Coexistence of PMSE with Aeronautical Services in the Band 960-1164MHz

Digital Microphone Test Report

JCSys/C053/06/4

Issue 4
Ray Blackwell

8th August 2017

ISO9001:2008
FS532684
JCSys Ltd Quality System
Registered to ISO9001:2008

Issue Status and Amendment Record

Issue Number	Date	Reason for Issue	Issued by
Issue 1	25th Apr 2017	Draft Issue 1	Oliver Parker
Issue 2	9th May 2017	Issue 2 with updated tables and corrections	Oliver Parker
Issue 3	20th Jun 2017	Final Issue	Oliver Parker
Issue 4	8th Aug 2017	Issue 4 with tabulated results corrections	Oliver Parker

Document Quality Record

This document was prepared by:

Ray Blackwell

Approved and released by:

Oliver Parker

Executive Summary

This report covers the testing carried out by JCSys on two DME Transponders and two DME Interrogators, while subjected to a Programme Making and Special Events Digital Microphone (PMSE DM) signal environment.

In the original PMSE Test report produced by JCSys (JCSys/C053/004/3), the Aeronautical Communications, Navigation and Surveillance (CNS) systems tested were subjected to an analogue PMSE CW signal. Since this report was issued it has become apparent that new PMSE hardware may wish to operate using a digital signal and as such it was decided that a comparison between the effects of Analogue and Digital signals should be carried out to establish if there are any noticeable differences. JCSys were tasked by Ofcom to test two representative DME Transponders (Fernau 2020 and Thales 415) and two Interrogators (Bendix/King KN64 and Rockwell Collins DME 900) under the same test conditions as used for the Analogue CW testing.

The results of the DME Transponder testing has shown that it can be concluded that a PMSE DM signal is no worse for a DME transponder than a PMSE CW signal, and in most cases it causes less of an effect.

The DME Interrogator tests show very similar results to the original PMSE CW tests, to within 1dB. It can therefore be concluded that PMSE DM signals are no worse for the CNS system tested than PMSE CW signals.

Contents

Glossary of Terms

BREAKLOCK – When a Breaklock occurs on a Distance Measuring Equipment (DME) Interrogator the range indication will display no data. A Breaklock can occur when the Interrogator is re-channelled to another frequency. An interference signal can cause a Breaklock, usually the Interrogator will go into search mode and try to Re-Acquire the desired signal. Loss of the Ground DME Beacon reply signal can also cause a Breaklock.

DME – Distance Measuring Equipment (DME) Interrogator is used by aircraft to receive signals from fixed position Ground DME beacons. The Interrogator will transmit interrogations to a Ground Beacon and determine the time taken to receive a Reply from the Beacon. The time (propagation delay) is converted to a slant range/distance to the Ground DME.

DSL – Desired Signal Level is a DME signal level generated and controlled to simulate the wanted signal of the DME unit under test.

LOCKED-ON – A DME Interrogator goes from search mode to track mode and a range/distance is displayed on an indicator so the DME is said to be Locked-on.

SCANNING DME INTERROGATOR – A scanning DME Interrogator is able to Interrogate up to 5 Ground DME beacons and provides range / distance data from all 5 beacons. There is a Free-scan capability which also scans all 252 channels in the background looking for the next strongest signal.

SEARCH MODE – A single channel DME Interrogator will transmit a number of interrogations to a Ground DME Beacon at around 120ppps. For a Scanning DME the search mode is a lower pulse rate of 12ppps.

TRACK MODE – A single channel DME Interrogator will transmit interrogations at 22ppps when it is Locked-on. A scanning DME tracks at between 2 to 4ppps.

TTA – Time to Acquire (TTA) is a measurement of the time it takes (in seconds) for a DME Interrogator to become locked-on to a Ground DME Beacon reply signal.

1 BACKGROUND

1.1 JCSys have been tasked by Ofcom to repeat elements of the original PMSE Testing to investigate if there is a difference in the effects seen on the Communications Navigation and Surveillance (CNS) equipment tested when the analogue PMSE CW signal is replaced with a PMSE Digital Microphone (DM) signal.

1.2 It was decided that two DME Interrogators and two DME Transponders should be tested as part of this follow up investigation. The following equipment was chosen by Ofcom, and agreed by the CAA, as representative samples of in-service DME equipment:

- DME Transponders
    - Fernau 2020 (Most common in the UK)
    - Thales 415 (modern DME Transponder)
- Interrogators
    - Bendix/King KN64 (Fixed Channel, often used by General Aviation)
    - Rockwell Collins DME 900 (Scanning Type)

1.3 All tests carried out are a repeat of the original testing with the PMSE CW signal replaced with a PMSE DM signal.

2 OBJECTIVE

2.1 The objective of this work is to determine if there is a difference between the effects of PMSE CW and PMSE DM signals on existing CNS equipment operating in the band 960-1164MHz.

3 TESTING APPROACH

3.1 A simulated PMSE DM transmission signal, recorded from a real PMSE Digital Microphone and replayed at the correct frequency, will be used to determine if there are any changes to the performance characteristics of various CNS equipment receivers in the presence of PMSE DM signals. To ensure an accurate representation of the real Radio Frequency (RF) environment is used, a complex RF signal environment will be simulated which includes the presence of Link-16 as detailed below in Test Configuration Sections of this document.

4 DME GROUND BEACON TEST CONFIGURATION

4.1 DME Pulse Environment

4.1.1 As with the original testing DME Transponder (Ground Beacon) testing was carried out on both X and Y channel.

4.1.2 The following DME pulse environments were used:

- For a Y mode DME beacon 1200 pulse pairs per second (ppps) on-code load (36us spacing) + 300ppps off-code load (12us spacing).
- For an X mode DME beacon 2200ppps on-code load (12us spacing) + 300ppps off-code load (36us spacing).

4.2 Link-16 Pulse Environment

4.2.1 The Link-16 pulse environment used in the testing represents the UK Any Point In Space (APIS) 70NM radius Geo Area at 60% Time Slot Duty Factor (TSDF), known as 70/60. This represents the pseudo random frequency hopping Link-16 pulse environment as approved to operate in the UK FIR.

4.3 PMSE Digital Microphone (DM) Signal

4.3.1 The Digital PMSE signal was generated from an SHURE QLXD1 digital microphone transmitter provided by Ofcom. The QLDX1 was configured to transmit at 961.8MHz and the output power was measured as +7.4dBm. The PMSE digital signal is shown below (measured via 10dB attenuator). No audio was applied to the SHURE QLDX1 (OFCOM).

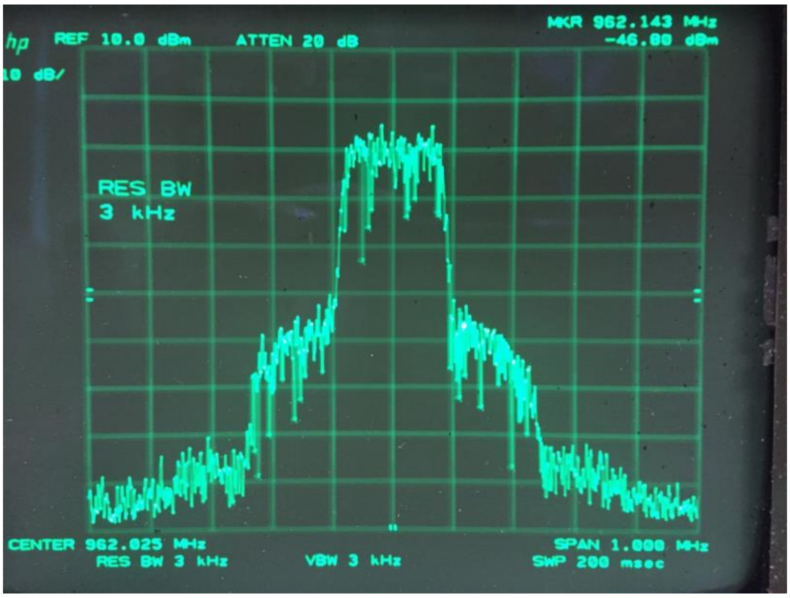


Figure 4-1 – Digital PMSE Signal

4.3.2 The signal was demodulated using the NI 5791 RF Transceiver module (part of the JCSys test system) and the demodulation was performed with a carrier frequency (Local Oscillator) of 961.8MHz. The resulting IQ (In-phase and Quadrature) data was streamed to disk at a sample rate of 10MHz. The recorded IQ data can then be replayed through the NI 5791 to reproduce the original waveform.

4.3.3 The sampled data is replayed using the NI 5791 but with a Local Oscillator frequency equal to the selected DME channel. This process enables the QLXD1 waveform to be transposed into the DME band to support the testing.

4.3.4 The QLDX1 signal was sampled four times with different carrier frequencies to obtain data at four offset frequencies: +700kHz, +250kHz, -100kHz and -400kHz. This generated four separate IQ data files.

4.3.5 Four NI 5791 channels were employed to enable the four offset frequencies to be generated at the same time. The carriers of the four channels were not synchronised so that each channel acts as independent digital microphone source.

4.3.6 The IQ data recordings were of 10 second duration and the files were looped so that RF generation was continuous throughout the test.

4.4 Measurement Approach

4.4.1 Testing was undertaken on DME Channel 101X (1125MHz) using a Desired Signal of 150ppps and then repeated on DME Channel 101Y.

4.4.2 In order to produce a Beacon Reply Efficiency (BRE) curve, 20 Desired Signal Levels were used:

- -50,-60,-70,-80,-82,-84,-85,-86,-87,-88,-89-90,-91,-92,-93,-94,-95,-96,-97,-98. (dBm)

4.4.3 Testing was carried out using the full pulse environment as specified above.

5 DME GROUND BEACON TESTING RESULTS

5.1 Pass/Fail Criteria

5.1.1 The performance requirements of a DME Ground Beacon are defined in ICAO Annex 10.

5.1.2 The specific test parameter to be measured is Beacon Reply Efficiency (BRE). BRE performance is the measurement of a known number of interrogations resulting in a processed number of replies normally expressed as a percentage (a BRE of 100% means all interrogations are processed successfully into replies).

5.1.3 ICAO Annex 10 states that a DME beacon must maintain 70% beacon reply efficiency and that it must be able to achieve this at a power density of -103dBW/m^2 for Enroute and -93dBW/m^2 for Aerodrome approach.

5.1.4 A UK criteria for DME Ground Beacons has been derived from ICAO Annex 10 using a typical antenna gain and cable loss to determine a signal level of -88dBm for Enroute and -78dBm for Aerodrome DMEs.

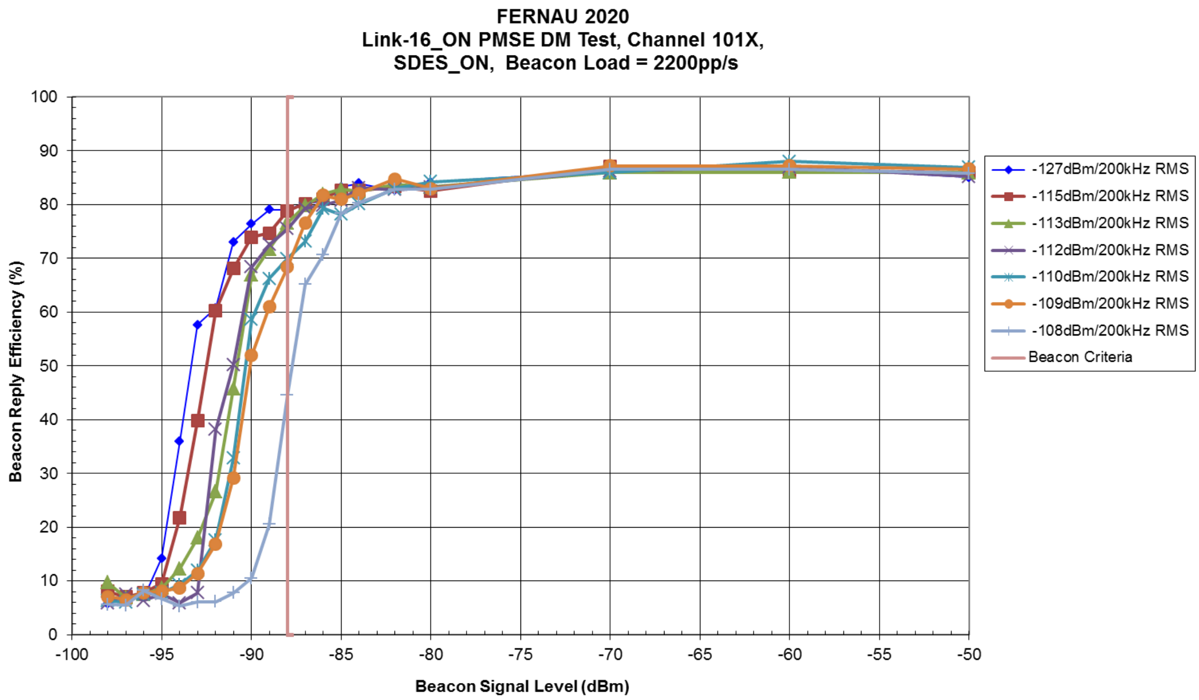
5.2 Fernau 2020 Test Results

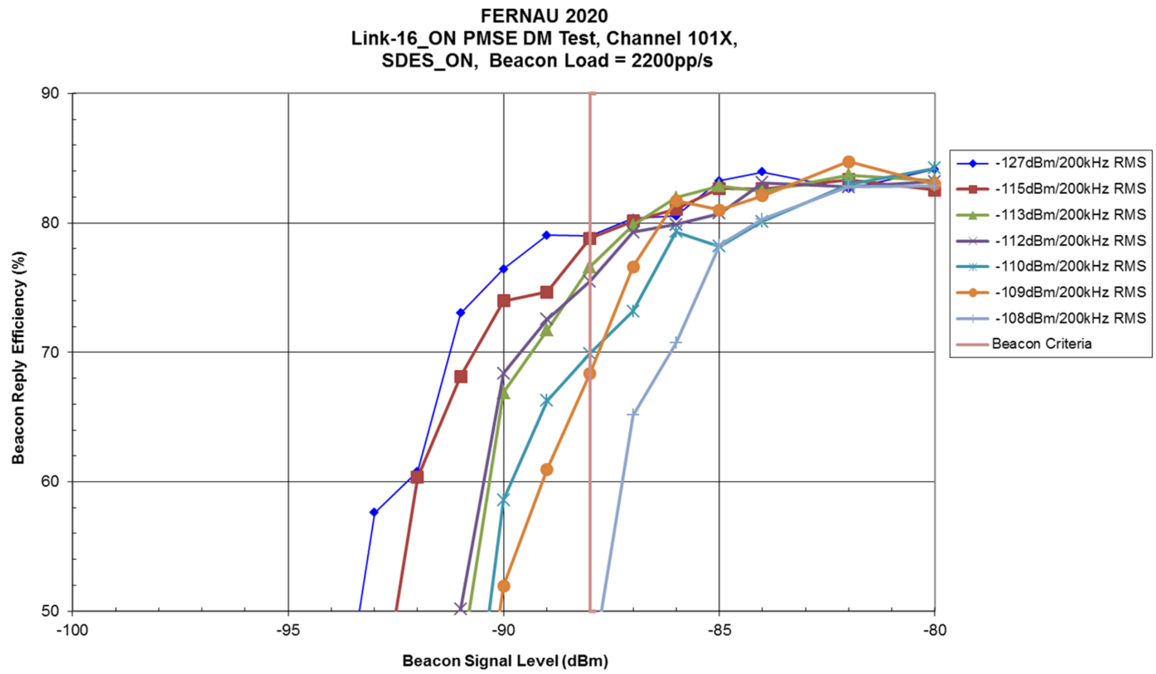
5.2.1 Fernau 2020 Full Pulse Environment Testing, Co-Channel

5.2.1.1 The charts below show a number of reply efficiency curves for a Fernau 2020 ground beacon operating in X and Y mode. Four PMSE DM signals were generated for co-channel testing. The following tests were undertaken:

- X-mode PMSE DM (4) Co-Ch. to DME Beacon. Link-16_ON
- Y-mode PMSE DM (4) Co-Ch. to DME Beacon. Link-16_ON
- X-mode PMSE DM (4) Co-Ch. to DME Beacon. Link-16_OFF
- Y-mode PMSE DM (4) Co-Ch. to DME Beacon. Link-16_OFF

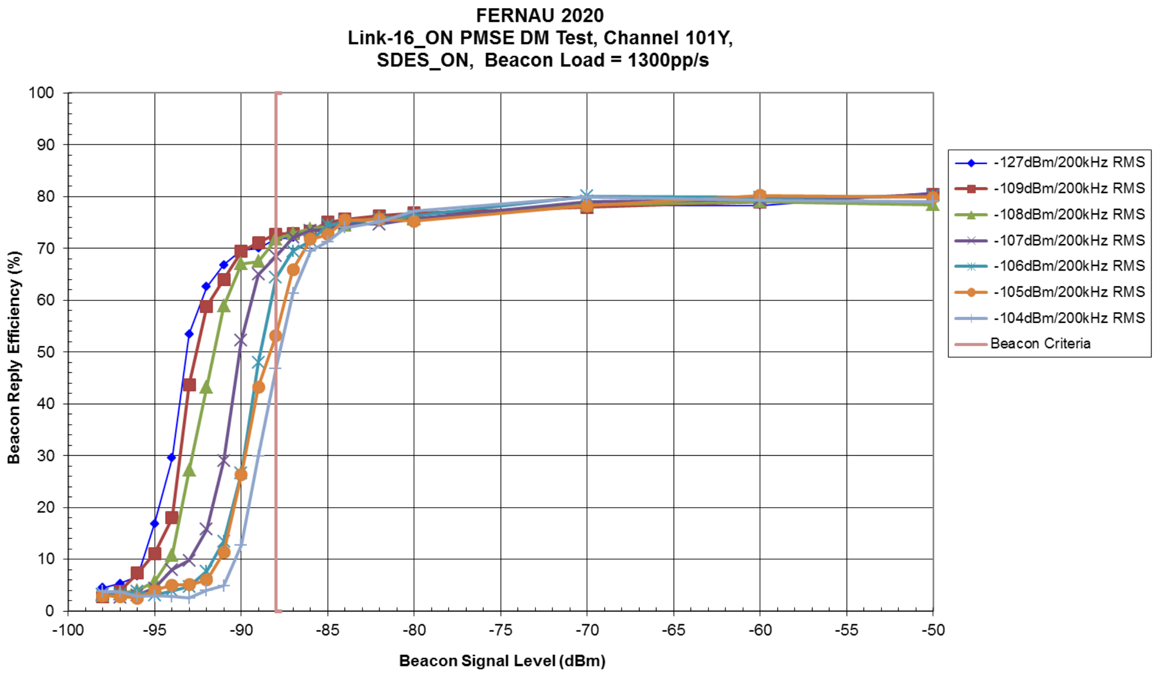
5.2.1.2 In each case the PMSE DM signal levels were coupled to the DME Beacon antenna port. Expanded views of the BRE curves are also provided.

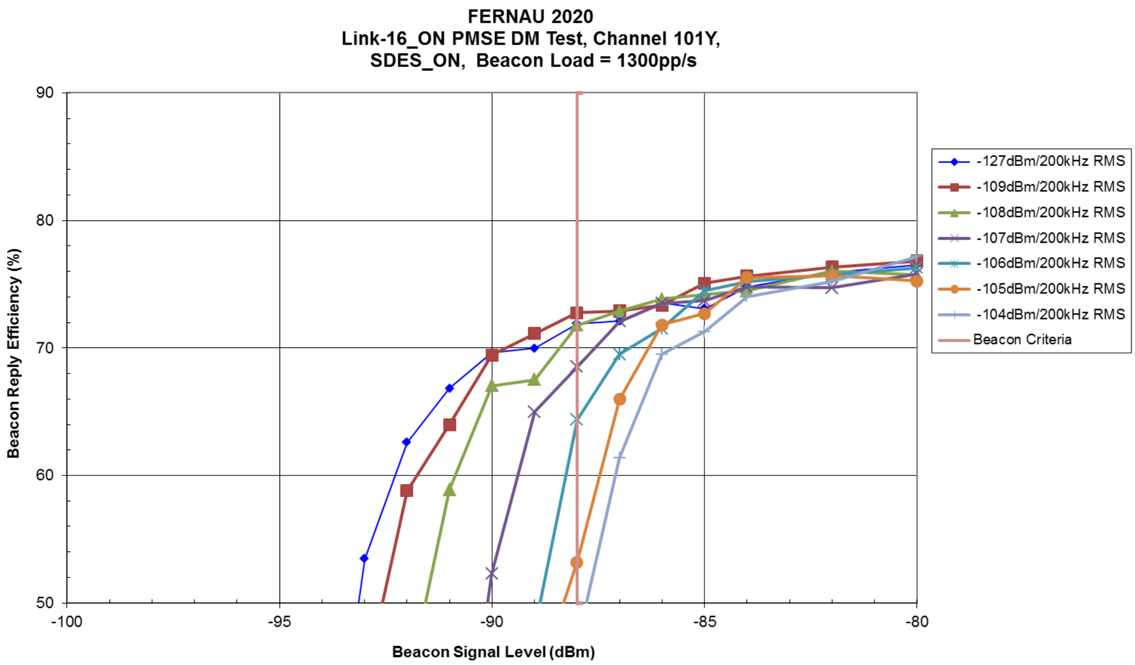




Figures 5-1 & 5-2 – Fernau 2020, 101X, Co-Channel Test, Full Pulse Environment

5.2.1.3 The test data indicates that a PMSE signal level of -110dBm/200kHz RMS should not be exceeded for the co-channel case for X mode.



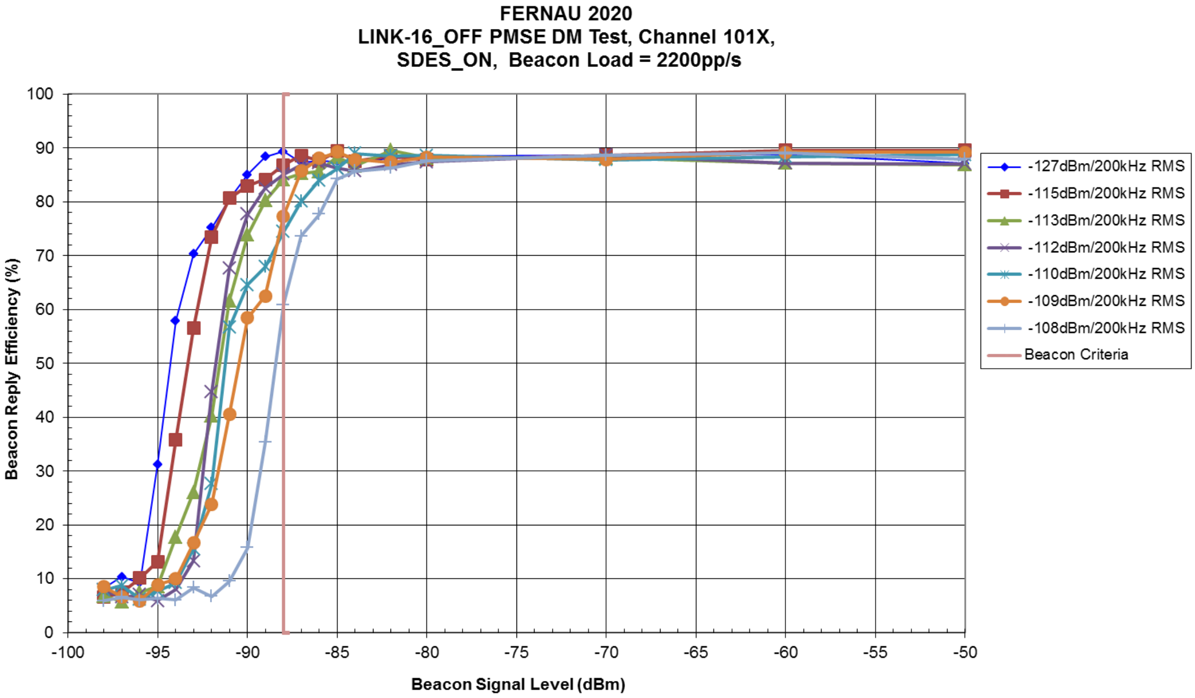


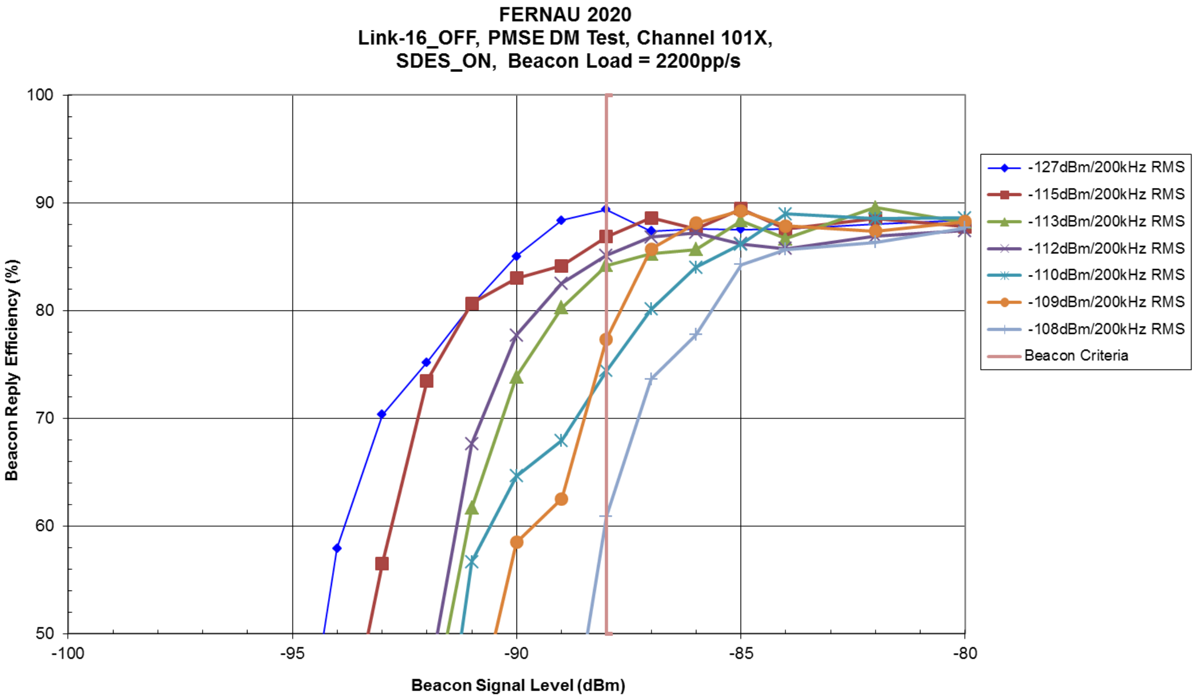
Figures 5-3 & 5-4 – Fernau 2020, 101Y, Co-Channel Test, Full Pulse Environment

5.2.1.4 The test data indicates that a PMSE signal level of -108dBm/200kHz RMS should not be exceeded for the co-channel case for Y mode.

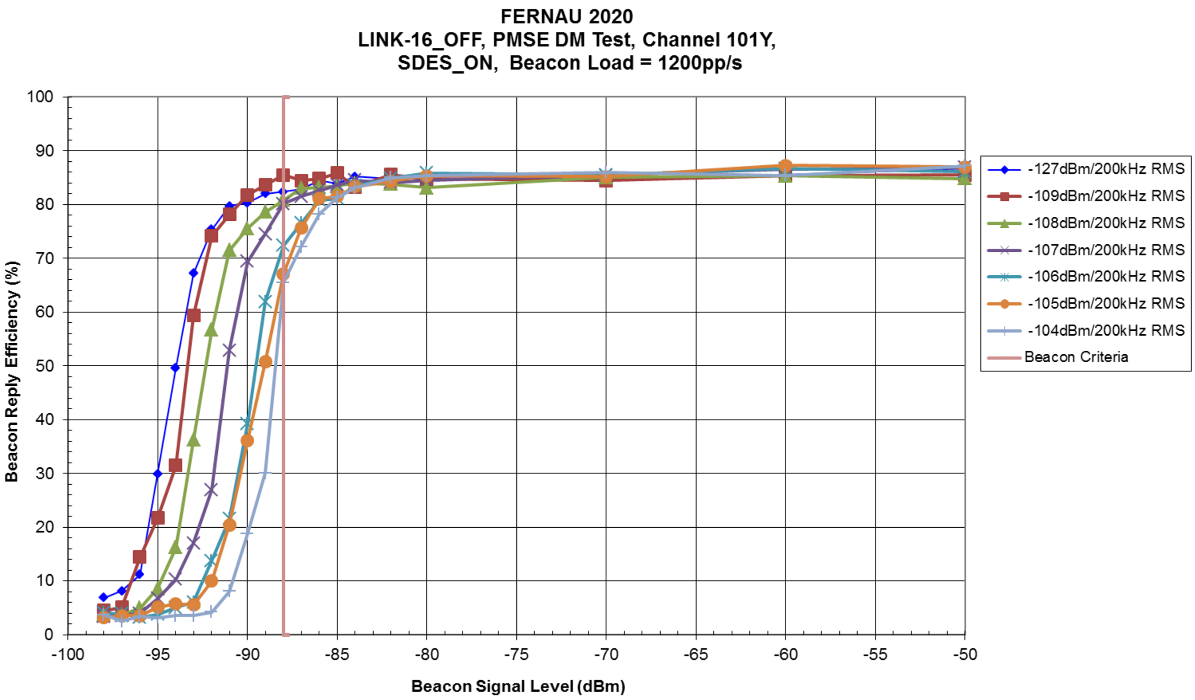
5.2.2 Fernau 2020 No Link-16 Testing, Co-Channel

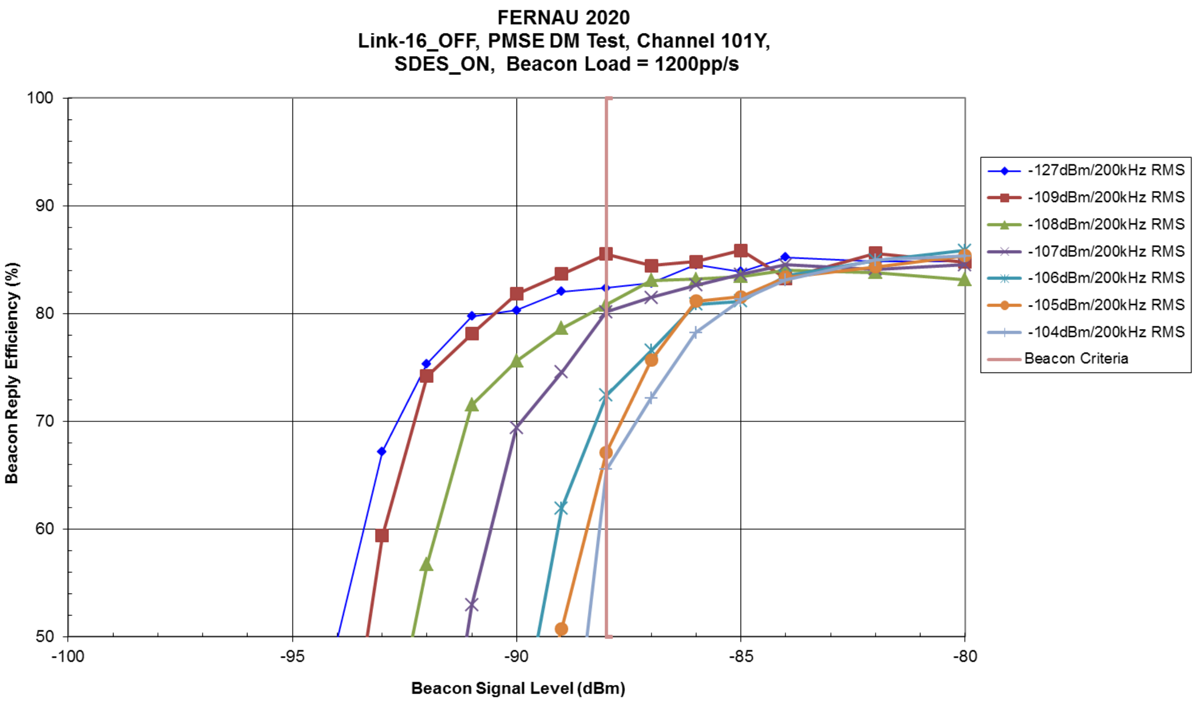
5.2.2.1 Testing was also carried without the presence of the specified Link-16 pulse environment for the purposes of completeness, the results were as follows:





Figures 5-5 & 5-6 – Fernau 2020, 101X, Co-Channel Test, No Link-16





Figures 5-7 & 5-8 – Fernau 2020, 101Y, Co-Channel Test, No Link-16

5.2.2.2 The test data indicates that a PMSE signal of -109dBm/200kHz RMS should not be exceeded for X mode and -106dBm/200kHz RMS for Y mode.

5.2.3 Fernau 2020 Off Frequency Rejection Curve (OFR)

5.2.3.1 In addition to testing the Fernau 2020 in the presence of PMSE DM Co-Channel signals, an Off Frequency Rejection Curve was also produced to gain an understanding of the susceptibility of the DME receiver to PMSE DM signals. An OFR curve was produced for both X and Y mode using a single PMSE signal.

5.2.3.2 The OFR curve was produced as follows: -

- Setting the DSL to -88dBm (as derived from ICAO Annex 10 power density of -103dBw/m^2)
- Ensure the BRE is 70% at 0MHz.
- Change the PMSE DM frequency in steps of 1MHz.
- At each 1MHz step, adjust the PMSE DM signal until 70% BRE is achieved, record the PMSE DM signal.

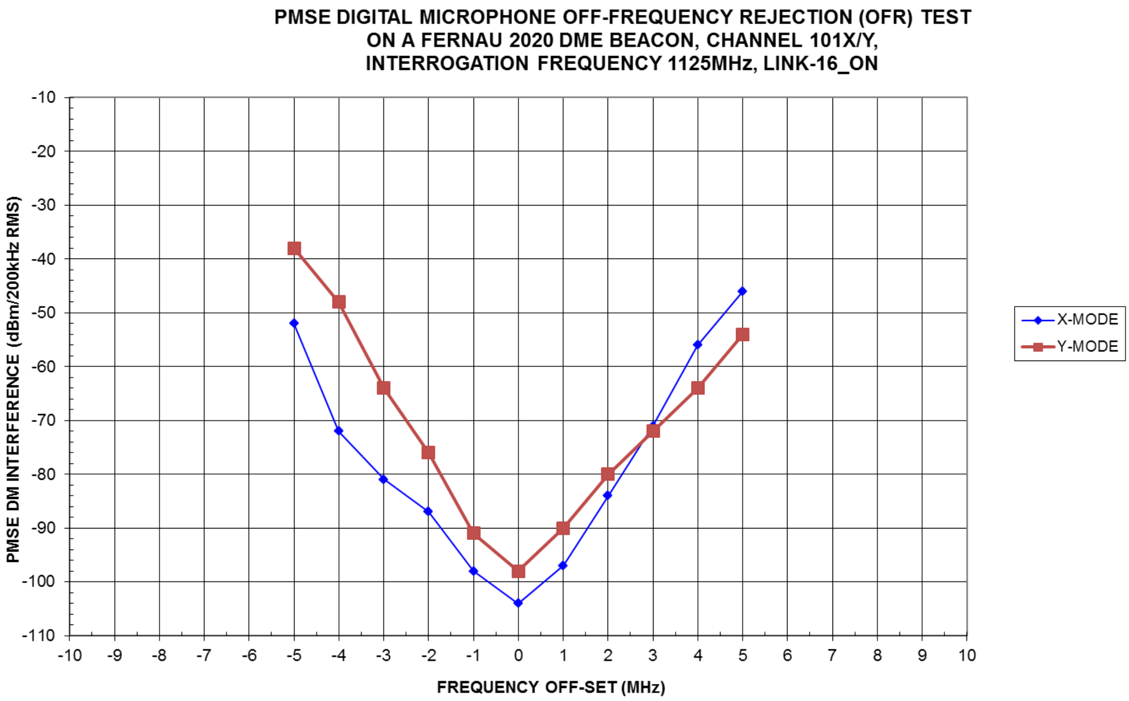


Figure 5-9 Fernau 2020 Off-Frequency Rejection Curve

5.2.4 Fernau 2020 Results Summary

5.2.4.1 The Fernau 2020 is used for both enroute and aerodrome and typically has a receiver sensitivity of -95dBm.

5.2.4.2 The test results for the Fernau 2020 indicate that the beacon is susceptible to a PMSE DM signal with the resulting effect of causing the reply efficiency to drop below 70% with the beacon operating in either X or Y mode.

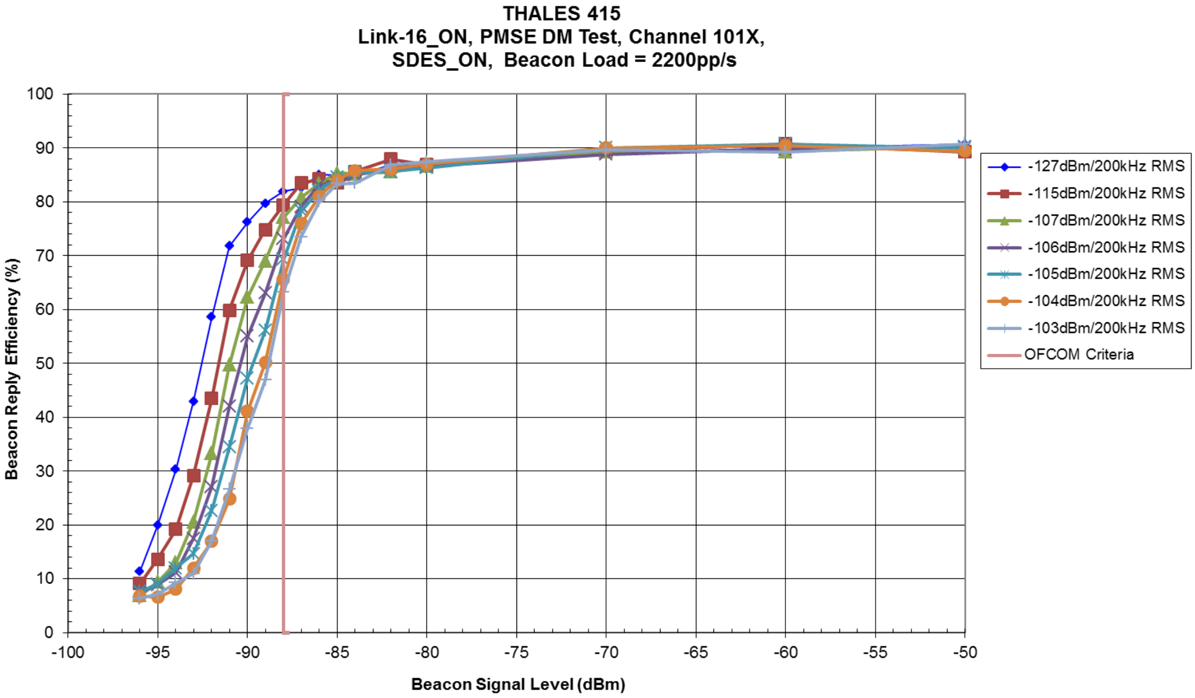
5.2.4.3 The test data indicates that a PMSE DM signal level of -110dBm/200kHz RMS should not be exceeded for either X or Y mode. For comparison -111dBm was recorded in the presence of PMSE CW.

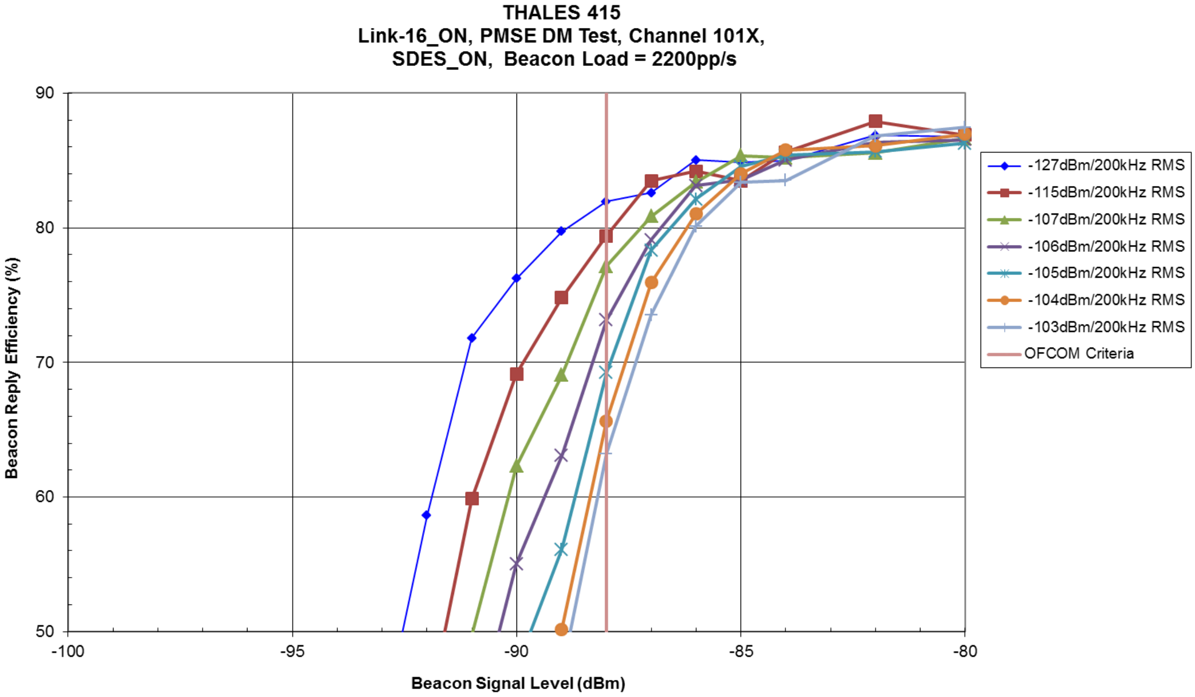
5.2.4.4 Without the presence of Link-16, the test data indicates that -109dBm/200kHz RMS should not be exceeded for X mode and -106dBm/200kHz RMS for Y mode. For comparison -109dBm PMSE CW was determined for X and Y mode.

5.2.4.5 The OFR curves show the PMSE DM signal required to cause the BRE to fall below 70% BRE at delta MHz above and below the Interrogation frequency. At 2MHz below with the Beacon operating in Y mode a PMSE DM signal of greater than -75dBM/200kHz RMS will cause the BRE to fall below 70%.

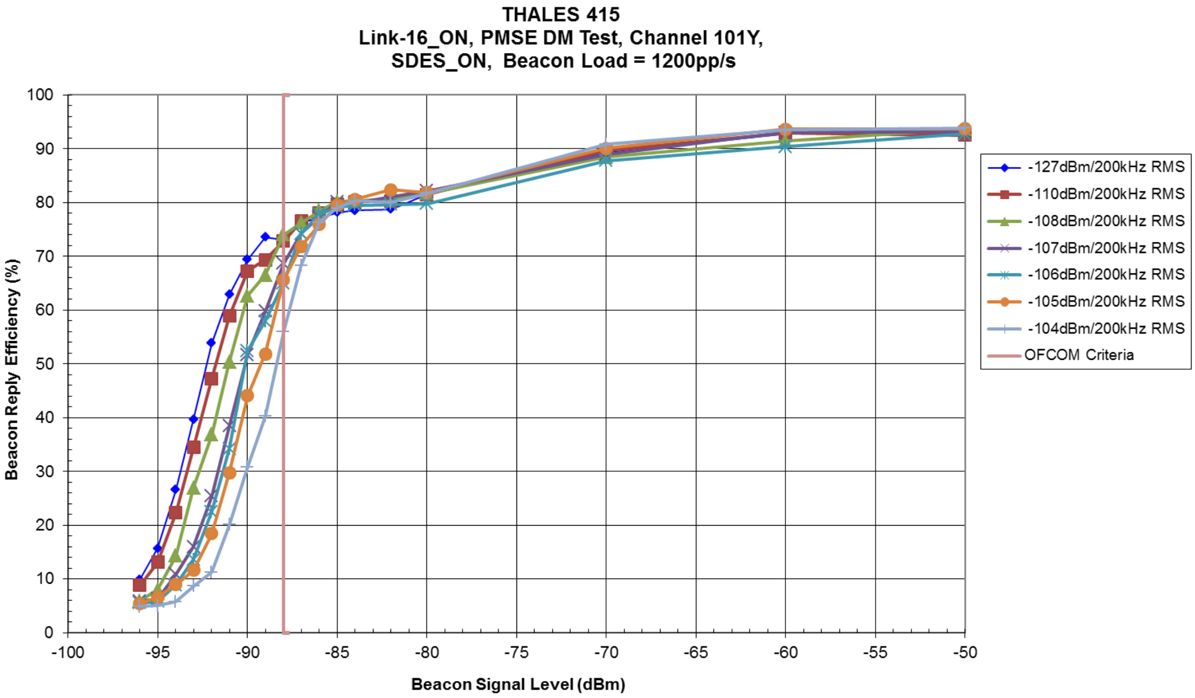
5.3 Thales DME 415 Test Results

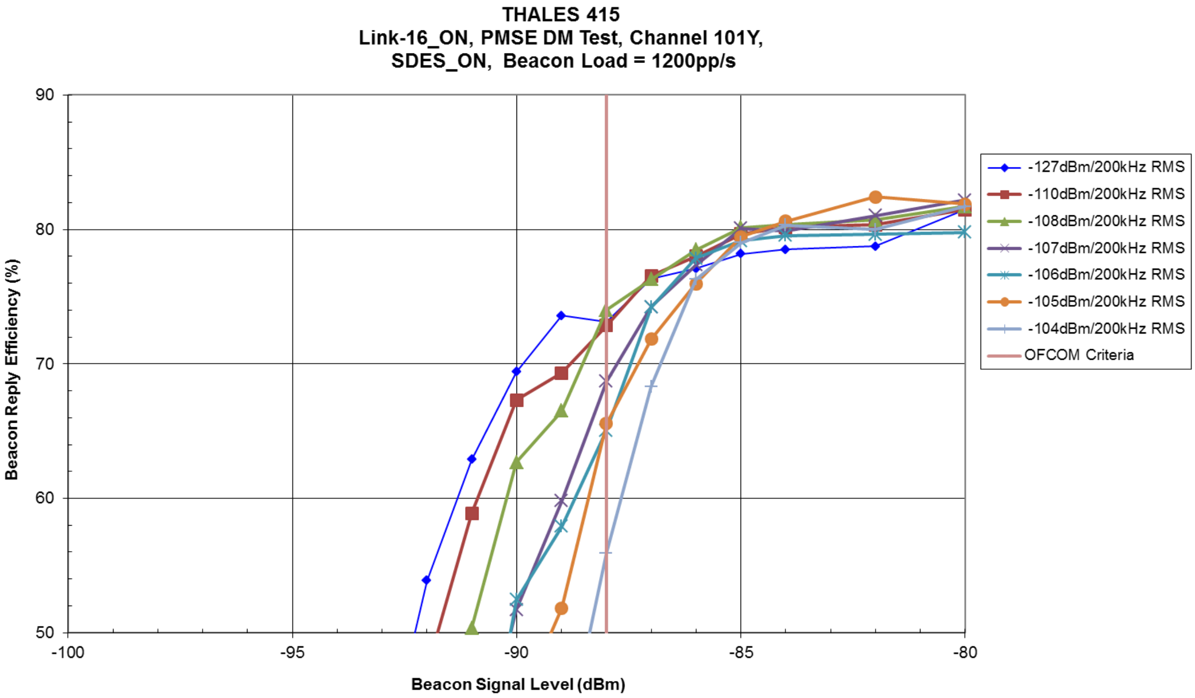
5.3.1 Thales DME415, Full Pulse Environment Testing, Co-Channel





Figures 5-10 & 5-11 – Thales 415, 101X, Co-Channel Test, Full Pulse Environment

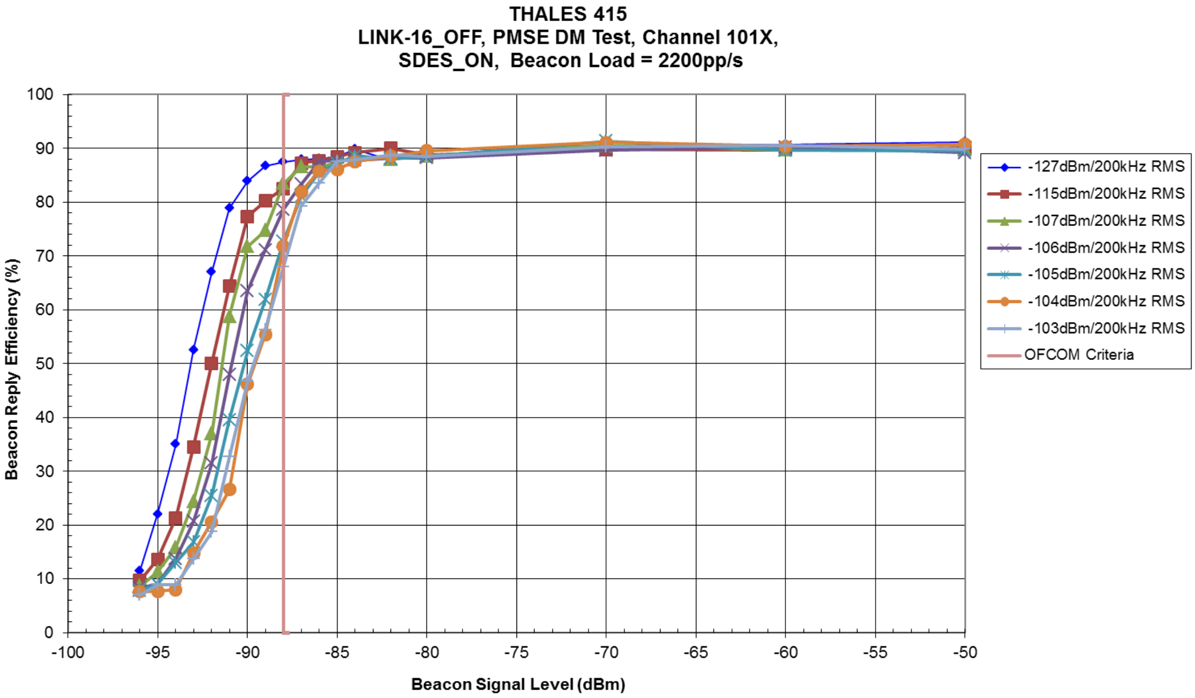


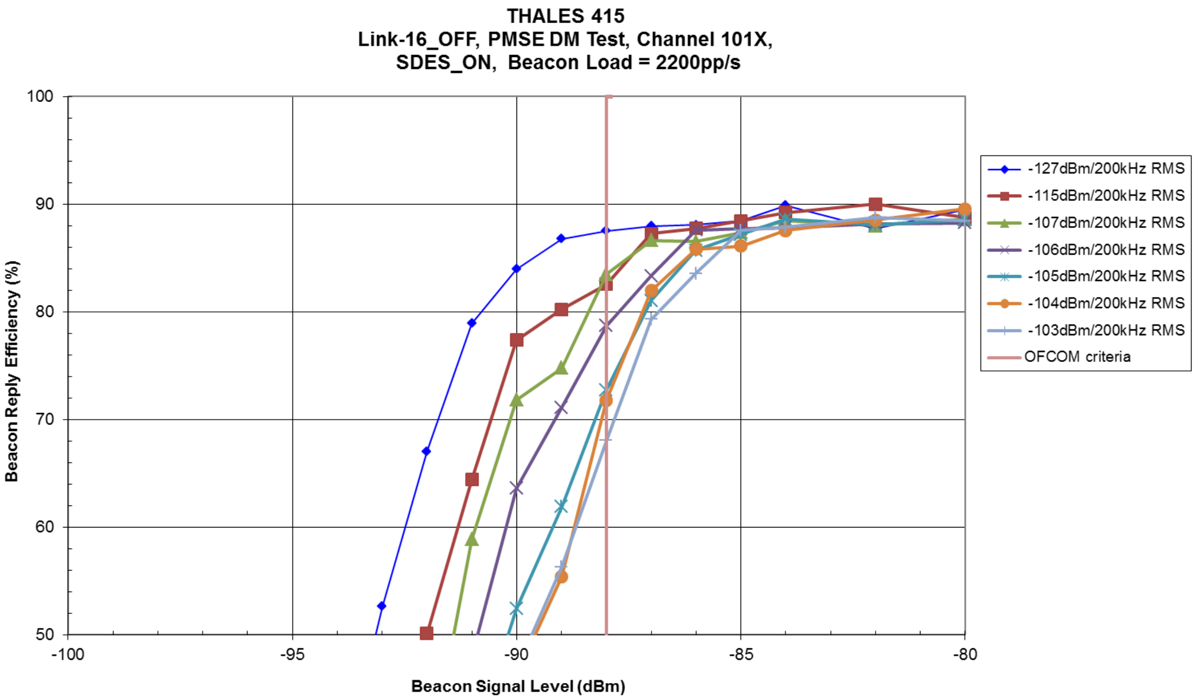


Figures 5-12 & 5-13 – Thales 415, 101Y, Co-Channel Test, Full Pulse Environment

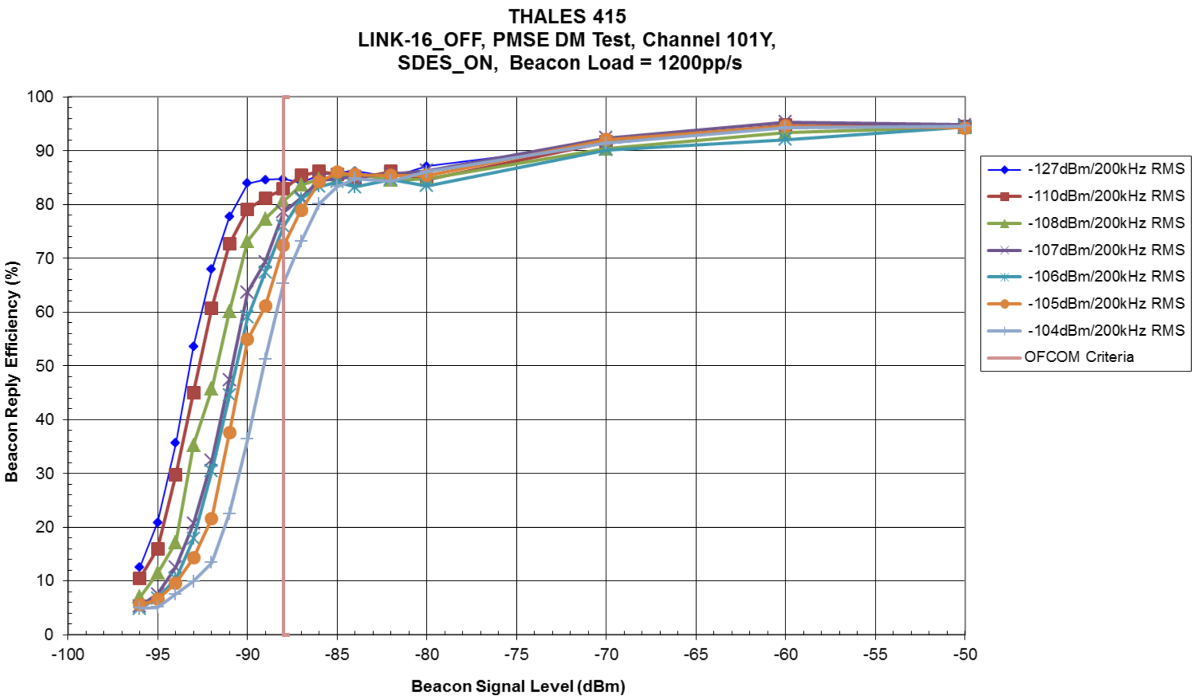
5.3.1.1 The PMSE Co-Channel test data indicates a PMSE signal level greater than -106dBm/200kHz RMS in X mode will cause the Thales DME415 to drop below the -88dBm criteria. For Y mode a signal level greater than -108dBm/200kHz RMS will cause a drop in BRE below 70% at -88dBm criteria. For comparison PMSE CW was -108dBm and -115dBm respectively.

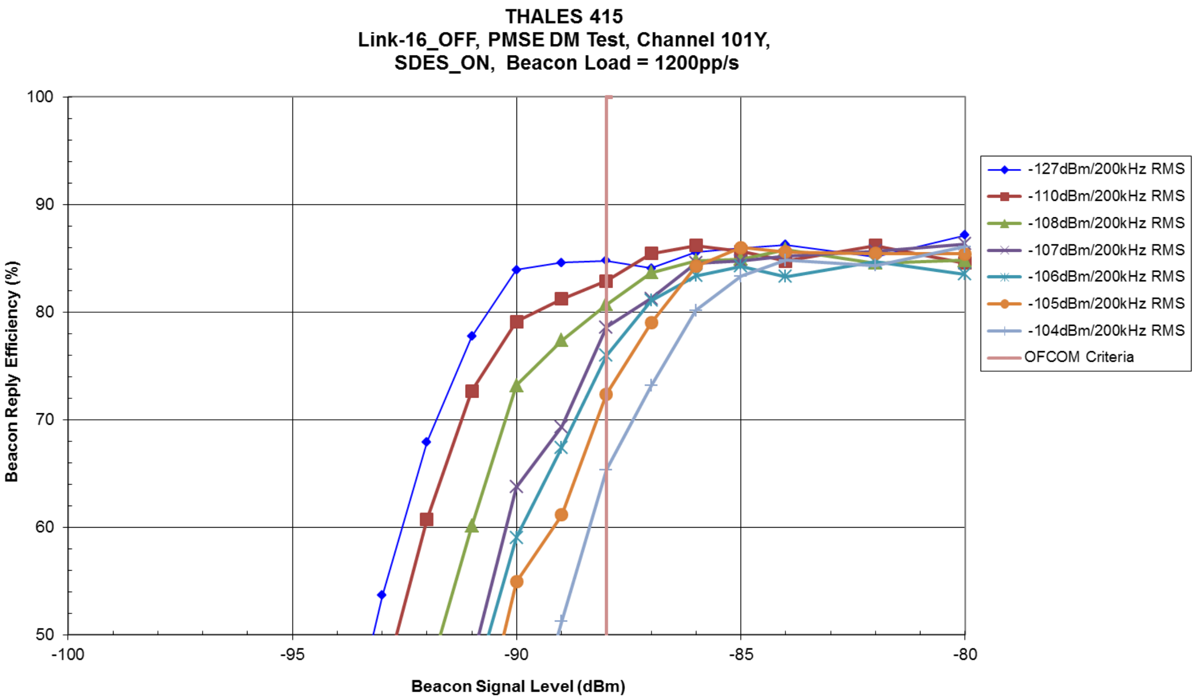
5.3.2 Thales DME415, No Link-16 Testing, Co-Channel





Figures 5-14 & 5-15 – Thales 415, 101X, Co-Channel Test, No Link-16





Figures 5-16 & 5-17 – Thales 415, 101Y, Co-Channel Test, No Link-16

5.3.2.1 With no Link-16 signals applied the test data indicates that a PMSE signal greater than -105dBm/200kHz RMS will cause BRE to fall below 70% at the -88dBm criteria. For comparison a PMSE CW signal of -108dBm caused the BRE to fall below 70%.

5.3.3 Thales 415 Off Frequency Rejection(OFR) Curve

5.3.3.1 The OFR curve was produced by using the same methodology as used for the Fernau 2020.

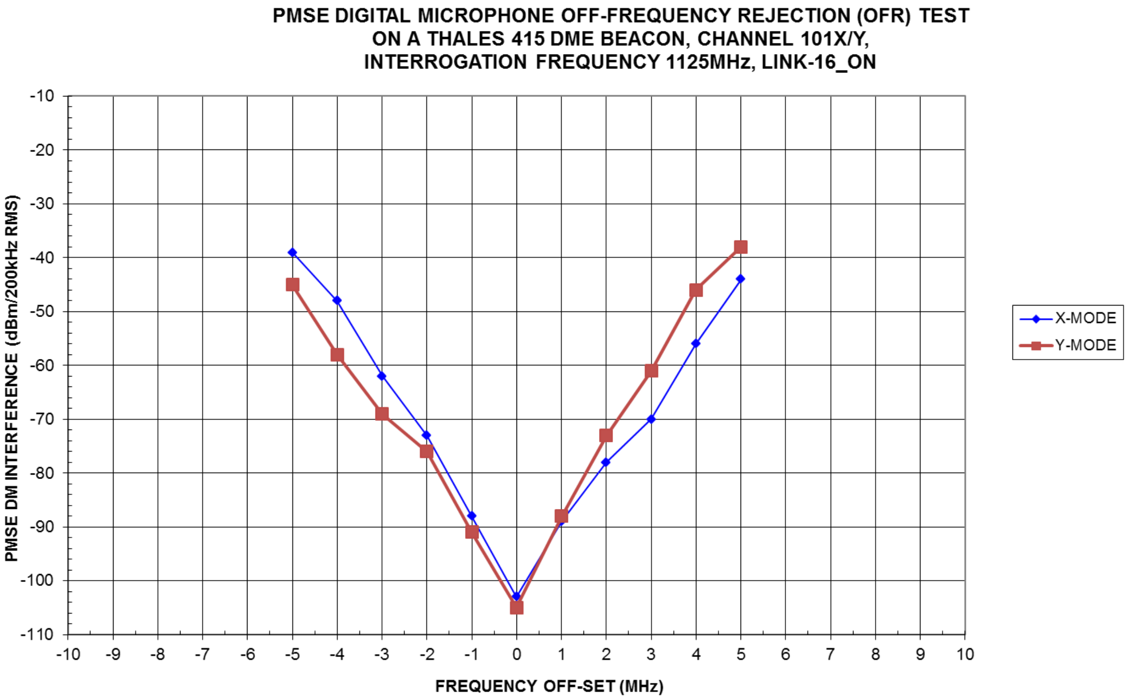


Figure 5-18 - Thales 415 Offset Rejection Curve

5.3.4 Thales DME415 Results Summary

5.3.4.1 Testing of the Thales DME415 Beacon gave similar results to the Fernau 2020 and in all cases caused the reply efficiency to drop to below 70%.

5.3.4.2 The PMSE Co-Channel test data indicates a PMSE signal level greater than -106dBm/200kHz RMS in X mode will cause the Thales DME415 to fail the criteria. For Y mode a signal level greater than -108dBm/200kHz RMS will cause a fail.

5.3.4.3 With no Link-16 signals applied the test data indicates that a PMSE signal of greater than -105dBm will also result in a fail.

5.3.4.4 As before the OFR curves show the PMSE DM signal required to cause the BRE to fall below 70% BRE at delta MHz above and below the Interrogation frequency. At 2MHz below with the Beacon operating in Y mode a PMSE DM signal of greater than -75dBM/200kHz RMS will cause the BRE to fall below 70%.

6 DME INTERROGATOR TEST CONFIGURATION

6.1 Introduction

6.1.1 The DME Interrogator test programme encompassed three separate sets of measurements to determine the performance of the DME Interrogators in the presence PMSE DM signals. The tests completed were:

- PMSE to DME Interrogator ASOP test
- PMSE Breaklock test
- PMSE signal Off-Frequency Rejection (OFR) (Selectivity) test

6.1.2 Two DME Interrogators types were tested:

- Bendix/King KN64 General Aviation (A high number operating within UK FIR), the receiver sensitivity is typically -85dBm.
- Rockwell Collins DME 900 Scanning DME

6.1.3 All tests were carried out with the inclusion of a Link-16 RF pulse environment, however and where appropriate JCSys also took measurements without the presence of Link-16 for the purposes of comparison.

6.2 PMSE to DME Interrogator ASOP testing

6.2.1 In order to evaluate the performance of a DME Interrogator the Time to Acquire (TTA) was measured at a number of beacon signal levels (BSLs), the raw data was then analysed to determine the Acquire Stable Operating Point (ASOP) of the DME interrogator, the point at which it can expect to receive a reliable service from the DME Ground Beacon. The BSL is controlled by the 8-NET software which in turn controls the beacon simulator signal level, the following parameters were pre-set into the beacon simulator:

- Channel 32X, 59Y (993MHz, 1146MHz)
- Squitter pulses set at 700ppps (Typical UK Beacon Level)
- Beacon Reply Efficiency at 70% (ICAO Annex 10)
- Range set at 200NM
- BSL (dBm) -60 to -100 in 1dB steps

6.2.2 The PMSE DM signal was introduced via a 20dB RF coupler with the PMSE DM signal being generated by JCSys test equipment. The PMSE DM signal level was set to -127dBm then increased in 1dB steps until a change in ASOP was determined.

6.2.3 As the ASOP values for the two DME Interrogator types, both with and without the presence of Link-16 are already known, these were used as a starting point for the testing.

6.2.4 The ASOP test was undertaken as follows: -

- Set beacon simulator to ASOP signal level.
- Ensure DME Interrogator locks on within 5 second search time or (manufacturers specified search time).
- Introduce PMSE Co-Channel signals to determine the PMSE signal level that changes the ASOP.
- If ASOP is already at ICAO Annex 10 signal level, then introduce PMSE DM Co-Channel signal levels that cause a change in ASOP of 1dB.
- Record PMSE DM Co-Channel signal level.

6.3 Breaklock Testing

6.3.1 This test determines the PMSE signal levels that is required to cause a Breaklock of a DME interrogator while simulating an aircraft inbound approach to an Aerodrome.

6.3.2 The Beacon signal level was set to a number of signal levels ranging from -78dBm (ICAO level) to -20dBm in 5dB steps. At each predetermined beacon reply signal level the PMSE DM signal was increased until a Breaklock occurs.

6.3.3 A Breaklock was measured as follows: -

- Set beacon simulator to appropriate range.
- Set beacon simulator squitter/reply signal level (i.e.-50dBm).
- Increase PMSE DM Co-Channel signals until Interrogator Breaklock occurs (allow 60 seconds for Breaklock to occur).
- Record PMSE signal level.
- Record beacon Simulator signal level.

6.3.4 All Breaklock tests were undertaken in the presence of the Link-16 environment.

6.4 Off-Frequency Rejection (OFR) (Selectivity) of a PMSE DM Signal test

6.4.1 The Off-Frequency Rejection curve is produced by:

- Setting the beacon simulator signal level to the ASOP value
- Ensure the interrogator is locked onto the beacon signal

- Change the PMSE DM frequency in steps of 1MHz.

6.4.2 At each 1MHz step adjust the PMSE signal level until a breaklock occurs, and record that signal level.

7 DME INTERROGATOR TEST RESULTS

7.1 Pass/Fail Criteria

7.1.1 For the ASOP test, the interrogator must achieve ASOP at a signal level of -78dBm or greater. Lock must be obtained within the period specified by the manufacturer (typically 5 seconds).

7.1.2 For Breaklock and OFR tests there are no defined pass or fail criteria as they simply provide an indication of performance in the presence in PMSE DM signals.

7.2 Bendix/King KN-64 Test Results

7.2.1 PMSE Co-Channel ASOP Test on a Bendix/King KN-64

7.2.1.1 The following graphs show the results of the ASOP tests for the Bendix/King KN-64.

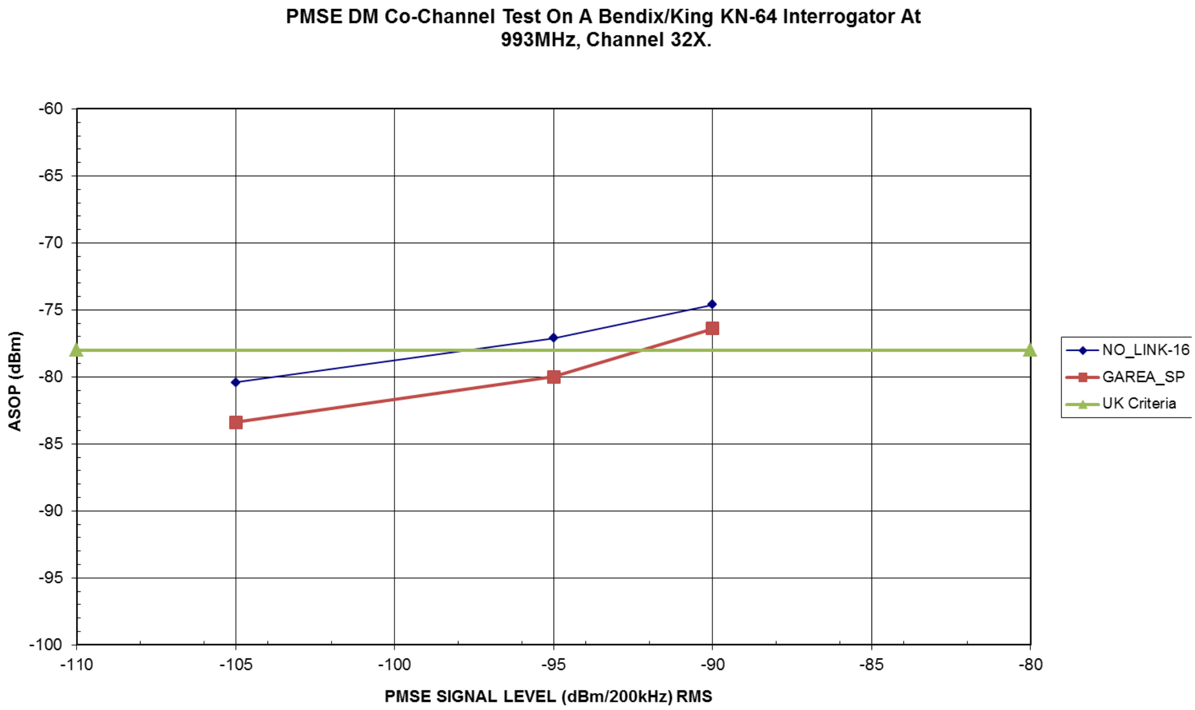


Figure 6-1 – Bendix/King KN-64 ASOP Test, X Channel

7.2.1.2 The ASOP test data for X mode indicates that a PMSE DM signal of -98dBm/200kHz RMS causes the No_Link-16 ASOP to fail the criteria. It can also be seen that the presence of the Link-16 environment improves the ASOP performance. The result for PMSE DM is marginally worse, by 3dB, than that recorded for PMSE CW.

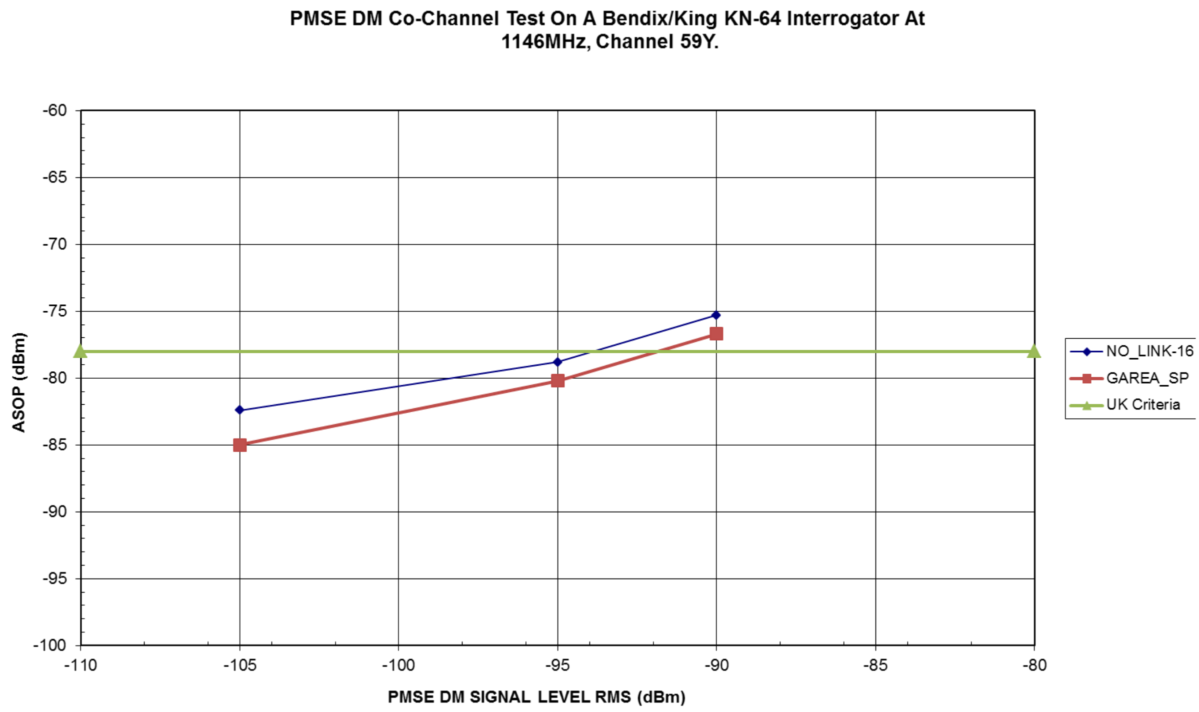


Figure 6-2 – Bendix/King KN-64 ASOP Test, Y Channel

7.2.1.3 The test data gathered for Y Mode, Figure 6-2, indicates that with a PMSE signal level of -94dBm/200kHz RMS, the No_Link-16 test meets the ASOP criteria of -78dBm. Again it can be seen that the Link-16 environment improves the ASOP performance of this DME interrogator type. For comparison the recorded PMSE CW signal is within 1dB.

7.2.2 PMSE Co-Channel Breaklock Test on a Bendix/King KN-64

7.2.2.1 Figure 6-3 below shows the relationship between the received signal strength from the DME Beacon and the signal level of PMSE DM necessary to cause Breaklock.

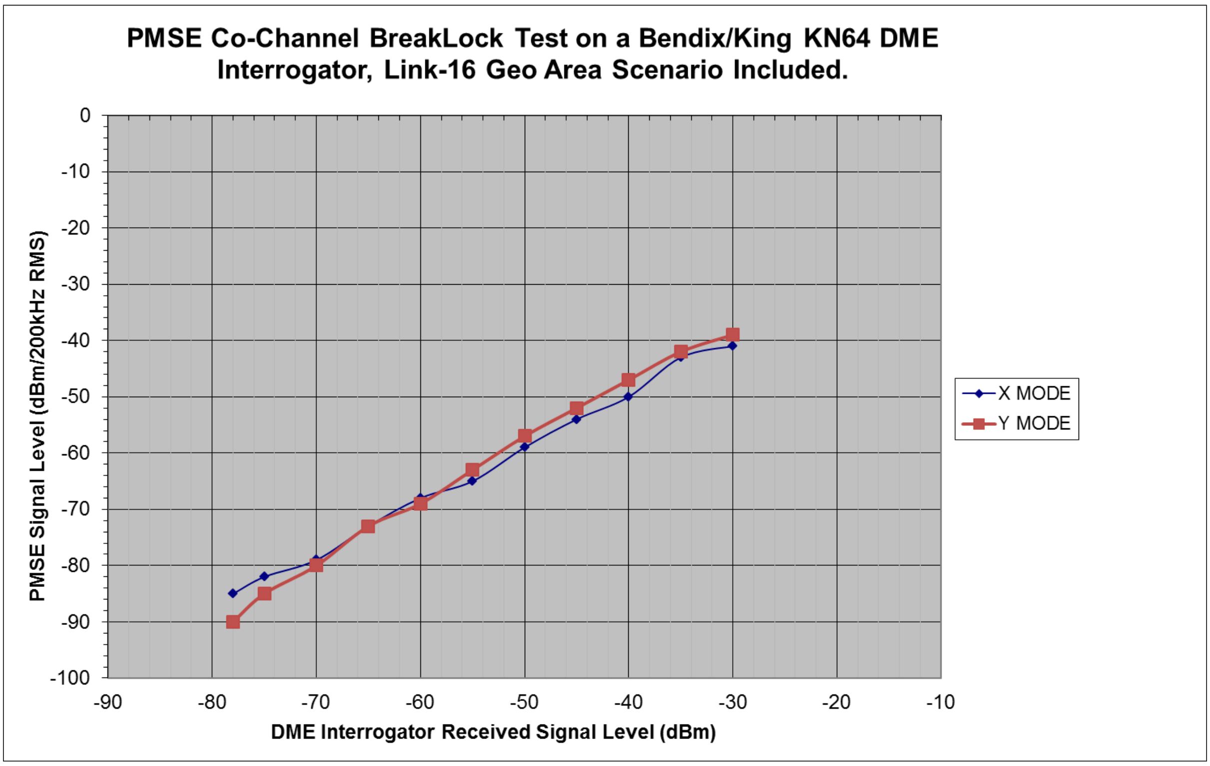


Figure 6-3 - Bendix/King KN-64 Breaklock Test

7.2.2.2 This breaklock data shows PMSE DM Co-Channel signal that causes a Bendix/King KN64 to breaklock while locked on to a DME Ground Beacon. The graph is approximately linear and shows that a 6dB increase in PMSE DM power causes a 6dB increase in the required received signal in order to maintain lock. This is a similar result to that found with PMSE CW.

7.2.2.3 Both X-mode and Y-mode are shown in Figure 6-3.

7.2.3 Bendix/King KN64 Off-Frequency Rejection (OFR)

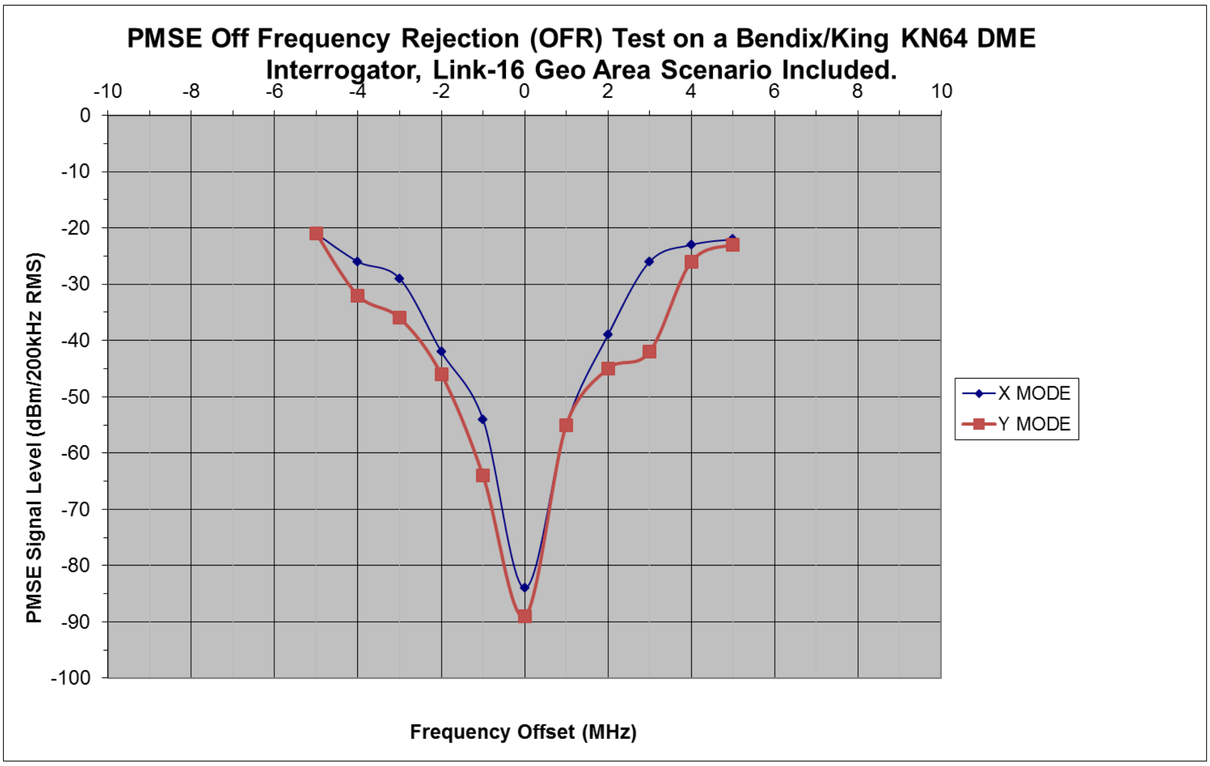


Figure 6-4 - Bendix/King KN64 Off-Frequency Rejection (OFR) Curve

7.2.3.1 Figure 6-4 shows that a breaklock will occur at a PMSE DM signal level of greater than -65dBm/200kHz RMS at a frequency 1MHz below the Beacon Reply frequency (CH-59Y, 1146MHz).

7.3 Rockwell Collins DME 900 Test Results

7.3.1 PMSE Co-Channel ASOP Test on a Rockwell Collins DME 900

7.3.1.1 The following graphs show the results of the ASOP tests for the Rockwell Collins DME 900.

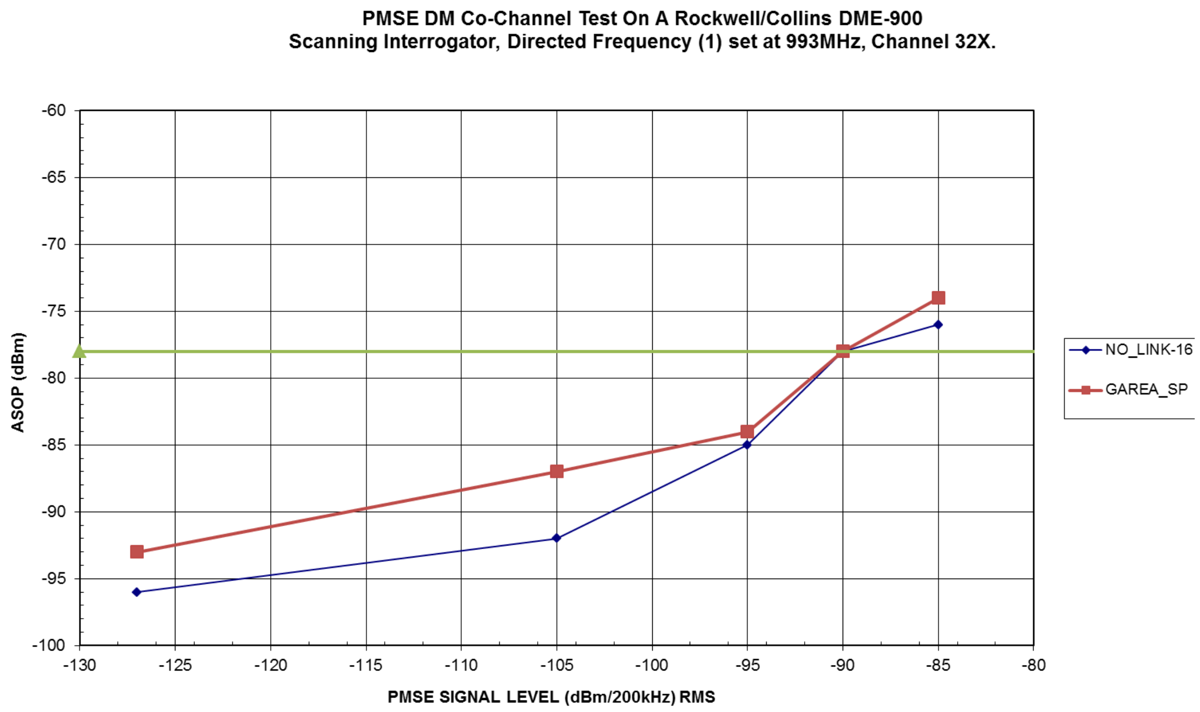


Figure 6-5 – Rockwell Collins DME 900 ASOP Test, X Channel

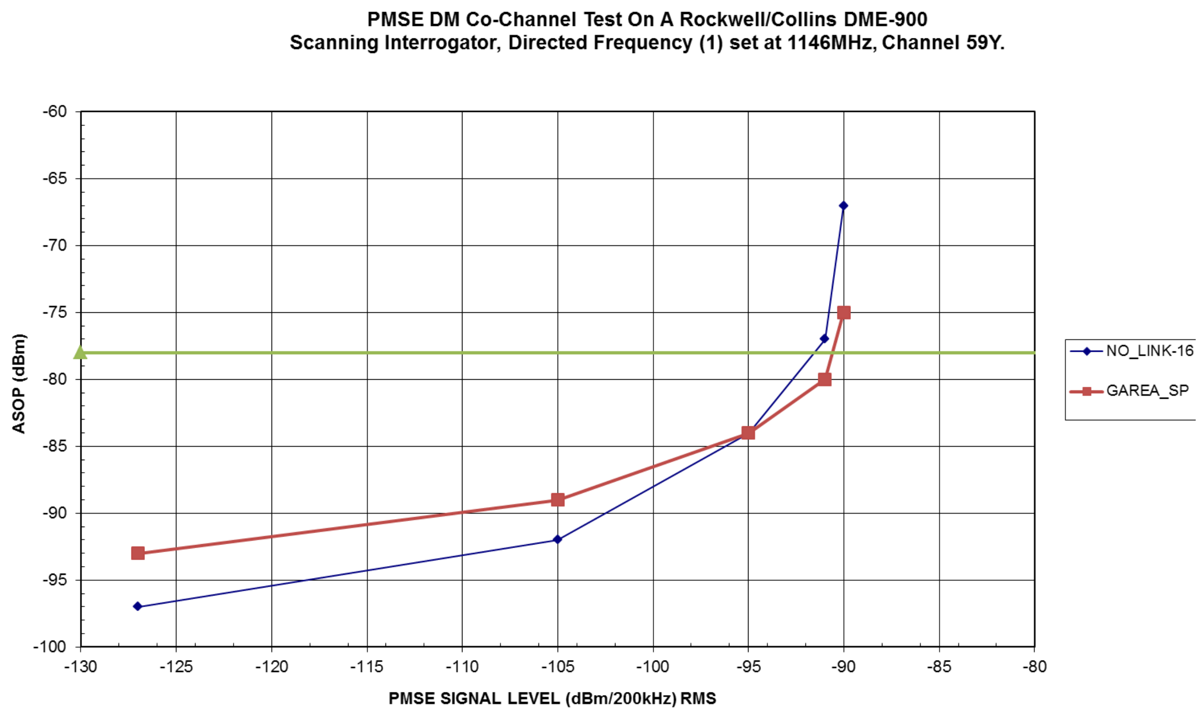


Figure 6-6 – Rockwell Collins DME 900 ASOP Test, Y Channel

7.3.1.2 The test data shows that for both X and Y mode the Rockwelll Collins DME-900 scanning interrogator meets the ICAO Annex 10 derived criteria (ASOP achieved at -78dBm) with PMSE DM signals no greater than -92dBm/200kHz RMS.

7.3.1.3 The ASOP performance of the Rockwell Collins DME 900 is improved within a Link-16 environment. The PMSE DM Co-Channel signals should be no greater than -90dBm/200kHz RMS.

7.3.2 PMSE Co-Channel Breaklock Test on a Rockwell Collins DME 900

7.3.2.1 Figure 6-7 below shows the relationship between the received signal strength from the DME Beacon and the level of PMSE necessary to cause Breaklock.

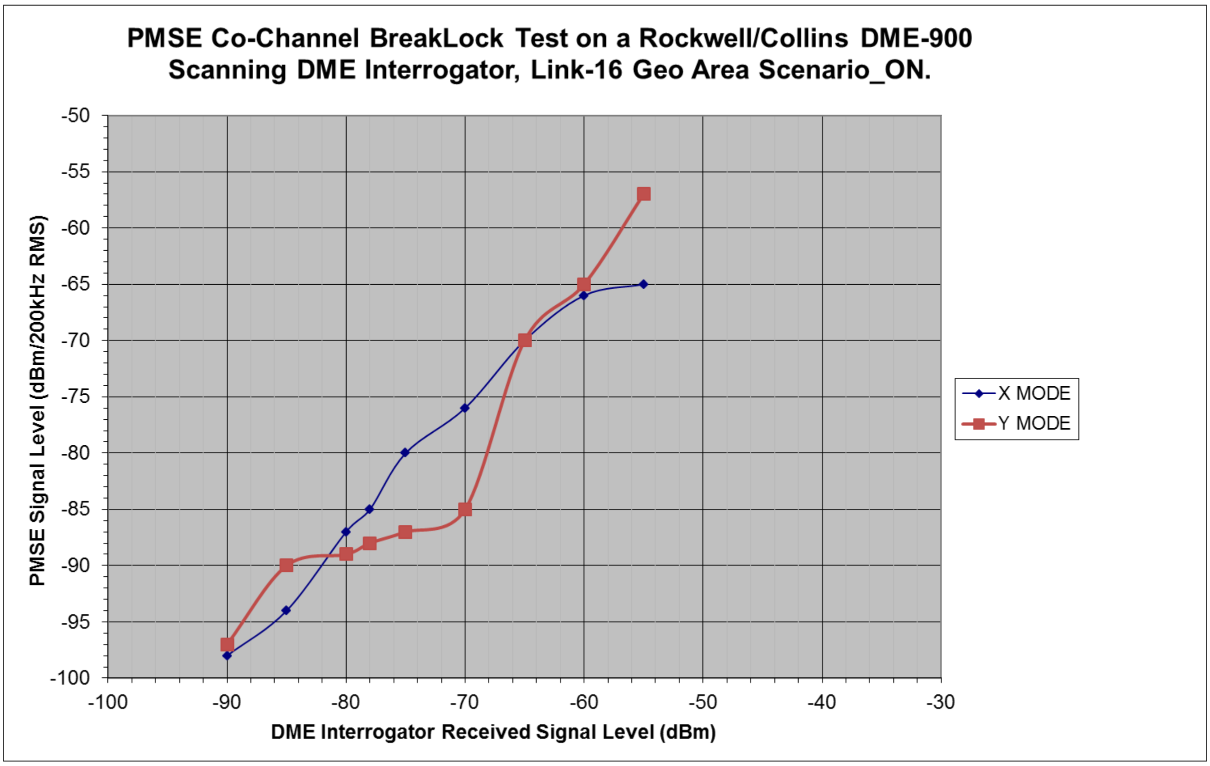


Figure 6-7 - Rockwell Collins DME 900 Breaklock Test

7.3.2.2 This breaklock data shows PMSE DM Co-Channel signal levels that cause a Rockwell Collins DME 900 to breaklock while locked on to a DME Ground Beacon. The graph for X-mode is approximately linear, however Y-mode sows a variation in the performance dependant on the power level of the received PMSE DM signal.

7.3.2.3 The breaklock result is similar to that found in previous testing of the Rockwell Collins DME 900 when a PMSE CW signal was used.

7.3.3 Rockwell Collins DME 900 Off-Frequency Rejection (OFR)

7.3.3.1 The OFR curve was measured in the same way as for the Bendix/King KN64. The measured results are shown below in Figure 6-8.

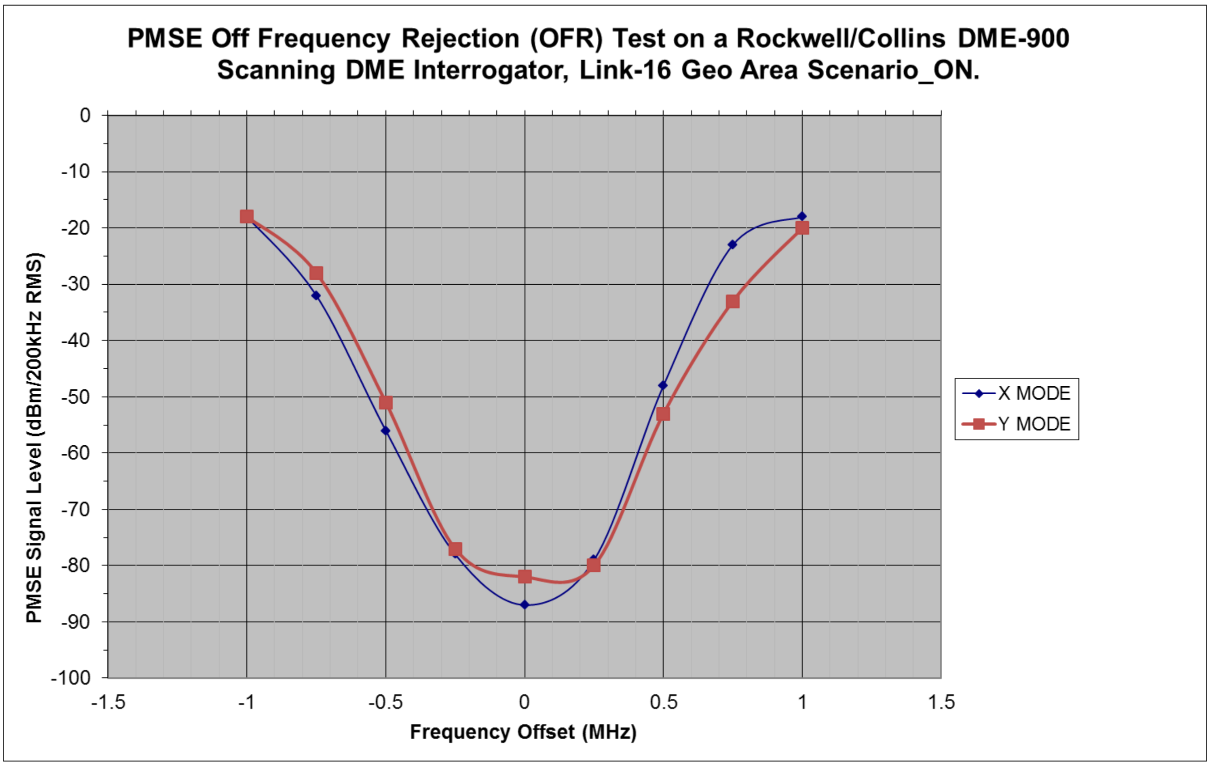


Figure 6-8 - Rockwell Collins DME 900 Off-Frequency Rejection (OFR) Curve

7.3.3.2 A PMSE DM signal of greater than -20dBm/200kHz RMS at a frequency 1MHz offset from the Beacon Reply frequency causes a breaklock. The OFR curves measured for this Scanning DME 900 Interrogator indicates it will have a much better rejection of PMSE signals than previously tested single channel DME Interrogators.

8 CONCLUSIONS

8.1 DME Beacon Testing

8.1.1 The DME Beacon test data recorded for the two different beacon types indicates that PMSE DM Co-Channel signal levels greater than -110dBm/200kHz RMS received at a DME beacon receiver input will have an impact on BRE performance. The signal environment used for this testing was based on a typical UK DME pulse load, a typical UK Link-16 pulse load and 4 PMSE DM co-channel signals.

8.1.2 This result is better than the -115dBm reported when a PMSE CW signal was used as the interfering signal. From the data gathered it can be concluded that a PMSE DM signal is no worse for a DME beacon than a PMSE CW signal, and in most cases it causes less of an effect.

8.1.3 As with the original OFR testing the PMSE DM curves can be used to reduce the impact on DME beacon reply efficiency performance. The results of the selectivity testing indicate that offsetting a PMSE DM signal by more than 2MHz will provide an additional 20dB margin for PMSE signals.

8.1.4 A summary of the DME Beacon testing data is shown below (The co-channel, 4 PMSE signal results are displayed in RED). The offset data is generated from the OFR curves which used a single PMSE signal.

Table 8-1 DME Beacon Summary

	PMSE RMS Power in 200kHz BW[dBm]			
	Full Pulse Environment			
	Fernau 2020		Thales 415	
Offset [MHz]	X Mode	Y Mode	X Mode	Y Mode
-5	-52	-38	-39	-45
-4	-72	-48	-48	-58
-3	-81	-64	-62	-69
-2	-87	-76	-73	-76
-1	-98	-91	-88	-91
0	-104/-110	-98/-108	-103/-106	-105/-108
1	-98	-90	-89	-88
2	-84	-80	-78	-73
3	-71	-72	-70	-61
4	-56	-64	-56	-46
5	-46	-54	-44	-38

8.2 DME Interrogator Testing

8.2.1 The DME Interrogator test data indicates that PMSE co-channel signal levels greater than -98dBm/200kHz RMS received at a DME Interrogator receiver result in a change in ASOP performance below the defined criteria.

8.2.2 The results of the OFR testing indicate that offsetting a PMSE DM signal by more than 1MHz will provide an additional 20dB margin.

8.2.3 These results are very similar, within 1dB, to those found when testing with a PMSE CW signal.

8.2.4 A summary of the DME Beacon testing data is shown below (The co-channel, 4 PMSE signal results are displayed in RED). The offset data is generated from the OFR curves which used a single PMSE signal.

Table 8-2 DME Interrogator Summary

	PMSE RMS Power in 200kHz BW[dBm/200kHz]			
	Full Pulse Environment			
	Bendix/King KN-64		Rockwell Collins DME 900	
Offset [MHz]	X Mode	Y Mode	X Mode	Y Mode
-5	-21	-21		
-4	-26	-32		
-3	-29	-36		
-2	-42	-46		
-1	-54	-64	-18	-18
-0.75			-32	-28
-0.5			-56	-51
-0.25			-78	-77
0	-84/-93	-89/-92	-87/-90	-82/-92
0.25			-79	-80
0.5			-48	-53
0.75			-23	-33
1	-55	-55	-18	-20
2	-39	-45		
3	-26	-42		
4	-23	-26		
5	-22	-23		

8.2.5 The results of breaklock testing show that the level of PMSE interference required to cause a breaklock is proportional to the DME reply power received by the interrogator.

8.2.6 The PMSE power required to cause breaklock is between 3dB and 15dB stronger than the level which prevents a lock being acquired. Hence if PMSE interference causes breaklock, the interrogator will be unable to re-acquire lock until the interference is reduced or removed.