TEST PROCEDURE

TITLE: Testing of Unlicensed Low Power Devices for FCC and IC Regulatory Compliance
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1.0 Purpose of Test

To determine the RF radiated emission levels and the AC Power line Conducted Emission Level of unlicensed low power devices as required for FCC and IC Regulatory Compliance and as requested by Design Engineering and Compliance Engineering.

2.0 Related Documents

FCC: CFR 47; Parts 15.109, 15.209, 15.231, 15.249(c) and 15.31(m)
Industry Canada: RSS-210, RSS-212, and TRC 43
ANSI C63.4-2001

3.0 Requirements

The individual performing the testing must be thoroughly familiar with the instrumentation used and the techniques required for emissions testing.
The individual must understand the calculations involved in converting from the raw data in dBm to field strength in dBµV/m and µV/m knowing the cable losses and antenna factors.
The test equipment required, listed in the Equipment List (Appendixes A and R), is located at the site and is part of the three-meter-site setup.

4.0 Worksite

The worksite includes the OATS (Open Area Test Site) which is the area enclosed by the Dome and the attached air lock / instrument room. For instruments used refer to the equipment list (Appendix A) and Photo 1 in Appendix B.

5.0 Introduction

The tests performed are Radiated Emissions and A.C. Power Line Conducted Emissions. The Radiated Emissions Testing is done at the Three Meter Site. A Three Meter Site has the measuring antenna positioned three meters away from the DUT center and has an RF reflective floor.

The DUT is centered on the Styrofoam block, which is centered on the rotary table. The Styrofoam block can be replaced with an all-wood table—stay away from composites because they are too dense and will produce reflections and/or absorption of the RF emissions thereby giving erroneous results. The top surface of the block/table is at 80 cm above the ground plane. The device is placed upright to simulate normal usage orientation. An exception to this is handhelds, which should be tested in all three planes.

The measuring antenna (vertically polarized or horizontally polarized) is centered at a three-meter horizontal distance from the center of the DUT.
The three-meter distance is measured from the center of the table to a point of measurement on the antenna as follows:
Dipole and Bi-conical – Measure to the element center.
Log Periodic – To the center element-this point is indicated by a label.
Double-Ridged Waveguide Horn – To the front edge.
The antenna is mounted to the carriage on the boom. For consistency, some of the antennas will need to be leveled with a bubble-level. Refer to Photos 2-16 in Appendix B.

The search, for emissions, is made with the measuring antenna over the range of 100 to 400 cm in height.
Two additional antennas are used during testing; one is for providing the wakeup signal (when necessary), the other is for monitoring for ERT fundamental transmissions when doing transmitter harmonic searches. These antennas must be positioned well off to the side to minimize the generation of interfering reflections. A convenient location for these two antennas is just to the east or west of the entrance door to the dome.

The table is rotated through the full 360 degrees in 30-degree increments initially and then the search for the final level is performed in much smaller increments.

The majority of digital spectrum analyzers, presently available, generally prove to be inadequate for emissions search due to their relatively long scan time.

When choosing a spectrum analyzer to be used for capturing transmissions it is important to ensure that the Scan Time across the display is equal to or much shorter than the duration of the transmission being measured.
Due to the short duration of the transmitted message (SCM = 5.86 msec and IDM = 44.92 msec) an analog spectrum analyzer (HP 141T with 8555A RF section and 8552B IF section) is used. Refer to Appendix C for SCM and IDM description.

Note that a SCAN TIME PER DIVISION setting of 0.1 msec. will be used and this condition will cause the 'DISPLAY UNCAL' indicator to be active. This fact is not important because we are looking for the relative maximum level. Even though this setting gives an indication that the display is un-calibrated, the relative maximum power level displayed will indicate the point of maximum level because the setting guarantees the capture of each transmission.

When the location (antenna height and table azimuth) of the maximum signal level is found, the actual level will be determined using a digital analyzer such as the HP 8593E as it can be configured to the resolution bandwidth and video bandwidth settings required by the FCC and IC. Final determination of power level, especially harmonics, may be by signal substitution using a power meter. This is required when measuring signals such as harmonics, which may be close to the noise floor.

Electric ERTs, which are bubble-up type or are designed with an IDM (Interval Data Message) personality which transmit a 44 msec. long message, with a 4 ± 2 second time delay between transmissions, present a near impossibility for testing in that state. These designs must be effected up front with the capability of placing the ERT in a 'nuts-mode', whereby messages will be transmitted every 100 msec. continuously. In this nuts-mode, of continuous consecutive messages, the message should be the shorter SCM 5.86 msec message.

The typical gas/water ERT, with an SCM (Standard Consumption Message personality) as shipped, is programmed to transmit eight messages spaced approximately 100 msec. apart with a delay of ten seconds before the next group of eight messages is transmitted. In order to speed up the testing, the ERTs to be tested should be reprogrammed using a ReadOne Pro with a 'Hal' personality to transmit 15 messages at a delay of two. This reduces the delay time, between transmissions, to approximately 3-4 seconds. CAUTION: A delay of one may shorten the delay time to the point that the ERTs cannot be reprogrammed.

Because of the short time period during which the ERT is transmitting, the search must be performed only during the period of time when the ERT is transmitting.
Only during the period of time that the ERT is transmitting can the antenna be raised or lowered or can the table be rotated.
The level of the harmonics will, at some combinations of antenna height and table azimuth, be so low that they cannot be observed on the spectrum analyzer. As such the fundamental must be monitored on a second spectrum analyzer and antenna as evidence of transmissions occurring.
The A.C. Power Line Conducted Emissions are also conducted at the Three Meter Site but with the erection of a temporary wall.
To help maintain the integrity of the test equipment male to female precision adapters, which are good up to 15 GHz, are used on the test equipment input ports otherwise the constant connect and disconnect will shorten the life of the input port. By contrast, the replacement of an adapter is a quick and inexpensive repair.

During off-hours, the test equipment, except for the power supplies and the device controller is always left in standby mode.

During off hours, the antenna is removed, the antenna boom is positioned at approximately 225 cm and the antenna polarization is set at "HOR'. The mast is then lowered into the holder/cradle provided to prevent damage to the dome and mast in case of dome deflation during high wind conditions. Refer to Photo 19 in Appendix B.

To ensure proper operation of test equipment and thereby obtain correct test results, the test environment must be maintained within the proper ambient temperature range. Refer to Appendix D.

The source of the Data Entry Sheet is Sheet 3 (Spurious Search above 900 MHz) of the latest EXCEL spreadsheet ‘FCC_FORMS&LIMITS_yymmdd’. The ‘yymmdd’ is a date stamping of the latest calibration factors being entered. For example ‘030228’ refers to 2003, February, 28.

All ‘Sheets’ referred to in this document are found in the above mentioned spreadsheet.
This is an active spreadsheet where the latest Antenna Factors, coax losses and amplifier gains are recorded. For that reason all copies are kept for historical reference.
During testing photos, to be included in the report, are taken of the RF Radiated emissions setup and the Power Line Conducted emissions setup.
In addition, detailed photos of the DUT showing the exterior (sides, top and bottom), the interior and the board assembly. These are to be included as an attachment to the report.
For terms encountered and conversions between dBm measured levels and field strength refer to Appendix E, Terms List and Appendix F, Conversions.

6.0 Setup Prior to Testing

6.1 Program the DUT

Refer to Appendix G for programming of ERTs prior to testing

6.2 Antenna Mast

Place Mast upright and secure in place with the pin provided. Ensure that the mechanical stop is in place to prevent damage to the Biconical antenna in case of a malfunction. (At times the control of device 1 or 2, antenna carriage or table, will be lost and the device will be driven to its extreme limit). Refer to photo 2 in Appendix B.

6.3 Multi-Device Controller

Turn on the 'Multi-device Controller' (EMCO Model 2090).
On DEVICE ONE set Antenna Polarization to VERT.
On DEVICE ONE set Antenna height to 100 cm (POSITION DOWN). This is 115 cm per display indication-refer to note which follows.
If necessary, measure to ensure that this actual height to display indication is correct. At times a peak level will occur when the antenna is at less than 100 cm; however only report the peaks that occur when the actual antenna height is between 100 cm and 400 cm.

Note: When the antenna is horizontally polarized the display gives the correct antenna height above the ground plane. However when the antenna is vertically polarized the antenna is 15 cm lower than the display indicates—therefore 115 cm indicated on the display equals 100 cm actual height. If in doubt measure the height of the center of the antenna above the ground plane.

On DEVICE TWO set turntable rotation to 0 degrees (POSITION CCW). Verify that the turntable is physically set at ZERO (stripe / arrow on turntable points towards antenna).

Note: If carriage position or turntable orientation is not correct in respect to the display, refer to the ‘Helpful Hints’ section 11.0 for alignment.

6.4 Antenna

Note: In order to save time, the search should be started at the harmonic frequency where a problem is anticipated to most likely exist. Following this a search of the fundamental can be done. In the event that there is no prior knowledge of a potential problem frequency, start at the fundamental.

Use the following antennas (Refer to equipment list in Appendix A and the photos in Appendix B).
Biconical - 30 MHz to 300 MHz – Photo 3
Log periodic - 200 MHz to 1000 MHz – Photo 4
Roberts Dipole -Transmit fundamental at 915 MHz (910 - 920 MHz) and Receiver at 953 MHz. – Photo 5. As an alternate use the Log Periodic.
Double-Ridged Waveguide Horn - 1 GHz to 18 GHz (for all harmonic measurements) – Photo 6.

When necessary, level the antenna while attaching.
Ensure that the antenna point of measurement is properly positioned above the front edge of the base/platform (the front edge of the base/platform is positioned three meters horizontally from the center of the table). Dependent upon the antenna being used, the carriage is positioned on the boom to provide the three meter required distance.

Refer to Photos 7-16 in Appendix B for leveling and alignment.

Note that at 915 MHz the Dipole element length is 3.125" measured from the center of the antenna boom to the element tips.

6.5 ERT Wakeup Setup (if required)

Preset the tone generator (Wavetek Model 171 or equivalent) as follows:
Set the Tone Generator to the appropriate tone for wake-up (generally 32.5 Hz).
Connect the Tone Generator '600 Ohm OUT' to 'MOD IN/OUT' on the RF SIGNAL GENERATOR.

Preset the signal generator (HP 8656A or equivalent) as follows:
Set EXT AM to 95% on the RF SIGNAL GENERATOR and adjust the level from the tone generator as required to the proper level.
Store the following settings:

Frequency (MHz)	Level (dBm)	Modulation	Store at
913	-32	None	01
915	-27	None	02
917	-32	None	03
952	-20	EXT AM @ 95%	08

Connect the output of the generator to the wake-up antenna, which is set off and to the side of and away from the DUT (beside the entrance door to the dome).

6.6 Setup of the 141 T Spectrum Analyzer

Preset the spectrum analyzer as follows:
BANDWIDTH: 100 kHz
SCAN WIDTH PER DIVISION: 1 MHz.
INPUT ATTENUATION: approximately equal to 10 dB
SCAN TIME PER DIVISION: 0.1 msec.
Adjust BASE LINE CLIPPER to eliminate the grass.
LOG REF. LEVEL: 10 dB LOG
VIDEO FILTER: OFF
SCAN MODE: INT
SCAN TRIGGER: AUTO

6.7 Establishing a –50 dBm Reference

Refer to Appendix H, Setup 2, and establish a 916 MHz CW (continuous wave) signal at a level of -50 dBm at D2. Refer to Appendix I for procedure for setting up a -50 dBm reference.
Set -50 dBm reference (cut the trace) at second line (-10 dB) on the 141T spectrum analyzer (connections D1, A2, B1 and C1).
NOTE: When setting a reference on the spectrum analyzer display, using a CW source and then monitoring ERT transmissions, it will be noted that the trace width or thickness of the ERT transmissions is never the same as the CW source. As a result using the edge of the trace as the reference will give erroneous results. To overcome this set the reference trace on the spectrum analyzer such that the center of the trace peak is centered on the reference line (cut the trace). The center of the width of the trace is a consistent reference regardless of the intensity. This practice will lessen the chance for error when interpreting the display. Disconnect the reference source.

6.8 HP 8593E Self Calibration

Prior to the start of testing verify that the HP 8593E has been through the self-calibration procedure within the last 30 days. If the calibration is necessary refer to Appendix J.

6.9 Data Entry Sheet

Fill in the heading of the Data Entry Sheet. This spreadsheet is located as follows: J:\Three Meter Site Testing\FORM (sheet 3 of the latest EXCEL file FCC_FORMS&LIMITS_yymmdd; yymmdd indicates year, month, date for example 030228 indicates 2003, Feb. 28)
For example of form refer to Appendix K and enter the following:
Model Number:

Serial Number:
Frequency Measured: TX 1 (915.XXX) or TX2 (1830.XXX), etc. **This will be filled in following Step 7.2**

Note the 'Antenna used' (Asset Number) and refer to Sheet 7 for the Antenna Factors (ACF) and the Cable Losses. Ensure that the correct coax is referred to for the losses.

7.0 Test Setup

Refer to Appendix H for test setup.
NOTE: The switches indicated are not physical switches but rather represent various connection scenarios

7.1 Equipment Setup

Place the DUT centered on the top of the Styrofoam block – ensure that the block is centered on the table.
Connect Antenna coax to the non-amplifier input (connection B1).
Turn on the wake-up signal (Recall [8]) and allow the ERT to transmit 3 to 4 blocks of fifteen transmissions. If ERT transmissions are not seen, increase the level of the wakeup generator by about 3 to 5 dB. If still no response, determine whether the DUT is functional.
Ensure that the transmissions are all within the display edges of the spectrum analyzer. Adjust the spectrum analyzer frequency to make it so.
On the spectrum analyzer set 'WRITING SPEED' to 'STD' and set 'PERSISTENCE' nearly to 'MAX'.
Adjust the intensity so the transmission traces can be clearly seen but are not blooming. After the display is satisfactory set 'PERSISTENCE' to 'MAX' and press 'ERASE'

7.2 Determine Center Frequency of Fundamental and all Harmonics

Refer to Appendix L.
Record the frequencies on copies of the latest EXCEL Spreadsheet 'FCC_FORMS&LIMITS_yymmdd' Refer to Appendix K for example.
Enter this center frequency in the generator and set spectrum analyzer frequency to center it on the display.

8.0 Radiated Emissions Test Procedure

Refer to Appendix M for the radiated emission limits.

8.1 Transmitter Fundamental

8.1.1 Ensure that the antenna is vertically polarized and that the Multi Device Controller- 'DEVICE ONE' is set to 115 cm and 'DEVICE TWO' is set to 0 degrees.
Turn on Wakeup (Recall 08).
Observe the transmissions indicated on the Spectrum Analyzer display.
If measuring harmonics monitor the fundamental on a second analyzer as evidence of transmission.
Set WRITING SPEED to STD, press ERASE and adjust INTENSITY to display the transmissions without blooming occurring.
Ensure that the transmissions observed are from the DUT. Ambient transmissions can cause confusion/problems.
Refer to Appendix N for Spectrum Analyzer setup.

8.1.2 Position a convenient finger on the 'INC' button in the Mast STEP block on the controller. When a transmission is noted immediately press the 'INC' button and hold until the first group of fifteen transmissions cease. Wait until the next group of fifteen transmissions and repeat.
Continue doing this until 'DEVICE ONE', the antenna position indicator, displays 400 cm. Note the maximum level, to the nearest 0.5 dB, and enter on the Data Entry Sheet in the appropriate degree block in the vert. meas. column.

8.1.3 Increment the table rotation by 30 degrees (right STEP block DEVICE TWO).
Erase Spectrum Analyzer display.
Position a convenient finger on the 'DEC' button in mast 'STEP' block (DEVICE ONE) on the controller. When a transmission is noted immediately press the 'DEC' button and hold until the transmissions cease. Wait until the next transmission and repeat. Continue doing this until 'DEVICE ONE", the antenna position indicator, displays 115 cm.
Note the maximum level, to the nearest 0.5 dB, and enter on the Data Entry Sheet in the appropriate degree block in the vert. column.

8.1.4 Increment the table rotation by 30 degrees (DEVICE TWO).

8.1.5 Repeat steps 8.1.2 through 8.1.4 until the full 360 degrees has been covered in twelve 30-degree steps.

8.1.6 Review the data and note the azimuth setting (degrees) where the greatest recorded level occurs and other azimuth settings with a level within one or two dB of this level. Return to the azimuth setting where the greatest level was detected and erase the SA display and adjust the antenna height until the maximum level is observed. Note the number of divisions that the trace is below the top of the display. Switch the 'LOG REFERENCE LEVEL' from 10 dB to 2 dB LOG. For every major division that the trace is below the top of the display increase the “LOG REF’ level by 10 dB.

8.1.7 Adjust the 'BASE LINE CLIPPER' and the 'LOG REF LEVEL' step-attenuator so that transmission peaks are displayed. Adjust the intensity for a clear display.
Adjust the azimuth within the ± 30 degree range, in small increments, until the maximum level is found.
Adjust the antenna height ± 10 cm or more in increments within the region of the noted maximum level.
Again, slightly adjust first the table azimuth and then the antenna height to obtain the peak reading. Repeat several times to ensure that the peak level is found.

8.1.8 Record the antenna polarization and the indicator displays for the antenna position and the table azimuth in that order followed by the level in dBm on the Data Entry Sheet as per the following example:
V 135 / 25° @ -47.

8.1.9 At this time also check in the region of the other settings noted above which are within one or two dB of the greatest level and repeat steps 8.1.7 and 8.1.8

8.1.10 Level Determination – Peak Measurement

Select the condition with the greatest level and position the antenna and the table at these settings.
If measuring the transmitter fundamental, connect the antenna source coax directly to the HP 8593E. If measuring harmonics, use an amplifier.
Setup spectrum analyzer as indicated below.
Press 'PRESET'
'FREQUENCY': (center of the band being measured)
'SCAN': (Equal to the integer of the harmonic being measured x 5 MHz)
'RBW': 120 kHz at Less than 1000MHz and 1MHz RBW at Greater than 1000 MHz.
'VBW': 300 kHz at Less than 1000MHz and 1MHz RBW at Greater than 1000 MHz

Press 'TRACE', 'CLEAR WRITE' and 'MAX HOLD'.

Sit back and allow the analyzer to collect transmissions. After three to five minutes press 'PEAK' and note the reading and enter on the sheet following the antenna and azimuth settings.

Alternate Method (Quasi Peak at Zero Span)

Span: 5 MHz
PEAK SEARCH
MARKER → CF
SPAN: 100 KHz
AUX CTRL
Quasi Peak
CLEAR QP DATA
CLEAR QP DATA
QP MAN AT MKR
TRACE
MAX HOLD A
ACCEPT QP DATA
RETURN.

8.1.11 Signal Substitution

Determination of the level, using signal substitution, is a necessity when amplifiers are used such as when measuring harmonics or the receiver.

Connect the reference generator source to the spectrum analyzer or amplifier input in place of the antenna coax. Set the generator frequency to the frequency at which the peak level occurred.

Press 'ERASE' and 'HOLD' on the analyzer.
Adjust the level of the signal generator until the level is the same as noted above. If the level is exceeded, decrease level, press 'ERASE' and try again.

When the level is achieved, disconnect the reference level at the analyzer and connect to the power sensor head. When measuring harmonics, the 40 dB attenuator will likely have to be removed when determining the power. When doing so, subtract the 40 dB value of the attenuator from the measured value. Refer to point D in test setup 3 in Appendix H.

CAUTION: Maximum input to the power sensor is –20 dBm. Ensure that the power limit of the power sensor will not be exceeded prior to connecting.
Note the level and record in the space provided on the data-recording sheet.
Disconnect the reference source from the power sensor and press 'RF OUTPUT' 'OFF' on the generator.

8.1.12 Horizontal Antenna Polarization

On the Multi-Device Controller set antenna polarization to 'HOR'. Verify that the antenna is horizontally polarized. If it is not, check the air supply and pressurize the tank to about 50 - 60 lbs/sq. in. minimum. (Note: The pressure to the mast should be a maximum of 20 lbs. as indicated by the regulator).

Press 'POSITION DOWN' (device one) and 'POSITION CCW' (device two).
The antenna should be horizontally polarized and at 100 cm in height and the table azimuth should return to zero degrees.
Repeat steps 8.1.2 to 8.1.11

8.2 Transmitter Harmonics and Spurious Test Procedure

Cautions to Observe During Harmonic Measurements

NOTE: When doing a search for harmonic peaks, caution must be observed. At the third harmonic and above the amplifier must be preceded by the High Pass Filter. The High Pass Filter cannot be used at the second harmonic because the second harmonic level will be attenuated. Therefore when searching for the second harmonic peak, awareness must be maintained that the high level fundamental may generate a second harmonic component in the test equipment especially the 141T. This can cause problems in two ways:
First – This internally generated second harmonic signal may be at a greater level than the actual harmonic being radiated by the DUT and cause a perceived failure of the DUT.

Second – This signal may be out of phase with the real second radiated by the DUT and the indication will be a lower level than actually exists. This may incorrectly produce an apparent passing condition where in actuality the real component is not at a passing level.
Either of these conditions can be present with the real peak existing at another antenna height and table azimuth setting.
To check if the peak is real, note the harmonic level and place a 3 dB attenuator before the amplifier – the resultant change in level should be 3 dB. A change greater than 3 dB indicates that harmonic generation is occurring in the instrumentation. This check must be made on the same setup, as the level was determined on.
Because the harmonic at times cannot be seen, monitor the fundamental on a second analyzer as evidence of transmission.
Refer to section 11.2 for conditions of operation which are less conducive to the generation of harmonics when using the 141T / 8555A / 8552B analyzer components.

8.2.1 Setup

Replace the antenna with a Double-Ridged Waveguide Horn antenna (Appendix B, Photo 6). Set antenna to vertical orientation at a height of 115 cm and the table at zero degrees.

Switch the 141T back to 10 dB LOG and set to the appropriate band and connect the appropriate amplifier to the input of the analyzer. Refer to Appendix A, Equipment List for notes on frequency range and amplifier gain. When measuring the third to the tenth harmonic also connect the high pass filter to the input of the amplifier.
Note the center of the harmonic frequency as calculated on the chart.

Set up a reference power level equal to -50 dBm on the RF generator using the power meter. Establish this –50 dBm reference on the second line down from the top on the 141T display. Refer to Appendix I.

Connect the Antenna coax to the amplifier input (when measuring the third to the tenth harmonic connect the high pass filter). Refer to Appendix H, Setup 3.
Repeat 8.1.2 to 8.1.12 for the second through the tenth harmonics.

8.2.2 HP 8593E

Determine the center of the second harmonic and enter on HP 8593E.
Set the 'SPAN' equal to the integer of the harmonic times 5 MHz.
Set the reference generator frequency to the center of the harmonic band.
Set WRITING SPEED to STD, press ERASE and adjust INTENSITY to display the transmissions without blooming occurring.

8.2.3 Spurious Search above 1 GHz

After completing the harmonics, search for other spurious emissions in the region between 1 GHz and the tenth harmonic.

8.2.4 Summation of transmitter Test Results

Enter the test results on a copy of the appropriate sheet; Sheet 9 for IDM or Sheet 10 for SCM; ‘TX Summation of Test Results’.

8.3 Receiver Emissions

Note the verbal communication from Joe Dichoso of the FCC on 01/16/1998. The message was as follows:
“In regard to the receiver (the super-regenerative receiver) during testing, the receiver should be cohered with the CW signal during testing and you’d measure it that way. And again don’t take the duty cycle correction factor and the pulse de-sensitivity factor - just keep the CW on. The CW should be at the operating frequency and have it continuously transmitting while you’re making the measurements on the receiver.”

The statement about the receiver being cohered with a CW signal means that an RF generator should be set up with an unmodulated signal at a frequency which is near to the receiver

frequency but not so close as to interfere with measurements. This signal is fed to an antenna causing the DUT to be immersed in the field.
First modulate the signal with the wakeup tone and increase the level until the DUT wakes up. Then Remove the modulation and increase the level by about 6 db. The purpose is to impart energy to the ERT receiver and thereby increase its output level. This should not be done during the peak search sequence but rather when the final measurement is taken to note if there is any difference with and without the coherer.

Refer to section 6.4 for the proper antenna to use.

8.3.1 Receiver Fundamental

The ERT receiver has an on-time pulse of approximately 150 nsec occurring at a 512 Hz. Rate. With a pulse occurring every 1.9 msec, the 20 msec sweep rate of a spectrum analyzer will not present a problem, however there will be desensitization occurring in the analyzer due to the short duration of the pulse if the resolution and video bandwidths are insufficient. The search will be at wide resolution and video bandwidths but the final measurements will be at RBW and VBW settings of 120 KHz and 300 KHz respectively as required per regulatory agencies.

Set up the HP8593E spectrum analyzer as follows:
Center Frequency: Near 953 MHz.
RBW: 1 MHz.
VBW: 3 MHz.
SPAN: 50 MHz.
PEAK SEARCH

Use JCA Technology amplifier; model JCA010-415.
Refer to Appendix H, Setup 3, connections A1, B1 and C1.

Follow the procedures in steps 7.1.2 to 7.1.12 except that the wake-up is not used; receiver is on continuously and therefore the mast can be in continuous motion going from 100 cm to 400 cm.
Starting at zero degrees, record the peak level at each 30-degree increment.
In doing the final peak search, it may be necessary to use the HP141T on the two dB scale to zero in.

When the final peak has been found, setup the HP8593E as follows:
Center Frequency: At the marker peak.
RBW: 120 kHz.
VBW: 300 kHz.
SPAN: 50 MHz.
PEAK SEARCH

To determine the Quasi Peak level press the following:
AUX CTRL
Quasi Peak
QP AUTO AT MKR
Read the QP level on the lower portion of the display.

8.3.2 Receiver Harmonics

Replace the search antenna with the Double-Ridged Waveguide Horn.
Multiply the center frequency of the fundamental by the harmonic integers two thru five to give the harmonic frequencies to search.
Use the preamplifier.
Use the same procedure to search for the receiver harmonics as was used for the fundamental. The fundamental level is sufficiently low that there are no harmonics generated within the instrumentation (HP8593E). If in doubt use the procedure outlined for the transmitter to check for harmonic generation in the instrumentation.

When the peak has been located at each harmonic, return to the antenna polarization and height and turntable azimuth position of the harmonic and set up the HP8593E as follows:

Center Frequency: At the marker peak of the harmonic.
RBW: 1 MHz.
VBW: 10 Hz.
SPAN: 0 MHz.
PEAK SEARCH

8.3.3 Summation of Receiver Test Results

Enter the test results on a copy of Sheet 9 or Sheet 10; RX Summation of Test Results

8.4 Below One GHz Spurious Search

NOTE: Use an analog spectrum analyzer to enable the capture of all spurious transmission products. The regions with higher concentrations of ambient signals will likely require search at a much narrower span. False spurious indications may occur as the result of the ERT transmit signal mixing with a high level ambient signal

8.4.1 Ambient Conditions Anechoic Chamber Pretest

The region between 30 MHz and 1000 MHz is cluttered with ambient signals in various portions of that spectrum. Refer to Appendix O for plots representative of the conditions encountered. Because of the RF clutter prevalent at the OATS, care must be exercised during the search to ensure that a spurious signal from the DUT is not missed. It is recommended that the DUT be placed in the anechoic chamber and a pre-search be done to locate any spurious signals prior to the OATS testing. Prior to placing the DUT in the anechoic chamber, the chamber should be sealed and a search made for ambient signals entering the chamber. There should be very few; the likely area of offence will be the FM broadcast and TV bands and below. Testing is to done with both the transmitter and the receiver functioning. First, note the presence of ambient signals and record the frequencies. Second, with the DUT on, note the presence and record the frequencies and the relative levels of any DUT generated signals. Determine the frequency at a narrow bandwidth to 0.005 MHz and record.

8.4.2 OATS Testing

Set up a reference level on the HP141T at the second line from the top of about -75 dBm. Refer to Sheet 6 (Spurious Limits below 1 GHz) for the exact limit levels with the coax losses and the Antenna Factors of the antennas at various frequencies. Note the frequency range of the antennas that will be used.

Follow Sheet 2 (Spurious Search below 1 GHz) to record the progress of the testing and to ensure that the testing is thorough. Refer to Appendix P.

8.4.2.1 30 MHz to 300 MHz Range

Use the Biconical Antenna for the range of 30 MHz to 300 MHz.
Position the antenna in a vertical orientation.
At the completion of each of the following sections, if DUT spurious emissions are found, use the technique in 8.1.6 to 8.1.8 to zero in on the peak level.
Use signal substitution method in 8.1.11 to determine the peak level.

A
Set SCAN WIDTH to 10 MHz/div. (100 MHz span)
Set the turntable at 0 degrees.

A1
Set a reference of 60 MHz centered on the spectrum analyzer display.
Search with the antenna from 115 thru 400 cm as displayed.

A2
Set a reference of 140 MHz centered on the spectrum analyzer display.

Search with the antenna from 115 thru 400 cm as displayed.

A3
Set a reference of 220 MHz centered on the spectrum analyzer display.
Search with the antenna from 115 thru 400 cm as displayed.

A4
Set a reference of 300 MHz centered on the spectrum analyzer display.
Search with the antenna with 115 thru 400 cm as displayed.

B
Set SCAN WIDTH to 10 MHz/div. (100 MHz span)
Set the turntable at 0 degrees.
Position the antenna in a horizontal orientation.

B1
Set a reference of 60 MHz centered on the spectrum analyzer display.
Search with the antenna from 100 thru 400 cm as displayed.

B2
Set a reference of 140 MHz centered on the spectrum analyzer display.
Search with the antenna from 100 thru 400 cm as displayed.

B3
Set a reference of 220 MHz centered on the spectrum analyzer display.
Search with the antenna from 100 thru 400 cm as displayed.

B4
Set a reference of 300 MHz centered on the spectrum analyzer display.
Search with the antenna from 100 thru 400 cm as displayed.

8.4.2.2 300 MHz to 1000 MHz Range

C
Use the Log Periodic Antenna for the range of 300 MHz to 1000 MHz.
Set SCAN WIDTH to 20 MHz/div. (200 MHz span)

C1
Set a reference of 350 MHz centered on the spectrum analyzer display.
Search with the antenna from 115 thru 400 cm as displayed.

C2
Set a reference of 500 MHz centered on the spectrum analyzer display.
Search with the antenna from 115 thru 400 cm as displayed.

C3
Set a reference of 650 MHz centered on the spectrum analyzer display.
Search with the antenna from 115 thru 400 cm as displayed.

C4
Set a reference of 800 MHz centered on the spectrum analyzer display.
Search with the antenna with 115 thru 400 cm as displayed.

C5
Set a reference of 950 MHz centered on the spectrum analyzer display.
Search with the antenna with 115 thru 400 cm as displayed.

D
Set SCAN WIDTH to 10 MHz/div. (100 MHz span)
Set the turntable at 0 degrees.

Set the antenna in horizontal orientation.

D1
Set a reference of 350 MHz centered on the spectrum analyzer display.
Search with the antenna from 100 thru 400 cm as displayed.

D2
Set a reference of 500 MHz centered on the spectrum analyzer display.
Search with the antenna from 100 thru 400 cm as displayed.

D3

Set a reference of 650 MHz centered on the spectrum analyzer display.
Search with the antenna from 100 thru 400 cm as displayed.
D4
Set a reference of 800 MHz centered on the spectrum analyzer display.
Search with the antenna from 100 thru 400 cm as displayed.
D5
Set a reference of 950 MHz centered on the spectrum analyzer display.
Search with the antenna from 100 thru 400 cm as displayed.

8.5 Bandwidth of Emissions Plot

15.231 (c) Bandwidth of Emissions Plot
Set up the spectrum analyzer - HP8593E as follows:
Set the Frequency center near the middle of the transmit band.
RBW: 100 kHz.
VBW: 30 kHz.
SPAN: 1-2 MHz.
PEAK SEARCH

Press 'TRACE', 'CLEAR WRITE' and 'MAX HOLD'
Turn on the wakeup and monitor the display. When a single transmission with complete slopes in excess of 20 dB is displayed remove the signal source.

Proceed as follows:
MKR 2; PEAK SEARCH
REF. SET

MKR 1; PEAK SEARCH
Decrease the marker 1 frequency until it is on the lowest frequency slope that is at least 20 dB down.

MKR 3; PEAK SEARCH
Increase the marker 3 frequency until it is on the highest frequency slope that is at least 20 dB down.

Frequency Table:

Refer to Appendix Q; Plot 1

8.6 Field Intensity over the Transmit Band

15.31 (m) Measurement of Relative Field Intensity at the High and Low End of the Frequency Band

Setup the spectrum analyzer - HP8593E as follows:
Set the Frequency center near the middle of the transmit band.
RBW: 100 kHz.
VBW: 30 kHz.
SPAN: 5 MHz.
PEAK SEARCH

MKR 2; PEAK SEARCH
REF. SET

MKR 1; PEAK SEARCH
Decrease the marker 1 frequency until it is on the lowest frequency peak.

MKR 3; PEAK SEARCH
Increase the marker 3 frequency until it is on the highest frequency peak.
Refer to Appendix Q; Plot 2

9.0 A. C. Power Line Conducted Emissions Test Procedure

Refer to Appendix R for test equipment required.
Refer to Appendix S for A. C. Power Line Conducted Emissions Limits.

9.1 Erection of the Vertical Back Plane

Refer to photos in Appendix T.

9.1.1 Remove the tape holding the ground straps (4) to the floor.

9.1.2 Remove the tape covering the three bolts and remove the bolts in the floor (two bolts for the mounting plate and one bolt for the support arm). Put the bolts away for safekeeping. (These bolts are only to keep debris out of the holes while not in use). (Photos 1 and 2.

9.1.3 Lift the ground straps (Photo 1)
Position the mounting plate on the floor such that the two holes, approximately one-foot distance from each end, are above the holes in the floor (the groove in the mounting plate is to the west).
Fasten the mounting plate to the floor using one-inch long bolts and washers.

9.1.4 Position and insert the eight-foot long mast over the upright in the mounting plate (It will only go on one way). (Photo 2)

9.1.5 Fasten the lower rear support arm to the floor with a 3/4-inch bolt and washer. (Photo 3)

9.1.6 Lift the just installed lower rear support arm and insert the upper portion of the support arm into it. Attach the upper portion of the support arm to the upright mast. (Note: Hole alignment only allows it to be attached to the upright in one orientation) Insert the bolt and apply the nut. With the compression bolt on the support arm loosened, push the upright mast into a vertical position and tighten the compression bolt to hold it in position. To check if vertical do a visual comparison with the vertical lines in the siding of the instrument room. (Photo 3).

9.1.7 Being very careful not to damage the panel edges, lift one of the four foot by eight-foot aluminum panels into position in the groove of the base mounting plate. Carefully slide it into position in the groove of the upright mast and tighten a few of the compression screws to hold it in position. (Note: Exposed edges, top and side, are covered with a plastic edging to protect hands during handling) (Photo 4)
Place the second panel in position and secure it.
Snug all the bolts on the upright and base plate – **Caution: Do not over-tighten!**

9.1.8 Bend the four copper grounding straps such that the holes in the strap align with the holes in the back plane. (Photo 5)

9.1.9 Secure the straps to the back plane with the 10-32 x ½" screws.

9.1.10 Position the EMI table (top at 80 cm above the ground-plane) as indicated by footprint on the floor. (Photo 6)

9.1.11 Remove the tape on the ground strap, which is to the left of the table (as viewed from the front).

9.2 LISN

Place the LISN in position and connect to the ground strap. (Photo 6)
Using the appropriate cable connect the input to the appropriate supply voltage.

9.3 Placement of the DUT

Place DUT (Device Under Test) on the table and connect to the output of the LISN (Front Panel) (Photo 6). Arrange cables and test per ANSI C63.4.

9.4 Setup of the Spectrum Analyzer and BenchLink

9.4.1 Set up the HP 8593E Spectrum Analyzer per procedure in Appendix U.

9.4.2 Turn on the computer and bring up the HP E4444A BenchLink application. Ensure that the application recognizes the spectrum analyzer.

9.5 Conducted Measurement

9.5.1 Port 'L1'

Connect the coax from port L1 of the LISN to the Spectrum Analyzer (HP 8593E). Ensure that a 50-ohm load is on the unused port (L2) and that the Earth Choke is switched out. Measure the conducted level on L1.
Using BenchLink, download the image from the spectrum analyzer. Save it under a unique, easily identifiable filename linking it to the DUT.

9.5.2 Port 'L2'

Connect the coax from port L2 of the LISN to the Spectrum Analyzer (HP 8593E). Ensure that a 50-ohm load is on the unused port (L1) and that the Earth Choke is switched out. Measure the conducted level on L2.
Using BenchLink, download the image from the spectrum analyzer. Save it under a unique, easily identifiable filename linking it to the DUT.

9.6 Troubleshooting

In the event that the exercise does not yield passing results check the following:
Disconnect the AC supply at the DUT (AC power cable disconnected from the DUT but still connected to the LISN) and note what the ambient levels are. Refer to Appendix V, 'Display of Ambient Levels - DUT Not Connected' and note the four plots showing typical ambient conditions.
If the ambient levels are in the limit fail category, then try testing at a different time during the day. The ambient interferers are low frequency RF signals, which will be stronger at times depending on the condition of the ionosphere.
If the ambient levels are not the cause of the failure, check that the length of the AC cable to the DUT is one meter maximum. Refer to ANSI C63.4.
If DUT still fails, inform design team of the results and supply the data.

9.7 Disassembly

Disconnect the coax and AC to the LISN. Shut down the computer.
Set HP 8593E intensity to minimum.
Disassemble the wall by performing the steps in section 9.1 in reverse. Use care so as not to damage the edges of the panels.
Reinsert the bolts into the three holes in the floor and re-tape bolt heads and ground straps.

10.0 Power Down / Shut Down

Set the 141T spectrum analyzer input attenuation to maximum (50dB), the intensity to minimum and the display to NON STORAGE (CONV.)
Set switch on HP8556A to STBY.
Set HP8673D to STBY and the lower section switch to off.
Set HP 8593E intensity to minimum.
At the end of the testing and during off-hours, position the antenna carriage at 225 cm, set the antenna polarization to "HOR', turn off the controller, and carefully remove the pin and lower the mast into the holder/cradle provided. This is done to prevent damage to the dome and mast in case of deflation and wind Refer to Photo 19 in Appendix B.

CAUTION: The antenna is removed, the carriage is placed at 225 cm and the power is turned off to the controller because if the AC power cycles off and on the carriage defaults to HOR. If the carriage interferes with the platform the carriage may be damaged; the larger antennas will be damaged. If the reset causes the DEVICE CONTROLLER to lose control, the carriage will be driven to either the base or the top of the mast.
Placing the carriage at 225 cm will provide sufficient headroom when removing and reinserting the pin. Also the headroom allows for greater safety when raising and lowering the mast.

11.0 Helpful Hints/Troubleshooting

11.1 Recalibration of Antenna and Turntable Displays

Place antenna in horizontal polarization and position carriage so the top of the carriage is aligned with the 100 cm marker per photo 17 in Appendix B. If the display indicating antenna position does not indicate 100 cm then proceed with calibration as follows:
Assume that the display for 'DEVICE ONE' indicates 264.7.
Press 'CURRENT POSITION'
Press 'INCRM' until a '0' is displayed in place of the '7'.
Press 'LOCAL' and the next digit to the left flashes.
Press 'INCRM' until a '0' is displayed in place of the '4'.
Press 'LOCAL' and the next digit to the left flashes.
Press 'INCRM' until a '0' is displayed in place of the '6'.
Press 'LOCAL' and the next digit to the left flashes.
Press 'INCRM' until a '1' is displayed in place of the '2'.
The display should now be '100.0'-if not make it so.
When complete press 'ENTER" to store the correct position.

With the stripe/arrow on the turntable pointing toward the antenna, the display for 'DEVICE ONE' should be approximately 000.0-if not follow the same procedure as above.

11.2 Maximum Input to 141T before Second Harmonic Generation

The levels listed below are the approximate maximum levels permissible which will not generate a second harmonic when using the HP 141T/8555A/8552B spectrum analyzer.

Settings	Input Level	
Input Attenuation / Log Ref. Level / Display Adjust	To Spectrum Analyzer	To Amplifier ZHL-1042J preceding the Analyzer
(dB)	(dBm)	(dBm)
-60 / 0 / -10	-44	-63
-50 / 10 / -10	-34	-63
-40 / 20 / -10	-22	-56
-30 / 30 / -10	-10	-48
-20 / 40 / -10	+3	-38

Appendix A

Equipment List for Radiated Emissions Testing

	Description	Manufacturer	Model	Serial Number	Itron Asset Number	Calibration Required
	Spectrum Analyzer					N
	Display Section	H.P.	141T	1337A07569	3063	
	RF Section	H.P.	8555A	1724A08466	3750	
	I.F. Section	H.P.	8552B	1952A17821	8932	
	Spectrum Analyzer					N
	Display Section	H.P.	141T	1615A11287	11994	
	RF Section	H.P.	8555A	1528A05430	11996	
	I.F. Section	H.P.	8552B	1736A13353	11995	
	Spectrum Analyzer					N
	Display Section	H.P.	141T	1337A06309	1855350	
	RF Section	H.P.	8555A	1724A07744	1855351	
	I.F. Section	H.P.	8552B	1952A17996	1855352	
[1]	Spectrum Analyzer	H.P.	8593E	3543A02032	6965	Annual
	Signal Generator	H.P.	8656A	2341A05541	3090	Two Year
	Signal Generator	H.P.	8673D	3123A01161	12392	Two Year
[2]	Power Meter	H.P.	437B	3125U16900	6520	Annual
[2]	Power Sensor	H.P.	8481D	3318A11513	6521	Annual
[2]	Power Meter	H.P.	437B	3125U11553	1872024	Annual
[2]	Power Sensor	H.P.	8481D	3318A08626	1872025	Annual
[3]	Biconical Antenna	EMCO	3108	9203-2455	16230	Annual
[3]	Biconical Antenna	EMCO	3110B	9807-3129	11730	Annual
[3]	Log Periodic Antenna	EMCO	3146	9203-3358	16248	Annual
[3]	Log Periodic Antenna	EMCO	3148	9901-1044	12005	Annual
	Tunable Dipole	Compliance Design	Roberts	3038	6294	Two Year
	Tunable Dipole	Compliance Design	Roberts		7341	Two Year
	Tunable Dipole	Compliance Design	Roberts	4106	12261	Two Year
	Double Ridged Waveguide Horn	EMCO	3115	9205-3878	16256	Two Year
	Double Ridged Waveguide Horn	EMCO	3115	9508-4550	6412	Two Year
[4]	LISN	EMCO	3825-2	9605-2535	8921	Annual
[4]	LISN	EMCO	3825-2	9508-2436	6552	Annual
	Function Generator	Wavetek	171	M6230187	15763	Two Year
	Multimeter	Fluke	8012A	2685277	3058	N
	Power Supply	H.P.	6284A	2320A-07135	4307	Two Year
	Power Supply	H.P.	6201B	1145A03611	4070	Two Year
[5]	Amplifier	MINI-CIRCUITS	ZHL-1042J	H110094-008	8420	N/A
[6]	Amplifier	JCA-TECHNOLOGY	JCA010-415	103		N/A
[7]	Amplifier	JCA-TECHNOLOGY	JCA618-801	106		N/A
	Antenna Mast	EMCO	2070-2	9601-1937		N/A
	Turntable	EMCO	2080-1.21	9511-1847	6924	N/A
	Multi-Device Controller	EMCO	2090	9510-1089	6923	N/A
	Computer					
	BenchLink Software	Agilent	HP E4444A			

NOTES:

[1] The calibration of the Spectrum Analyzer (HP8593E) can be accelerated by the payment of an additional fee.

[2] The power sensor is calibrated first and when it returns from calibration the power meter is sent in for calibration.

[3] Biconical antenna and Log Periodic antennas: One of each is kept current with calibration. The reserve antenna is sent in about one month prior to the expiration date of the current antenna.
Horizontal polarization at three meters for EMI testing is requested.
Prior to 'Site Attenuation' testing, calibration of all four antennas is required. Both horizontal and vertical polarization antenna correction factors are required.
As a minimum, Site Attenuation Measurement must occur every three years.

[4] LISN – Line Impedance Stabilization Network. As long as peripheral equipment is not required in the testing of the ERTs, only one LISN needs to be current with calibration.

[5] ZHL-1042J, S/N H110094-008	30 MHz – 5000 MHz	About 27 dB Gain
[6] JCA010-415, S/N 103	1000 MHz – 10 GHz	About 45 dB Gain
[7] JCA618-80, S/N 1106	5 GHz – 15 GHz	About 42 dB Gain

Appendix B
Photos Test Equipment

Photo 1

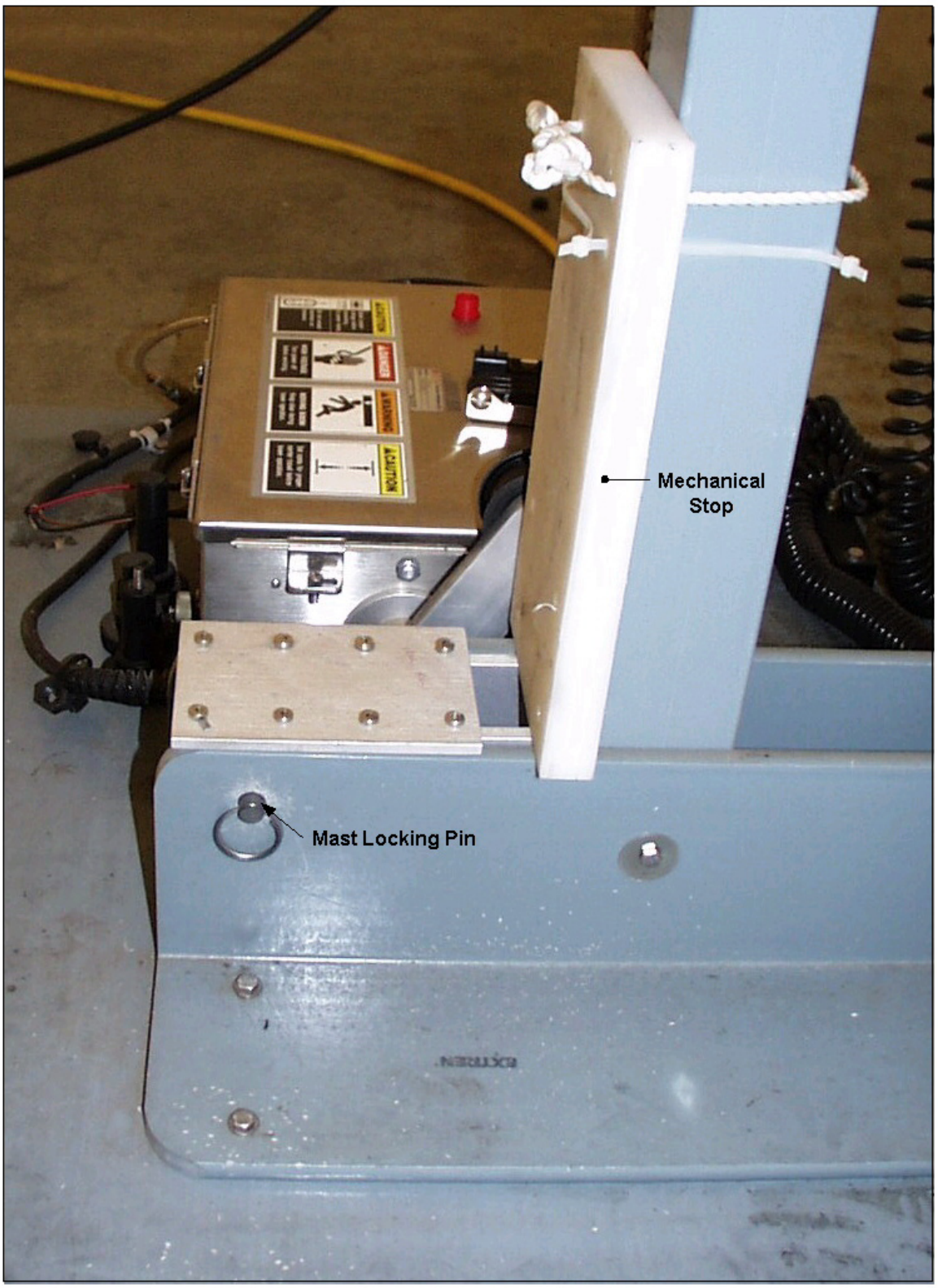

Photo 2

Photo 3
Top Antenna: Model 3108; AN 16230, SN 9203-2455
Bottom Antenna: Model 3110B; AN 11730, SN 9807-3129

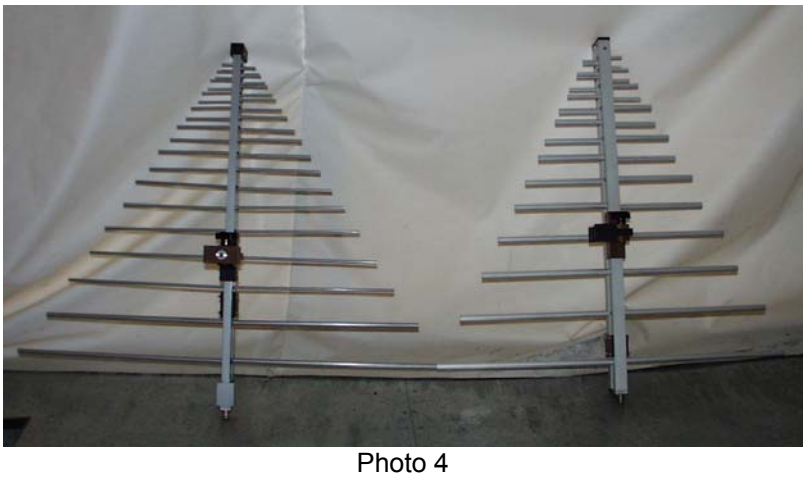

Photo 4
Left Antenna: Model 3148, AN 12005, SN 9901-1044. Right Antenna: Model 3146, AN 16248, SN 9203-3358

Photo 5
Roberts Dipole
AN 6294, 6309, 7341

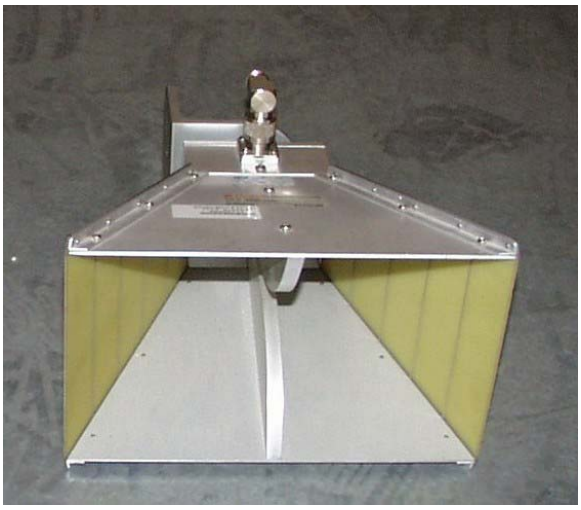

Photo 6
Double-Ridged Waveguide Horn
Model 3115; AN 16256, SN 9205-3878
Model 3115; AN 6412, SN 9508-2436

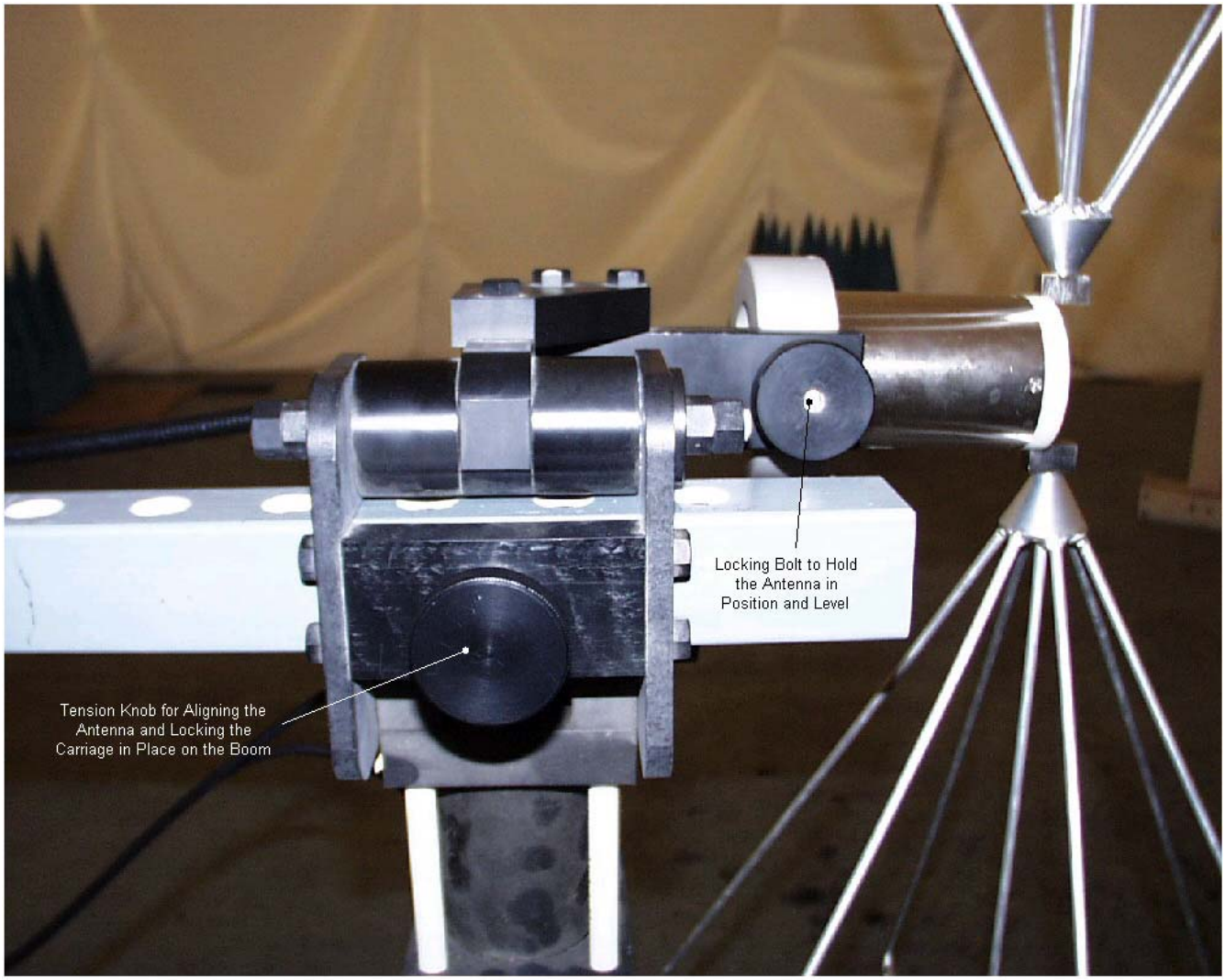
Locking Bolt to Hold the Antenna in Position and Level
Tension Knob for Aligning the Antenna and Locking the Carriage in Place on the Boom

Photo 7

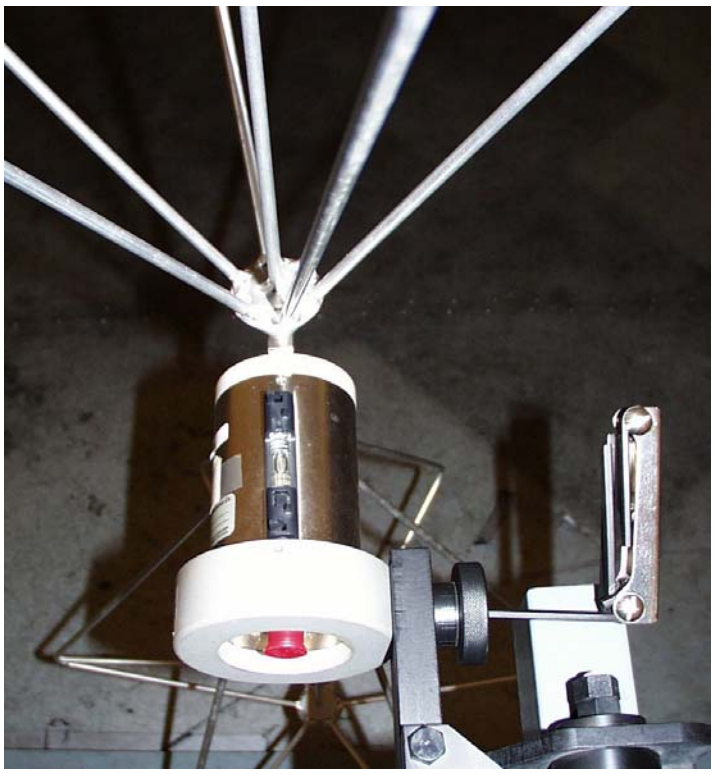

Photo 8
Leveling Using Bubble Level

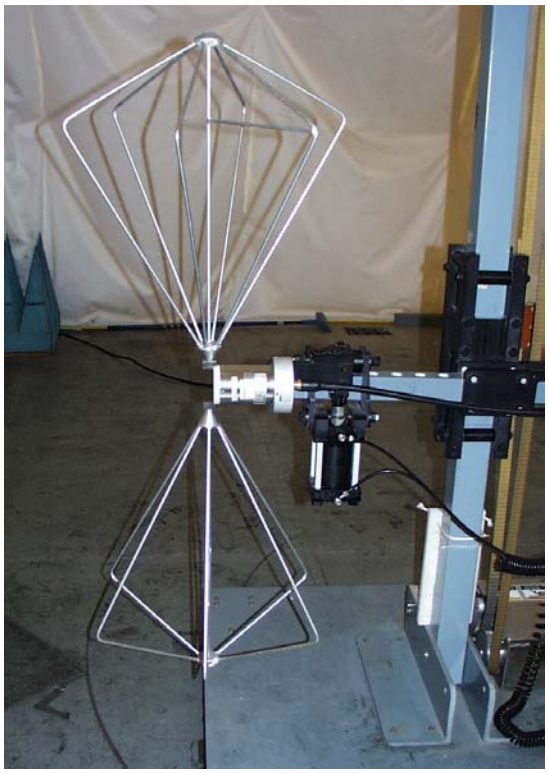

Photo 9
Alignment of the Center of Antenna
(AN 16230) with Platform Edge

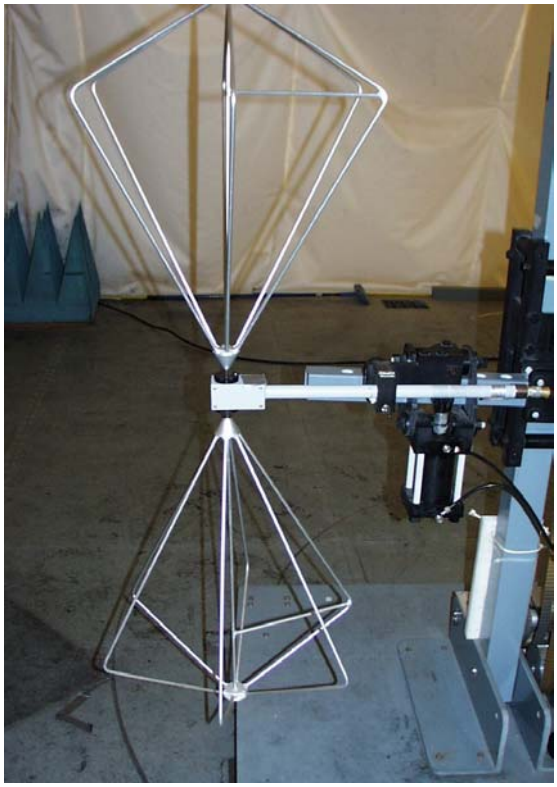

Photo 10
Alignment of the Center of Antenna
(AN 11730) with Platform Edge

Photo 11
Indication of Center of Antenna

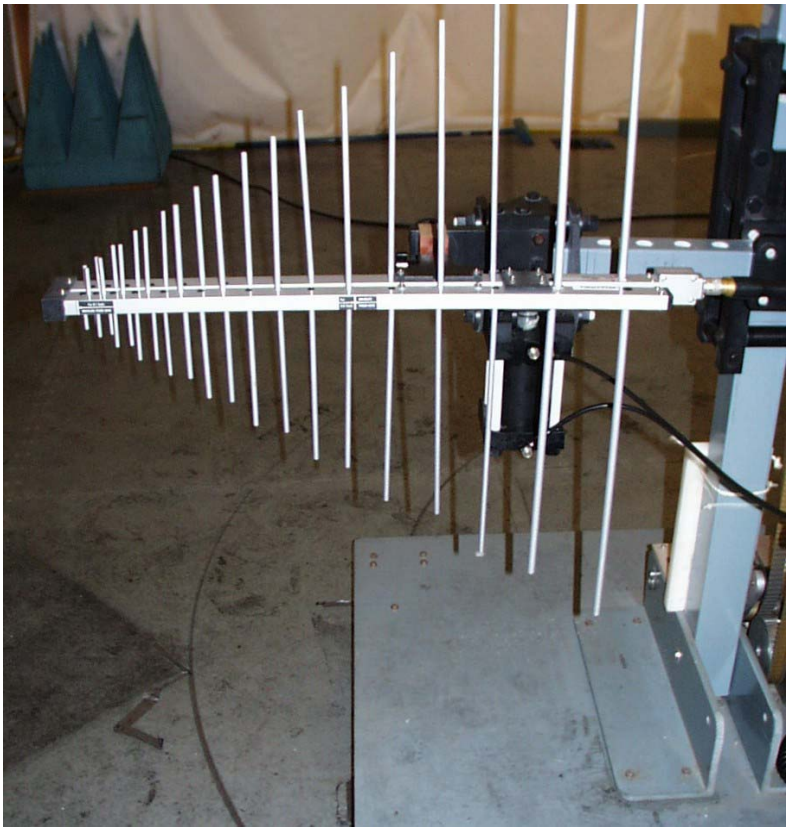

Photo 12
Alignment of the Center of Antenna with the Platform Edge

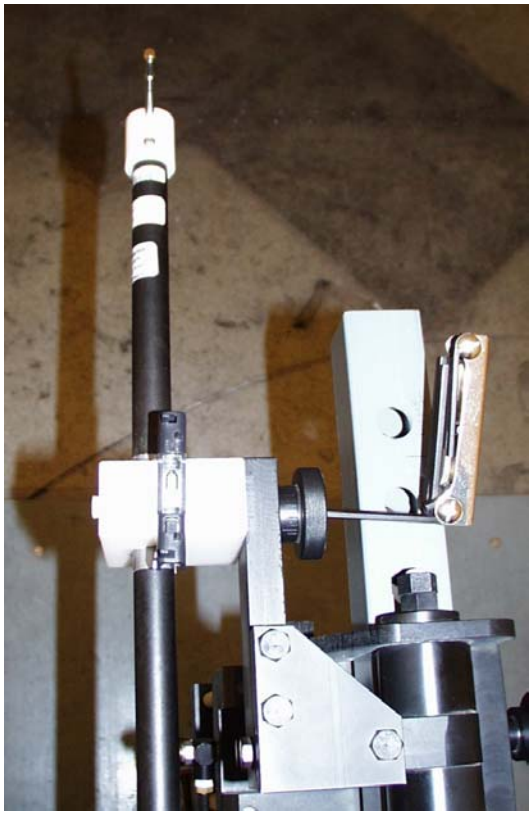

Photo 13
Leveling Using Bubble Level

Photo 14
Alignment of the Center of Antenna
with the Platform Edge

Photo 15
Leveling Using Bubble Level

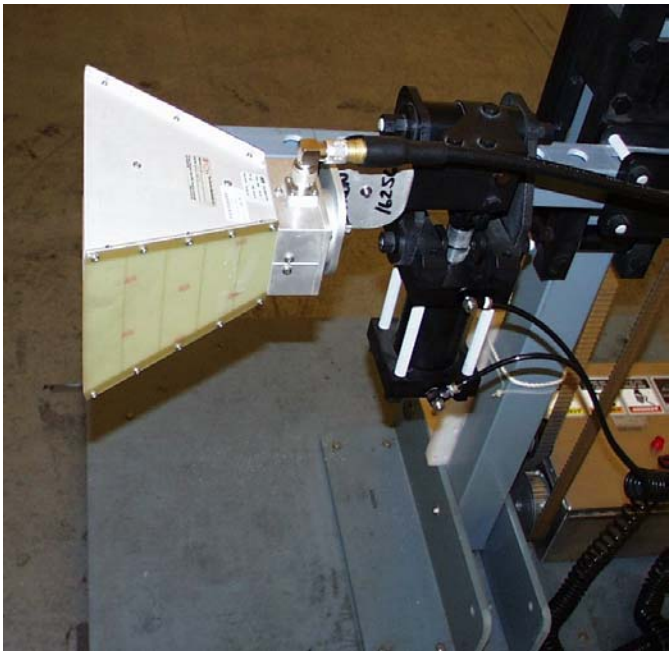

Photo 16
Alignment of the Center of Antenna
with the Platform Edge