilize for 2 hours at the test temperature and was then turned on and allowed a 15-minute warm-up period before conducting the following tests:

a. Transmitter power output.

b. Message format and structure.

c. Modulation.

d. Transmitted Frequency.

e. Spurious output.

f. VSWR check.

g. Self-test mode.

2.2 THERMAL SHOCK TEST

The UUT, while turned off, was allowed to stabilize within a chamber for 2 hours at - 20° C. The chamber was then ramped at its maximum rate of change of ≥25° C per minute to a final temperature of -10° C. The UUT was then turned on and allowed to operate for 15 minutes before the following electrical and functional tests were conducted:

a. Transmitted frequency.

b. Transmitted power output.

c. Message format and structure.

2.3 OPERATING LIFETIME AT MINIMUM TEMPERATURE

The operational lifetime test is intended to establish, with reasonable confidence, that the UUT will function at its minimum operating temperature for its rated life using a battery that has reached its expiration date. The life test was performed with a fresh battery pack.

The UUT was operated at its minimum operating temperature for its rated life. During this period, the following parameters were measured on each transmission:

- Transmitted frequency
- Transmitter power output
- Message format and structure

The 18-sample analysis window of the stability calculations is advanced in time through the period such that each succeeding data set includes the latest frequency sample and drops the earliest one.

This test was performed with a long format message.

2.4 FREQUENCY STABILITY TEST WITH TEMPERATURE GRADIENT

A temperature chamber was programmed to execute the temperature gradient profile defined by Figure 2-1. The UUT was placed in the chamber, and the following electrical and functional tests were conducted continuously throughout the temperature gradient test:

a. Transmitted frequency

b. Transmitted power output

c. Message format and structure

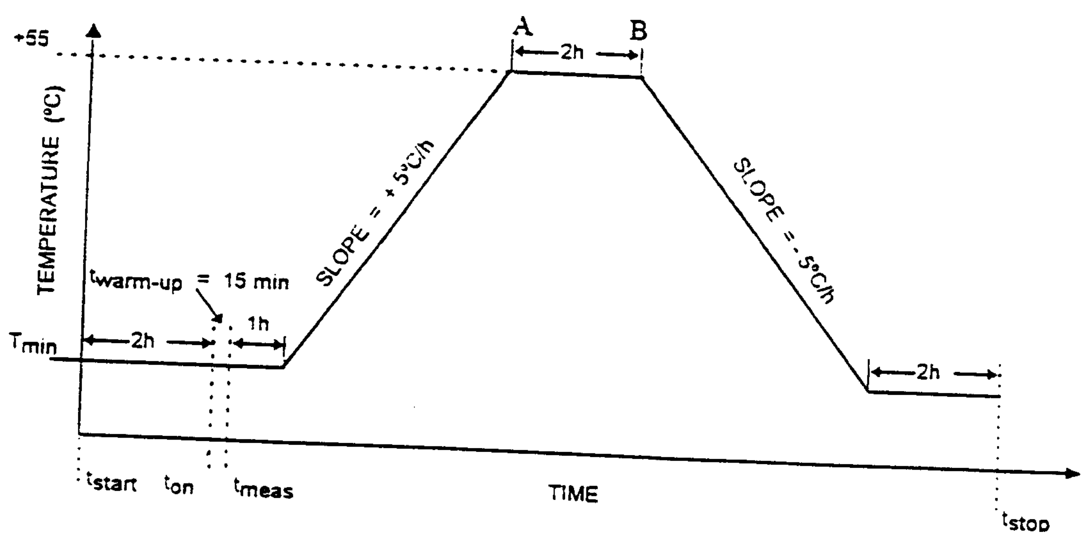

Figure 2-1. Temperature Gradient.

2.5 SATELLITE QUALITATIVE TESTS

This test was performed in coordination with the U.S. Mission Control Centre (MCC) and local authorities. This test was performed in an environment that approximated, as closely as possible, the intended use of the beacon.

The UUT operated in the open during at least three satellite passes, and downlink data were checked for correctness of:

Location data computed by the local user terminal (LUT)
Message format and structure

The UUT was successfully located and identified by a Cospas-Sarsat Low Earth Orbit (LEO) LUT. A summary of the results is located in Appendix A, Annex V.

2.6 ANTENNA CHARACTERISTICS

The beacon antenna test was performed as described in Section 3.4, at the ambient temperature of the test facility, and a correction factor was applied to the data to calculate the radiated power at -20° C at the end of the operating lifetime in computing the values of $ERP_{max\ EOL}$ and $ERP_{min\ EOL}$. This test was performed using the standard antenna-configured UUT.

2.7 NAVIGATION SYSTEM

The UUT was tested as described in Section 3.5 to verify the beacon output message, including the correct position data, Bose-Chaudhuri-Hocquenhem (BCH) error-correcting code(s), default values, and update rates. The navigation-input system was operating for the duration of all tests to ensure that it did not affect the 406-MHz signal and that the UUT could operate for the required operating lifetime. The message format and structure were monitored during all tests.

2.8 SELF-TEST MODE

The duration of the radio frequency (RF) energy burst of the UUT was measured, the frame synchronization pattern was checked, and the encoded location was checked for the correct default code. The format flag bit was reported.

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SECTION 3. TYPE APPROVAL CERTIFICATION TEST PROCEDURES FOR COSPAS-SARSAT BEACONS

The following are the detailed electrical and functional test procedures for the tests required.

3.1 MESSAGE FORMAT AND STRUCTURE

The following parameters were measured in accordance with the procedure prescribed in this section:

3.1.1 Repetition Period

3.1.2 Continuous wave (CW) Preamble (Duration of the Unmodulated Carrier)

3.1.3 Total Transmission Time

3.1.4 Bit Rate and Stability

3.1.5 Message Coding

3.1.1 Repetition Period

3.1.1.1 Scope.

a. References:

(1) C/S T.001, paragraph 2.2.1.

(2) C/S T.001 Annex B, paragraph B.3.1.1.

b. The objective was to measure the randomized repetition period T_r of the beacon transmissions.

c. *Repetition Period*, T_r, is the period between two successive beacon transmissions.

3.1.1.2 Facilities and Instrumentation.

- Environmental Test Facility
  - Cospas-Sarsat Measurement System (see Figure 3-1)
  - IBM Compatible Computer System
  - HP-1631D Logic Analyzer
  - HP-423B Crystal Detector w/50-ohm Termination
  - 20-decibel (dB) Attenuator
  - 3-dB Attenuator
  - HP-11667A Power Splitter

3.1.1.3 Test Conditions.

a. Normal ambient or any other specified environmental condition.

b. Performed these measurements on the unmodulated portion of the carrier.

c. Nominal operating voltage.

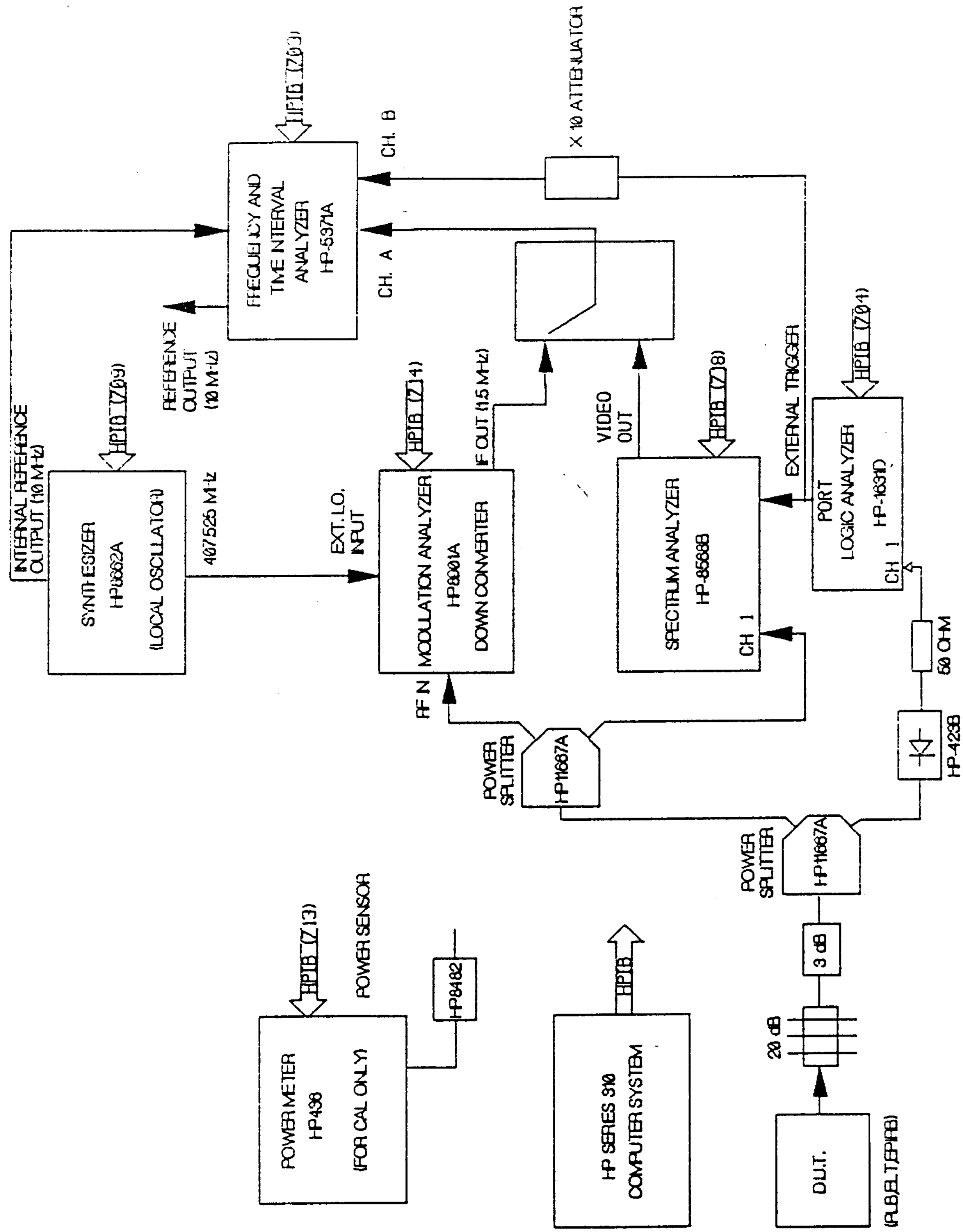


Figure 3-1. Cospas-Sarsat measurement system.

3.1.1.4 Test Procedure.

a. The power of the beacon radio output was derived from the crystal detector output applied to the analog input of the HP-1631D Logic Analyzer.

b. The HP-1631D was programmed to capture the rising edge of the burst waveform. Each voltage data point was converted into a power data point using the crystal detector power transfer equation and the attenuator/ power splitter attenuation value. The peak envelope voltage (100% power point) was then calculated by averaging 100 power data points, 6 milli-seconds (ms) after the trigger (-0.3 volt falling edge). The time between the 10% and 90% power points was found by counting the number of samples between these two points. Each sample was 10 microseconds (μs). At the end of the rise time measurement, the Logic Analyzer was then programmed to trigger at the 10% power point level.

c. Captured and recorded the time interval measurements for 18 successive transmissions.

d. Calculated the mean repetition period and the standard deviation.

e. Recorded any repetition period that fell outside of specified limits.

3.1.1.5 Data Reduction and Presentation.

Presented the recorded data in tabular form and annotated those readings which exceeded the specified limits.

3.1.2 CW Preamble (Duration of the Unmodulated Carrier)

3.1.2.1 Scope.

a. References:

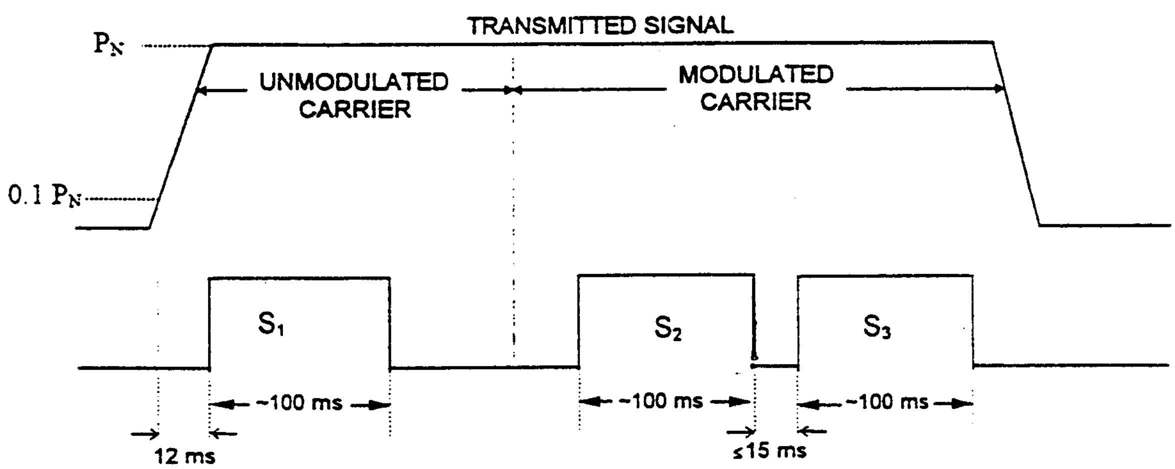
(1) C/S T.001, paragraph 2.2.2.

(2) C/S T.001, paragraph 2.2.3.

(3) C/S T.001 Annex B, paragraph B3.1.2.

b. The objective was to measure the unmodulated carrier duration between the beginning of a transmission and the beginning of the data modulation.

c. *Unmodulated carrier duration,* T_1, is the period between the beginning of transmission and the beginning of data modulation (see Figure 3-2).



The S_1 pulse starts 12 ms after the beginning of the unmodulated carrier.
The S_2 pulse starts at the beginning of bit 23.
The S_3 pulse starts not later than 15 ms after the end of S_2.

Figure 3-2. Definition of measurement intervals.

3.1.2.2 Facilities and Instrumentation.

- Environmental Test Facility

  - Cospas-Sarsat Measurement System (see Figure 3-1)
  - IBM Compatible Computer System
  - HP-1631D Logic Analyzer
  - HP-5371A Frequency and Time Interval Analyzer
  - HP-423B Crystal Detector w/50-ohm Termination
  - 20-dB Attenuator
  - 3-dB Attenuator
  - HP-1667A Power Splitter (2 each)

3.1.2.3 Test Conditions.

a. Normal ambient or any other specified environmental condition.

b. Performed these measurements on the unmodulated portion of the carrier.

c. Nominal operating voltage.

3.1.2.4 Test Procedure.

a. While the total transmission time was measured by the Logic Analyzer, the CW preamble was measured using the Frequency and Time Interval Analyzer. The Frequency and Time Interval Analyzer was programmed to acquire event versus time data after being triggered by Channel B signal (Logic Analyzer trigger out at 10% of P_n). The first phase transition of the modulated portion of the waveform was detected, and the time interval from that point to the trigger point on the rising edge of the waveform was measured.

b. Repeated the above measurements for 18 successive transmissions.

3.1.2.5 Data Reduction and Presentation.

Presented the recorded data in tabular form and annotated those readings which exceeded the specified limits.

3.1.3 Total Transmission Time

3.1.3.1 Scope.

a. References:

(1) C/S T.001, paragraph 2.2.2.

(2) C/S T.001, paragraph 2.2.3.

(3) C/S T.001 Annex B, paragraph B.3.1.2.

b. The objective was to measure the unmodulated carrier duration between the beginning of a transmission and the beginning of the data modulation and to measure the total transmission time of the transmitted waveform.

c. *Unmodulated carrier duration,* T_1, is the period between the beginning of transmission and the beginning of data modulation (see Figure 3-2, definition of measurement intervals).

d. *Total transmission time* is the period between the 10% power point on the rising edge of the waveform to 10% power point of the falling edge of the waveform.

3.1.3.2 Facilities and Instrumentation.

- Environmental Test Facility

  - Cospas-Sarsat Measurement System (see Figure 3-1)
  - IBM Compatible Computer System
  - HP-1631D Logic Analyzer
  - HP-423B Crystal Detector w/50-ohm Termination
  - 20-dB Attenuator
  - 3-dB Attenuator
  - HP-11667A Power Splitter

3.1.3.3 Test Conditions.

a. Normal ambient or any other specified environmental condition.

b. Performed these measurements on the unmodulated portion of the carrier.

c. Nominal operating voltage.

3.1.3.4 Test Procedure.

a. The power of the beacon radio output was derived from the crystal detector output applied to the analog input of the HP-1631D Logic Analyzer.

b. The HP-1631D was programmed to capture the rising edge of the burst waveform. Each voltage data point was converted into a power data point using the crystal detector power transfer equation and the attenuator/ power splitter attenuation value. The peak envelope voltage (100% power points) was then calculated by averaging 100 power data points, 6 ms after the trigger (-0.3-volt falling edge). The time between 10% power point levels of the rising and falling edges was measured.

c. Captured and recorded the total transmission times for 18 successive transmissions.

d. Recorded any total transmission time that fell outside of specified limits.

3.1.3.5 Data Reduction and Presentation.

Presented the recorded data in tabular form and annotated those readings which exceeded the specified limits.

3.1.4 Bit Rate and Stability

3.1.4.1 Scope.

a. Reference: C/S T.001, paragraph 2.2.1.

b. The objective was to measure the bit rate and stability of the baseband digital data.

c. *Bit Rate,* f_b, in bits per second (bps) is measured over at least the first 50 bits of one transmission.

d. *Stability* is the variation in bit rate measured over 18 transmissions.

3.1.4.2 Facilities and Instrumentation.

- Environmental Test Facility
  - Cospas-Sarsat Measurement System (see Figure 3-1)
  - IBM Compatible Computer System
  - HP-1631D Logic Analyzer
  - HP-8901 Modulation Analyzer/Down Converter
  - HP-5371A Frequency and Time Interval Analyzer
  - HP-8662A Frequency Synthesizer
  - HP-11667A Power Splitter (2 each)
  - 20-dB Attenuator
  - 10-dB Attenuator
  - 3-dB Attenuator

3.1.4.3 Test Conditions.

a. Normal ambient or any other specified environmental condition.

b. Performed these measurements on the modulated portion of the carrier.

c. Nominal operating voltage.

3.1.4.4 Test Procedure.

a. The bit rate, f_b, in bps was derived by measuring the period T_n encompassed by the first 50 bits of the modulated waveform. The bit rate is then $f_b = 50/T_n$.

b. The trigger marking the 0.1 P_n of the start of the burst waveform was generated by the Logic Analyzer. The phase information marking the start of the modulated waveform was obtained from the event versus time data acquired by the Frequency and Time Interval Analyzer. The event versus time data were acquired after a holdoff delay of 159 ms from the Logic Analyzer trigger event. Frequency and interval measurements started slightly before the start of the first bit. The sampling interval was 31.7 μs. A total acquisition time of 130 ms was used to encompass the first 50 bits of the modulated portion of the burst waveform.

c. The above measurement was repeated 18 times.

3.1.4.5 <u>Data Reduction and Presentation</u>.

a. Calculated the bit rate for each of the 18 measurements. The bit rate was equal to the measured time interval encompassing 50 bits divided by 50.

b. Presented the bit rate data in tabular form.

c. Presented the maximum and minimum bit rates and determined whether the values satisfy the requirement that:

$$396 \text{ bps} < f_b < 404 \text{ bps}$$

3.1.5 Message Coding

3.1.5.1 Scope.

a. References:

(1) C/S T.001, paragraph 3.

(2) C/S T.001 Annex A.

b. The objective was to check the content of the digital message for validity and compliance with the format for each data field, bit by bit.

3.1.5.2 Facilities and Instrumentation.

- Environmental Test Facility

  - Cospas-Sarsat Measurement System (see Figure 3-1)
  - IBM Compatible Computer System
  - HP-1631D Logic Analyzer
  - HP5371A Frequency and Time Interval Analyzer
  - HP-423B Crystal Detector w/50-ohm termination
  - 20-dB Attenuator
  - 3-dB Attenuator
  - HP-1667A Power Splitter (2 each)

3.1.5.3 Test Conditions.

a. Normal ambient or any other specified environmental condition.

b. Performed these measurements on the modulated portion of the carrier.

c. Nominal operating voltage.

3.1.5.4 Test Procedure.

a. The modulated portion of the transmitted signal was demodulated.

b. The message data contained in bit positions 25-85 were decoded using the BCH error-correcting code in positions 86-106 (short message format). The message data in bit positions 25-85 and 107-132 (long message format) were decoded using the BCH error-correcting codes in bit positions 86-106 and 133-144, respectively.

3.1.5.5 Data Reduction and Presentation.

a. Processed the bit sequence captured by the measurement system.

b. Presented the decoded message by field and checked the result for validity and compliance with the format for each field.

c. Verified that the decoded message was in agreement with that provided by the manufacturer.

3.2 MODULATOR AND 406-MHz TRANSMITTER

The following parameters were measured in accordance with the procedures prescribed in this section:

3.2.1 Transmitted Frequency

3.2.2 Transmitter Power Output

3.2.2.1 Transmitter Power Output Level

3.2.2.2 Transmitter Power Output Rise Time

3.2.2.3 Spurious Output

3.2.3 Data Encoding and Modulation

3.2.1 Transmitted Frequency

3.2.1.1 Scope.

a. Reference: C/S T.001, paragraph 2.3.1.

b. The objective was to measure the deviation of the transmitter's RF from the selected frequency versus operating time after switch-on, under specified conditions of power supply and temperature.

c. This test procedure applies to 406-MHz beacon transmitters.

d. Frequency accuracy is the maximum allowable relative difference between the measured frequency and the selected frequency during the measurement period.

3.2.1.2 Facilities and Instrumentation.

- Environmental Test Facility

  - Cospas-Sarsat Measurement System (see Figure 3-1)
  - IBM Compatible Computer System
  - HP-1631D Logic Analyzer
  - HP-8901A Modulation Analyzer/Down Converter
  - HP-5371A Frequency and Time Interval Analyzer
  - HP-8662A Frequency Synthesizer
  - HP11667A Power Splitter (2 each)
  - 20-dB Attenuator
  - 10-dB Attenuator
  - 3-dB Attenuator

3.2.1.3 Test Conditions.

a. Normal ambient conditions or any other specified environmental condition.

b. Performed these measurements in the designated measurement intervals S_1, S_2, and S_3 as defined in Figure 3-2.

c. Nominal operating voltage.

3.2.1.4 Test Procedure.

a. Before starting this test, the UUT was stabilized at the laboratory ambient temperature in a non-operating condition. The UUT was then allowed to operate for 15 minutes before measurements were started.

b. The measurement system was triggered by the transmitter burst. Measurement commenced 12 ms after the start of the carrier relative to 0.1 P_n. Three sampling periods were defined where frequency measurements were made (see Figure 3-2, definition of measurement intervals).

c. Turned the beacon transmitter on and measured the frequency of the transmitter during the three 100-ms sampling intervals of the carrier.

d. Repeated the above measurement 18 times.

3.2.1.5 Data Reduction and Presentation.

a. The mean transmission frequency f_0, was determined from 18 successive measurements of $f_i^{(1)}$ as follows:

$$f_0 = f^{(1)} = \frac{1}{n} \sum_{i=1}^{n} f_i^{(1)}$$

where n=18

b. The short-term frequency stability was derived from measurements of $f_i^{(2)}$ and $f_i^{(3)}$ made during the intervals S2 and S3 during 18 successive transmissions, as follows:

$$\sigma_{100ms} = \left\{ \frac{1}{2n} \sum_{i=1}^{n} \left(\frac{f_i^{(2)} - f_i^{(3)}}{f_i^{(2)}} \right)^2 \right\}^{1/2}$$

where n=18

c. The medium-term frequency stability was derived from measurements of $f_i^{(2)}$ made over 18 successive transmissions at instants t_i (see Figure 3-3.).

$$A = \frac{n\sum_{i=1}^{n} t_i f_i - \sum_{i=1}^{n} t_i \sum_{i=1}^{n} f_i}{n\sum_{i=1}^{n} t_i^2 - \left(\sum_{i=1}^{n} t_i\right)^2}$$

d. The ordinate at the origin of the least-squares straight line was given by:

$$B = \frac{\sum_{i=1}^{n} f_i \sum_{i=1}^{n} t_i^2 - \sum_{i=1}^{n} t_i \sum_{i=1}^{n} t_i f_i}{n \sum_{i=1}^{n} t_i^2 - \left(\sum_{i=1}^{n} t_i \right)^2}$$

where n=18

e. The residual frequency variation was given by:

$$\sigma = \left\{ \frac{1}{n} \sum_{i=1}^{n} \left(f_i - At_i - B \right)^2 \right\}^{1/2}$$

where n=18

f. Plotted the transmitter frequency error (E) as a function of the operating time.

g. Plotted the transmitter frequency error (E) as a function of temperature (for data collected during temperature tests).

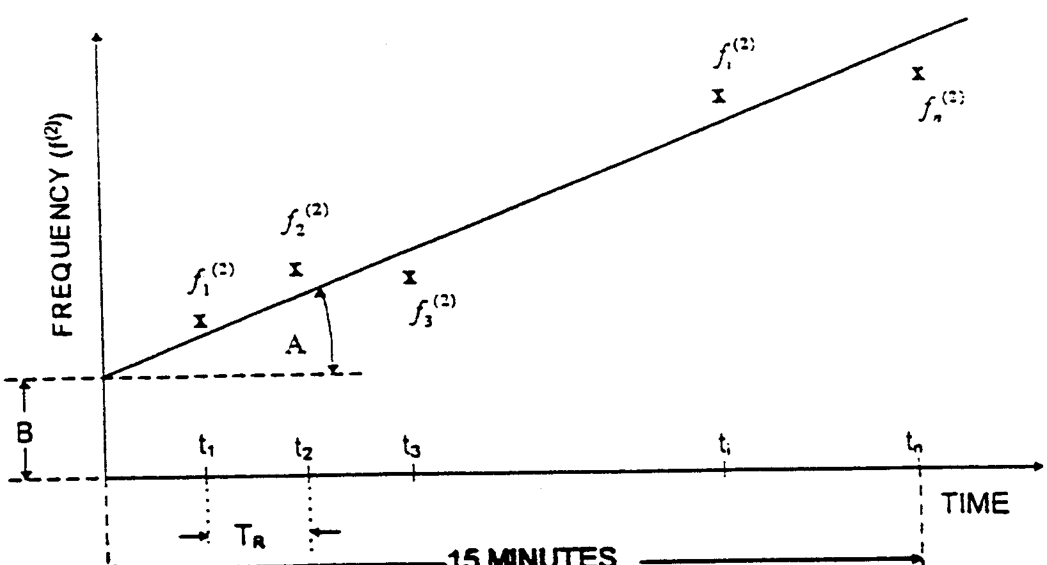


Figure 3-3. Medium-term frequency stability measurement.

3.2.2 Transmitter Power Output

3.2.2.1 Transmitter Power Output Level

3.2.2.1.1 Scope.

a. Reference: C/S T.001, paragraph 2.3.2.

b. The objective was to measure the transmitter RF output power.

c. RF output power is the power that the beacon transmitter delivers to the antenna or to a load with the same VSWR as the antenna at the operational frequency. This power is defined for the unmodulated carrier-on condition.

3.2.2.1.2 Facilities and Instrumentation.

- Environmental Test Facility
    - Cospas-Sarsat Measurement System (see Figure 3-1)
    - IBM Compatible Computer System
    - HP-1631D Logic Analyzer
    - HP-423B Crystal Detector w/50-ohm Termination
    - HP-11667A Power Splitter
    - 20-dB Attenuator
    - 3-dB Attenuator

3.2.2.1.3 Test Conditions.

a. Normal ambient or any other specified environmental condition.

b. Performed these measurements on the unmodulated portion of the waveform.

3.2.2.1.4 Test Procedure for RF Power Output.

a. The RF output of the transmitter was applied to the HP-423B crystal detector. The output of the detector was applied to the analog input of the HP-1631D analog input. The HP-1631D was programmed to capture the burst envelope. The trigger threshold setting used with the HP-1631D in conjunction with the burst envelope rise time tests ensures power is less than -10 dBm at time 1 ms before burst.

b. Ensured that the battery in the UUT was at full capacity.

c. Measured the VSWR of the antenna and replaced the antenna with a dummy load with a VSWR equal to that of the antenna under normal operational conditions.

d. Keyed the transmitter and measured the RF power (P_1), in watts, into the dummy load at the transmission frequency. The Logic Analyzer captured the waveform to measure the transmitted power.

e. Measured the RF power (P_1) during the 100-ms period following a 12-ms offset measured from the 10% power point of the transmitted signal envelope rise time.

3.2.2.1.5 Data Reduction and Presentation.

a. Recorded the measured transmitter power and noted any anomalies such as irregularity in amplitude during the 100-ms unmodulated carrier portion of the carrier.

b. Peak envelope voltage was obtained by averaging 800 voltage data points during 400 ms of the burst (see Figure 3-4.). The peak envelope voltage was then converted into transmitter output power by using the crystal detector polynomial power transfer equation and the attenuators/power splitter attenuation value. The polynomials and the attenuation value were stored on disk files during the calibration subprogram.

c. Presented the measured power output in tabular form.

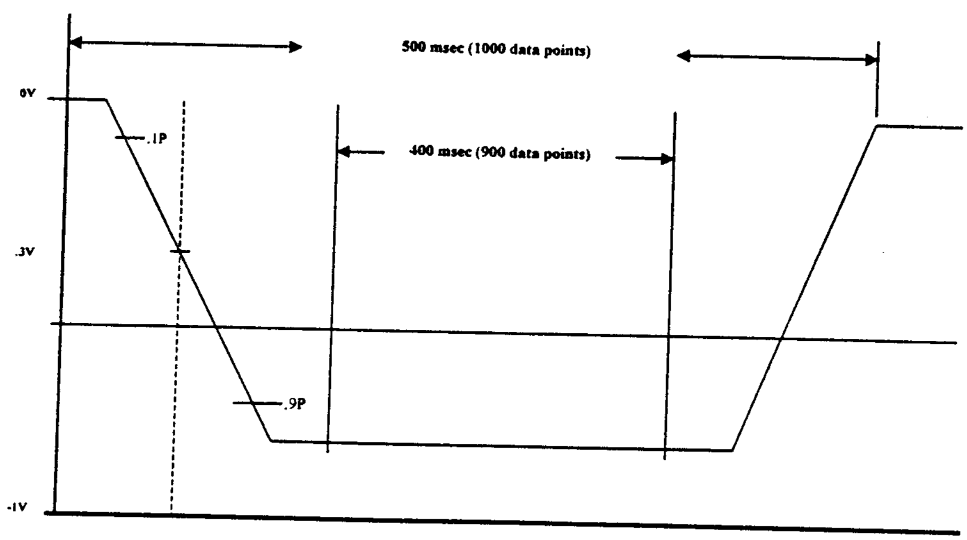


Figure 3-4. Burst envelope data acquisition.

3.2.2.2 Transmitter Power Output Rise Time

3.2.2.2.1 Scope.

a. Reference: C/S T.001 paragraph 2.3.2

b. The objective was to measure the power output rise time.

c. Rise Time is the time required for power to increase from 10% to 90% of its steady-state value (see Figure 3-2, definition of measurement intervals).

3.2.2.2.2 Facilities and Instrumentation.

- Environmental Test Facility
  - COSPAS-SARSAT Measurement System (see Figure 3-1)
  - IBM Compatible Computer System
  - HP-1631D Logic Analyzer
  - HP-423B Crystal Detector w/50-ohm Termination
  - 3 dB Attenuator
  - 20 dB Attenuator
  - HP-1667A Power Splitter (2 each)

3.2.2.2.3 Test Conditions.

a. Normal ambient or any other specified environmental condition.

b. Performed these measurements on the unmodulated portion of the carrier.

c. Nominal operating voltage.

3.2.2.2.4 Test Procedure.

a. The HP-1631D was programmed to capture the rising edge of the burst waveform. Each voltage data point was converted into a power data point using the crystal detector power transfer equation and the attenuator/power splitter attenuation value. The time between the 10% and 90% power points was found by counting the number of samples between these two points. Each sample was 10 μs.

b. Repeated the above measurements for 18 successive transmissions.

3.2.2.2.5 Data Reduction and Presentation.

Presented the recorded data in tabular form and annotated those readings which exceeded the specified limits.

3.2.2.3 Spurious Output

3.2.2.3.1 Scope.

a. References: C/S T.001, paragraph 2.3.4.

b. The objective was to determine the level of the transmitter harmonic and spurious signals. These are unwanted signals at discrete frequencies due to frequency synthesis or to non-linearities at the output stages of the transmitter.

c. A *harmonic* is a signal with a frequency which is an integer multiple of the transmitter frequency.

d. A *spurious signal* is an unwanted signal with a frequency that is not an integer multiple of the transmitter frequency.

e. Harmonic and spurious signal powers are expressed as levels in decibels with reference to the carrier (dBc), related to the transmitter power.

3.2.2.3.2 Facilities and Instrumentation.

- Environmental Test Facility
  - Cospas-Sarsat Measurement System (see Figure 3-1)
  - IBM Compatible Computer System
  - HP-8568B Spectrum Analyzer
  - HP-8662A Synthesizer
  - HP-1631D Logic Analyzer
  - 20-dB Attenuator
  - 3-dB Attenuator
  - 2 each HP-11667A Power Splitter

3.2.2.3.3 Test Conditions.

a. Normal ambient conditions or any other specified environmental conditions.

b. Nominal operating voltage.

3.2.2.3.4 Test Procedures.

a. The Spectrum Analyzer was programmed with the following settings:

Center frequency:	406.025 MHz
Frequency span:	50.000 kHz
Resolution Bandwidth:	100.000 Hz
Sweep time:	10 seconds
Trace mode:	maximum hold

b. The "maximum hold" mode displayed and held on the cathode ray tube (CRT), the maximum response of the input signal. In order to capture the spectral characteristics of the 406-MHz signal, the Spectrum Analyzer sweep was allowed to freely run continuously until the full spectral response was integrated without gaps. The integration period could take up to 5 hours. In order to facilitate expeditious completion of this process, the trigger of the Spectrum Analyzer was dithered under program control to randomize over a small period, the start of the sweep.

c. When the spectral response was fully integrated or after 5 hours (whichever came first), the marker peak function found the unmodulated carrier amplitude that was the 0-dB carrier reference. The marker function of the Spectrum Analyzer and the computer verified that the spurious response was lower than the allowable limits as indicated in Figure 3-5.

3.2.2.3.5 Data Reduction and Presentation.

a. Presented the computer plots of the spectral response with the limit mask superimposed on the spectral response.

b. Presented the recorded data in tabulated form with the frequency and amplitude of those spurs, which exceeded the specified limits.

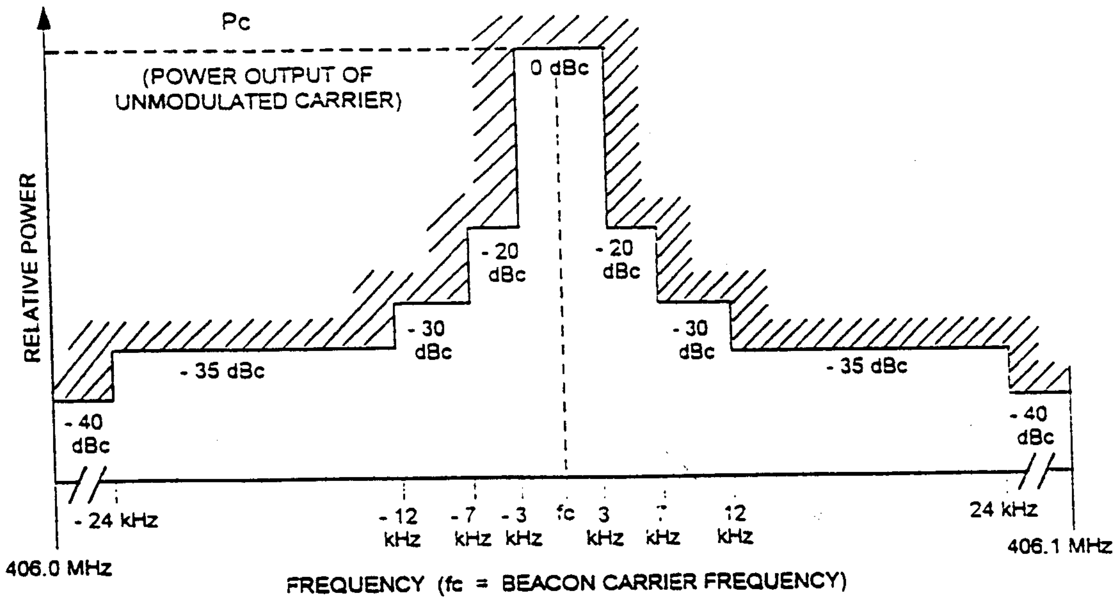


Figure 3-5. In-band spurious emission mask.

3.2.3 Data Encoding and Modulation

3.2.3.1 Scope.

a. References:

(1) C/S T.001, paragraph 2.3.5.

(2) C/S T.001, paragraph 2.3.6.

b. The objective was to measure data encoding, modulation sense, modulation phase deviation, modulation rise and fall times, and modulation symmetry of the bi-phase demodulated signal were measured.

3.2.3.2 Facilities and Instrumentation.

- Environmental Test Facility
  - Cospas-Sarsat Measurement System (see Figure 3-1.)
  - IBM Compatible Computer System
  - HP-1631D Logic Analyzer
  - HP-8901A Modulation Analyzer/Down Converter
  - HP-5371A Frequency and Time Interval Analyzer
  - HP-8662A Frequency Synthesizer
  - HP-11667A Power Splitter (2 each)
  - 20-dB Attenuator
  - 10-dB Attenuator
  - 3-dB Attenuator

3.2.3.3 Test Conditions.

a. Normal ambient conditions or any other specified environmental conditions.

b. Nominal operating voltage.

3.2.3.4 Test Procedure.

a. The Frequency and Time Interval Analyzer captured time versus event data of the down converted modulated burst waveform.

b. Following capture of the time versus event data, the data were processed to remove the effect of the difference between the actual carrier frequency and the estimated carrier frequency represented by the downconverter frequency. This removed the increasing phase versus time offset, which would compromise the accuracy of the measurement of the demodulated waveform characteristics.

c. Modulation rise and fall times, modulation symmetry, and phase deviation were then derived from the processed waveform.

3.2.3.5 Data Reduction and Presentation.

a. Presented a printout of the modulation waveform and tabulated data on the measure modulation parameters.

b. Annotated those readings which exceeded specified limits.

3.3 VOLTAGE STANDING WAVE RATIO

3.3.1 Scope.

a. References:

(1) C/S T.001, paragraph 2.3.7

(2) C/S T.007 Annex A, paragraph A3.3

b. The objective was to determine if the transmitter would be damaged by any load from open circuit to short circuit. For the purpose of this test, the test loads were:

(1) Open circuit

(2) Short circuit

(3) 3:1 VSWR load

3.3.2 Facilities and Instrumentation.

- Environmental Test Facility
  - Cospas-Sarsat Measurement System (see Figure 3-1)
  - IBM Compatible Computer System
  - HP-1631D Logic Analyzer
  - HP-5371A Frequency and Time Interval Analyzer
  - 20-dB Attenuator
  - 3-dB Attenuator w/shorting plug
  - 3-dB Attenuator
  - HP-1667A Power Splitter (2 each)

3.3.3 Test Conditions.

a. Normal ambient conditions or any other environmental conditions.

b. Nominal operating voltage.

3.3.4 Test Procedure.

3.3.4.1 Mismatched Load Simulation.

a. Short circuit condition was achieved with a shorting connector attached to the end of the transmission cable.

b. A 3:1 VSWR was achieved by using a 3-dB attenuator with a shorting connector attached to one end of the attenuator. This configuration presented a load to the transmitter with 6-dB return loss. The shorted attenuator was then attached to the end of the transmission cable.

3.3.4.2 Measurement Procedure.

a. With the transmitter on, a short circuit condition was applied to the transmitter output for 5 minutes.

b. An open circuit condition was then applied to the transmitter output for 5 minutes.

c. A 3:1 VSWR load was then applied to the transmitter output for 5 minutes.

d. Measured the transmitter nominal frequency, digital message content, and modulation parameters to verify that transmitter performance had not been degraded.

3.3.5 Data Reduction and Presentation.

Presented the recorded data in tabular form and annotated those readings which exceeded the specified limits.

3.4 ANTENNA CHARACTERISTICS

3.4.1 Scope.

a. Reference: C/S T.007, Annex B.

b. The objective was to measure the radiation characteristics of the beacon.

c. The beacon shall produce a field equivalent to an ERP in the range of 1.6 to 20 watts. The polarization of the beacon antenna shall be linear or right-hand circular. The gain variation shall not exceed 3 dB at an elevation angle of 40 degrees. The VSWR shall not exceed 1.5:1 at 406.025 MHz.

3.4.1 Facilities and Instrumentation.

- Antenna Test Facility

  - HP-8562A Spectrum Analyzer
  - HP-83640A Synthesized Sweeper
  - Scientific-Atlanta-26-0.1 log periodic dipole antennas
  - HP-438A Power Meter
  - HP-8481A Power Sensor

3.4.2 Test Conditions.

a. Normal ambient conditions or any other environmental conditions.

b. Nominal operating voltage.

3.4.4 Test Procedures.

a. Description of test range. The arc range utilizes a vertically mounted, 75-foot (23 meter) radius arc with a 60-foot (18.3 meter) diameter horizontal turntable below its focal point. The arc range is constructed of non-metallic materials, with the exception of some RF components and the turntable. The vertical arc member is supported by four laminated wooden legs in a four-sided, pyramidal design. The inside curvature of the arc is covered with a metallic track and RF energy scatter shield that facilitate the movement of a sled-mounted probe antenna. The scatter shield is designed to prevent the reflection of RF energy back into the test area. A wooden UUT rack is used to position the beacon antenna up to the focal point of the arc, approximately 29 feet above ground level. RF energy is radiated from the beacon antenna and is received by the probe antenna 75 feet (23 meters) away on the vertical arc. The probe antenna maintains a constant distance to the beacon antenna and also remains oriented perpendicular to the direction of propagation from the beacon antenna as it is raised and lowered in elevation (see Figure 3-6).

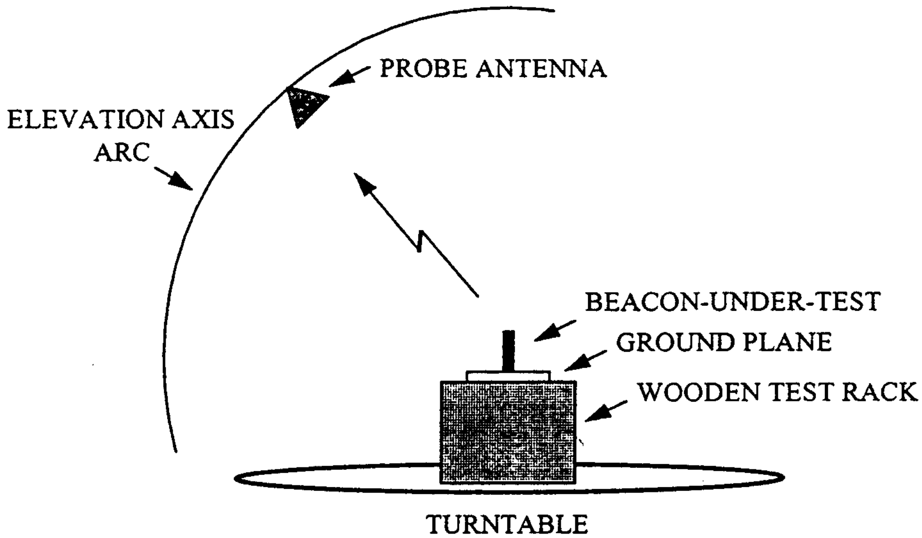


Figure 3-6. Arc range.

b. UUT configuration. The beacon was placed over the center of the test range turntable on top of the wooden UUT rack. The beacon was placed in the center of a 125-centimeter radius ground plane constructed of plywood covered with aluminum window screen material. The beacon was oriented on top of the ground plane in the manner in which it is designed to operate.

c. Range calibration. A standard gain antenna was used to calibrate the range for all ERP measurements. The range was calibrated at 0 degrees elevation and 0 degrees azimuth by radiating a known ERP level at the location of the beacon antenna under test, and measuring the received signal level of a spectrum analyzer connected to the probe antenna.

d. Beacon ERP measurement. The UUT was transmitting normally with a fresh battery. The elevation angle of the probe antenna on the vertical arc member was held constant at the desired elevation angle relative to the beacon antenna. A spectrum analyzer was connected to the probe antenna to capture one beacon test pulse for each azimuth and elevation angle combination. Data were collected as the turntable stepped in 30 degree azimuth increments from 0 to 330 degrees. Measurements were conducted at elevation angles of 10, 20, 30, 40 and 50 degrees. Position accuracy was within ±3 degrees.

The maximum ERP variation at 40 degrees elevation was determined by calculating the difference between the maximum and minimum ERP values tabulated in Appendix B, Table B-3 for an elevation angle of 40 degrees.

The maximum and minimum ERP values of Appendix B, Table B-3 were used to compute the values of ERP_{maxEOL} and ERP_{minEOL}. The value for ERP_{maxEOL} of 4.498 watts met the criterion of less than or equal to 20 watts. The value for ERP_{minEOL} will meet the criterion of greater than or equal to 1.6 watts when increased by 2.45 dB to allow for antenna range instrumentation accuracy (1.074 watts = 30.31 dBm, 30.31 dBm + 2.45 dB = 32.76 dBm = 1.888 watts).

e. Antenna polarization measurement. Spectrum analyzer received signal levels were measured for all azimuth and elevation angle combinations using both vertical and horizontal polarization for the probe antenna.

The polarization of the beacon antenna was determined by calculating the difference between the vertically and horizontally received signal levels of tables B-1 and B-2 in Appendix B. The vertical polarization levels were at least 10 dB greater than the horizontal polarization levels for all of the 60 azimuth/elevation points (100% of all data collected).

3.4.5 <u>Data Reduction and Presentation</u>.

Presented the recorded data in tabular form and annotated those readings which exceeded the specified limits.

3.5 NAVIGATION SYSTEM

3.5.1 Scope.

a. References: C/S T.001, paragraphs 4.5.5, 4.5.5.1, 4.5.5.2, 4.5.5.3, and C/S T.007, Annex A, paragraph 3.8.

b. The objective was to test the ability of the beacon to handle and process all appropriate navigation system requirements and accept/process data from an external navigation device.

3.5.2 Facilities and Instrumentation.

- Environmental Test Facility
  - Cospas-Sarsat Measurement System (see Figure 3-1)
  - IBM Compatible Computer System
  - HP-1631D Logic Analyzer
  - HP-5371A Frequency and Time Interval Analyzer
  - 20-dB Attenuator
  - 3-dB Attenuator w/shorting plug
  - 3-dB Attenuator
  - HP-1667A Power Splitter (2 each)
  - Personal computer (laptop)

3.5.3 Test Conditions.

a. Normal ambient conditions or any other environmental conditions.

b. Nominal operating voltage.

3.5.4 Test Procedures.

a. Verification of data default values. This was accomplished throughout all ambient and environmental closed-link parametric testing when no external GPS stimulus was applied. An example of these default message values are shown in Appendix A, page A-I-2.

b. Verification of position acquisition time. This was accomplished during input of the 20 worldwide GPS positions as shown in Table 3-1 below. Appropriate GPS position messages were provided to the beacon via the RS-232 serial interface and with the beacon powered on. Data messages were obtained from the beacon within the next 5 minutes and verified to be correct (see Appendix A, pages A-VI-4 through A-VI-23.

TABLE 3-1. SIMULATED WORLDWIDE LOCATIONS

Location number	Geographic Location	Position Coordinates
1	North Pole	90° N, 0° E/W
2	South Pole	90° S, 0° E/W
3	Mag. North	78° 18' N, 104° W
4	Mag. South	60° S, 140° E
5	Equator 1	0° N, 21° 28' W
6	Equator 2	0° N/S, 0° E
7	Equator 3	0° N/S, 180° W
8	Greenland	77° 30' N, 44° 50' W
9	Alaska	64° N, 154° 34' W
10	Mexico	19° 41' N, 104° 27'W
11	Hawaii	18° 45' N, 157° 10' W
12	China	53° 45' N, 21° 28' E
13	USA	38° 08' N, 101° W
14	England	51° N, 0° E
15	Kalgoorie, Australia	30° 27' S, 121° 21' E
16	Northern Brazil (Manaus)	3° 00' S, 60° 00' W
17	Aukland, New Zealand	36° 32' S, 174° 27' E
18	Kenya (Kisumu)	00° 01' S, 34° 27' E
19	Aruba	12° 17' N, 70° 00' W
20	Balleny Island	67° S, 164° E

c. Verification of position update interval. This beacon is not capable of updating the encoded position data; therefore, this requirement is not applicable.

d. Verification of delta offset. Delta offsets in both the positive and negative direction were accomplished in the course of tests simulating the 20 worldwide GPS positions (see Appendix A, pages A-VI-4 through A-I-23. Test of overrange to two times coarse resolution is not applicable as this beacon requires an external GPS receiver.

e. Verification of last valid position. This test was conducted by first confirming a correct encoded message and then removing the simulated GPS serial data. Beacon encoded position data were then captured approximately 2 minutes later and confirmed to have been correctly retained as indicated in Appendix A, page A-VI-2. Beacon power was then recycled with no GPS stimulus and the previous location confirmed to have been cleared as evidenced by the captured default latitude and longitude values as shown in Appendix A, page A-VI-3.

3.5.5 Data Reduction and Presentation.

a. Processed the bit sequence captured by the measurement system.

b. Presented the decoded message by field and checked the result for validity and compliance with the format for each field.

c. Presented the recorded data in tabular form and annotated those readings which exceeded the specified limits.

3.6 SELF-TEST MODE

3.6.1 Scope.

a. Reference: C/S T.001, paragraph 2.3.7

b. The objective was to test the built-in self-test capability of the UUT.

3.6.2 Facilities and Instrumentation.

- Environmental Test Facility
    - Cospas-Sarsat Measurement System (see Figure 3-1)
    - IBM Compatible Computer System
    - HP-1631D Logic Analyzer
    - HP-5371A Frequency and Time Interval Analyzer
    - 20-dB Attenuator
    - 3-dB Attenuator w/shorting plug
    - 3-dB Attenuator
    - HP-1667A Power Splitter (2 each)

3.6.3 Test Conditions.

a. Normal ambient conditions or any other specified environmental conditions.

b. Perform these tests on the modulated portion of the carrier.

c. Nominal operating voltage.

3.6.4 Test Procedure.

a. Activated the self-test mode on the UUT.

b. The modulated portion of the transmitted signal was demodulated.

c. The message data were decoded and the encoded location was checked for the correct default code. The format flag bit was reported.

d. Checked the frame synchronization pattern and encoded location for the default code.

e. Burst envelope timing was measured to ensure compliance to specification.

3.6.5 Data Reduction and Presentation.

a. Processed the bit sequence captured by the measurement system.

c. Presented the decoded message by field and checked the results for validity and compliance with the format for each field. Verified that the decoded message complied with the test user protocol.

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