5. Observations.

5.1 The equipments supplied for testing do not meet the near signal selectivity requirement of Draft MPT specification 1376 at a frequency separation of 10kHz. Improvement in equipment performance for this parameter from that of the unit tested would be likely to significantly decrease the protection requirement of the unit at and around this frequency separation.

5.2 The units supplied for testing operates near or at the limit sensitivity as defined in MPT specification 1376. Likely future improvements in receiver sensitivity will decrease the absolute power of interference signal required to produce a set degradation.

5.3 The wanted signal used for all tests was that representing the output from a LM transmitter when modulated with a 1 kHz tone. As a result the modulation product was 10 dB above that of the tone in band. The magnitude of modulation products in a system modulated by speech would be significantly nearer to the TIB level. A subjective trial of speech transmission would be required to accurately assess the effect of co and adjacent channel services to LM reception.

6. Conclusions.

6.1 Tabulated results of all tests can be found in Appendix 3.

6.2 Linear modulation (LM) systems are most sensitive to co-channel interference in the region of the pilot frequency. An improvement of at least 7 dB in co-channel rejection can be achieved when a carrier wave interferer is moved from a 0.1 kHz to a 1 kHz separation from the pilot frequency. From these results it is evident that system engineering could minimise the occurrence of pilot tone clashes which would have the effect of greatly increasing the co-channel performance of a LM system.

6.3 Application of the simulated LM signal simulation produced a more even co-channel response. This would be expected as the energy of the signal is more evenly spread across the band in a similar fashion to that which is likely to be present in a speech modulated system.

6.4 The LM system met the co-channel rejection limit as specified for a PMR transceiver in MPT specification 1326 for all modulation types tested (CW, LM, FM and DAB).

However it should be noted that the wanted signal used for all tests was that representing the output from a LM transmitter when modulated with a 1 kHz tone. As a result the modulation information was 10 dB above that of the tone in band. The magnitude of modulation products in a system modulated by speech would be significantly nearer to the TIB level. A subjective trial of speech transmission would be required to accurately assess the effect of co and adjacent channel services to LM reception.

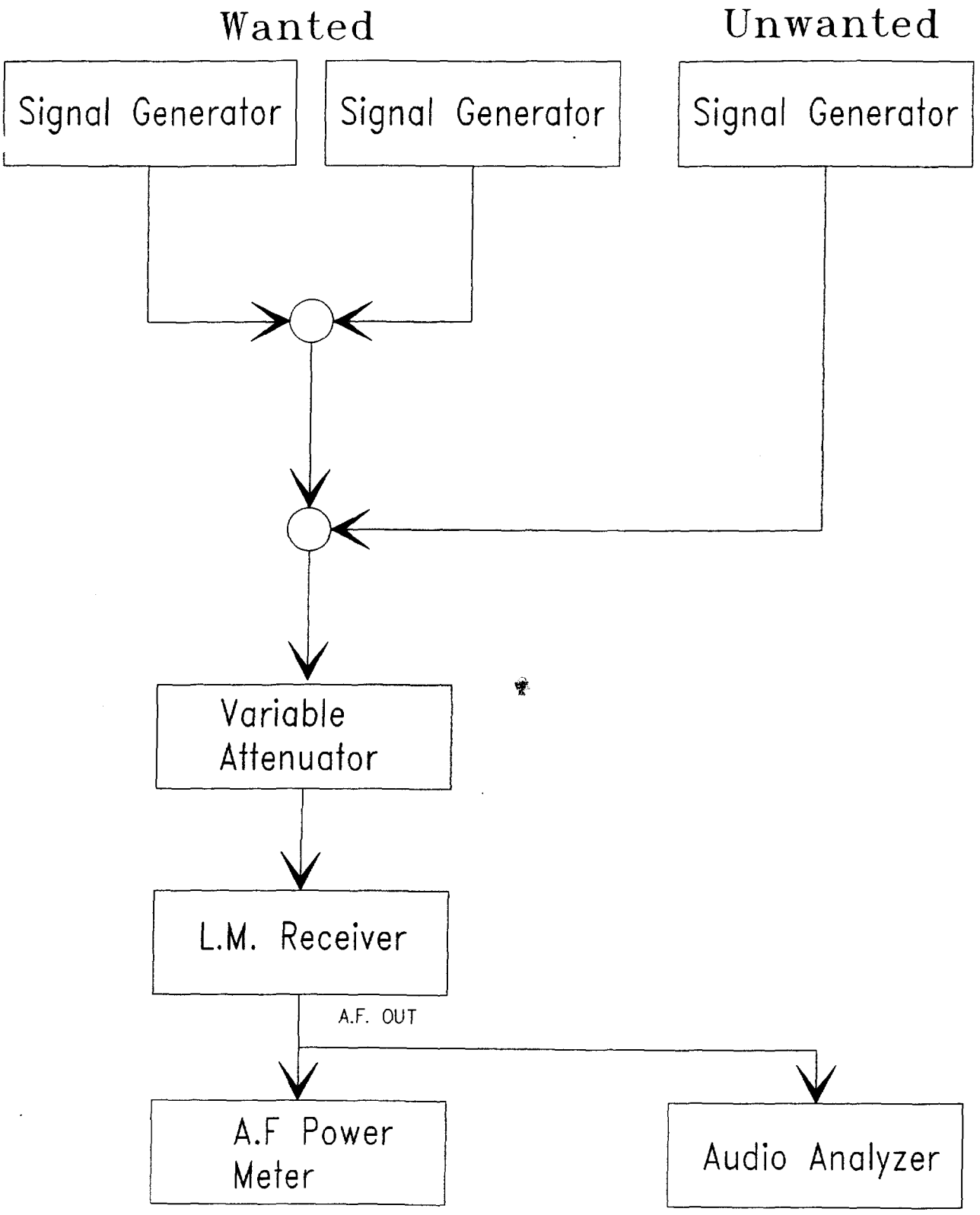
6.5 Comparison of the LM receiver's immunity to interference from Digital Audio Broadcasting (DAB) signal with those of a standard PMR receiver (project No.135 DAB/PMR Adjacent channel compatibility) show a significantly improved co-channel performance (in the region of 10 dB) and an improved out of band performance of approximately 4 dB. The improvement in co-channel performance is likely to be caused by the first DAB carrier falling outside the pilot tone region of the LM receiver, variation in the out of band performance is likely to be attributable to differences in individual equipment and the level of wanted signal used between the two tests.

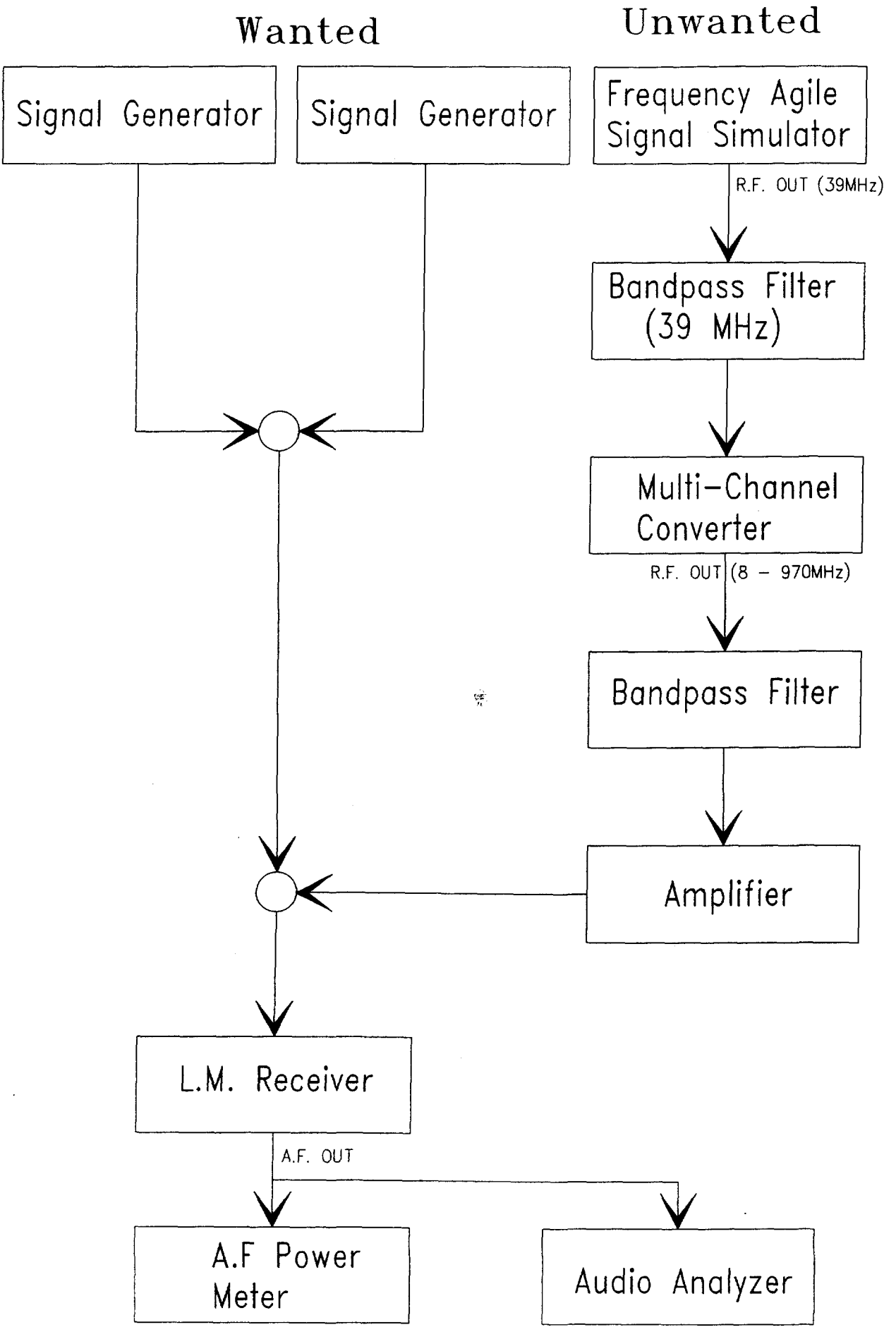
6.6 It can be seen from the test results that the protection co-channel rejection performance of the data system differed from those of speech in pattern but were similar in absolute value.

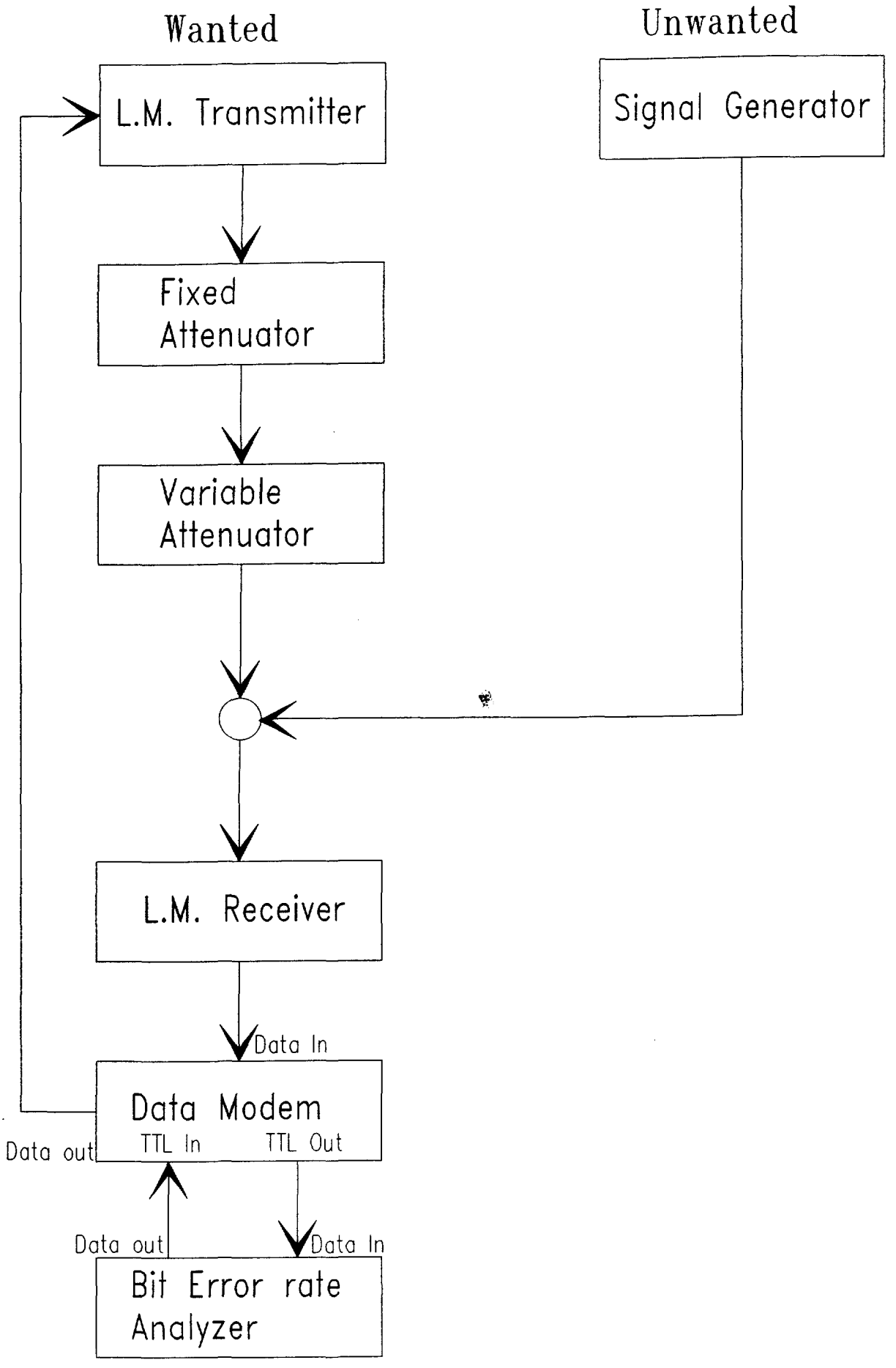
6.7 Limited time was available for this work. It is suggested that at a future date the following work is carried out to acquire more information to fully assess the co and adjacent channel requirements of LM.

(a) Subjective speech transmission assessment of the co-channel requirement of a LM system.
(b) Assessment of 5kHz QPSK 9.6 k/baud data system.

INDEX OF APPENDICES.


Wanted
Unwanted
Signal Generator
Signal Generator
Signal Generator
Variable Attenuator
L.M. Receiver
A.F. OUT
A.F Power Meter
Audio Analyzer


Wanted
Unwanted
Signal Generator
Signal Generator
Frequency Agile Signal Simulator
R.F. OUT (39MHz)
Bandpass Filter (39 MHz)
Multi-Channel Converter
R.F. OUT (8 - 970MHz)
Bandpass Filter
Amplifier
L.M. Receiver
A.F. OUT
A.F Power Meter
Audio Analyzer


Wanted
Unwanted
L.M. Transmitter
Signal Generator
Fixed Attenuator
Variable Attenuator
L.M. Receiver
Data In
Data Modem
TTL In
TTL Out
Data out
Data out
Data In
Bit Error rate Analyzer

TEST EQUIPMENT USED.

Description	Plant Number
Marconi 2019 Signal Generator	1020
Marconi 2019 Signal Generator	1022
Marconi 2019A Signal Generator	1028
Marconi 2017 Signal Generator	1063
Hewlett Packard 8903B Audio Analyzer	1240
Hewlett Packard step attenuator	616/617
Philips PM3260 Oscilloscope	165
Dymar 2085 AF Power Meter	1135
Keithley 179-20A Multimeter	1217
Roband Varex 30-10 Power supply	1174
30 dB, 50Ω attenuator	1122
30 dB, 50Ω attenuator	1819
Variable 600Ω attenuator	1310
Marconi 6960A RF power meter	1762
Rhode & Schwartz step attenuator	1000
Marconi Power Sensor Head	1766
Tunable band reject filter	1099
Countant LQT100 Dual Power Supply	134
Hewlett Packard 1645A data error analyzer	—
6 dB Power combiner/divider	111
6 dB Power combiner/divider	955
6 db Power combiner/divider	57
Hewlett Packard Spectrum analyzer	1611
Hewlett Packard 8771 FASS System	1572
Philips PM5960 Multi Channel Converter	1822
EIN Linear Amplifier	1297
K & L Band Reject Filter	1096

Note: — Equipment on loan to Kenley RTL.

CARRIER WAVE / LINEAR MODULATION CO– CHANNEL
COMPATIBILITY TEST RESULTS BASED ON DEGRADATION TO 14dB SINAD

Wanted Tone In Band Signal Level : MUS : −117 dBm

Frequency offset CW – LM (kHz)	Unwanted Signal Level (CW) (dBm)	Corrosponding error rate (10 ^ −4)	C/I Ratio (dB)
0.1	−124.0	59.20	7
0.2	−118.0	19.60	1
0.4	−120.0	0.00	3
0.5	−119.0	0.00	2
1.0	−109.0	1800.00	−8
1.5	−114.0	0.00	−3
2.0	−98.0	3.25	−19
2.5	−75.0	0.25	−42
−0.1	−123.0	11.00	6
−0.2	−117.0	437.00	0
−0.5	−117.0	8.50	0
−1.0	−115.0	0.00	−2
−1.5	−112.0	0.00	−5
−2.0	−103.0	0.00	−14
−2.5	−75.0	0.00	−42
A	B	C	D

Column

A Frequency offset between CW carrier and LM pilot frequency
B Unwanted Signal (CW) level
C Error rate achieved with 1200 Baud data
D Carrier / Interference ratio (Wanted signal level (LM) minus unwanted signal level (CW).)

CARRIER WAVE / LINEAR MODULATION CO– CHANNEL COMPATIBILITY
TEST RESULTS BASED ON DEGRADATION TO A VARIETY OF SINAD LEVELS

Wanted Tone In Band Signal Level : MUS + 15dB : −102 dBm

Frequency	for 30dB SINAD			for 25dB SINAD			for 20dB SINAD			for 14dB SINAD		
offset CW−LM	Unwanted Signal Level	Error rate	C/I Ratio	Unwanted Signal Level	Error rate	C/I Ratio	Unwanted Signal Level	Error rate	C/I Ratio	Unwanted Signal Level	Error rate	C/I Ratio
kHz	dBm	10^−4	dB	dBm	10^−4	dB	dBm	10^−4	dB	dBm	10^−4	dB
0.10	−128.00	0.00	26.00	−120.00	0.00	18.00	−114.00	0.00	12.00	−107.00	0.00	5.00
0.20	−122.00	0.00	20.00	−113.00	0.00	11.00	−107.00	0.00	5.00	−100.00	195.25	−2.00
0.40	−123.00	0.00	21.00	−115.00	0.00	13.00	−109.00	0.00	7.00	−102.00	0.00	0.00
0.50	−124.00	0.00	22.00	−115.00	0.00	13.00	−109.00	0.00	7.00	−103.00	0.00	1.00
1.00	−114.00	0.00	12.00	−107.00	0.00	5.00	−102.00	0.00	0.00	−92.00	>2000.00	−10.00
1.25	−123.00	0.00	21.00	−114.00	0.00	12.00	−109.00	0.00	7.00	−102.00	0.00	0.00
1.50	−119.00	0.00	17.00	−110.00	0.00	8.00	−104.00	0.00	2.00	−98.00	0.00	−4.00
2.00	−99.00	0.00	−3.00	−92.00	0.00	−10.00	−88.00	0.00	−14.00	−83.00	11.00	−19.00
2.50	−80.00	0.00	−22.00	−70.00	0.00	−32.00	−65.00	0.00	−37.00	−58.00	0.00	−44.00
−0.10	−128.00	0.00	26.00	−119.00	0.00	17.00	−109.00	4.75	7.00	−105.00	52.00	3.00
−0.20	−122.00	0.00	20.00	−113.00	0.00	11.00	−107.00	0.00	5.00	−101.00	17.25	−1.00
−0.40	−122.00	0.00	20.00	−114.00	0.00	12.00	−107.00	0.00	5.00	−101.00	0.00	−1.00
−0.50	−124.00	0.00	22.00	−113.00	0.00	11.00	−107.00	0.00	5.00	−100.00	17.50	−2.00
−1.00	−120.00	0.00	20.00	−111.00	0.00	9.00	−105.00	0.00	3.00	−98.00	0.00	−4.00
−1.25	−119.00	0.00	18.00	−110.00	0.00	8.00	−104.00	0.00	2.00	−97.00	0.00	−5.00
−1.50	−108.00	0.00	17.00	−108.00	0.00	6.00	−102.00	0.00	0.00	−96.00	0.00	−6.00
−2.00	−78.00	0.00	6.00	−98.00	0.00	−4.00	−93.00	0.00	−9.00	−91.00	0.00	−11.00
−2.50	−102.00	0.00	−24.00	−70.00	0.00	−32.00	−66.00	0.00	−36.00	−58.00	0.00	−44.00
A	B	C	D	B	C	D	B	C	D	B	C	D

Column

A Frequency offset between CW carrier and LM pilot frequency

B Unwanted Signal (CW) level

C Error rate achieved with 1200 Baud data

D Carrier / Interference ratio (Wanted signal level (LM) minus unwanted signal level (CW).)

CARRIER WAVE / LINER MODULATION CO – CHANNEL
COMPATIBILITY RESULTS BASED ON DEGRADATION TO A BIT ERROR RATE OF 10^-2

Wanted Tone in Band Signal Level : MUS : −117 dBm

Frequency offset kHz	Unwanted Level dBm	C/I Ratio dB
0.1	−124	7
0.2	−117	0
0.4	−111	−6
0.5	−111	−6
1.0	−116	−1
1.5	−103	−14
2.0	−95	−22
2.5	−68	−49
−0.1	−121	4
−0.2	−121	4
−0.5	−114	−3
−1.0	−107	−10
−1.5	−102	−15
−2.0	−95	−22
−2.5	−68	−49
A	B	C

Column

A Frequency offset between CW carrier and LM pilot frequency

B Unwanted Signal (CW) level

C Carrier / Interference level (Wanted signal level (LM) minus unwanted signal level (CW).)

CARRIER WAVE / LINER MODULATION CO – CHANNEL
COMPATIBILITY RESULTS BASED ON DEGRADATION TO A BIT ERROR RATE OF 10^ −2

Wanted Tone in Band Signal Level : MUS +15dB : −102 dBm

Frequency offset kHz	Unwanted Level dBm	C/I Ratio dB
0.10	−103	1
0.20	−102	0
0.40	−96	−6
0.50	−95	−7
1.00	−95	−7
1.25	−91	−11
1.50	−89	−13
2.00	−81	−21
2.50	−50	−52
−0.10	−105	3
−0.20	−100	−2
−0.40	−96	−6
−0.50	−98	−4
−1.00	−92	−10
−1.25	−88	−14
−1.50	−88	−14
−2.00	−81	−21
−2.50	−48	−54
A	B	C

Column

A Frequency offset between CW carrier and LM pilot frequency

B Unwanted Signal (CW) level

C Carrier / Interference level (Wanted signal level (LM) minus unwanted signal level (CW).)

LINEAR MODULATION / LINEAR MODULATION CO – CHANNEL
COMPATABILITY TEST RESULTS BASED ON A DEGRADATION TO 14dB SINAD

Wanted Tone in Band Signal Level : MUS : −117 dBm

Frequency offset	Unwanted Level	Corresponding error rate	C/I Ratio
kHz	dBm	10^−4	dB
0.00	−123	11.80	6
0.10	−124	47.45	7
0.20	−122	80.25	5
0.40	−124	2.25	7
0.50	−124	0.00	7
1.00	−121	127.00	4
1.50	−125	7.00	8
2.00	−122	7.25	5
2.50	−118	6.25	1
−0.10	−127	2.00	10
−0.20	−123	7.50	6
−0.40	−124	5.00	7
−0.50	−124	9.25	7
−1.00	−122	14.30	5
−1.50	−124	8.00	7
−2.00	−120	11.50	3
−2.50	−117	0.50	0
A	B	C	D

Column

A Frequency offset between first LM pilot frequency and second LM pilot frequency

B Unwanted Signal level

C Error rate achieved with 1200 Baud data

D Carrier / Interference ratio (Wanted signal level minus unwanted signal level)

LINEAR MODULATION / LINEAR MODULATION CO – CHANNEL
COMPATIBILITY RESULTS BASED ON A DEGRADATION TO A BER OF 10^-2

Wanted Tone in Band Signal Level : MUS : −117 dBm

Frequency offset kHz	Unwanted Level dBm	C/I Ratio dB
0.00	−122	5
0.10	−123	6
0.20	−122	5
0.40	−120	3
0.50	−120	3
1.00	−123	6
1.50	−122	5
2.00	−119	2
2.50	−113	−4
−0.10	−123	6
−0.20	−121	4
−0.40	−121	4
−0.50	−122	5
−1.00	−121	4
−1.50	−121	4
−2.00	−118	1
−2.50	−111	−6
A	B	C

Column

A Frequency offset between first LM pilot frequency and second LM pilot frequency

B Unwanted Signal level

C Carrier / Interference ratio (Wanted signal level minus unwanted signal level)

LINEAR MODULATION / LINEAR MODULATION CO – CHANNEL
COMPATIBILITY TEST RESULTS BASED ON A DEGRADATION TO A BER OF 10^-2

Wanted Tone In Band Signal Level : MUS+15dB : −102 dBm

Frequency offset	Unwanted Level	C/I Ratio
kHz	dBm	dB
0.00	−101	−1
0.10	−106	4
0.20	−106	4
0.40	−103	1
0.50	−103	1
1.00	−102	0
1.50	−104	2
2.00	−102	0
2.50	−106	4
−0.10	−105	3
−0.20	−105	3
−0.40	−105	3
−0.50	−107	5
−1.00	−105	3
−1.50	−104	2
−2.00	−101	−1
−2.50	−95	−7
A	B	C

Column

A Frequency offset between first LM pilot frequency and second LM pilot frequency

B Unwanted Signal level

C Carrier / Interference ratio (Wanted signal level minus unwanted signal level)

FREQUENCY MODULATION / LINEAR MODULATION CO– CHANNEL COMPATIBILITY TEST RESULTS BASED ON DEGRADATION TO 14dB SINAD

Wanted Signal Level : MUS : −107 dBm

Frequency offset CW – LM (kHz)	Unwanted Signal Level (CW) (dBm)	C/I Ratio (dB)
0.0	−117.0	10
5.0	−79.8	−27
6.3	−63.0	−44
10.0	−53.0	−54
12.5	−53.0	−54
−5.0	−78.0	−29
−6.3	−63.0	−44
−10.0	−53.0	−54
−12.5	−54.0	−53
A	B	C

Column

A Frequency offset between frequency carrier and linear modulation pilot frequency

B Unwanted Signal level

C Carrier / Interference ratio (Wanted signal level minus unwanted signal level)

FREQUENCY MODULATION / LINEAR MODULATION CO – CHANNEL COMPATILBILITY

DAB (DIGITAL AUDIO BROADCASTING) / LINEAR MODULATION CO – CHANNEL COMPATIBILITY TEST RESULTS BASED ON DEGRADATION TO 14dB SINAD

Wanted Signal Level (LM) : MUS : −100 dBm

Frequency offset DAB – LM (kHz)	Unwanted Signal Level (DAB) (dBm)	Corrected Unwanted Signal Level (DAB) (dBm)	C/I Ratio (dB)
0.0	−103.6	−96.6	−3.4
12.5	−65.0	−43.2	−56.8
25.0	−63.2	−41.4	−58.6
50.0	−60.9	−39.1	−60.9
200.0	−56.0	−34.2	−65.8
500.0	−50.5	−28.7	−71.3
1000.0	−41.0	−19.2	−80.8
8000.0	−28.6	−6.8	−93.2
16000.0	−16.8	5.0	−105.0
A	B	C	D

Column

A Frequency offset between first DAB carrier and LM pilot frequency

B Unwanted Signal (DAB) level as measured on HP8566 Sprectrum Analyser

C Corrected unwanted level : Conversion factor applied (See appendix 5 DAB Correction Factor.)

D Carrier / Interference ratio (Wanted signal level (LM) minus unwanted signal level)

DAB (DIGITAL AUDIO BROADCASTING) / LINEAR MODULATION CO – CHANNEL COMPATIBILITY TEST RESULTS BASED ON DEGRADATION TO 14dB SINAD

Wanted Signal Level (LM) : MUS+15dB : −85 dBm

Frequency offset	for 30 dB SINAD			for 25 dB SINAD			for 20 dB SINAD			14 dB Degradation		
DAB – LM	Unwanted Signal Level	Corrected Unwanted Signal Level	C/I Ratio	Unwanted Signal Level	Corrected Unwanted Signal Level	C/I Ratio	Unwanted Signal Level	Corrected Unwanted Signal Level	C/I Ratio	Unwanted Signal Level	Corrected Unwanted Signal Level	C/I Ratio
kHz	dBm	dBm	dB	dBm	dBm	dB	dBm	dBm	dB	dBm	dBm	dB
0.0	−109.6	−102.6	17.6	−104.6	−97.6	12.6	−94.6	−87.6	2.6	−87.6	−80.6	−4.4
12.5	−71.0	−49.2	−35.8	−62.0	−40.2	−44.8	−56.0	−34.2	−50.8	−34.5	−12.7	−72.3
25.0	−69.2	−47.4	−37.6	−59.2	−37.4	−47.6	−54.2	−32.4	−52.6	−47.2	−25.4	−59.6
50.0	−65.9	−44.1	−40.9	−56.9	−35.1	−49.9	−50.9	−29.1	−55.9	−43.9	−22.1	−62.9
200.0	−62.0	−40.2	−44.8	−52.0	−30.2	−54.8	−46.0	−24.2	−60.8	−40.5	−18.7	−66.3
500.0	−57.5	−35.7	−49.3	−47.5	−25.7	−59.3	−43.5	−21.7	−63.3	−39.5	−17.7	−67.3
1000.0	−44.0	−22.2	−62.8	−40.0	−18.2	−66.8	−38.0	−16.2	−68.8	−35.0	−13.2	−71.8
8000.0	−37.6	−15.8	−69.2	−27.6	−5.8	−79.2	−22.6	−0.8	−84.2	−18.3	3.5	−88.5
16000.0	−26.8	−5.0	−80.0	−17.8	4.0	−89.0	−10.8	11.0	−96.0	−6.8	15.0	−100.0
A	B	C	D	B	C	D	B	C	D	B	C	D

Column

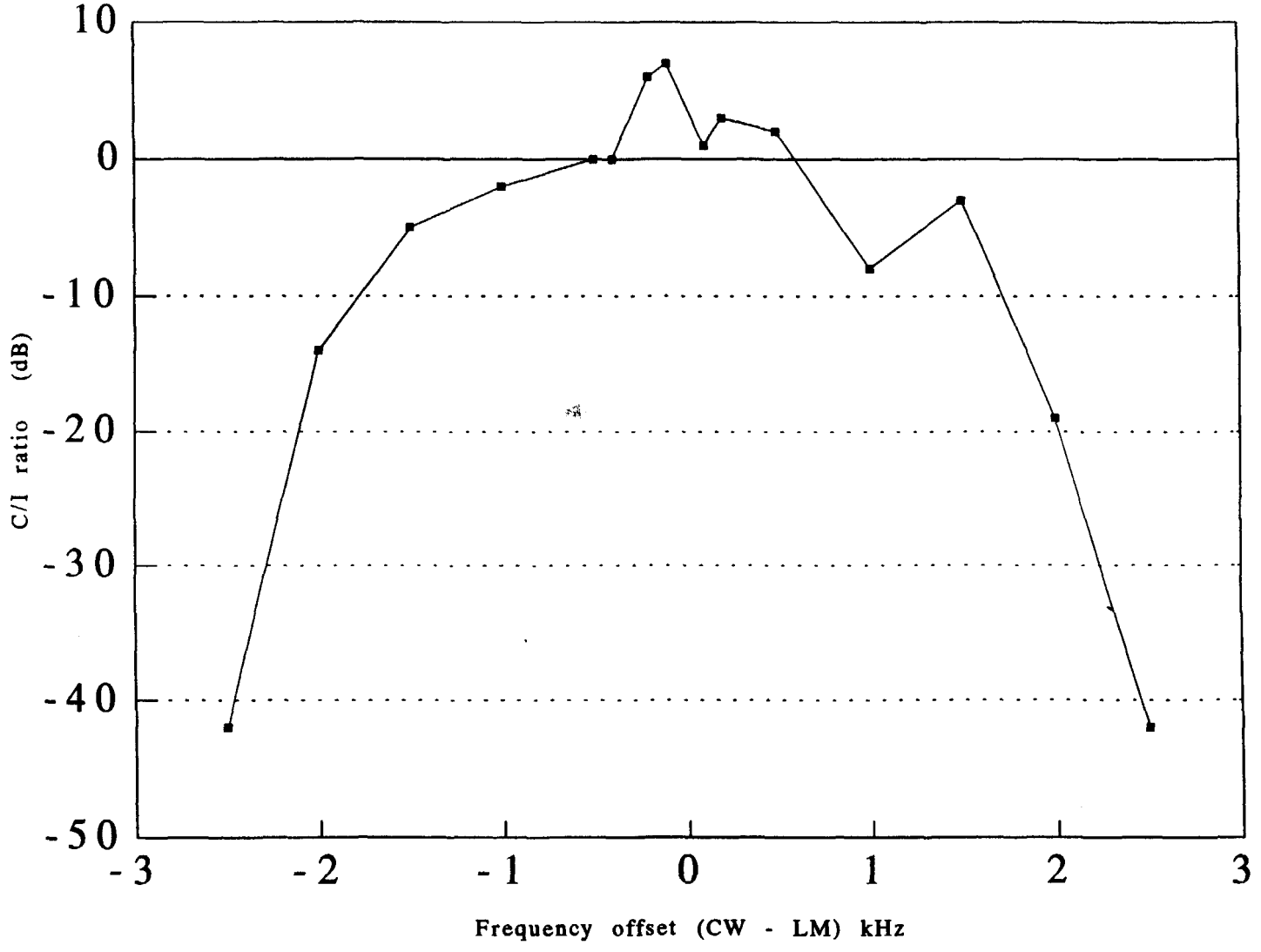
A Frequency offset between first DAB carrier and LM pilot frequency

B Unwanted Signal (DAB) level as measured on HP8566 Sprectrum Analyser

C Corrected unwanted level : Conversion factor applied (See appendix 5 DAB Correction Factor.)

D Carrier / Interference ratio (Wanted signal level (LM) minus unwanted signal level)

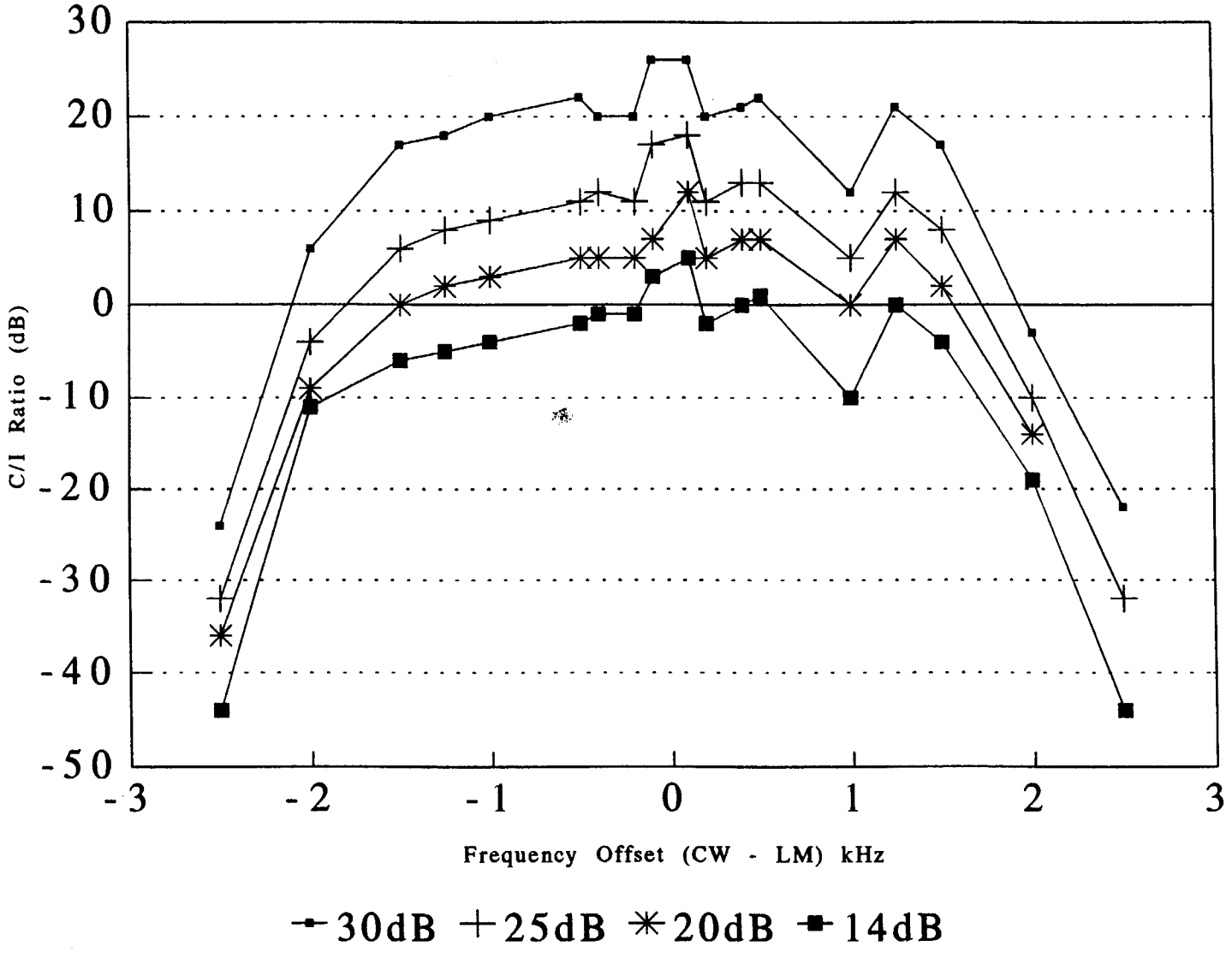
CW/LM compatibility based on a degradation to 14dB SINAD



Wanted Signal Level : MUS : -117dBm

Appendix 4
Figure 1

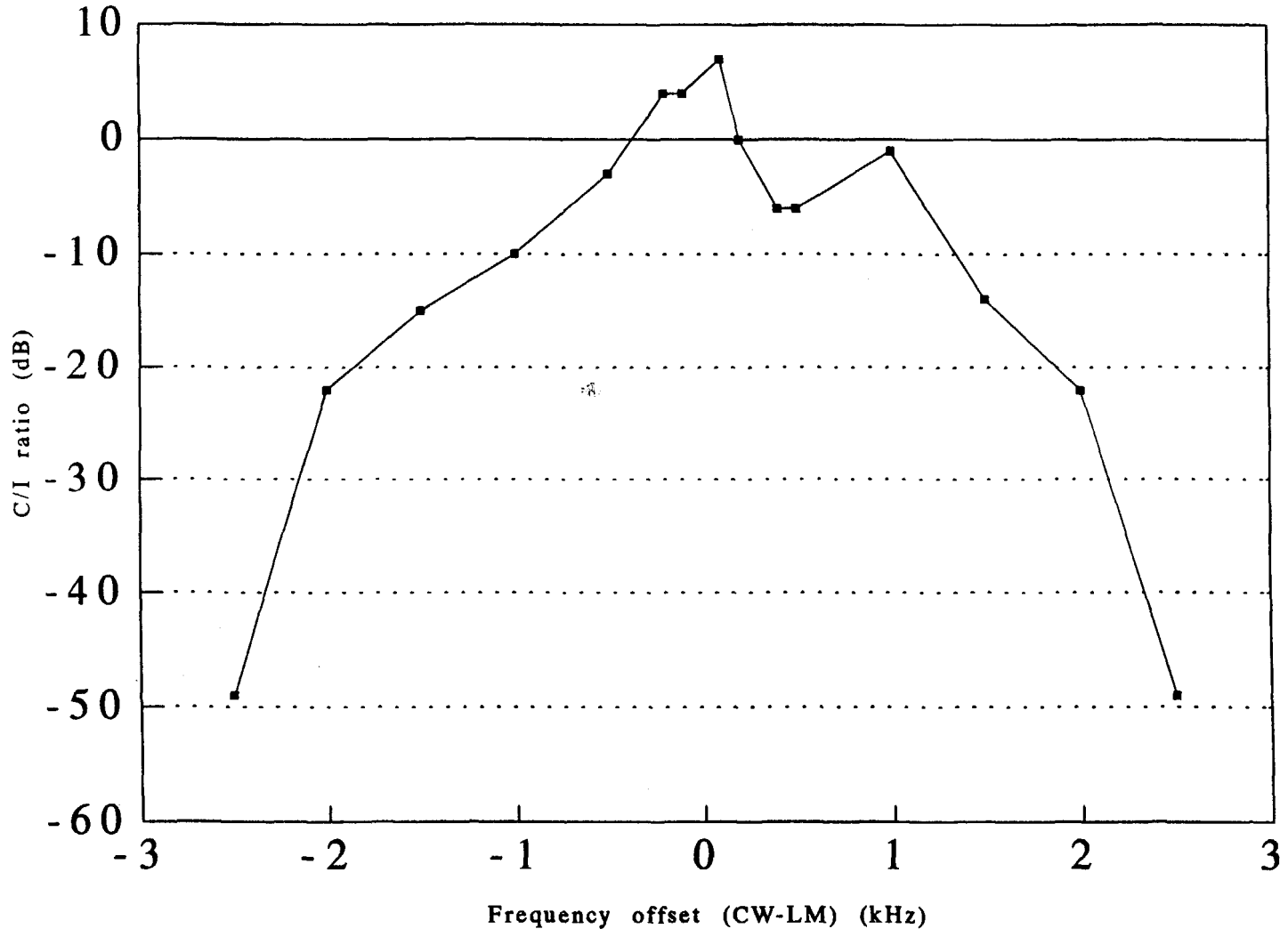
CW/LM Co-channel Compatibility



Wanted Signal Level : MUS+15dB : -102dBm

Appendix 4
Figure 2

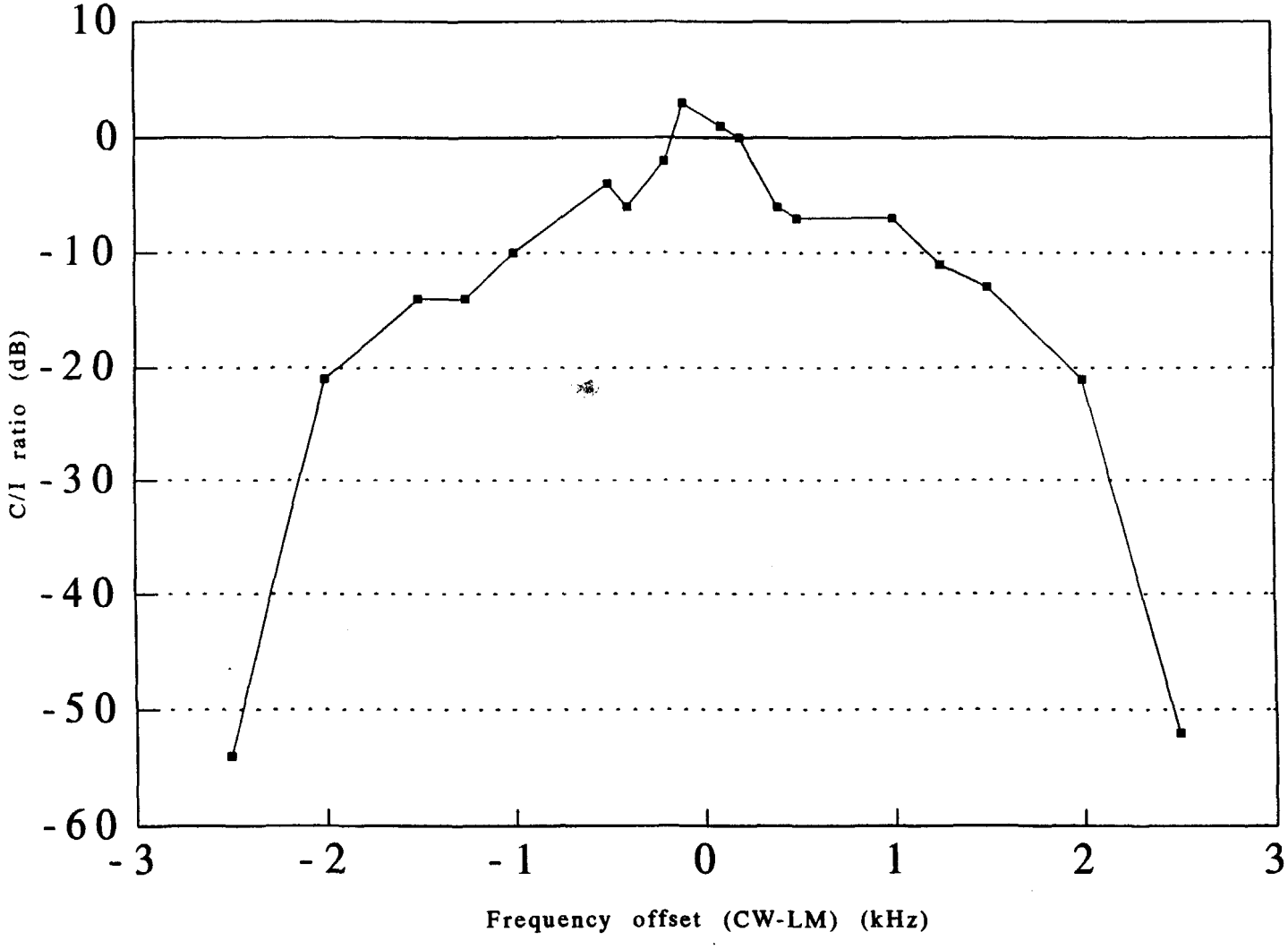
CW/LM Compatibility based on a degradation to a BER 10^-2



Wanted Signal Level : MUS : -117dBm

Appendix 4
Figure 3

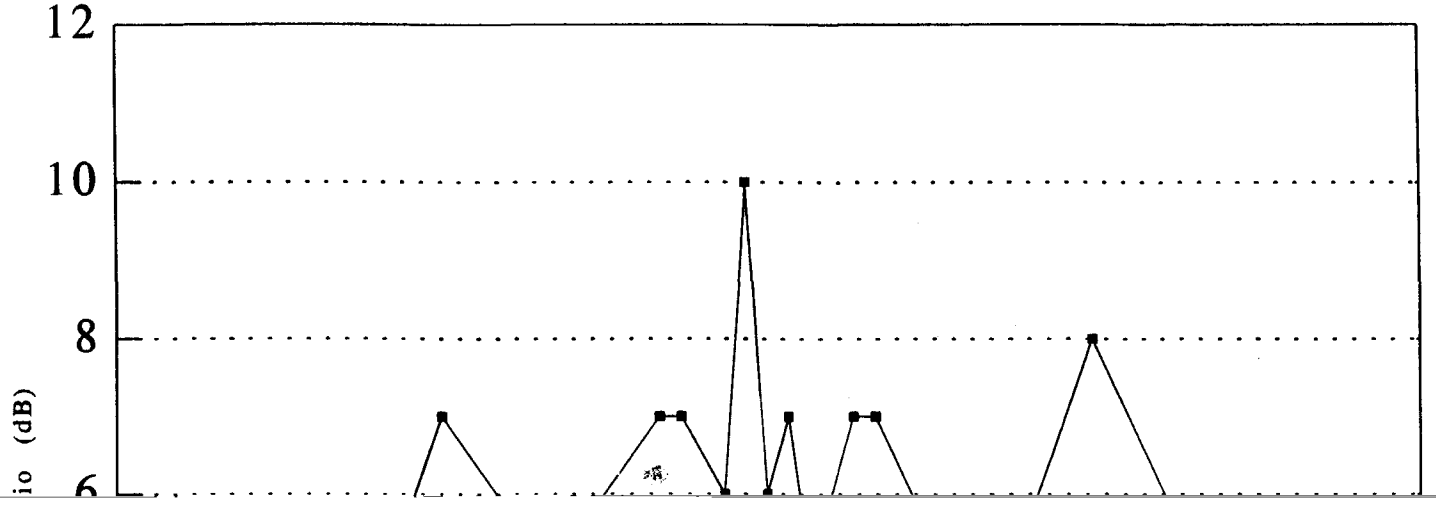
CW / LM compatibility based on a degradation to a BER of 10^-2 BER



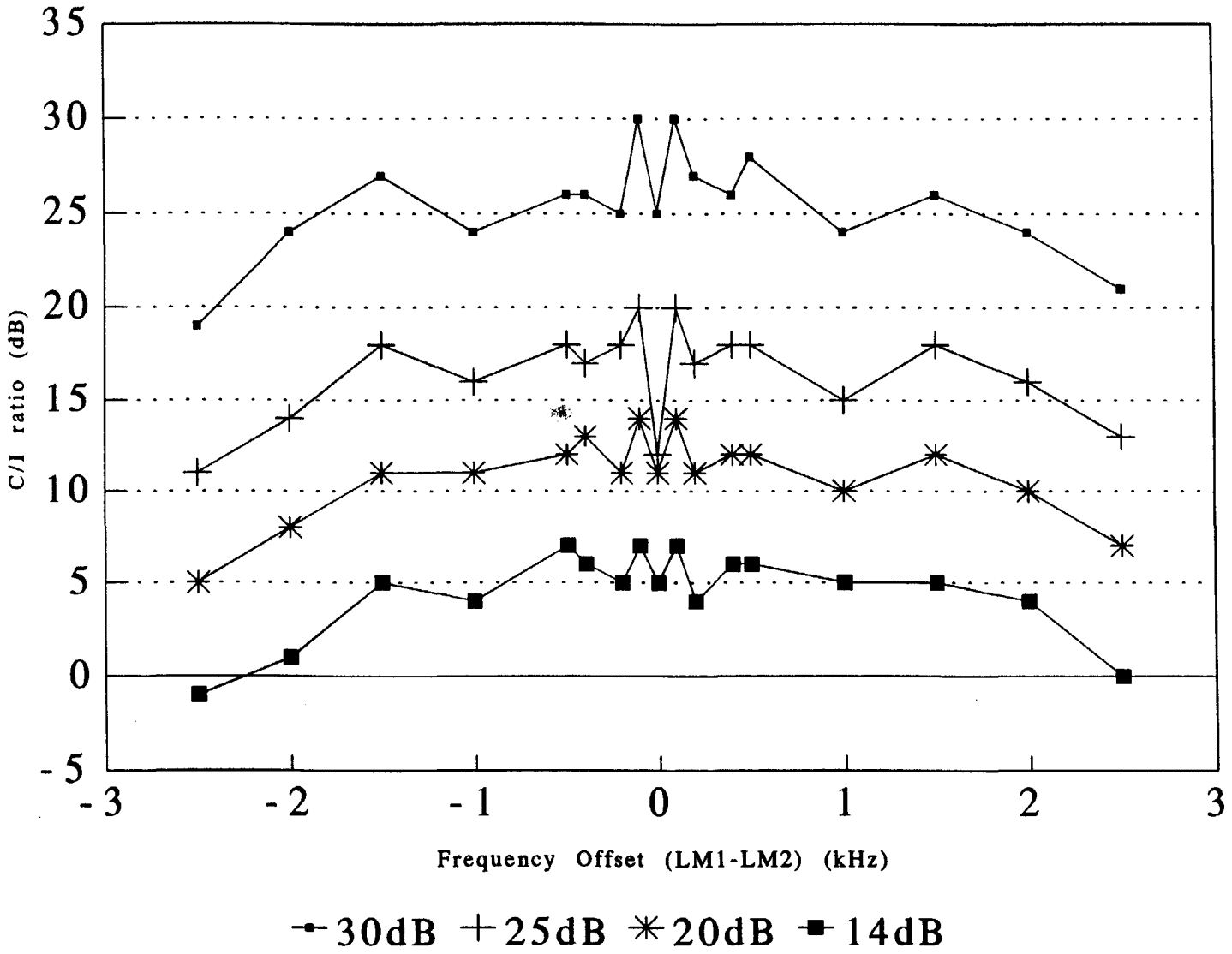
Wanted Signal Level : MUS+15dB : -102dBm

Appendix 4
Figure 4

LM/LM compatibility based on a degradation to 14dB SINAD



LM/LM Co-channel Compatibility



Wanted Signal Level : MUS+15dB : -102dBm

Appendix 4
Figure 6