LS Research Inc.

Attachment to :
Test Report Number 90354

Trans-Lux Fair-Play Quick Pitch

Model: **QP-100-RF**
FCC ID Number: **OMF-QP-100-RF**

Part 15.247 Type Acceptance, Conducted Measurements

prepared for

Fair-Play, a Division of Trans-Lux Midwest Corporation

Revision 1.0

Table of Contents

Trans-Lux Fair-Play Quick Pitch

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Proposal File:	Quick Pitch
Job Number:	850QP

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Technical Approval

I. FCC Conducted Tests

A. Part 15.247

1. 15.247 (a) (2) Emission 6 dB Bandwidth

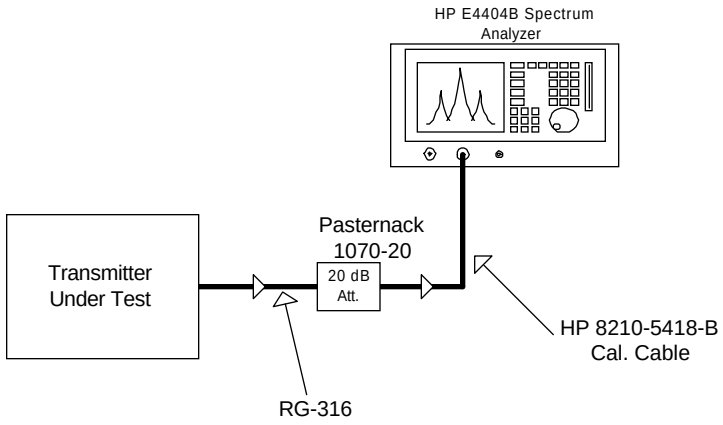
a) Test Requirement

The 6 dB bandwidth of the Equipment emission must be greater than 500 kHz.

$$B_{-6\,dB} > 500\ kHz$$

b) Test Configuration

The test configuration is presented below:



c) Test Conditions: Equipment Under Test

The equipment under test is tunable and is set to 3 different channels, one representing the minimum tunable frequency, one representing a midband frequency and one representing the maximum tunable frequency. The frequencies and their channel designators are presented below for reference.

Channel 1: 908.50 MHz

Channel 6: 914.75 MHz

Channel 15: 926.25 MHz

Test indications under these three frequency conditions are presented.

The output power is fixed.

d) Test Conditions: Instrumentation Conditions

The readings indicated on the spectrum analyzer are a result of a marker search function which searches for the 6 dB bandwidth of the indicated spectrum. The spectrum analyzer display indicates its conditions as follows:

Center: Center Frequency

Span: Frequency Span

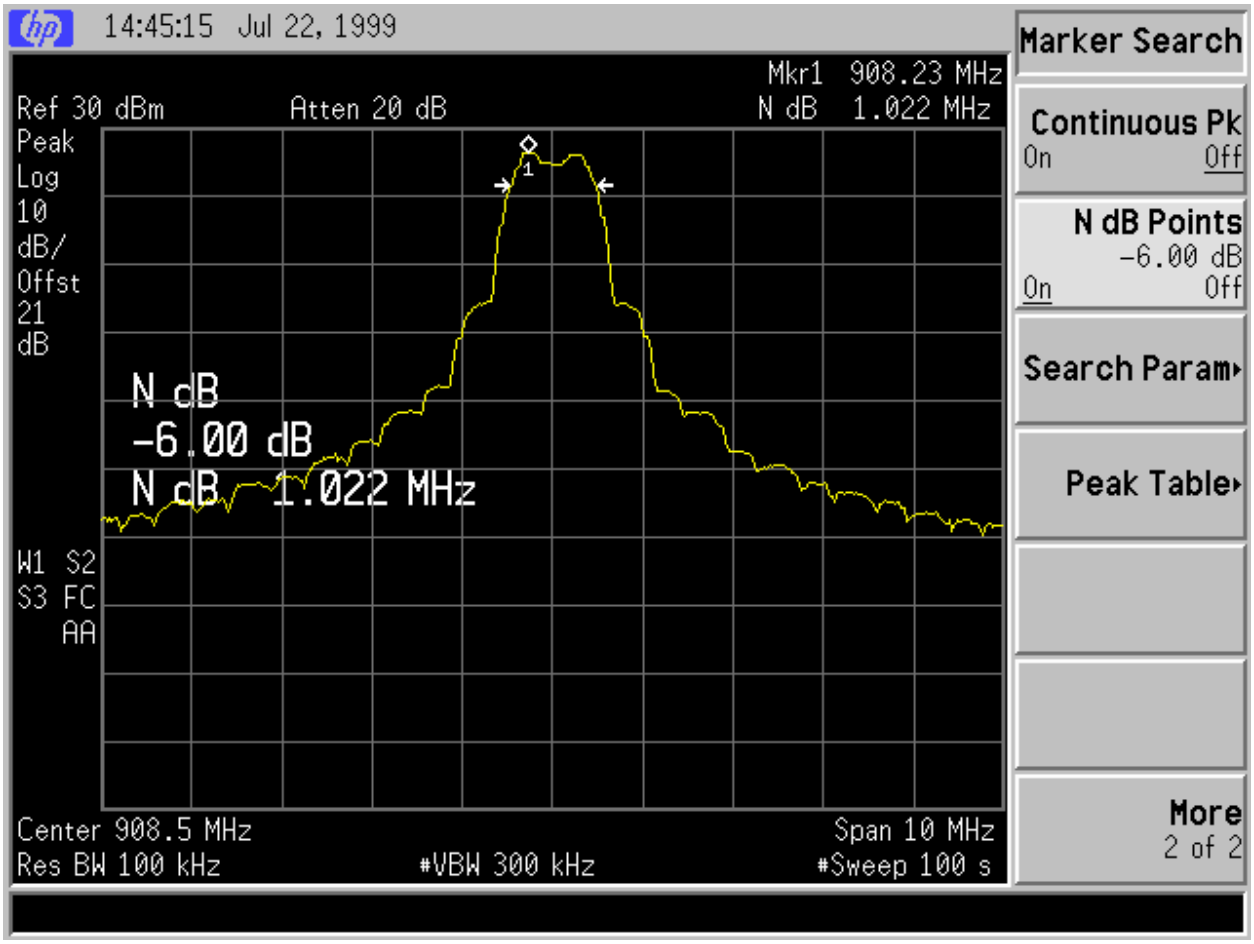
Res BW: Resolution Bandwidth

VBW: Video (averaging) Bandwidth

Sweep: Frequency Sweep time over indicated frequency Span.

Offst: Amplitude Offset, Entered by User to correct for external attenuator and cable losses. Value determined by Vector Network Analyzer transmission measurement of cable/attenuator assembly.

e) Test Indications

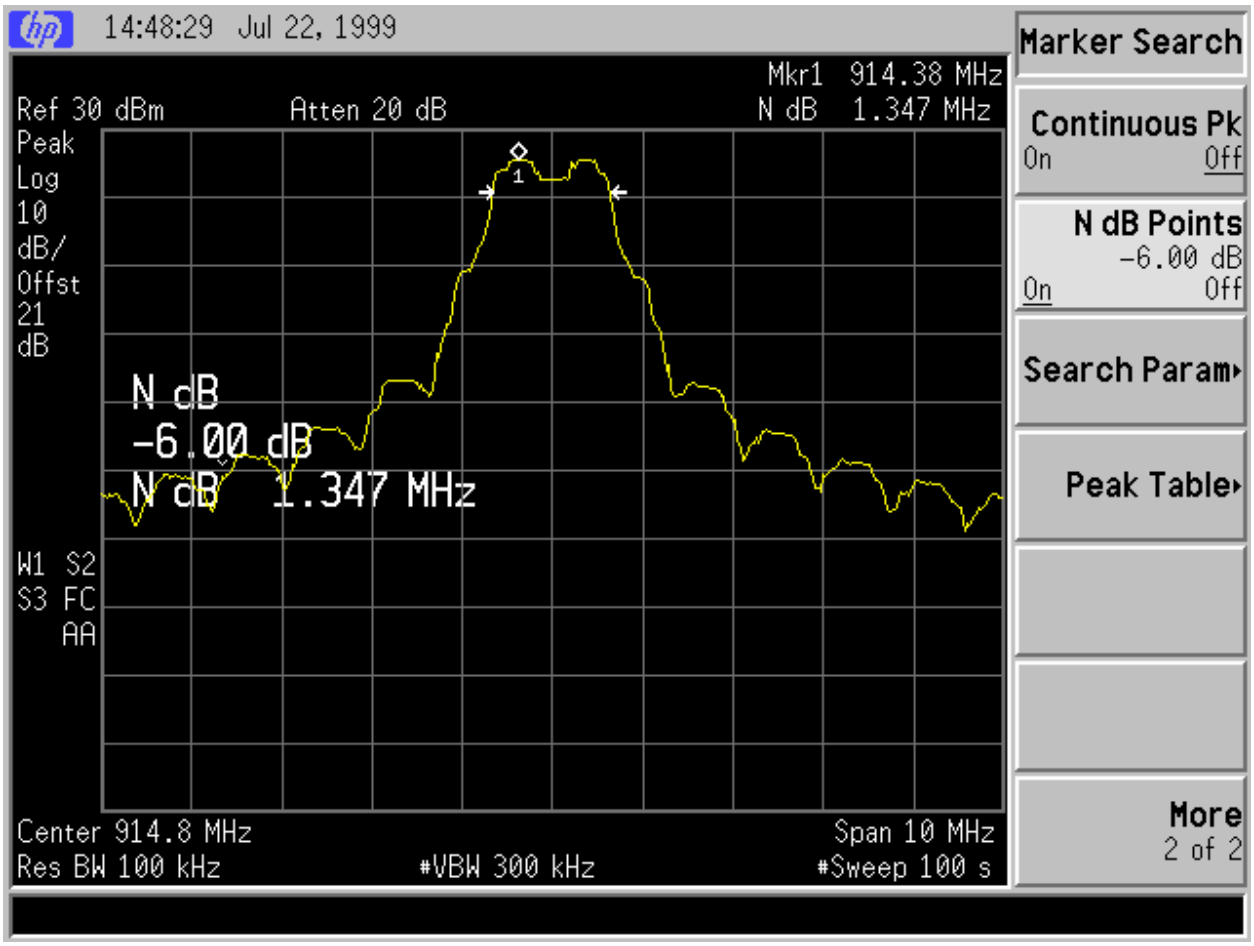


Test Condition: Channel 1: 908.50 MHz

Test Limit: 500 kHz, minimum.

Test Indication: 1.022 MHz

Test Outcome: 1.022 MHz > 500 kHz → PASS

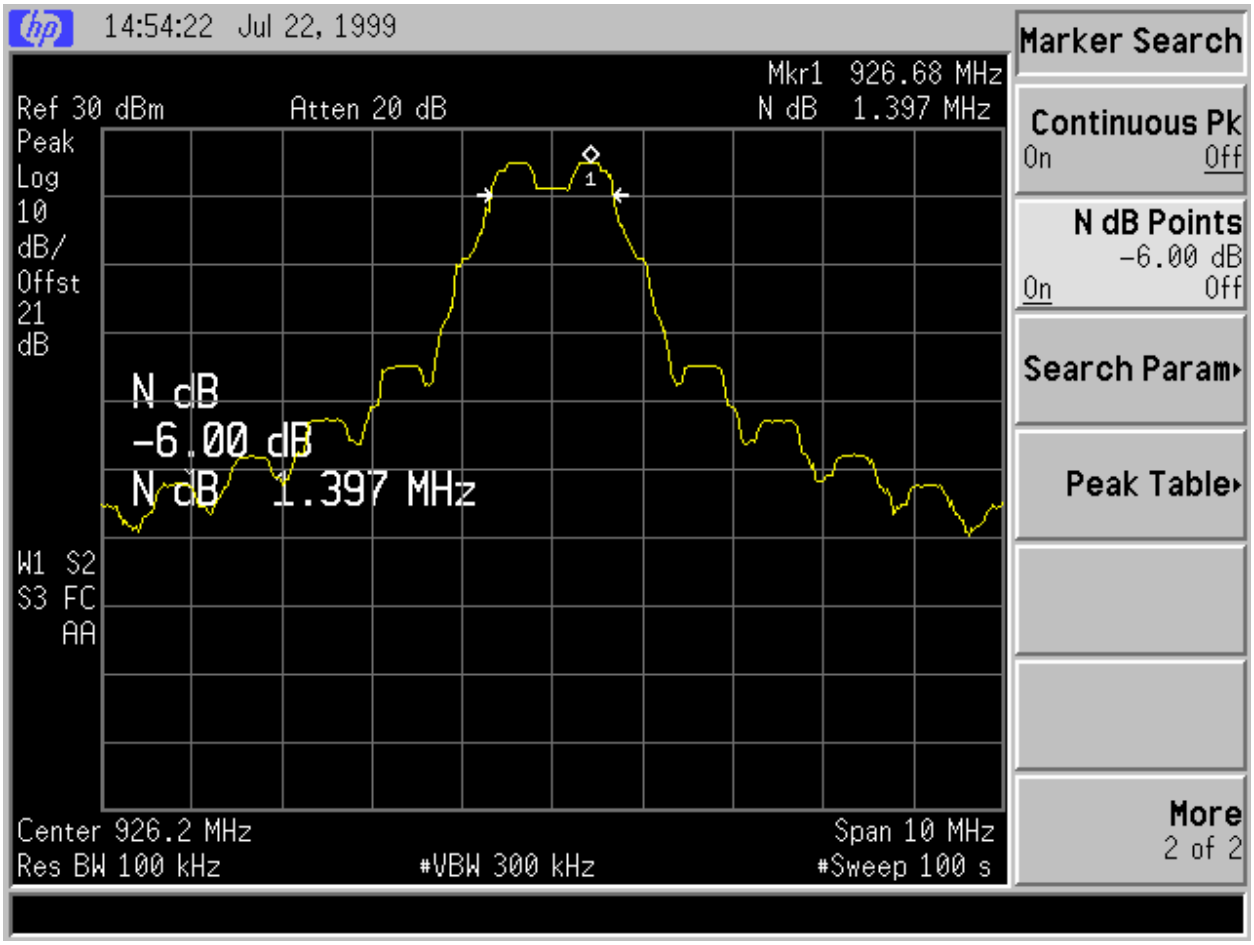


Test Condition: Channel 6: 914.75 MHz

Test Limit: 500 kHz, minimum.

Test Indication: 1.347 MHz

Test Outcome: 1.347 MHz > 500 kHz → PASS



Test Condition: Channel 15: 926.25 MHz

Test Limit: 500 kHz, minimum.

Test Indication: 1.397 MHz

Test Outcome: 1.397 MHz > 500 kHz → PASS

2. 15.247 (b) (1) Output Power

a) Test Requirement

The conducted output power of the Equipment emission must be less than 1 W (30 dBm).

$$P_O < 30\ dBm$$

b) Test Configuration

The test configuration is presented in section II-A-1b.

c) Test Conditions: Equipment Under Test

The equipment under test is tunable and is set to 3 different channels, one representing the minimum tunable frequency, one representing a mid-band frequency and one representing the maximum tunable frequency. The frequencies and their channel designators are presented below for reference.

Channel 1: 908.50 MHz

Channel 6: 914.75 MHz

Channel 15: 926.25 MHz

Test indications under these three frequency conditions are presented.

d) Test Conditions: Instrumentation Conditions

The first set of readings indicated on the spectrum analyzer are a result of a direct spectrum analyzer measurement where the entire emission is contained within the resolution bandwidth of the spectrum analyzer.

Since the bandwidth of the emission approaches the widest resolution bandwidth setting, as alternative measurement, a second set of readings indicated on the spectrum analyzer are a result of a spectrum analyzer function which measures the integrated channel power between the indicated frequency limits.

Center: Center Frequency

Span: Frequency Span

Res BW: Resolution Bandwidth

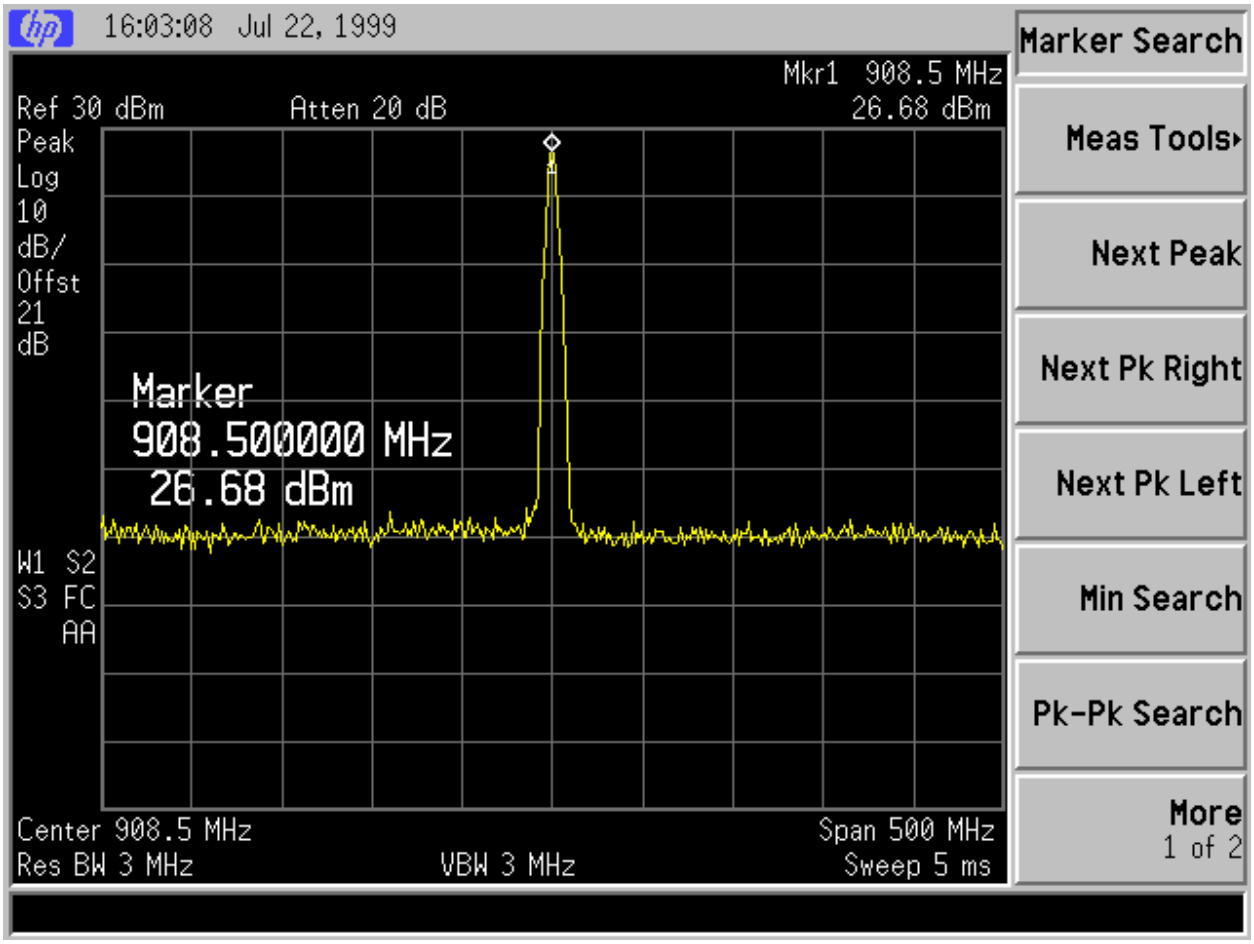
VBW: Video (averaging) Bandwidth

Sweep: Frequency Sweep time over indicated frequency Span.

Integration BW: Bandwidth over which power spectral density is integrated to determine integrated channel power.

Offst: Amplitude Offset, Entered by User to correct for external attenuator and cable losses. Value determined by Vector Network Analyzer transmission measurement of cable/attenuator assembly.

e) Test Indications

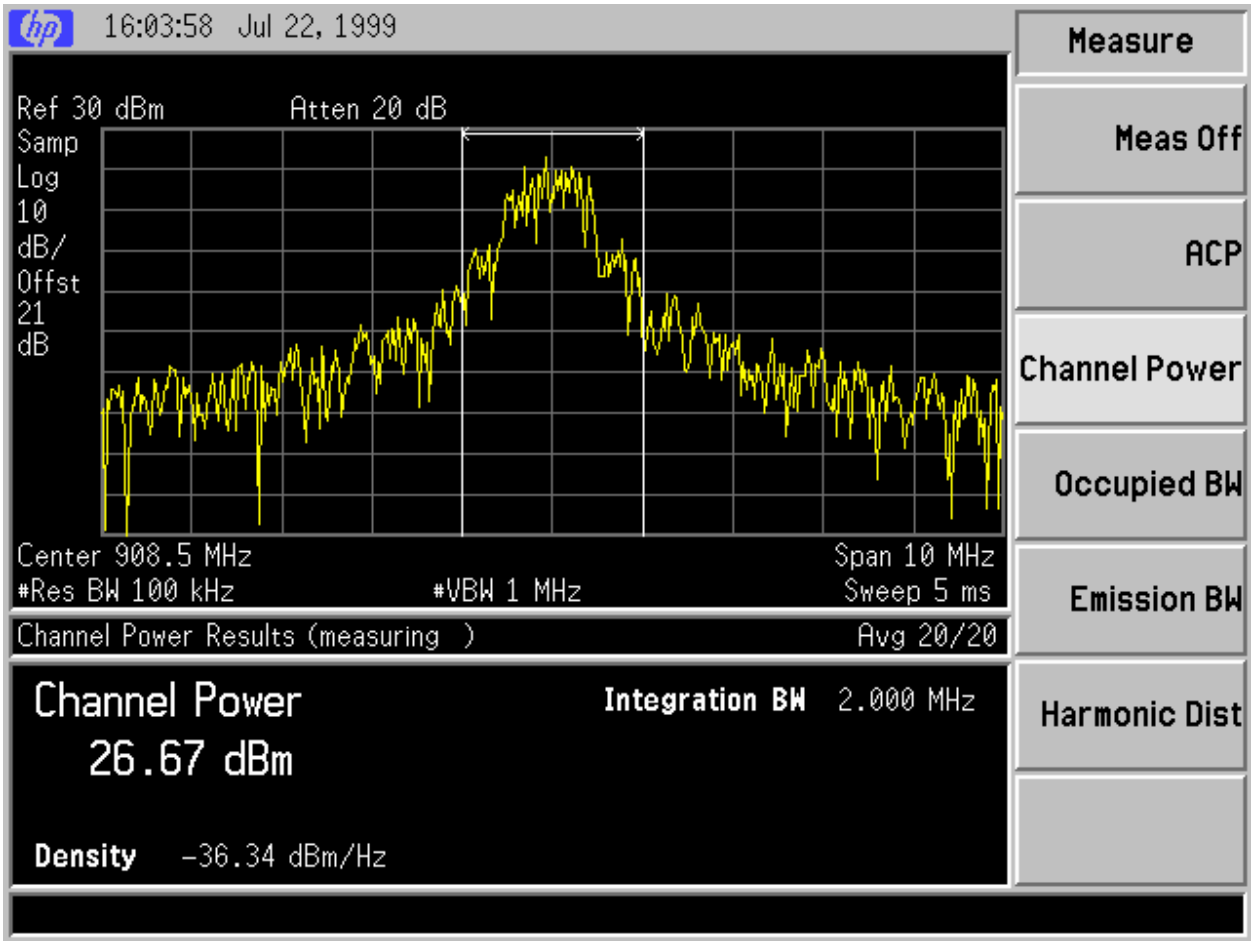


Test Condition: Channel 1: 908.50 MHz, Wide Resolution BW

Test Limit: 30 dBm, Maximum.

Test Indication: 26.7 dBm

Test Outcome: 26.7 dBm < 30 dBm → PASS

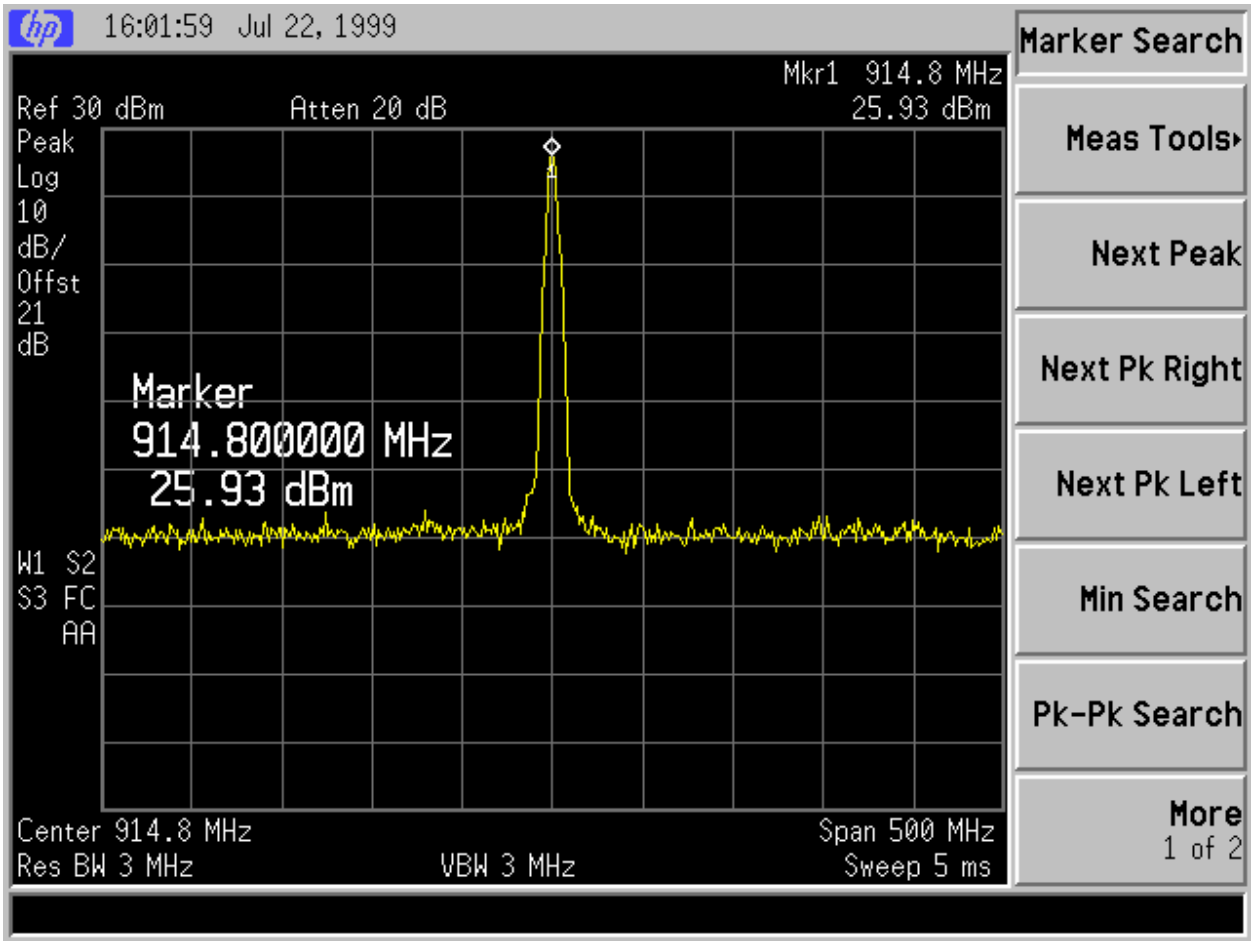


Test Condition: Channel 1: 908.50 MHz, Integrated Power

Test Limit: 30 dBm, Maximum.

Test Indication: 26.7 dBm

Test Outcome: 26.7 dBm < 30 dBm → PASS

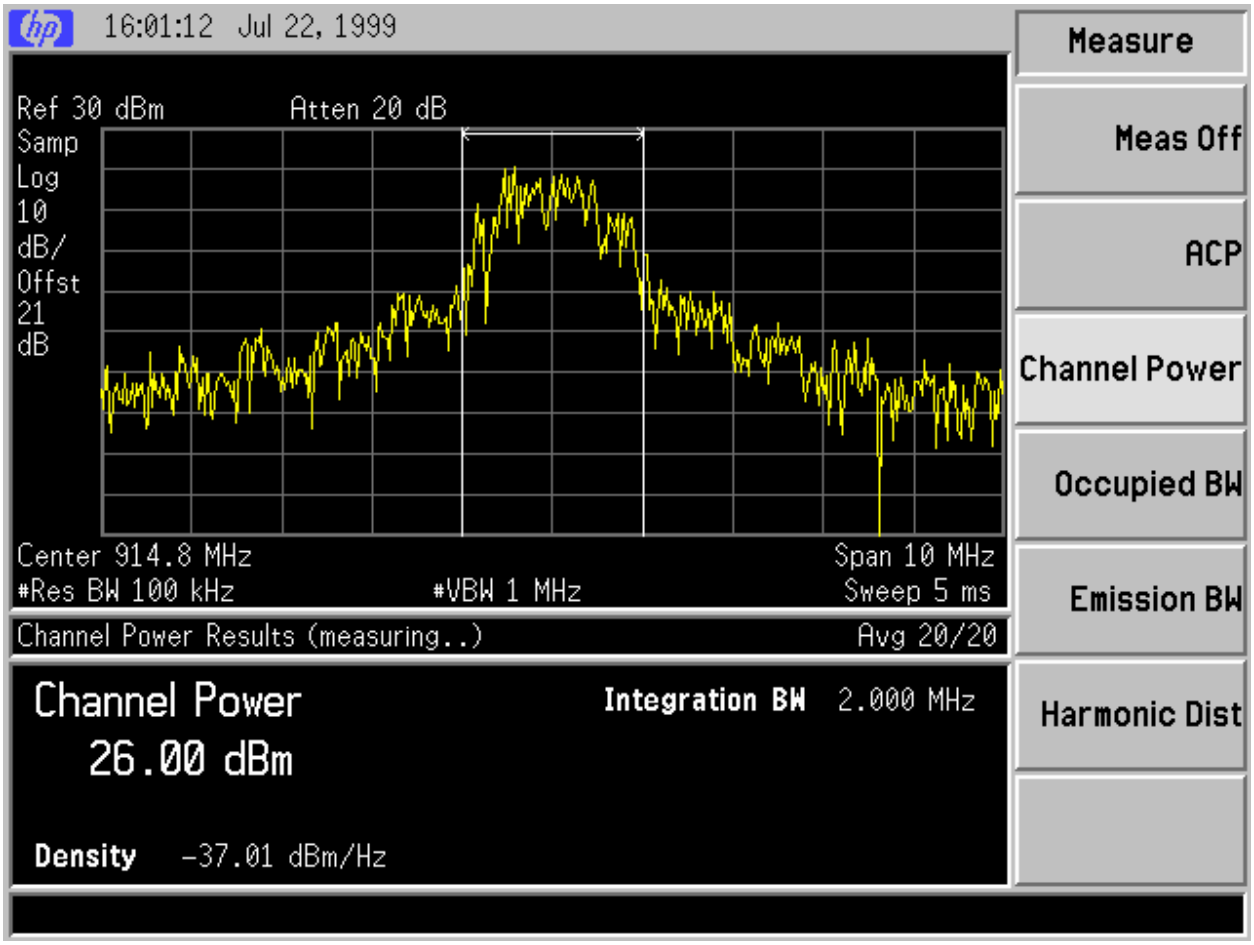


Test Condition: Channel 6: 914.75 MHz, Wide Resolution BW

Test Limit: 30 dBm, Maximum.

Test Indication: 25.9 dBm

Test Outcome: 25.9 dBm < 30 dBm → PASS

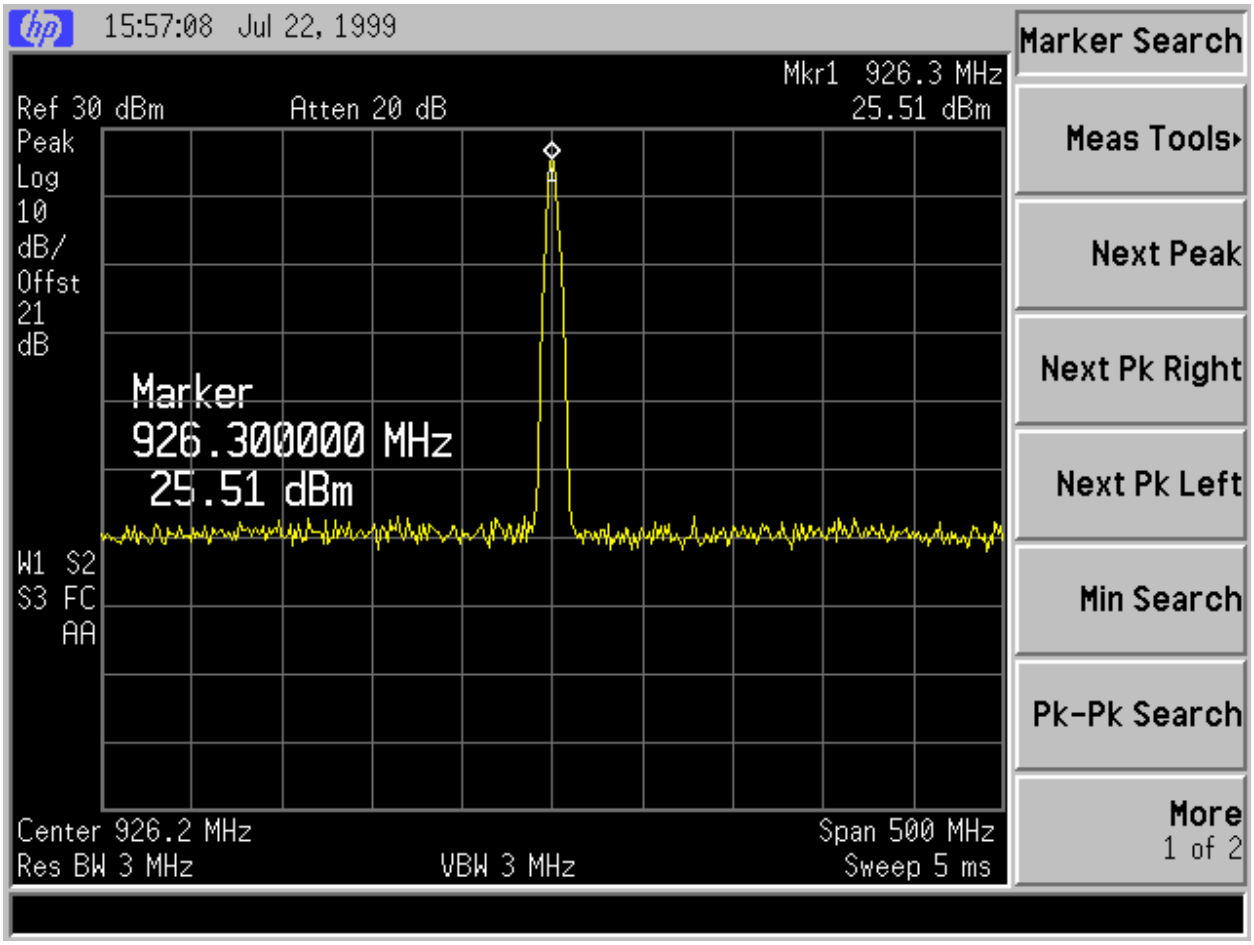


Test Condition: Channel 6: 914.75 MHz, Integrated Power

Test Limit: 30 dBm, Maximum.

Test Indication: 26.0 dBm

Test Outcome: 26.0 dBm < 30 dBm → PASS

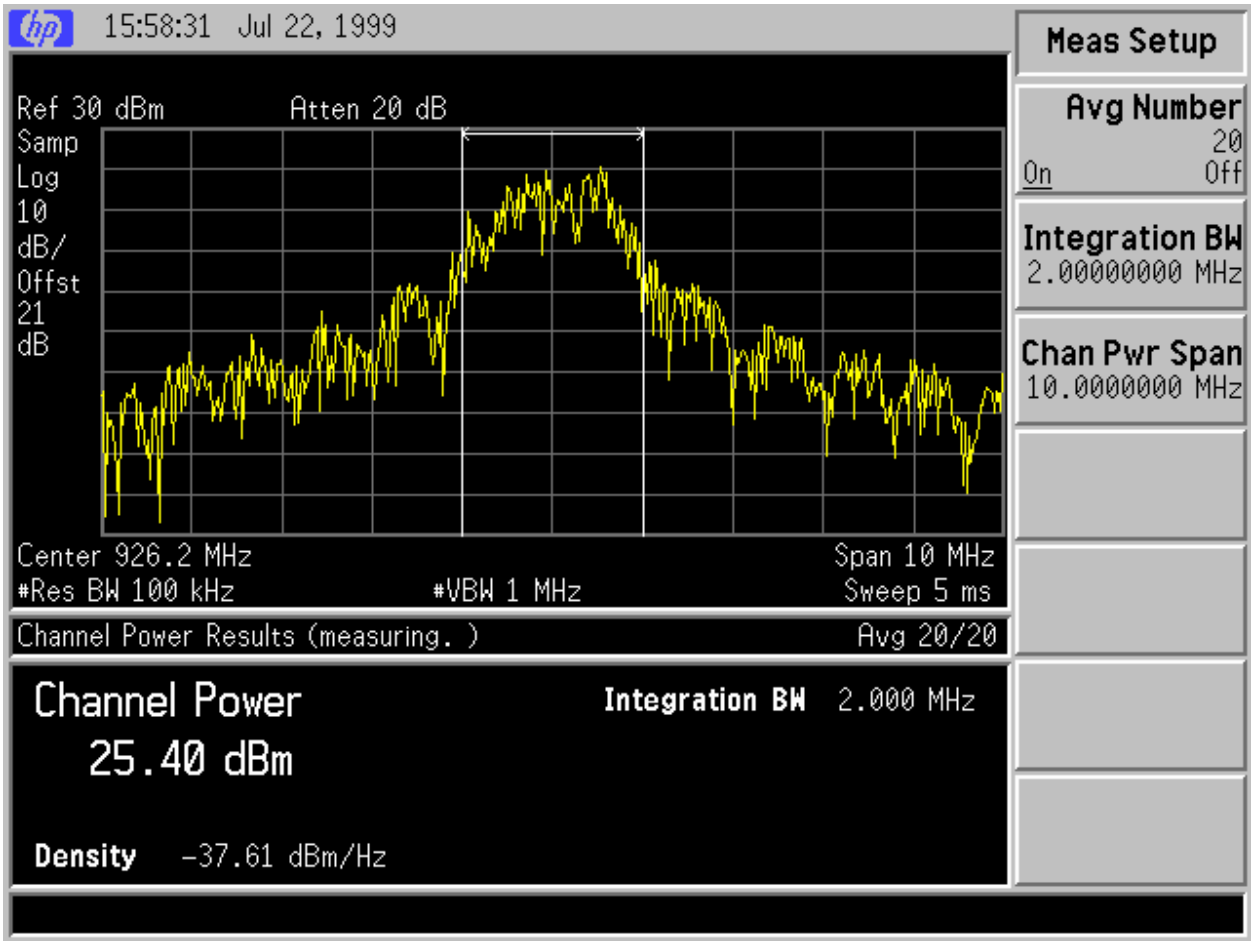


Test Condition: Channel 15: 926.25 MHz, Wide Resolution BW

Test Limit: 30 dBm, Maximum.

Test Indication: 25.5 dBm

Test Outcome: 25.5 dBm < 30 dBm → PASS



Test Condition: Channel 15: 926.25 MHz, Integrated Power

Test Limit: 30 dBm, Maximum.

Test Indication: 25.4 dBm

Test Outcome: 25.4 dBm < 30 dBm → PASS

3. 15.247 (b) (3) Effective Radiated Power

The indicated conducted power is connected to a Centurion EXR-902-TNC, Half-wavelength, center-fed dipole antenna which exhibits a maximum antenna gain of 0 dB, referenced to a standard dipole. The standard dipole antenna gain with respect to an isotropic radiator is 2.1 dB. Based on this application, the maximum ERP of the system is 29.1 dBm and will not exceed the limit of 36 dBm.

4. 15.247 (c) Spurious Modulation Products

a) Test Requirement

The conducted spurious modulation products outside of the authorized band measured within a 100 kHz bandwidth shall be 20 dB below the authorized band peak emission measured within a 100 kHz bandwidth.

$$10 \log_{10}\left(\frac{P_{Authorized}/100\,kHz}{P_{spurious}/100kHz}\right) > 20\ dBc$$

b) Test Configuration

The test configuration is presented in section II-A-1b.

c) Test Conditions: Equipment Under Test

The equipment under test is tunable and is set to 3 different channels, one representing the minimum tunable frequency, one representing a midband frequency and one representing the maximum tunable frequency. The frequencies and their channel designators are presented below for reference.

Channel 1: 908.50 MHz

Channel 6: 914.75 MHz

Channel 15: 926.25 MHz

Test indications under these three frequency conditions are presented.

d) Test Conditions: Instrumentation Conditions

The following conducted spurious emissions are measured for each channel setting:

Wide-band Scan of Emissions with peak emission table, 9 kHz to 10 GHz in continuous transmission and in packet mode transmission. Peak Hold Mode.

In-band Scan of Emissions showing band-edge compliance in both continuous transmission and in packet mode transmission. Peak Hold Mode.

Center: Center Frequency

Span: Frequency Span

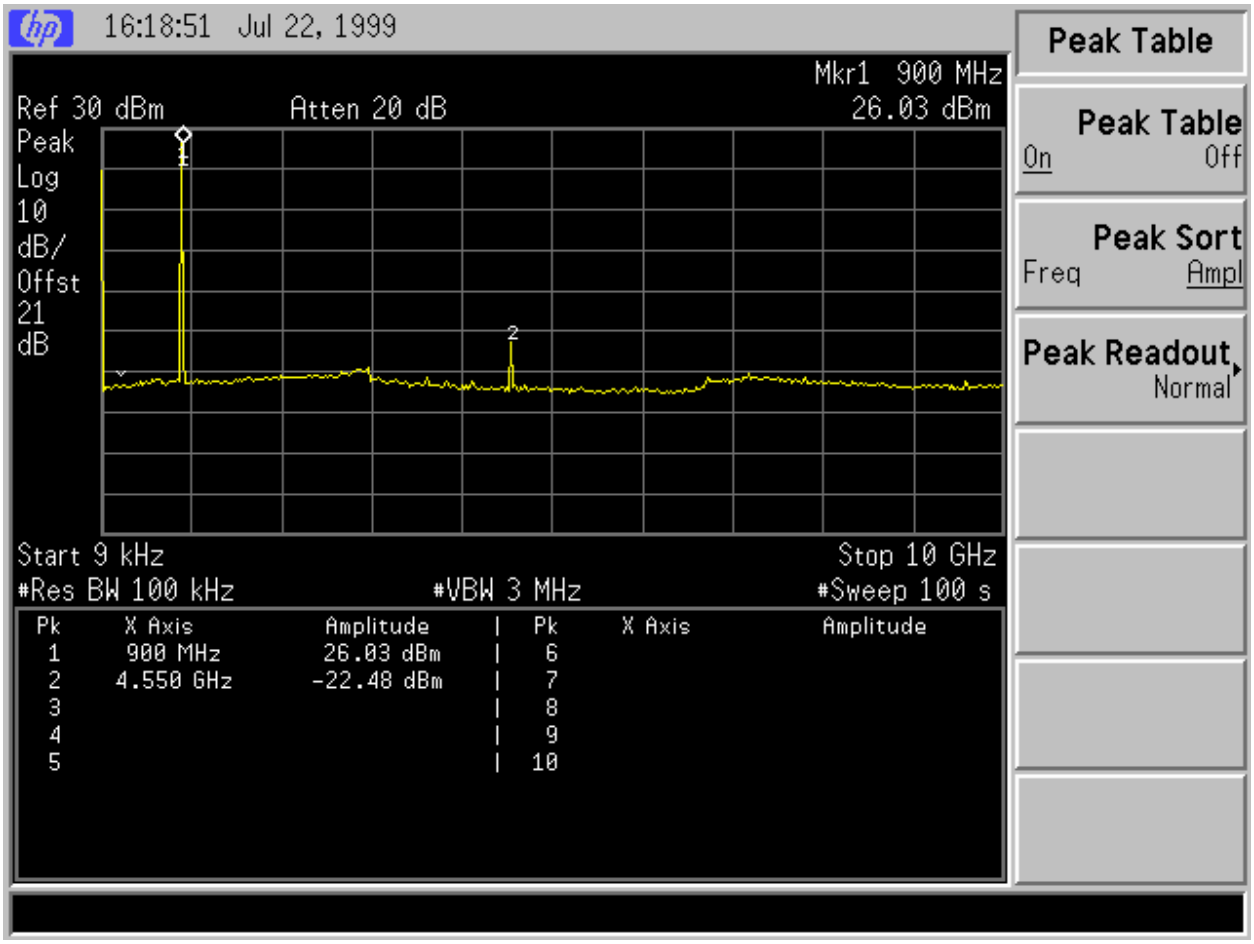
Res BW: Resolution Bandwidth

VBW: Video (averaging) Bandwidth

Sweep: Frequency Sweep time over indicated frequency Span.

Offst: Amplitude Offset, Entered by User to correct for external attenuator and cable losses. Value determined by Vector Network Analyzer transmission measurement of cable/attenuator assembly.

e) Test Indications:

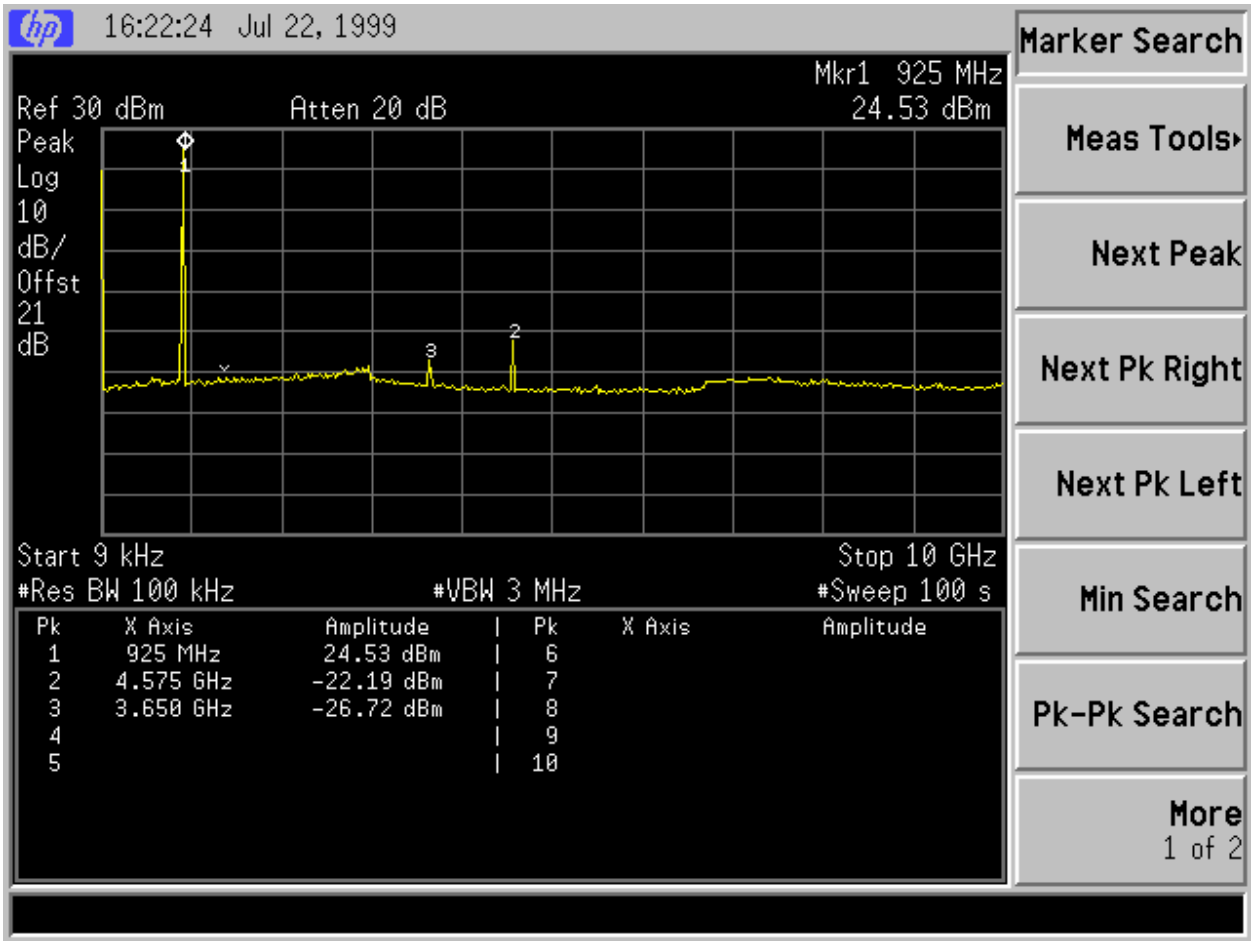


Test Condition: Channel 1: 908.50 MHz, CW

Test Limit: 20 dBc, Minimum.

Test Indication: 26.03 dBm-(-22.48 dBm)= 48.5 dBc

Test Outcome: 48.5 dBc > 20 dBc → PASS

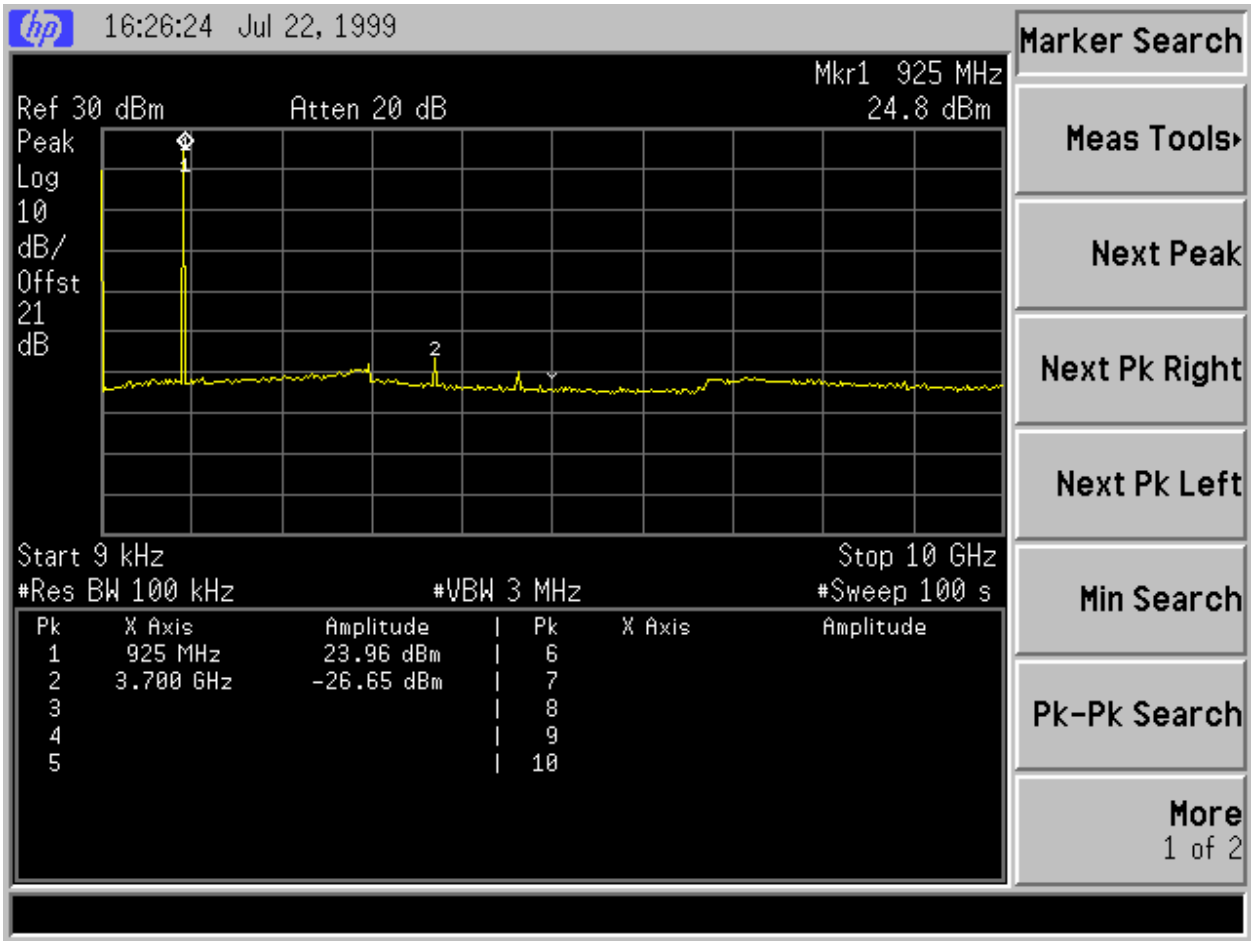


Test Condition: Channel 6: 914.75 MHz, CW

Test Limit: 20 dBc, Minimum.

Test Indication: 24.53 dBm-(-22.19 dBm)= 46.7 dBc

Test Outcome: 46.7 dBc > 20 dBc → PASS

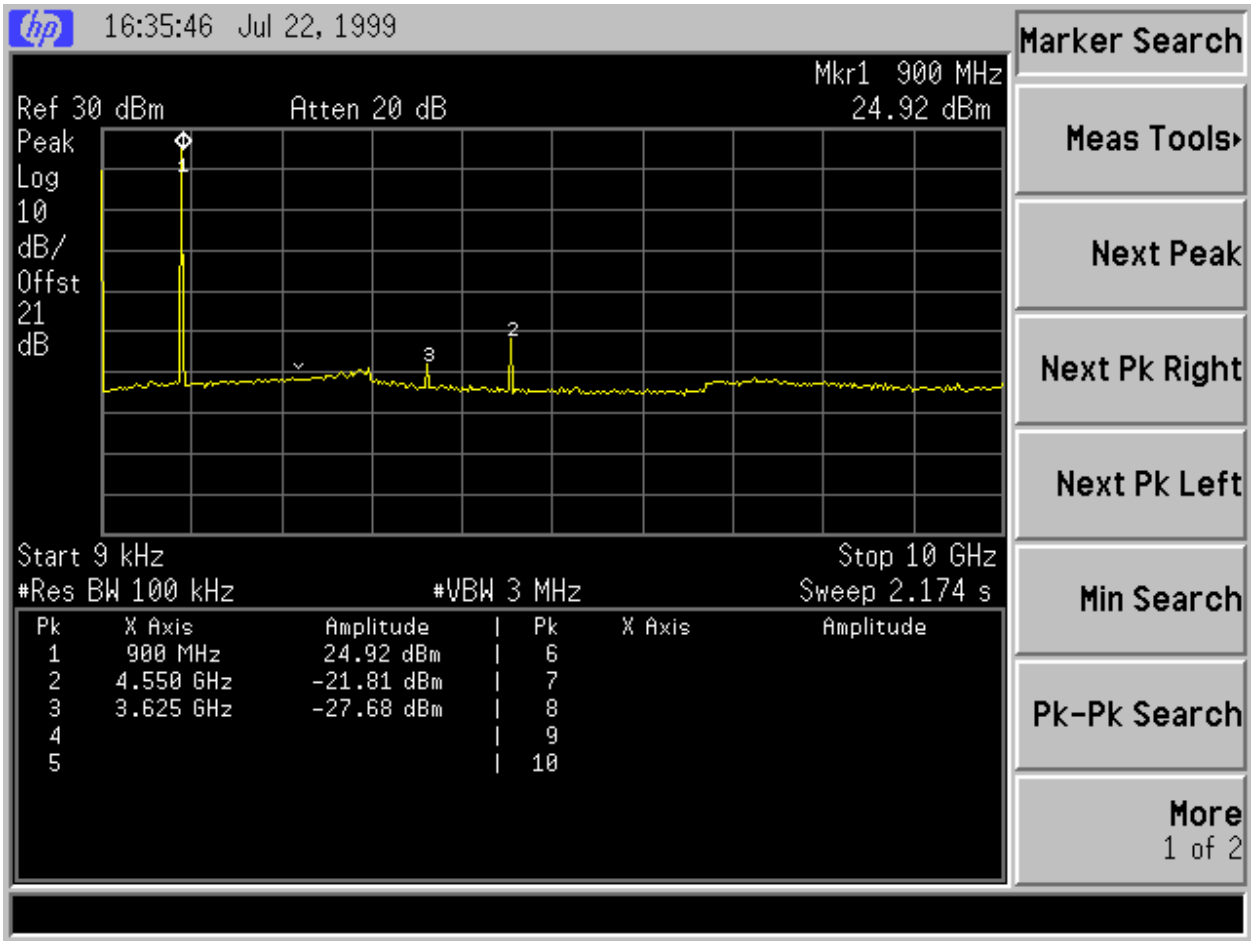


Test Condition: Channel 15: 914.75 MHz, CW

Test Limit: 20 dBc, Minimum.

Test Indication: 23.96 dBm-(-26.65 dBm)= 50.6 dBc

Test Outcome: 50.6 dBc > 20 dBc → PASS

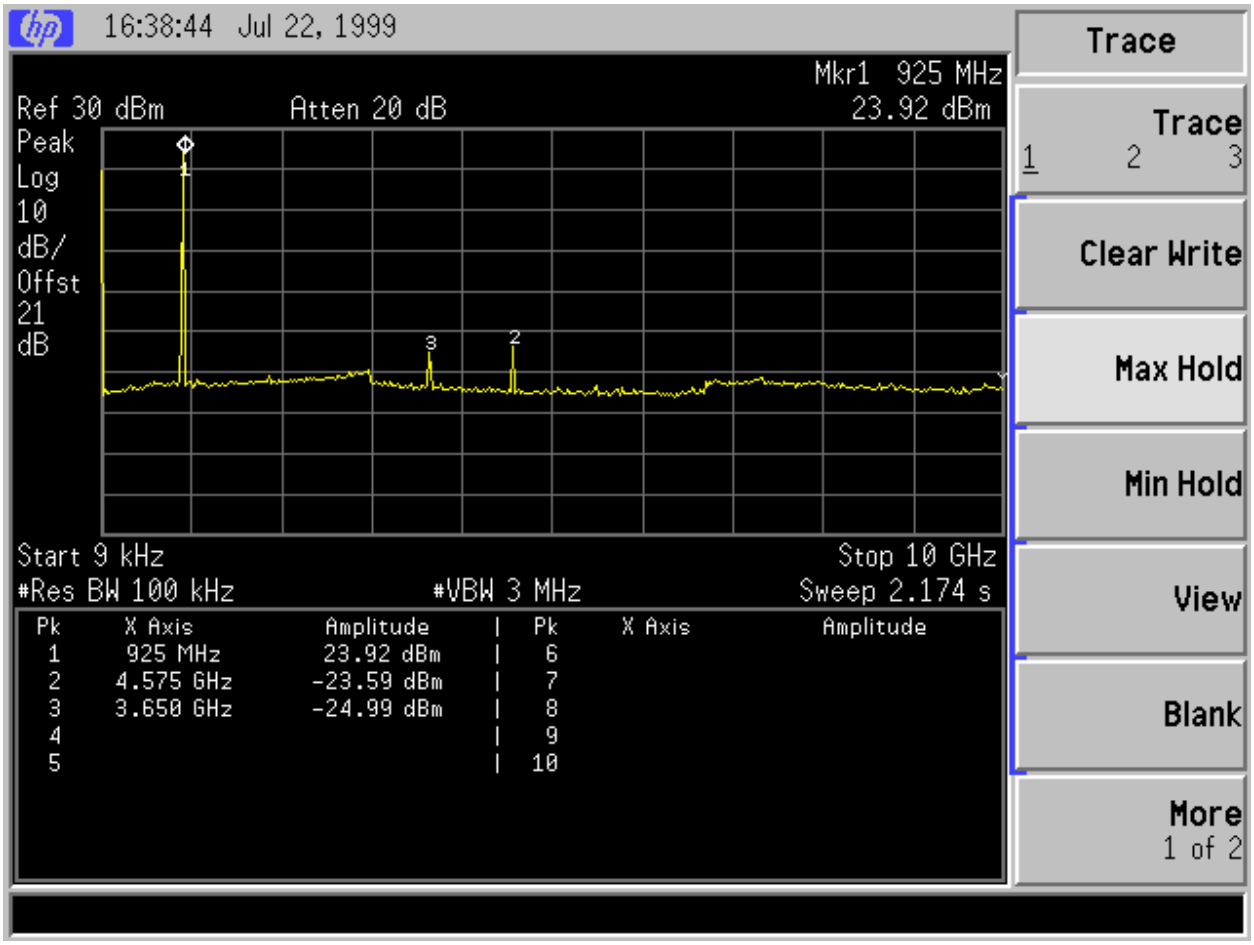


Test Condition: Channel 1: 908.50 MHz, Packet Mode

Test Limit: 20 dBc, Minimum.

Test Indication: 24.92 dBm-(-21.81 dBm)= 46.7 dBc

Test Outcome: 46.7 dBc > 20 dBc → PASS

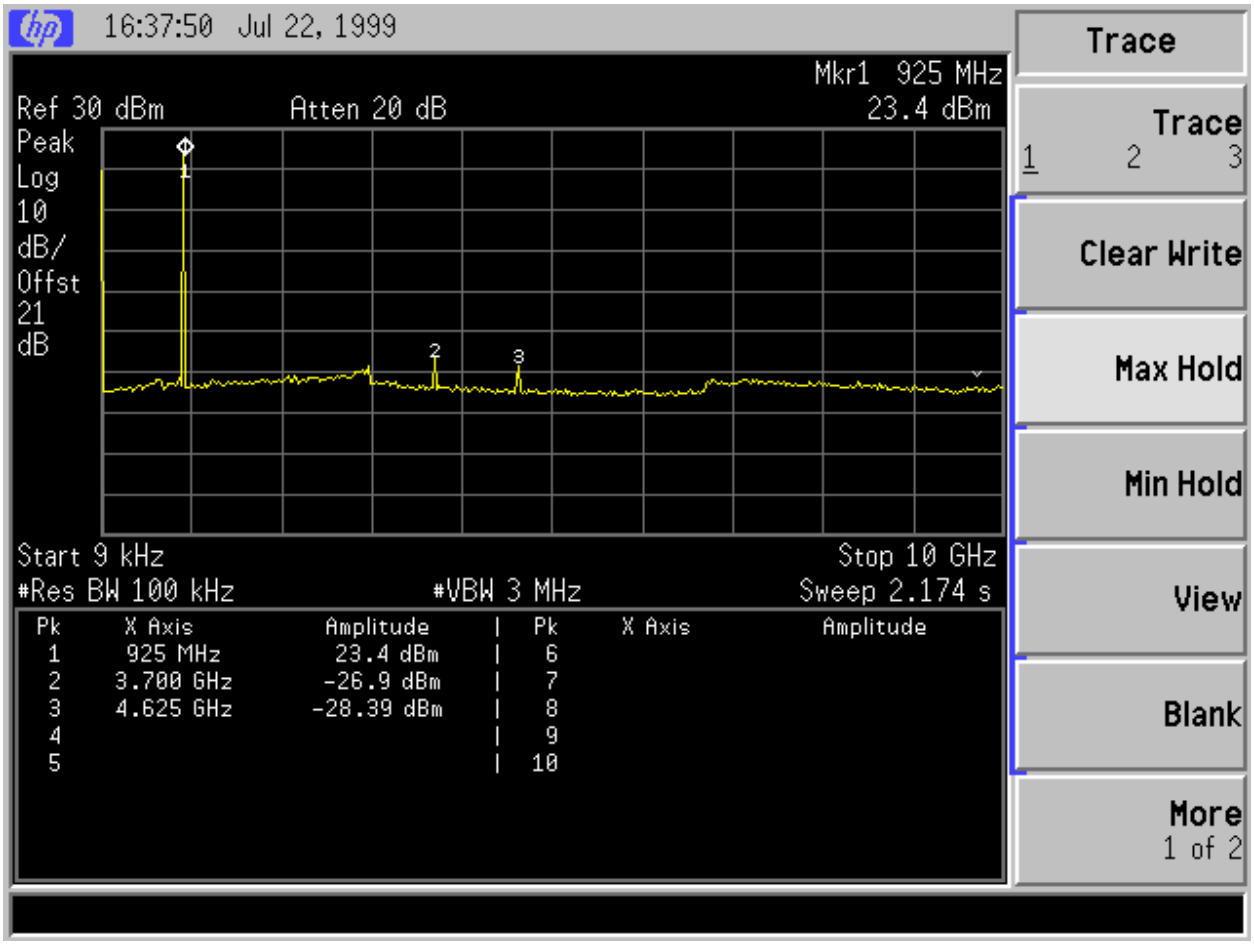


Test Condition: Channel 6: 914.75 MHz, Packet Mode

Test Limit: 20 dBc, Minimum.

Test Indication: 23.92 dBm-(-23.59dBm)= 47.5 dBc

Test Outcome: 47.5 dBc > 20 dBc → PASS

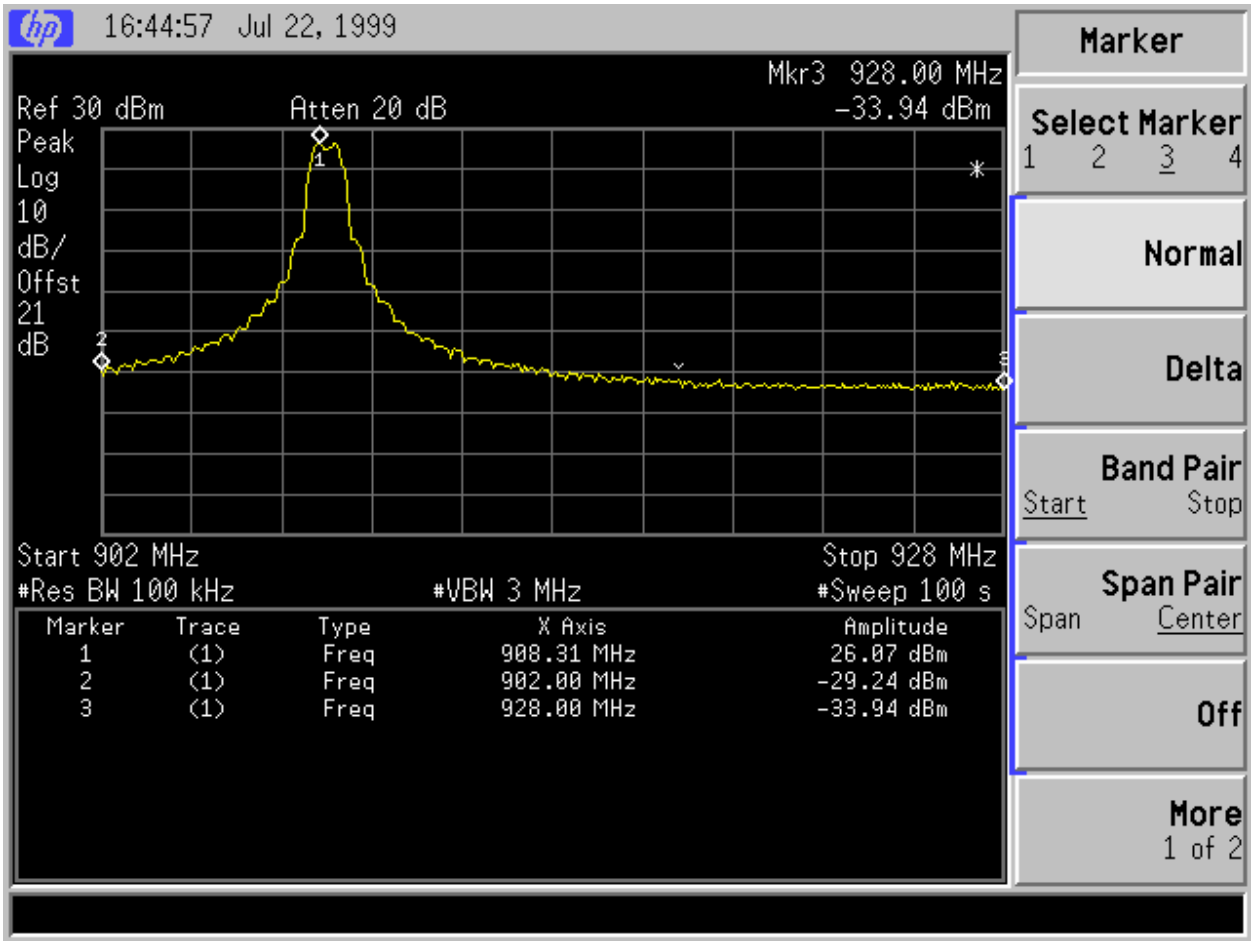


Test Condition: Channel 15: 914.75 MHz, Packet Mode

Test Limit: 20 dBc, Minimum.

Test Indication: 23.4 dBm-(-26.9 dBm)= 50.3 dBc

Test Outcome: 50.3 dBc > 20 dBc → PASS

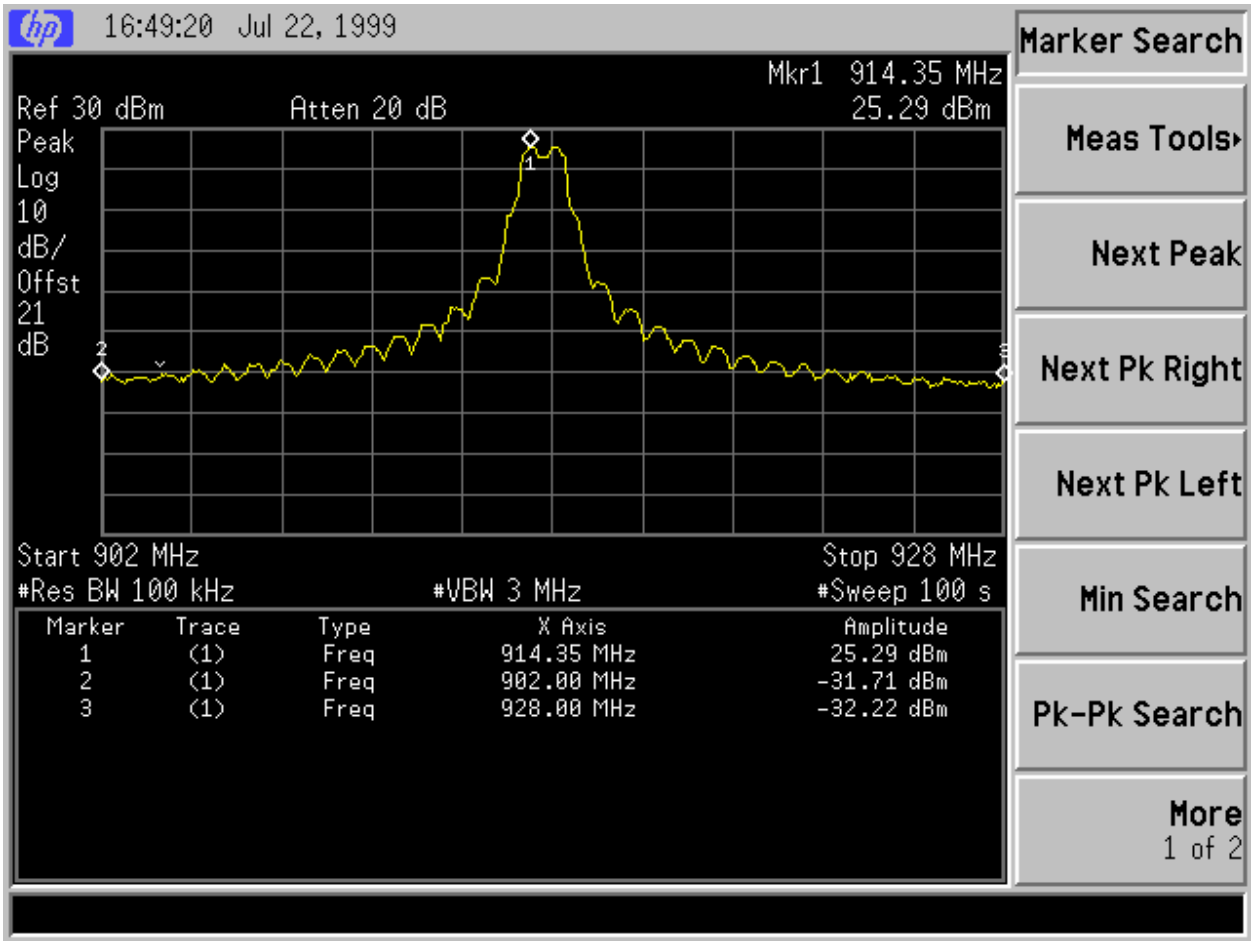


Test Condition: Channel 1: 908.50 MHz, CW

Test Limit: 20 dBc, Minimum.

Test Indication: 26.07 dBm-(-29.24 dBm)= 55.3dBc

Test Outcome: 55.3 dBc > 20 dBc → PASS

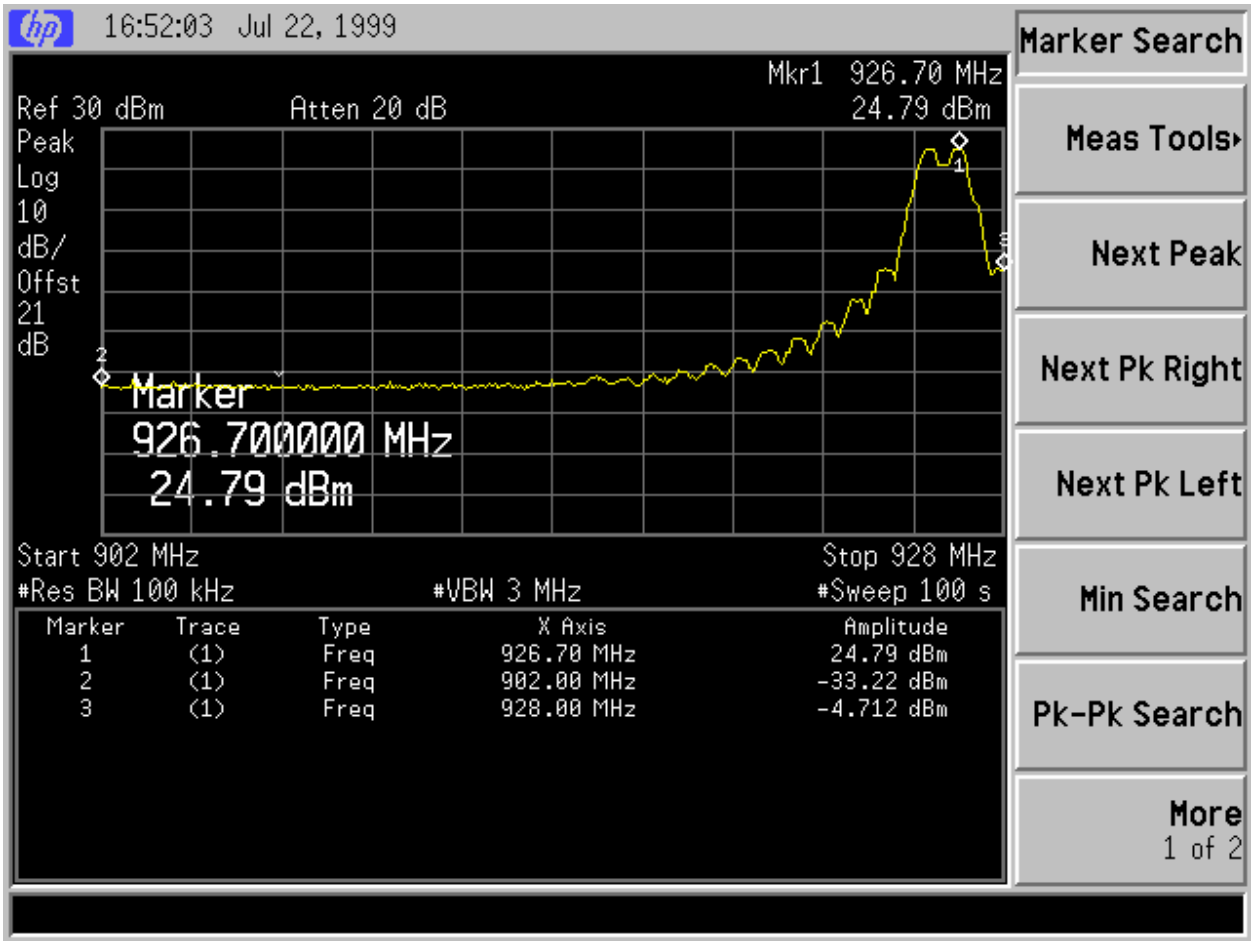


Test Condition: Channel 6: 914.75 MHz, CW

Test Limit: 20 dBc, Minimum.

Test Indication: 25.29 dBm-(-31.71 dBm)= 57 dBc

Test Outcome: 57 dBc > 20 dBc → PASS

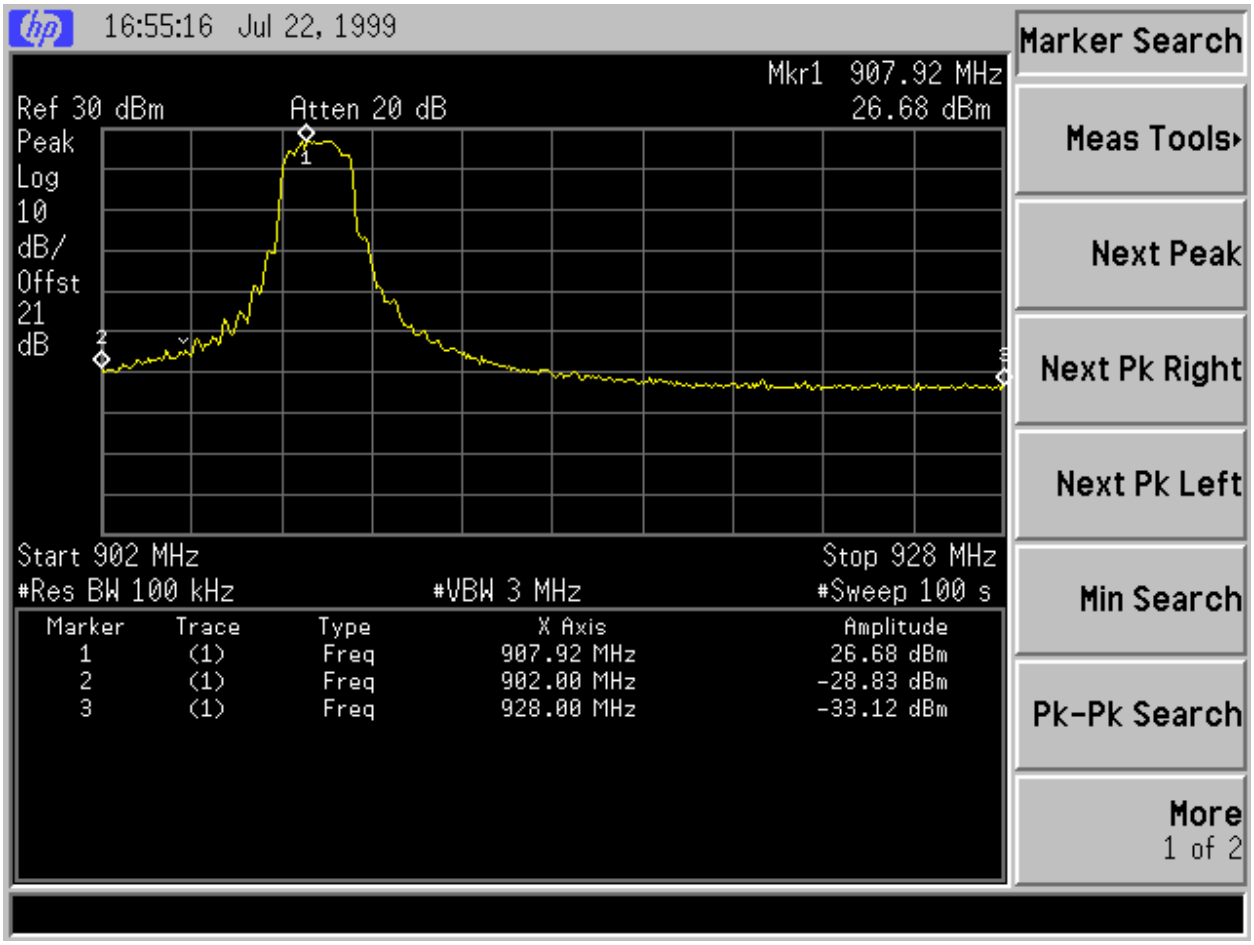


Test Condition: Channel 15: 926.25 MHz, CW

Test Limit: 20 dBc, Minimum.

Test Indication: 24.79 dBm-(-4.71 dBm)= 29.5 dBc

Test Outcome: 29.5 dBc > 20 dBc → PASS

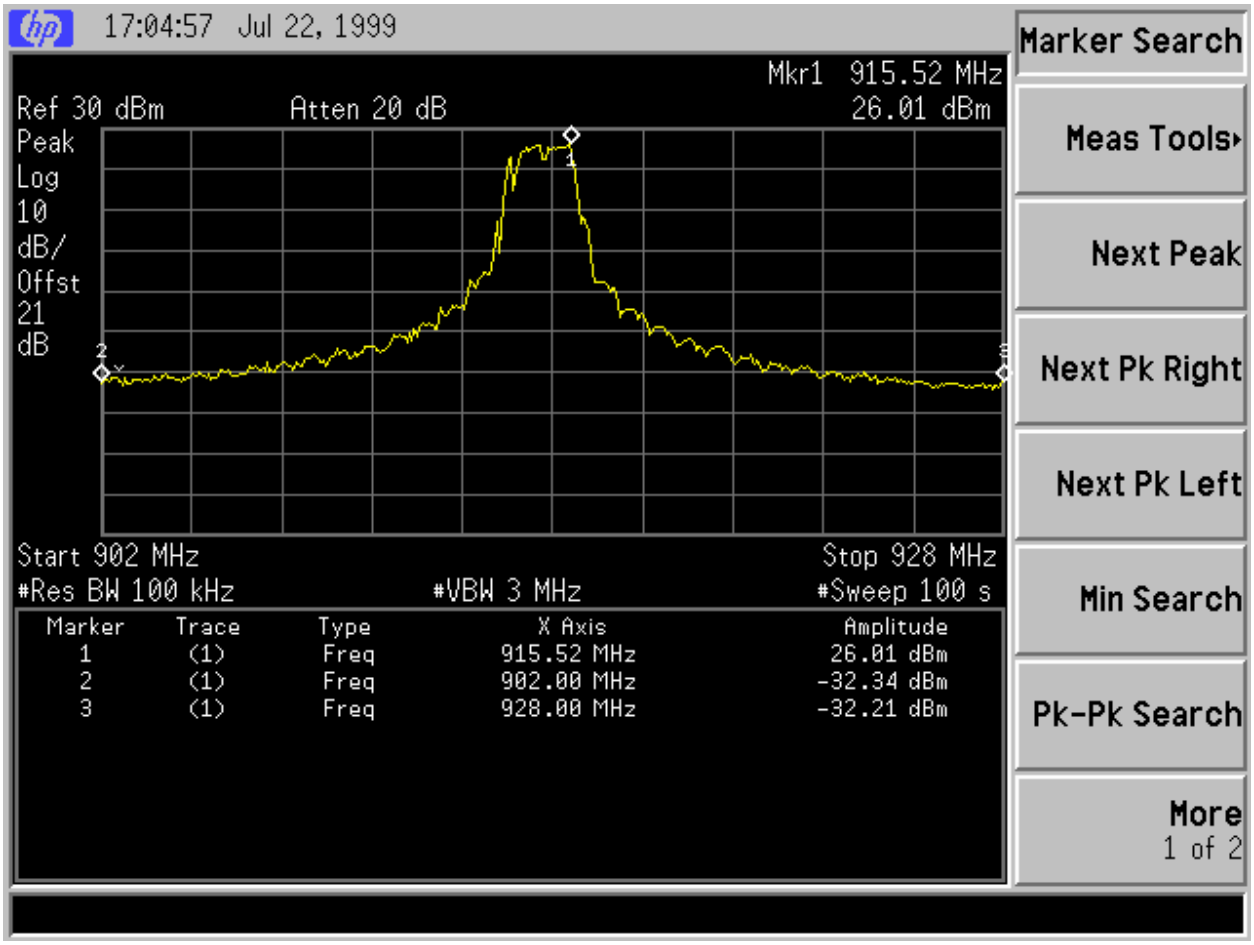


Test Condition: Channel 1: 908.50 MHz, Packet Mode

Test Limit: 20 dBc, Minimum.

Test Indication: 26.68 dBm-(-28.83 dBm)= 55.5 dBc

Test Outcome: 55.5 dBc > 20 dBc → PASS

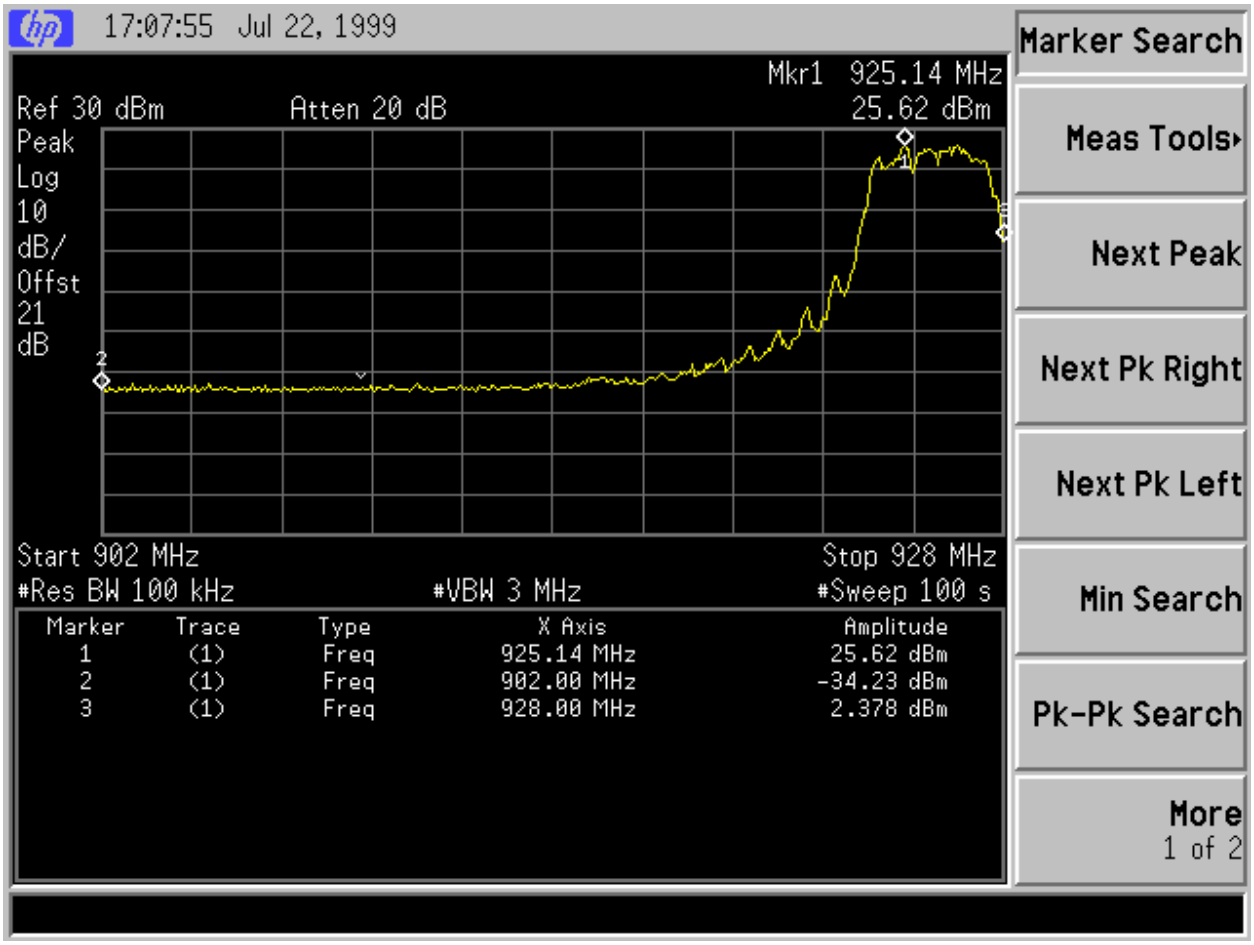


Test Condition: Channel 6: 914.75 MHz, Packet Mode

Test Limit: 20 dBc, Minimum.

Test Indication: 26.01 dBm-(-32.21 dBm)= 55.2 dBc

Test Outcome: 58.2 dBc > 20 dBc → PASS



Test Condition: Channel 15: 926.5 MHz, Packet Mode

Test Limit: 20 dBc, Minimum.

Test Indication: 25.62 dBm-(-2.38 dBm)= 23.24 dBc

Test Outcome: 23.24 dBc > 20 dBc → PASS

5. 15.247 (d) Power Spectral Density

a) Test Requirement

The maximum power spectral density allowed in the authorized band is 8 dBm/3kHz.

$$P_{authorized} / 3kHz < 8\ dBm / 3kHz$$

b) Test Configuration

The test configuration is presented in section II-A-1b.

c) Test Conditions: Equipment Under Test

The equipment under test is tunable and is set to 3 different channels, one representing the minimum tunable frequency, one representing a mid-band frequency and one representing the maximum tunable frequency. The frequencies and their channel designators are presented below for reference.

Channel 1: 908.50 MHz

Channel 6: 914.75 MHz

Channel 15: 926.25 MHz

Test indications under these three frequency conditions are presented.

The following conducted power spectral densities are measured for each channel setting:

d) Test Conditions: Instrumentation

The localized peak in the emission spectrum is examined using the noise marker function implemented by the spectrum analyzer. The noise marker method is chosen, since the spectral lines of the emission are not resolvable and have noise-like properties. The power spectral density as indicated is measured in a 1 Hz bandwidth and is corrected for measurement artifacts such as noise bandwidth, and logarithmic amplification weighting. The test indication is then re-normalized to a 3 kHz bandwidth by adding the following correction factor:

$$10 \log_{10}\left(\frac{3\ kHz}{1\ Hz}\right) = 34.8\ dB$$

Center: Center Frequency

Span: Frequency Span

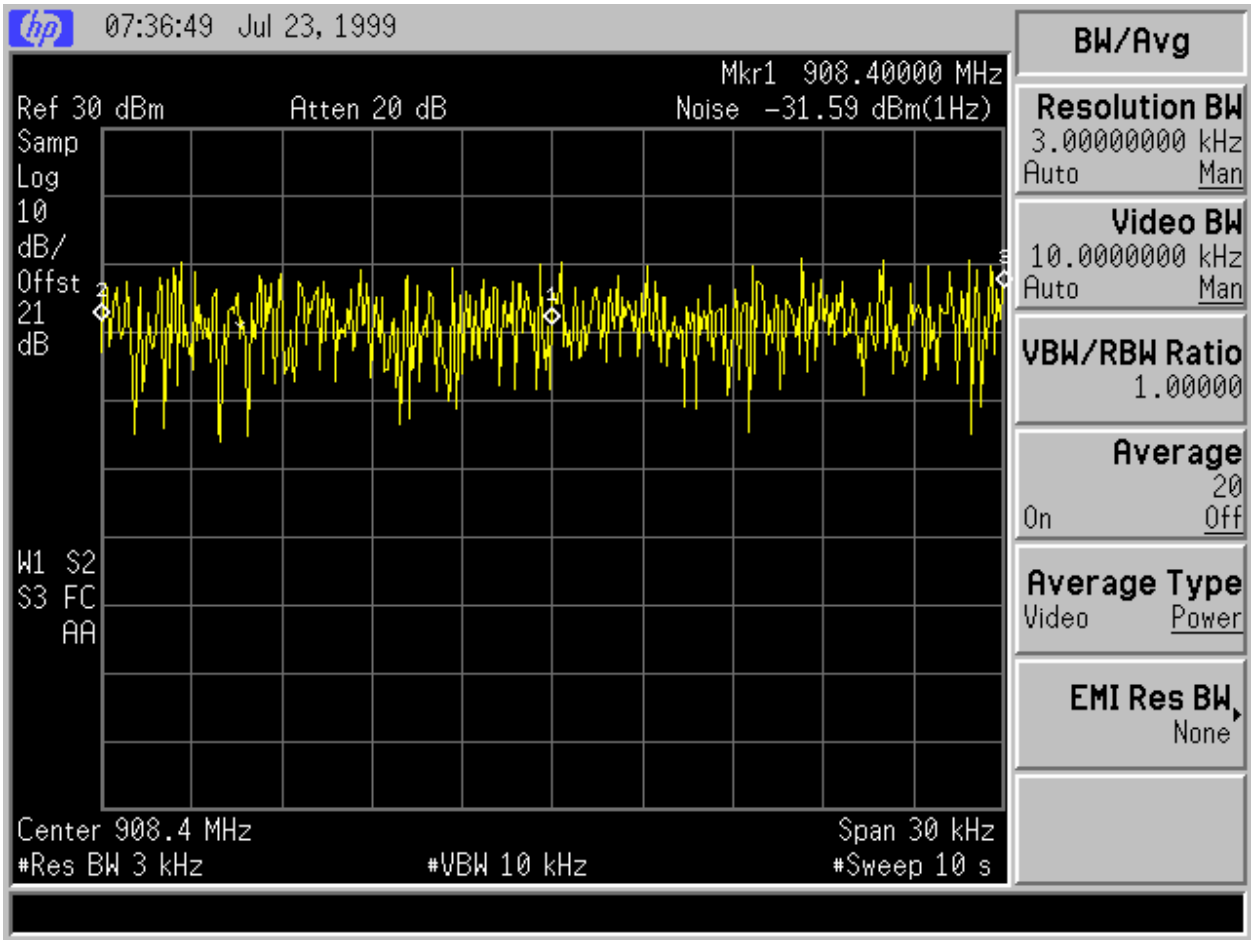
Res BW: Resolution Bandwidth

VBW: Video (averaging) Bandwidth

Sweep: Frequency Sweep time over indicated frequency Span.

Offst: Amplitude Offset, Entered by User to correct for external attenuator and cable losses. Value determined by Vector Network Analyzer transmission measurement of cable/attenuator assembly.

e) Test Indications

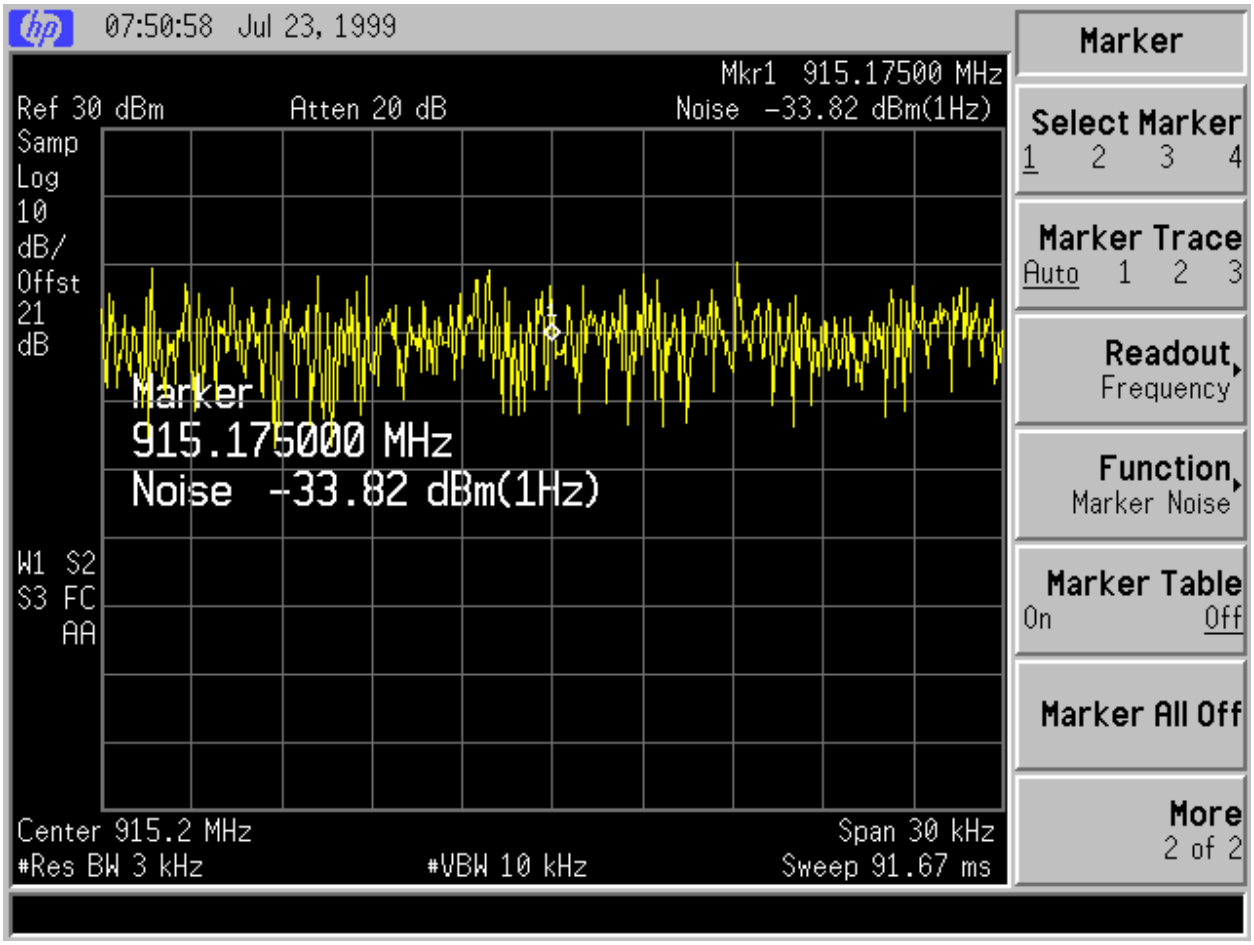


Test Condition: Channel 1: 908.5 MHz

Test Limit: 8 dBm/3 kHz, Maximum.

Test Indication: -31.59 dBm/Hz + 34.8 dB = 3.2 dBm/3kHz

Test Outcome: 3.2 dBm/3kHz < 8 dBm/3kHz → PASS

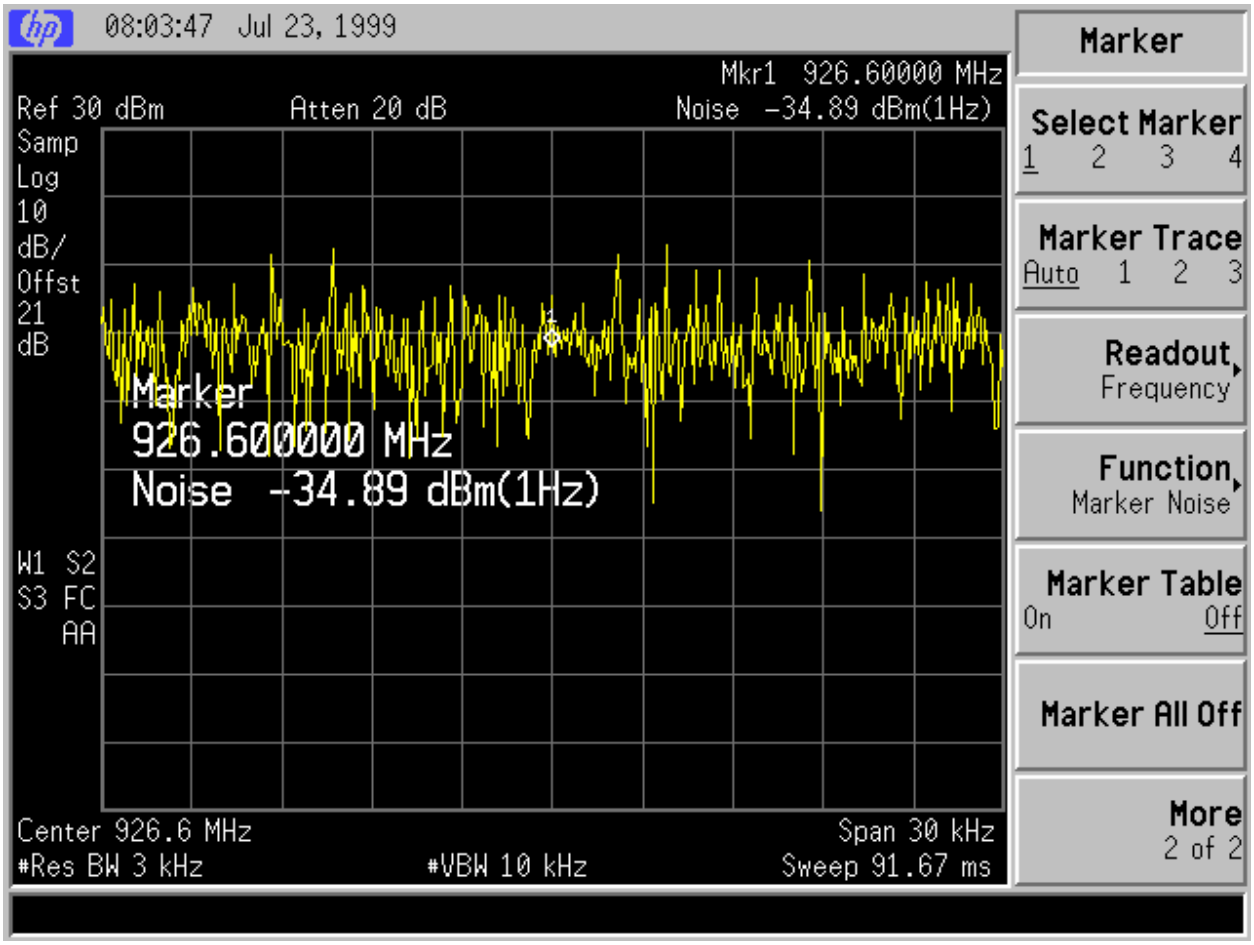


Test Condition: Channel 6: 914.75 MHz

Test Limit: 8 dBm/3 kHz, Maximum.

Test Indication: -33.82 dBm/Hz + 34.8 dB = 1.0 dBm/3kHz

Test Outcome: 1.0 dBm/3kHz < 8 dBm/3kHz → PASS



Test Condition: Channel 15: 926.25 MHz

Test Limit: 8 dBm/3 kHz, Maximum.

Test Indication: -34.89 dBm/Hz + 34.8 dB = -0.1 dBm/3kHz

Test Outcome: -0.1 dBm/3kHz < 8 dBm/3kHz → PASS

6. 15.247 (e) Processing Gain

a) Test Requirement

The minimum processing gain exhibited by the system must be at least 10 dB. The processing gain will be determined by measuring the jamming margin across the receiver pass-band in 50 kHz increments. The worst 20% of the jamming margin points are discarded for the determination of the processing gain. The worst case point elimination process is equivalent to the determination of the 20th percentile value for the processing gain data set.

The processing gain is related to the jamming margin as follows:

$$G_p = \frac{J}{S} + \left(\frac{S}{N}\right)_{BER\_REF} + 2\ dB(system\,loss)$$

$$G_p = \frac{J}{S} + \left(\frac{S}{N}\right)_{BER=1\times10^{-4}} + 2\ dB(system\,loss)$$

The demodulation process is non-coherent FSK and its bit error ratio (BER) versus signal to noise ratio (S/N) performance characteritic is described by:

$$BER = \frac{1}{2} e^{-\frac{1}{2}\left(\frac{S}{N}\right)}$$

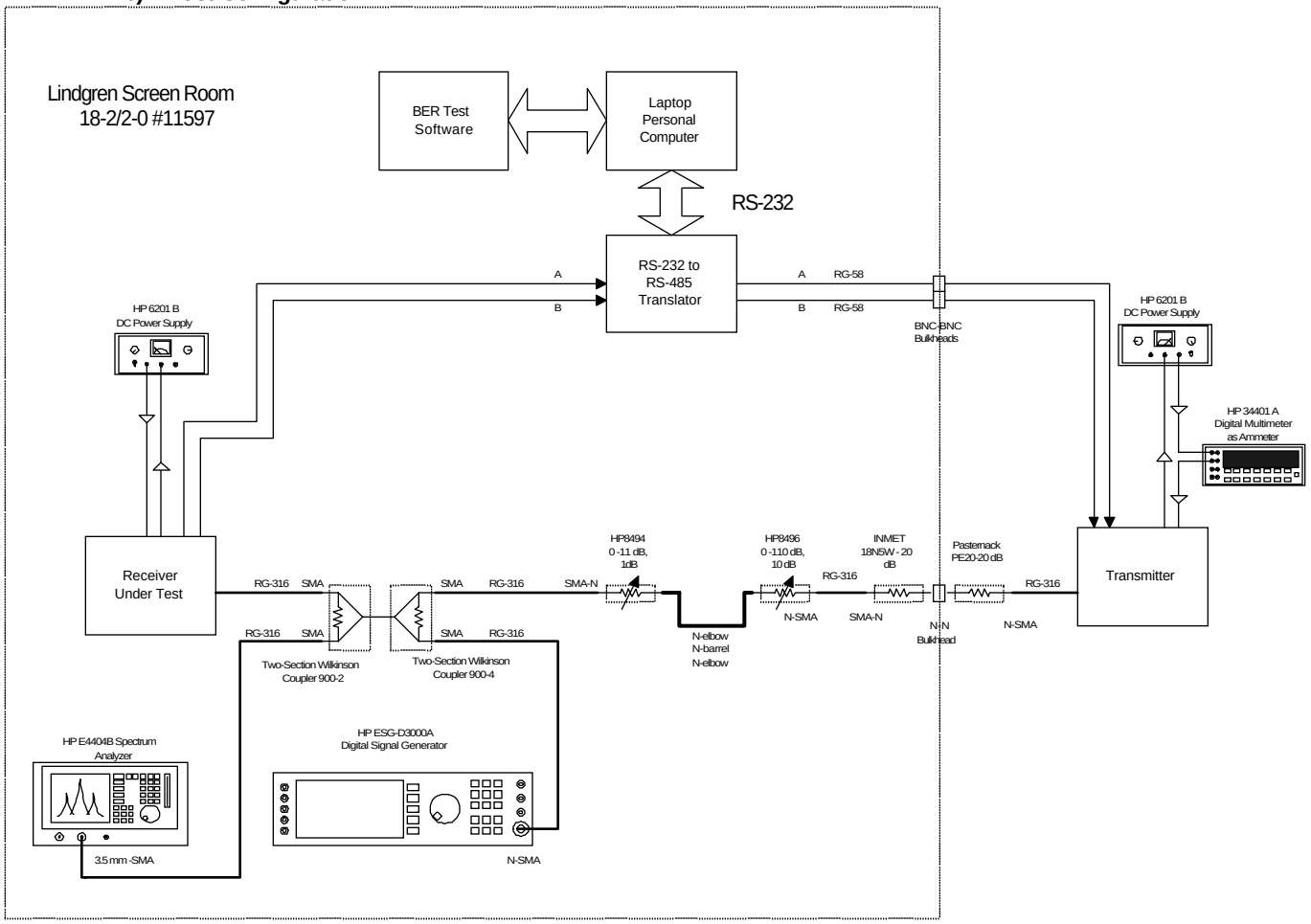
The signal to noise ratio associated with the reference BER of 1X10^{-4} is:

$$10\log_{10}\left(\frac{S}{N}\right) = 10\log_{10}\left(-2\ln\left(2\cdot1\times10^{-4}\right)\right) = 12.3\,dB$$

Therefore, procesing gain and jamming margin are related by:

$$G_p = \frac{J}{S} + 14.3\ dB$$

b) Test Configuration



c) Test Conditions: Equipment Under Test

The equipment under test is tunable and is set to 3 different channels, one representing the minimum tunable frequency, one representing a midband frequency and one representing the maximum tunable frequency. The frequencies and their channel designators are presented below for reference.

Channel 1: 908.50 MHz

Channel 6: 914.75 MHz

Channel 15: 926.25 MHz

Test indications under these three frequency conditions are presented.

The following processing gain tests are measured for each channel setting:

d) Test Conditions: Instrumentation

The bit error ratio (BER) software is run on a laptop PC to emulate the base-band packet protocol to be used over the radio link. A standard BER test set (FIREBERD 6000A) could not be used due to the fact that the asynchronous data rate of 57.6 kbps exceeded its asynchronous measurement capability. Secondly, the protocol uses the idle line state for packet framing and the BER test set does not support that framing method.

The BER software generates a packet data stream and transmits it out of the serial port with RS-232 logic levels into the level translator board. The level translator board converts the RS-232 logic levels into a uni-polar differential RS-485 line which is fed to the transmitter. The transmitter signal is fed into the jamming margin test system as the desired signal. The receiver demodulates and de-spreads the signal back to its original base-band form and is available as an RS-485 signal pair. The RS-485 signal pair is fed to the translator board, which converts the logic levels to RS-232 and feeds the received data stream into the PC for processing.

The software performs a bit-by-bit comparison of the received packets and calculates the instantaneous bit-error-rate for the incoming packet and also calculates the cumulative BER over all the packets transmitted in the test interval.

The cumulative BER is used as a set-point in the adjustment of the jamming signal level (and consequently the J/S ratio). The set-point or reference BER is $1X10^{-4}$.

A complete description of the BER software and the level-translator board is presented in Section V.

e) Procedure

1. Referring to the test set-up presented in part b of this sub-section, note that there are two Wilkinson couplers. These couplers have a maximum amplitude imbalance of 0.1 dB and maximum phase imbalance of 1 degree over the test frequency band (s-parameters on record).

2. The first coupler is used to combine the desired signal and the tone jamming signal.

3. The second coupler is used to sample the composite input signal to the receiver. The signal is sampled by a spectrum analyzer. The cable lengths on the output of the sampling coupler are of the same type (RG-316) and of similar length. However due to the amplitude balance of the coupler, the J/S ratio in each arm of the coupler will correlate to within 0.1 dB.

4. Using the integrated channel power measurement function, the desired signal power is set to about –50 dBm at the sampled port. The level at the receiver will be very close to this sampled level.. The desired signal is adjusted by means of the two step attenuators. The transmitter is placed in the CW mode during this step. Ensure that the jamming signal generator is disabled.

5. The transmitter is disabled and the jamming signal generator is enabled and set to the transmitter carrier frequency and is measured by the spectrum analyzer using the integrated channel power function. The jamming power is set to the exact level (to within 0.1 dB) of the previous reading of the desired signal. Since the desired and the jamming signal levels were measured under the same conditions, the J/S ratio at receiver given these settings is at 0 dB.

6. Given the jamming signal generator absolute amplitude reference setting established in step 5. The signal generator amplitude setting is normalized to this absolute level using the amplitude reference function on the signal generator. Therefore, the generators indicated setting is relative to the 0 dB J/S setting. Further settings are recorded as a test indications of the J/S ratio. With every set of test indication, the absolute reference indications are also presented to ensure the confidence of the 0 dB J/S setting.

7. With the jamming signal attenuated substantially (-30 dB J/S), enable transmission and reception of the packet data, the BER should indicate 0 (error free operation) over a short test interval of 30 seconds.

8. While monitoring the BER, increase the jamming signal level until the BER indicates 1×10^{-4} or less. Record the relative amplitude level setting on the jamming signal generator ,this is the J/S ratio per the normalization method presented earlier.

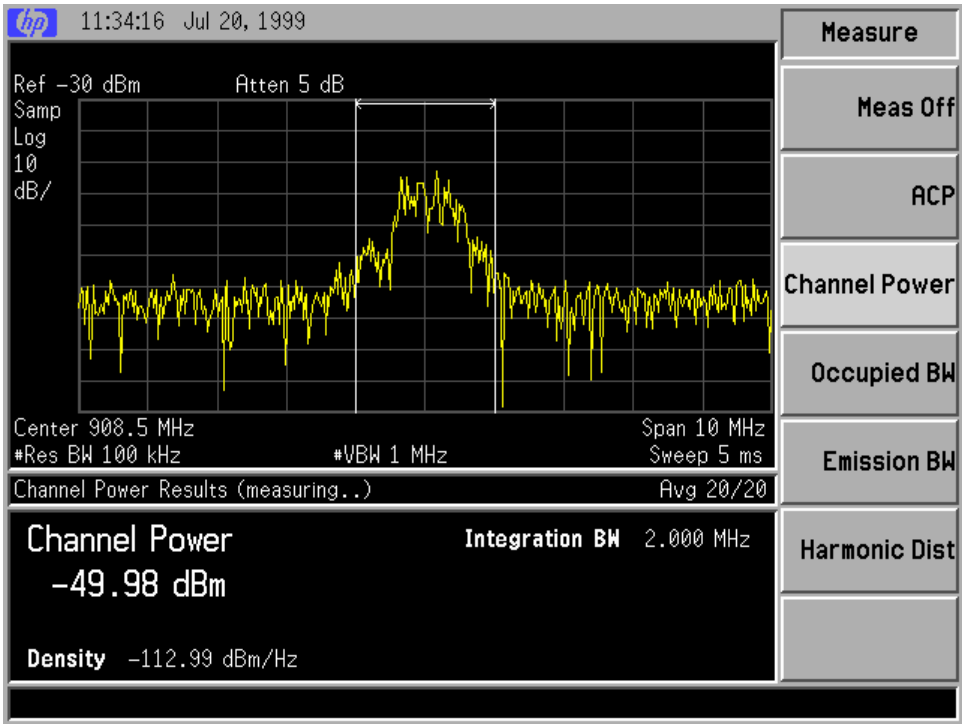
9. Repeat across the pass-band of the receiver in 50 kHz increments, recording the J/S ratio at every frequency. Repeat for minimum, mid-band, and maximum channel frequencies.

f) Test Indication Organization

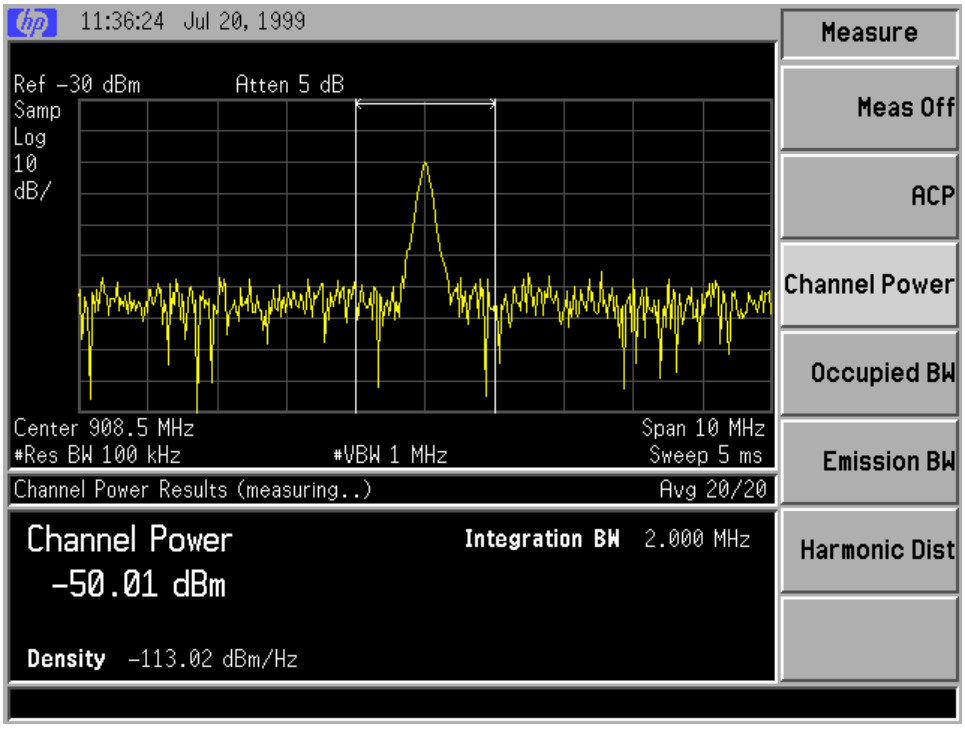
For each channel setting, the test indications presented will be as follows:

1. Reference desired signal and jamming signal levels at 0 dB J/S.
2. Numerical J/S data and conversion to processing gain.
3. 20^{th} percentile value for the processing gain data set for indication of processing gain for 20% of worst indications removed.
4. Plot of processing gain over pass-band of receiver.

g) Test Indications Channel 1 (908.50 MHz)



Test Indication: Channel 1: 908.5 MHz, Desired Signal Reference Level Setting



Test Indication: Channel 1: 908.5 MHz, Jamming Signal Reference Level Setting

CHANNEL	1	
FREQUENCY	908.50	MHz
HP8496B	20	dB
HP8494B	1	dB

Frequency	J/S	Gp
907.50	9.90	24.21
907.55	8.40	22.71
907.60	6.70	21.01
907.65	3.70	18.01
907.70	1.60	15.91
907.75	0.60	14.91
907.80	-0.60	13.71
907.85	-1.10	13.21
907.90	-2.10	12.21
907.95	-2.10	12.21
908.00	-3.00	11.31
908.05	-3.00	11.31
908.10	-2.50	11.81
908.15	-3.30	11.01
908.20	-3.30	11.01
908.25	-1.50	12.81
908.30	-1.50	12.81
908.35	-1.50	12.81
908.40	-1.40	12.91
908.45	-1.60	12.71
908.50	-1.30	13.01
908.55	-2.00	12.31
908.60	-2.70	11.61
908.65	-3.60	10.71
908.70	-3.60	10.71
908.75	-3.90	10.41
908.80	-3.90	10.41
908.85	-4.10	10.21
908.90	-3.80	10.51
908.95	-3.50	10.81
909.00	-3.80	10.51
909.05	-2.70	11.61
909.10	-2.80	11.51
909.15	-2.40	11.91
909.20	-2.40	11.91
909.25	0.60	14.91
909.30	0.50	14.81
909.35	1.10	15.41
909.40	2.10	16.41
909.45	5.30	19.61
909.50	7.40	21.71

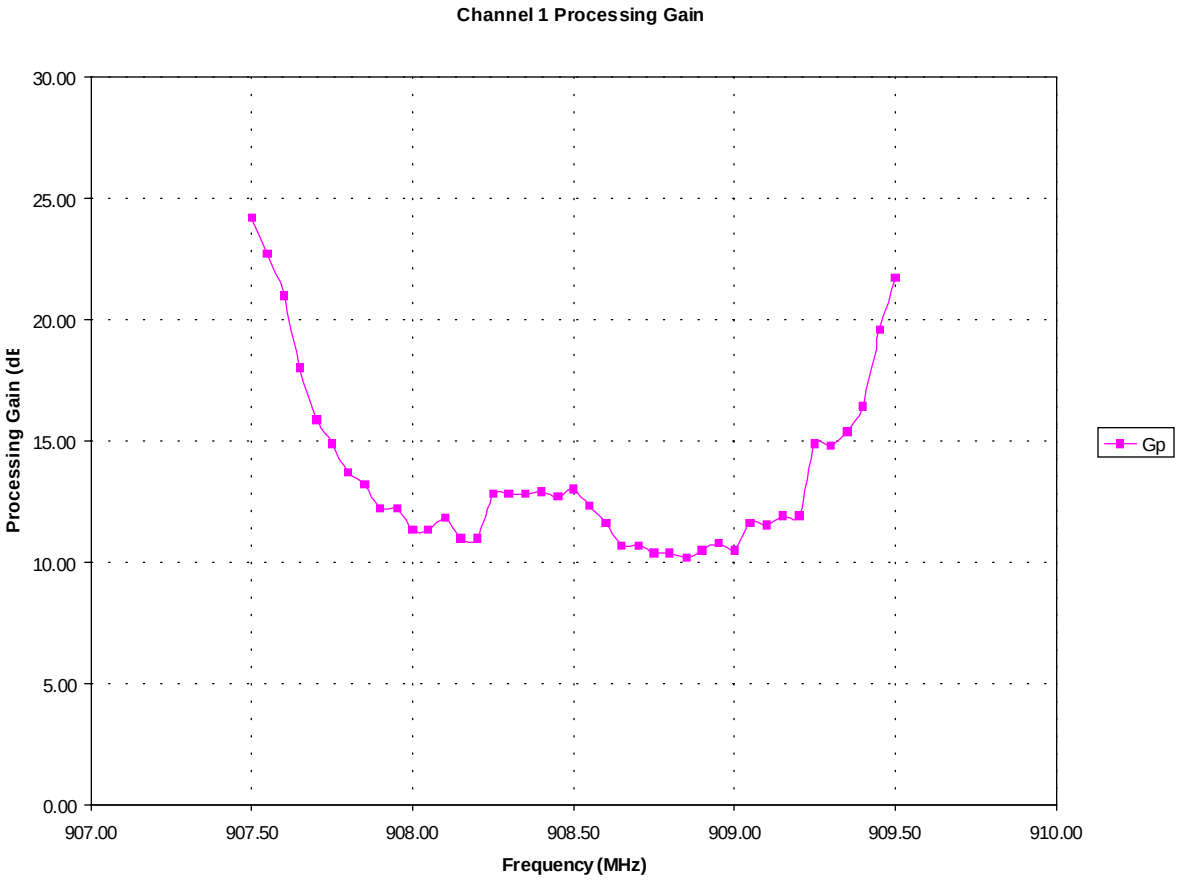
0.2 Percentile		11.01

Test Condition: Channel 1: 908.5 MHz, J/S and Processing Gain

Test Limit: 20th Percentile Processing Gain: 10 dB, minimum.

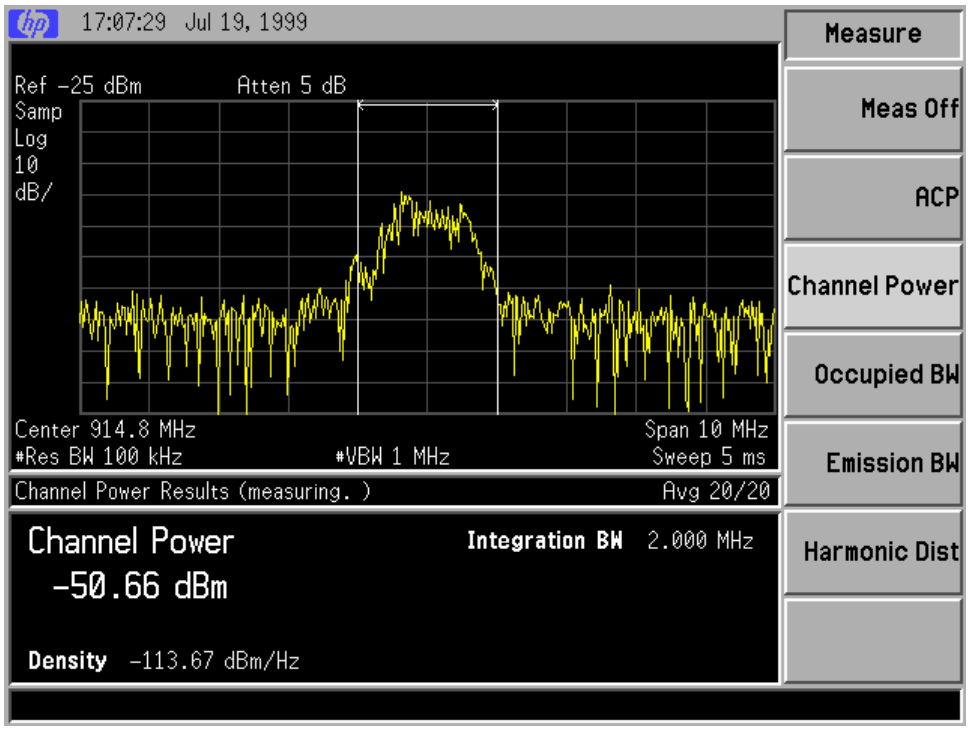
Test Indication: 20th Percentile Processing Gain = 11.01 dB

Test Outcome: 20th Percentile Processing Gain = 11.01 dB > 10 dB → PASS

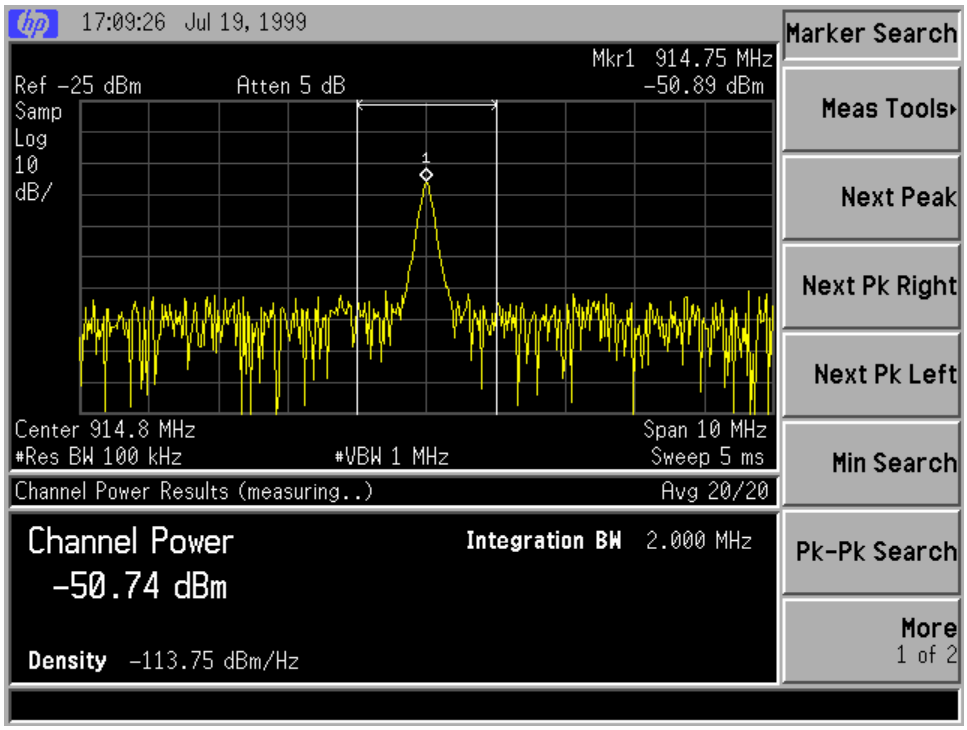


Test Indication: Channel 1 Processing Gain versus Frequency.

h) Test Indications Channel 6 (914.75 MHz)



Test Indication: Channel 6: 914.75 MHz, Desired Signal Reference Level Setting



Test Indication: Channel 6: 914.75 MHz, Jamming Signal Reference Level Setting

CHANNEL	6	
FREQUENCY	914.75	MHz
HP8496B	20	dB
HP8494B	2	dB

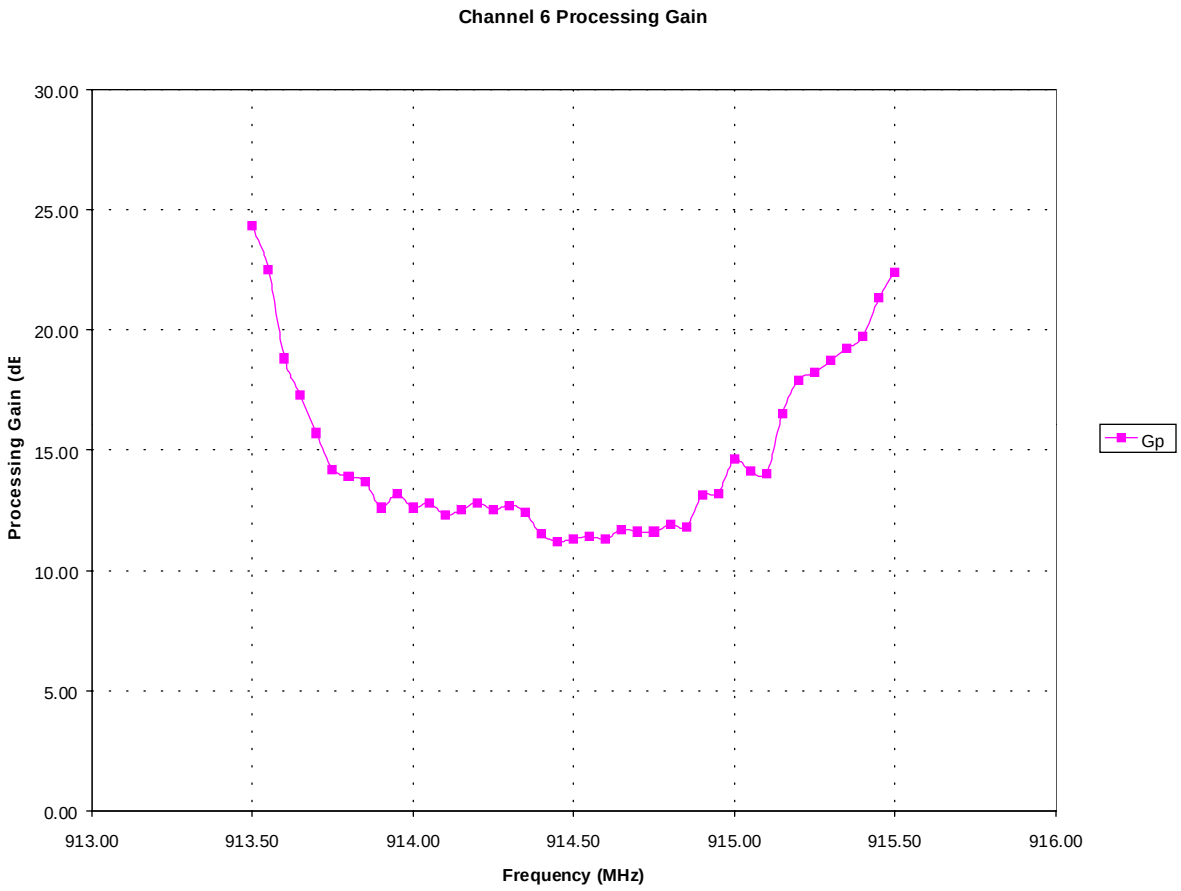
Frequency	J/S	Gp
913.50	10.00	24.31
913.55	8.20	22.51
913.60	4.50	18.81
913.65	3.00	17.31
913.70	1.40	15.71
913.75	-0.10	14.21
913.80	-0.40	13.91
913.85	-0.60	13.71
913.90	-1.70	12.61
913.95	-1.10	13.21
914.00	-1.70	12.61
914.05	-1.50	12.81
914.10	-2.00	12.31
914.15	-1.80	12.51
914.20	-1.50	12.81
914.25	-1.80	12.51
914.30	-1.60	12.71
914.35	-1.90	12.41
914.40	-2.80	11.51
914.45	-3.10	11.21
914.50	-3.00	11.31
914.55	-2.90	11.41
914.60	-3.00	11.31
914.65	-2.60	11.71
914.70	-2.70	11.61
914.75	-2.70	11.61
914.80	-2.40	11.91
914.85	-2.50	11.81
914.90	-1.20	13.11
914.95	-1.10	13.21
915.00	0.30	14.61
915.05	-0.20	14.11
915.10	-0.30	14.01
915.15	2.20	16.51
915.20	3.60	17.91
915.25	3.90	18.21
915.30	4.40	18.71
915.35	4.90	19.21
915.40	5.40	19.71
915.45	7.00	21.31
915.50	8.10	22.41
0.2 Percentile		11.81

Test Condition: Channel 6: 914.75 MHz, J/S and Processing Gain

Test Limit: 20th Percentile Processing Gain: 10 dB, minimum.

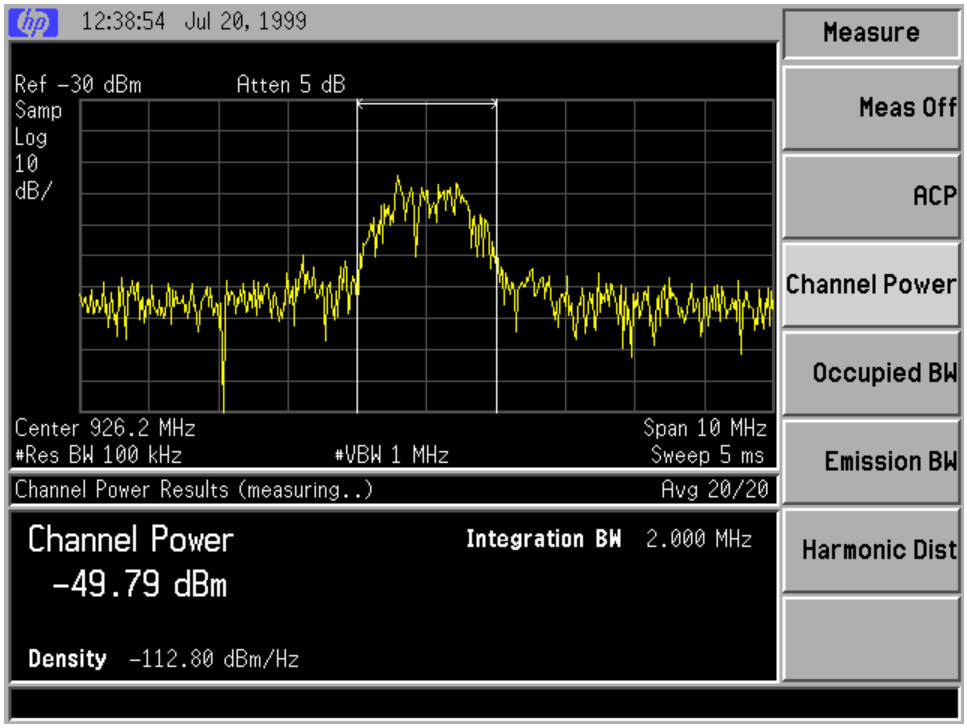
Test Indication: 20th Percentile Processing Gain = 11.81 dB

Test Outcome: 20th Percentile Processing Gain = 11.81 dB > 10 dB → PASS

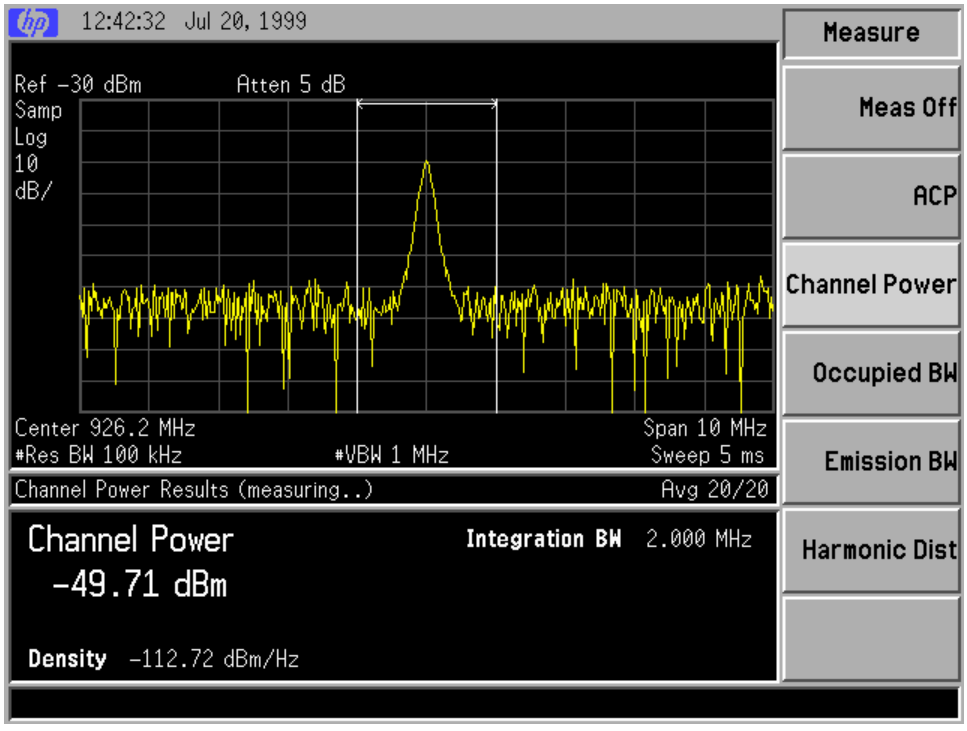


Test Indication: Channel 6 Processing Gain versus Frequency.

i) Test Indications Channel 15 (926.25 MHz)



Test Indication: Channel 15: 926.25 MHz, Desired Signal Reference Level Setting



Test Indication: Channel 15: 926.25 MHz, Jamming Signal Reference Level Setting

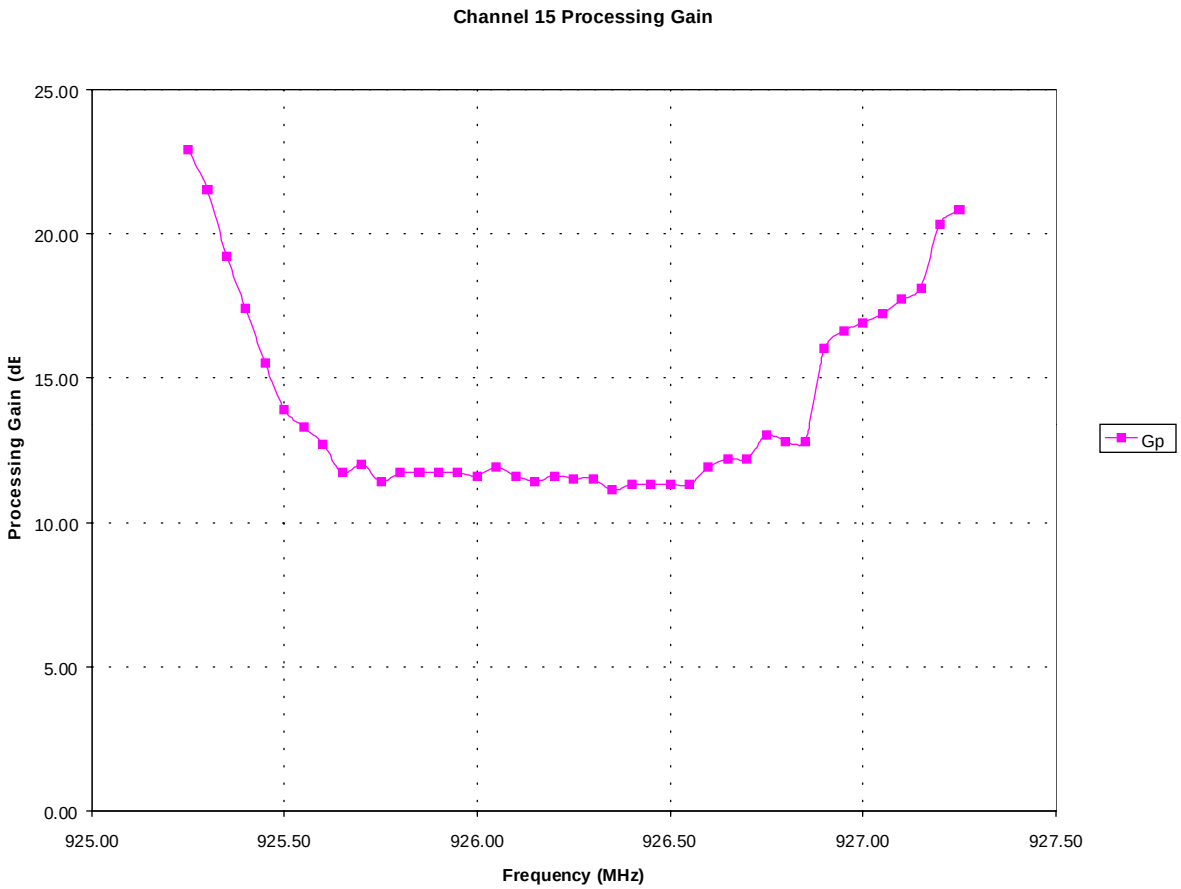
CHANNEL	15	
FREQUENCY	926.25	MHz
HP8496B	20	dB
HP8494B	1	dB
Frequency	J/S	Gp
925.25	8.60	22.91
925.30	7.20	21.51
925.35	4.90	19.21
925.40	3.10	17.41
925.45	1.20	15.51
925.50	-0.40	13.91
925.55	-1.00	13.31
925.60	-1.60	12.71
925.65	-2.60	11.71
925.70	-2.30	12.01
925.75	-2.90	11.41
925.80	-2.60	11.71
925.85	-2.60	11.71
925.90	-2.60	11.71
925.95	-2.60	11.71
926.00	-2.70	11.61
926.05	-2.40	11.91
926.10	-2.70	11.61
926.15	-2.90	11.41
926.20	-2.70	11.61
926.25	-2.80	11.51
926.30	-2.80	11.51
926.35	-3.20	11.11
926.40	-3.00	11.31
926.45	-3.00	11.31
926.50	-3.00	11.31
926.55	-3.00	11.31
926.60	-2.40	11.91
926.65	-2.10	12.21
926.70	-2.10	12.21
926.75	-1.30	13.01
926.80	-1.50	12.81
926.85	-1.50	12.81
926.90	1.70	16.01
926.95	2.30	16.61
927.00	2.60	16.91
927.05	2.90	17.21
927.10	3.40	17.71
927.15	3.80	18.11
927.20	6.00	20.31
927.25	6.50	20.81
0.2 Percentile		11.51

Test Condition: Channel 15: 926.25 MHz, J/S and Processing Gain

Test Limit: 20th Percentile Processing Gain: 10 dB, minimum.

Test Indication: 20th Percentile Processing Gain = 11.51 dB

Test Outcome: 20th Percentile Processing Gain = 11.51 dB > 10 dB → PASS



Test Indication: Channel 15 Processing Gain versus Frequency.

j) Test Set-Up Photographs for Jamming Margin

Transmitter Configuration

Receiver Configuration

Receiver Configuration

II. Equipment List

EQUIPMENT DESCRIPTION	LSR Serial Number	Serial Number	Calibration
Hewlett Packard E4407B Spectrum Analyzer	-	US39160256	6/16/99
Hewlett Packard ESG-D3000 Signal Generator	CC000162C	On Record	6/1/97
Hewlett Packard HP34401A Digital Multimeter	CC000180C	US36040932	11/5/97
Hewlett Packard HP6111A Power Supply (TX)	CC000220C	2125A-03064	Initial Only
Hewlett Packard HP6111A Power Supply (RX)	CC000220C	2411A-03503	Initial Only

III. Equipment Uncertainties

Specified Characteristic	Specified Probability Density	Specified Uncertainty
HP EE4407 Spectrum Analyzer		
Total Absolute Amplitude Uncertainty	Uniform	+/-0.35 dB
Wilkinson Power Couplers		
Amplitude Imbalance	Uniform	+/-0.1 dB
HP ESG-D3000 Signal Generator		
Absolute Amplitude Accuracy	Uniform	+/- 0.5 dB

IV. Bit Error Ratio Test Software

Theory of Operation

The Bit Error Rate Tester (BERT) program meets the need of performing a bit error rate test on a simplex system with a proprietary, asynchronous packetized protocol. The custom program is written using Microsoft® Visual Basic 6.0® and executes on Microsoft® Windows 95/98® or NT®.

BERT uses a serial port for communications with the device under test (DUT). Data packets are formulated by BERT and sent via the serial port TX line through an RS232 to RS485 converter to the radio transmitter. Data packets are received by the radio receiver pass through an RS485 to RS232 converter and return to BERT via the RX line on the same serial port.

Prior to sending the next packet of data, BERT compares the received data with the sent data. All comparisons are done on a bit by bit basis. Bit error rate is calculated as the ratio of the number of bits received in error to the total number of bits sent.

Program Specifications	
Data Rate	57.6Kbps
Packet Rate	≈55mS*
Packet Duration	70 bytes (12.15mS @ 57.6Kbps)
Packet Data	Fixed
Error Detection Method	Bit by bit compare of received vs. sent data
*Due to the properties of the system timers in Windows®, timing cannot be guaranteed. Occasionally slightly longer timer periods (>55mS) are present. The only effect this has on the program is to take slightly longer to perform a test in packet mode and send fewer packets in timed mode.	

Detailed information regarding the operation of BERT can be found in Figure 1 - BERT Main Screen, Figure 2 - BERT Test Mode Screen, Figure 3 - BERT Software Flowchart and Appendix A - BERT Software Listing.

Screen Shots

The following screen shots show the user interface to BERT.

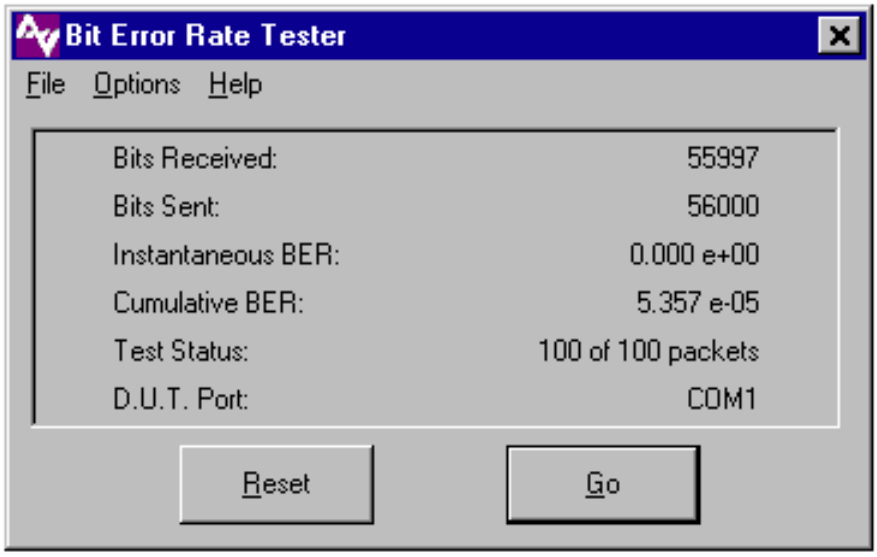


Figure 1 - BERT Main Screen

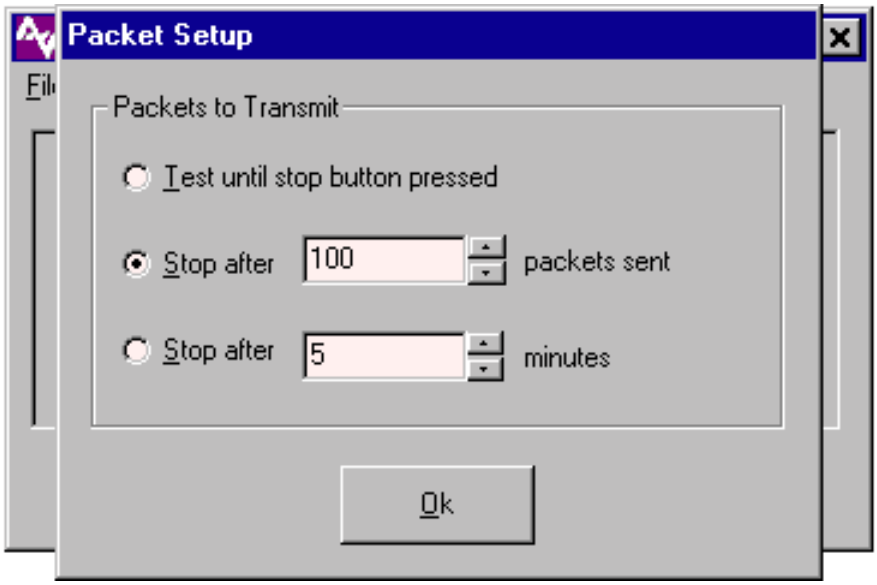
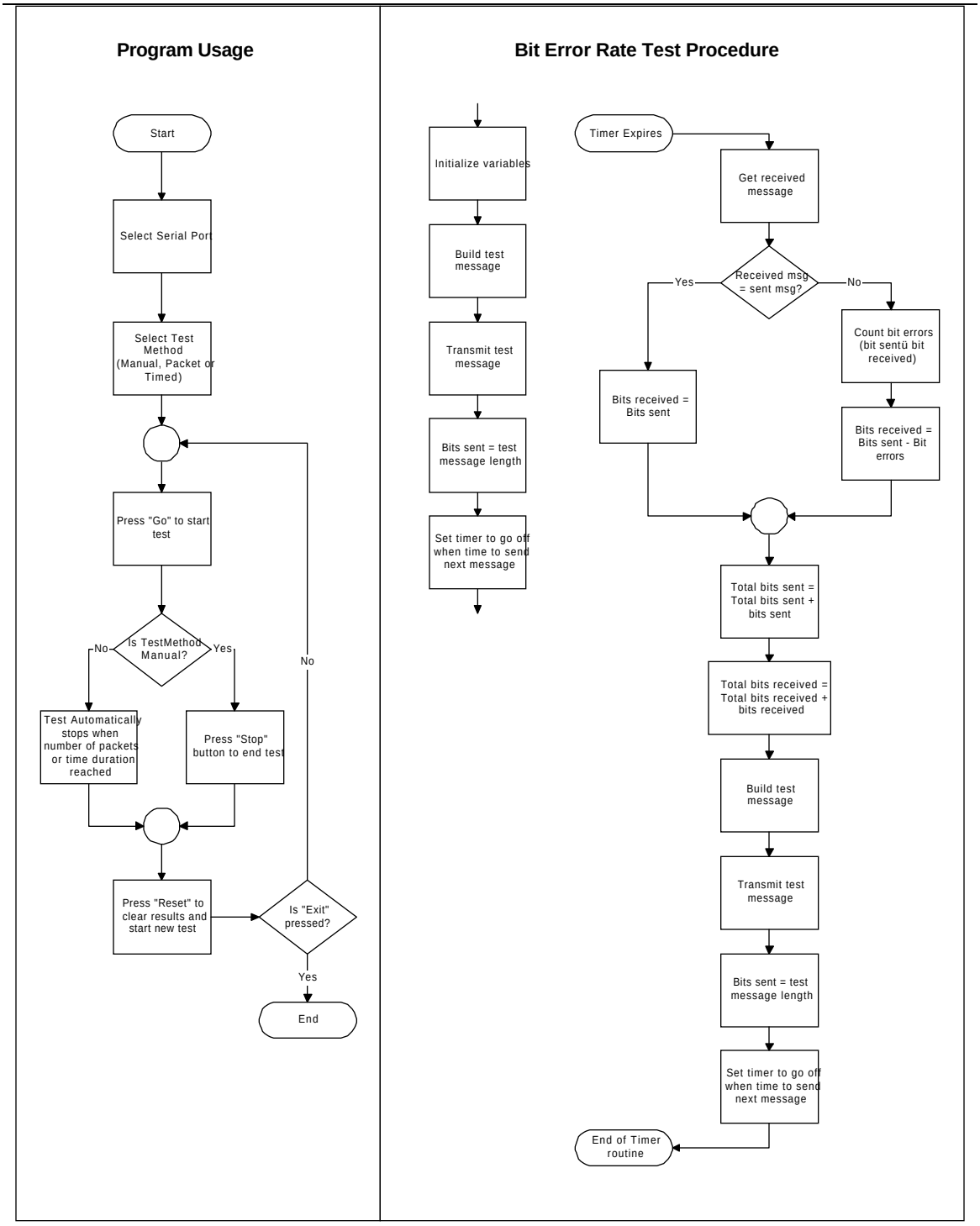


Figure 2 - BERT Test Mode Screen



L.S. RESEARCH, Inc. HIGH TECHNOLOGY ELECTRONIC CONSULTANTS		SIZE	FSCM NO	DWG NO	REV
DRAWN	HENRY WAGNER	B		BERT Software Flowchart	ORG
ISSUED	July 22, 1999	SCALE	None	SHEET	1 OF 1

Figure 3 - BERT Software Flowchart

Appendix A - BERT Software Listing

Listing of frmMain.frm:

```
'''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
'
'   Bit Error Rate Tester v1.0
'   Copyright © 1999 L.S. Research, Inc.
'
'   Written by  July 16, 1999
'               Henry Wagner, L.S. Research, Inc.
'
'''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''

Option Explicit
Dim BitsSent As Long
Dim BitsReceived As Long
Dim BitsNotReceived As Long
Dim TotalBitsSent As Long
Dim TotalBitsReceived As Long
Dim TotalBitsNotReceived As Long
Dim InstBER As Double
Dim CumBER As Double
Dim TestMessage As String
Dim RcvBuf As String


Private Sub cmdReset_Click()
    BitsSent = 0
    BitsReceived = 0
    BitsNotReceived = 0
    TotalBitsSent = 0
    TotalBitsReceived = 0
    TotalBitsNotReceived = 0
    InstBER = 0
    CumBER = 0
    Minutes = 0
    Packets = 0
    lblData(0).Caption = Str(TotalBitsReceived)
    lblData(1).Caption = Str(TotalBitsSent)
    lblData(2).Caption = Format(InstBER, "0.000 e+00")
    lblData(3).Caption = Format(CumBER, "0.000 e+00")
    If frmPackets!optAuto(1).Value Then
        lblData(4).Caption = Packets & " of " & frmPackets!txtNumberPackets.Text & " packets"
    ElseIf frmPackets!optAuto(2).Value Then
        lblData(4).Caption = Minutes & " of " & frmPackets!txtTime.Text & " minutes"
    End If

End Sub

Private Sub cmdRun_Click()

    If g_DUTPort = "" Then
        MsgBox "You must select a serial port to communicate with your D.U.T.",
vbApplicationModal Or vbOKOnly, "Hey!"
    Else
        If Timer1.Enabled = False Then
            Timer1.Interval = 20
            Timer1.Enabled = True
            Minutes = 0
            Packets = 0
            If frmPackets!optAuto(0).Value Then
                cmdRun.Caption = "&Stop"
                lblData(4).Caption = "Manual Stop"
            Else
                cmdRun.Caption = "&Cancel"
                If frmPackets!optAuto(1).Value Then
                    lblData(4).Caption = Packets & " of " & frmPackets!txtNumberPackets.Text & "
packets"
                ElseIf frmPackets!optAuto(2).Value Then
                    lblData(4).Caption = Minutes & " of " & frmPackets!txtTime.Text & " minutes"
```

```
                End If
            End If
        Else
            Timer1.Enabled = False
            cmdRun.Caption = "&Go"
        End If
    End If
End Sub

Private Sub Form_Unload(Cancel As Integer)
    End
End Sub

Private Sub mnuAbout_Click()
    frmAbout.Show 1
End Sub

Private Sub mnuExit_Click()
    Unload Me
End Sub

Private Sub mnuPackets_Click()
    frmPackets.Show 1
End Sub

Private Sub mnuPorts_Click()
    frmPorts.Show 1
End Sub

Private Sub MSComm1_OnComm()

    Select Case MSComm1.CommEvent
    ' Handle each event or error by placing
    ' code below each case statement

    ' Errors
        Case comEventBreak   ' A Break was received.
        Case comEventFrame   ' Framing Error
        Case comEventOverrun   ' Data Lost.
        Case comEventRxOver   ' Receive buffer overflow.
        Case comEventRxParity   ' Parity Error.
        Case comEventTxFull   ' Transmit buffer full.
        Case comEventDCB   ' Unexpected error retrieving DCB]

    ' Events
        Case comEvCD   ' Change in the CD line.
        Case comEvCTS   ' Change in the CTS line.
        Case comEvDSR   ' Change in the DSR line.
        Case comEvRing   ' Change in the Ring Indicator.
        Case comEvReceive   ' Received RThreshold # of
                        ' chars.

        Case comEvSend   ' There are SThreshold number of
                    ' characters in the transmit
                    ' buffer.
        Case comEvEOF   ' An EOF charater was found in
                    ' the input stream
    End Select
End Sub

Private Sub Timer1_Timer()

    Dim i, j As Integer
    Dim x As Byte
    Dim testlimit As Integer
    Dim SentByte As Byte
    Dim RcvByte As Byte
    Static StartTime As Integer
    Static TimeFlag As Boolean
```

```
    If frmPackets!optAuto(1).Value = True Then
        lblData(4).Caption = Packets & " of " & frmPackets!txtNumberPackets.Text & " packets"
        If Packets = frmPackets!txtNumberPackets.Text Then
            cmdRun_Click
        End If
    ElseIf frmPackets!optAuto(2).Value = True Then
        lblData(4).Caption = Minutes & " of " & frmPackets!txtTime.Text & " minutes"
        If Minutes = frmPackets!txtTime.Text Then
            cmdRun_Click
        End If
    End If


    TestMessage = "SDO" & Chr$(64) &
"01234567012345670123456701234567012345670123456701234567012345670123456701234567CS"
    BitsNotReceived = 0
    BitsReceived = 0

    If BitsSent > 0 Then
        RcvBuf = MSComm1.Input
        If RcvBuf = TestMessage Then
            BitsReceived = Len(RcvBuf) * 8
        Else
            If Len(TestMessage) < Len(RcvBuf) Then
                testlimit = Len(TestMessage)
            Else
                testlimit = Len(RcvBuf)
            End If
            If testlimit > 0 Then
                For i = 1 To testlimit
                    SentByte = Asc(Mid(TestMessage, i, 1))
                    RcvByte = Asc(Mid(RcvBuf, i, 1))
                    x = (SentByte And (Not (RcvByte))) Or (Not (SentByte) And RcvByte)
                    j = &H80&
                    While j
                        If x And j Then
                            BitsNotReceived = BitsNotReceived + 1
                        Else
                            BitsReceived = BitsReceived + 1
                        End If
                        j = j / 2
                    Wend
                Next i
            End If
            BitsNotReceived = BitsNotReceived + ((Len(TestMessage) - testlimit) * 8)
        End If
    Else
        StartTime = Format(Time, "s")
        TimeFlag = True
    End If
    TotalBitsReceived = TotalBitsReceived + BitsReceived
    TotalBitsNotReceived = TotalBitsNotReceived + BitsNotReceived

    lblData(0).Caption = Str(TotalBitsReceived)
    lblData(1).Caption = Str(TotalBitsSent)
    If BitsSent > 0 Then
        InstBER = CDbl(BitsNotReceived) / CDbl(BitsSent)
        lblData(2).Caption = Format(InstBER, "0.000 e+00")
        CumBER = CDbl(TotalBitsNotReceived) / CDbl(TotalBitsSent)
        lblData(3).Caption = Format(CumBER, "0.000 e+00")
    End If
    RcvBuf = MSComm1.Input      ' read input buffer to empty it
    MSComm1.Output = TestMessage
    BitsSent = Len(TestMessage) * 8
    TotalBitsSent = TotalBitsSent + BitsSent

    i = Format(Time, "s")
    If i = StartTime And TimeFlag = False Then
        Minutes = Minutes + 1
        TimeFlag = True
```

```
    End If

    If i = ((StartTime + 1) \ 60) Then
        TimeFlag = False
    End If

    Packets = Packets + 1
End Sub
```

Listing of frmAbout.frm:

```
Option Explicit

Private Sub cmdOK_Click()
    Me.Hide
End Sub
```

Listing of frmPackets.frm:

```
Option Explicit

Private Sub cmdOK_Click()
    If optAuto(1).Value Then
        frmMain!lblData(4).Caption = Packets & " of " & frmPackets!txtNumberPackets.Text & "
packets"
    ElseIf optAuto(2).Value Then
        frmMain!lblData(4).Caption = Minutes & " of " & frmPackets!txtTime.Text & " minutes"
    End If
    Me.Hide
End Sub
```

Listing of frmPorts.frm:

```
Private Sub cmdOK_Click()

    'open selected port

    frmMain!MSComm1.Settings = "57600,N,8,1"
    frmMain!MSComm1.CommPort = Val(Mid$(cboDUTPort.List(cboDUTPort.ListIndex), 4, 1))
    frmMain!MSComm1.InputMode = comInputModeText
    frmMain!MSComm1.InputLen = 0
    frmMain!MSComm1.RThreshold = 1
    frmMain!MSComm1.OutBufferSize = 256
    frmMain!MSComm1.PortOpen = True
    g_DUTPort = cboDUTPort.List(cboDUTPort.ListIndex)
    frmMain!lblData(5).Caption = g_DUTPort
    Unload Me

End Sub

Private Sub Form_Load()
    Dim i As Integer
    Dim s As String


    On Error GoTo CommTestErrorHandler
    cboDUTPort.Clear
    frmMain!MSComm1.Settings = "57600,N,8,1"
    For i = 1 To 4
        frmMain!MSComm1.CommPort = i
        frmMain!MSComm1.PortOpen = True
        If frmMain!MSComm1.PortOpen = True Then
            s = "COM" & i
            cboDUTPort.AddItem s
            frmMain!MSComm1.PortOpen = False
        End If
        frmMain!MSComm1.PortOpen = False
        frmMain!MSComm1.PortOpen = False
    Next i
    Exit Sub
```

```
CommTestErrorHandler:
   Resume Next

End Sub



Private Sub Form_Activate()
    Dim i As Integer

    cboDUTPort.ListIndex = 0
    For i = 0 To cboDUTPort.ListCount - 1
        If g_DUTPort = cboDUTPort.List(i) Then
            cboDUTPort.ListIndex = i
        End If
    Next i

End Sub
```