

RTCA Special Committee 186, Working Group 5

ADS-B UAT MOPS (DO-282), Revision A

Meeting #15

Diplexer Testing Effort

Presented by: Tom Pagano

April 23, 2003

FAA WJ Hughes Technical Center

Purpose and Scope

- Investigate Feasibility to share UAT ADS-B Transceiver with ATCRBS/Transponder Antenna
 - Eliminate need for additional antenna for UAT Equipage
 - Application to existing and new installations
 - Air Transport and GA applicability
- Use of Diplexer with Characteristics for UAT and Transponder Operation
 - UAT passband required at 978 MHz
 - Transponder passband required at 1030 and 1090 MHz
- Conduct Tests to Validate Concept and Produce Requirements for Usage

Activities

- Diplexer Industry – Government Team Established
 - Two Telecons held to date
 - Draft Test Plan reviewed
- Diplexer Bench Testing Proceeding
 - Diplexer Characteristics Measurements
 - UAT Performance via diplexer
 - Transponder Performance via diplexer

Activities (2)

- Bench Testing Systems Prepared
 - DATAS Transponder Test Support Capability
 - Calibration
 - Maintenance/Repair
 - ATCRBS and Mode S Transponders Equipment Setup
 - Honeywell Mode S Transponder
 - Rockwell Collins Mode S Transponder
 - Narco AT-150 and AT-155 ATCRBS Transponders
 - Bendix King KT-76A and KT-76C ATCRBS Transponders
 - Garmin GTX-330 Mode S Transponder

Methodology

- Conduct Bench Tests according to Test Plan
- Measure and Characterize Prototype Diplexers
- Evaluate UAT and ATCRBS/Mode S Transponder Performance
 - Verify no performance degradation to UAT and Transponder due to diplexer – diplexer usage impact would solely be the signal power loss through the diplexer

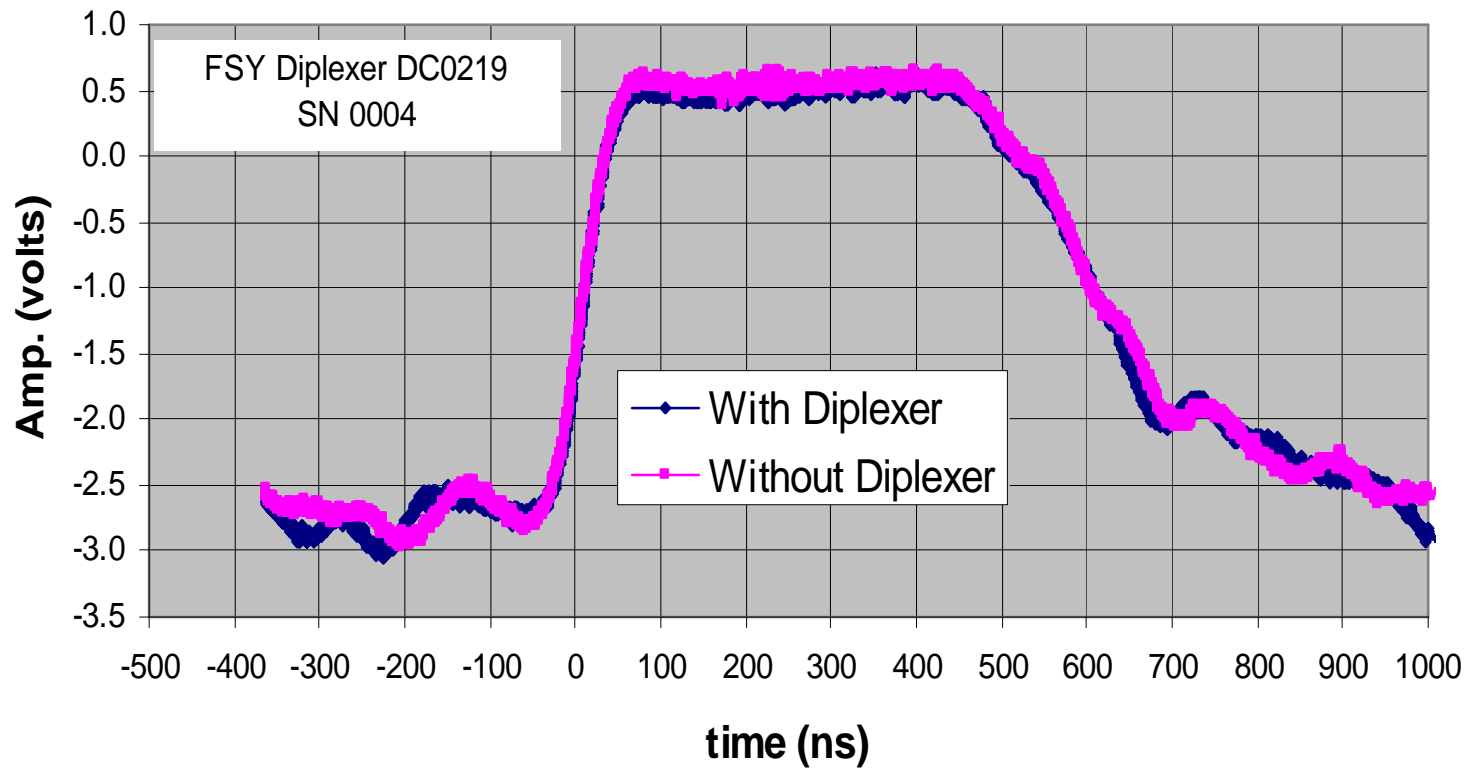
Bench Testing Results

- Interim results
 - Diplexer Characterization
 - UAT Performance Measurements
 - ATCRBS/Mode S Transponder Measurements
 - DATAS Calibrated and Readied for Testing
 - Standard Interrogation and Reply Characteristics Measured on 3 Transponders
 - Captured Reply Pulses through Diplexer Received and Viewed at Log Receiver

Potential Outcomes of Test Effort

- Include diplexer requirements as a normative Appendix to DO-282A to cover diplexer under TSO-C154
- Perform flight test at FAATC to demonstrate no perceptible functional degradation of TXPDR or UAT and document in an FAATC report.
- Issue advisory circular for guidance on adapting diplexer to individual installations.

Mode S Transponder - 1st Pulse ATCRBS Reply Honeywell SN 95120215



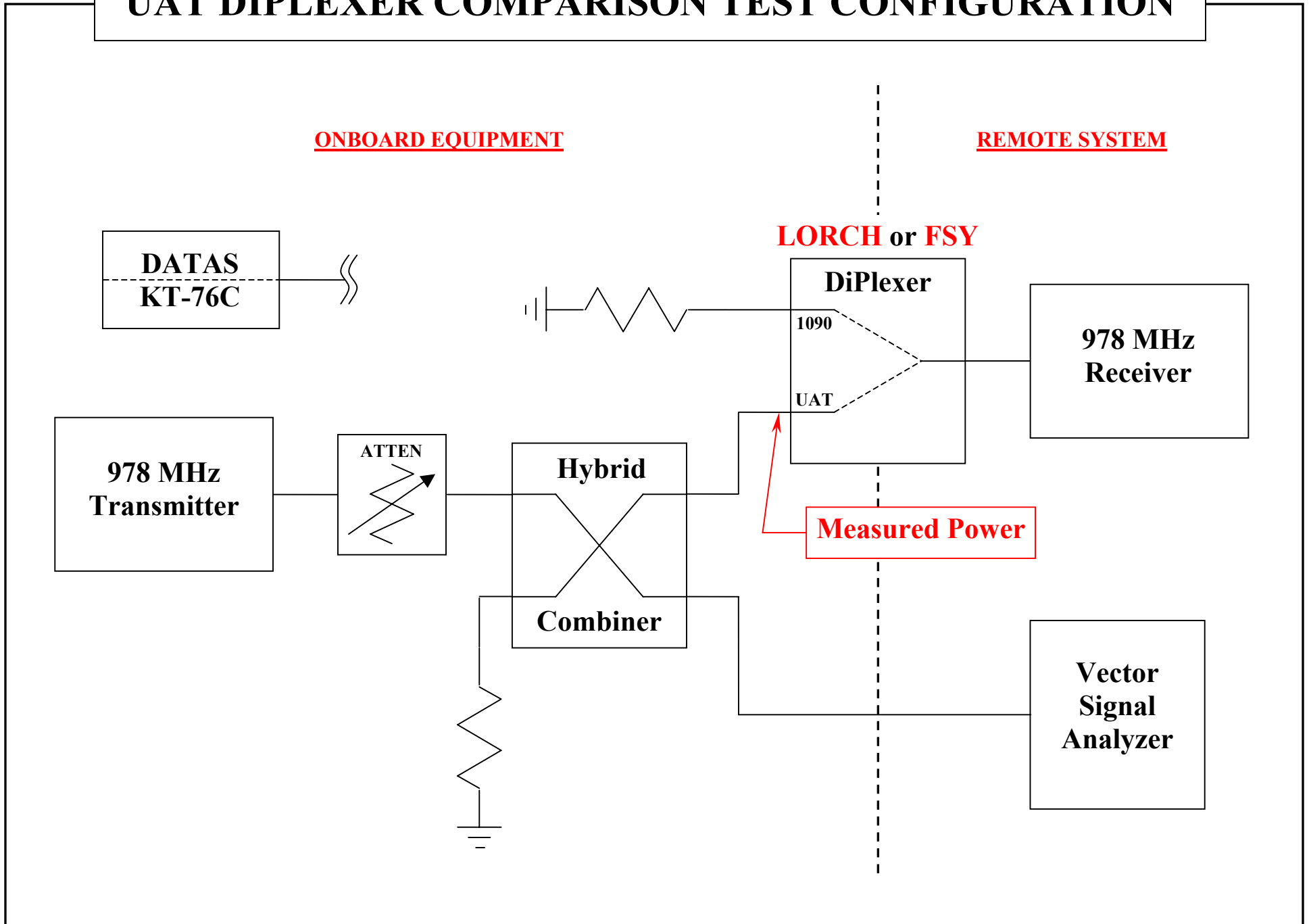
Diplexer Testing Issues

- Diplexer specs are a concern
 - Prototype specs based on engineering analysis
 - Concerns were raised that production units to meet the prototype specs may be difficult and costly
 - Recommendation made to examine reasonable limits to diplexer specs
 - Will be contacting diplexer manufacturer to provide feedback on specs effect on production

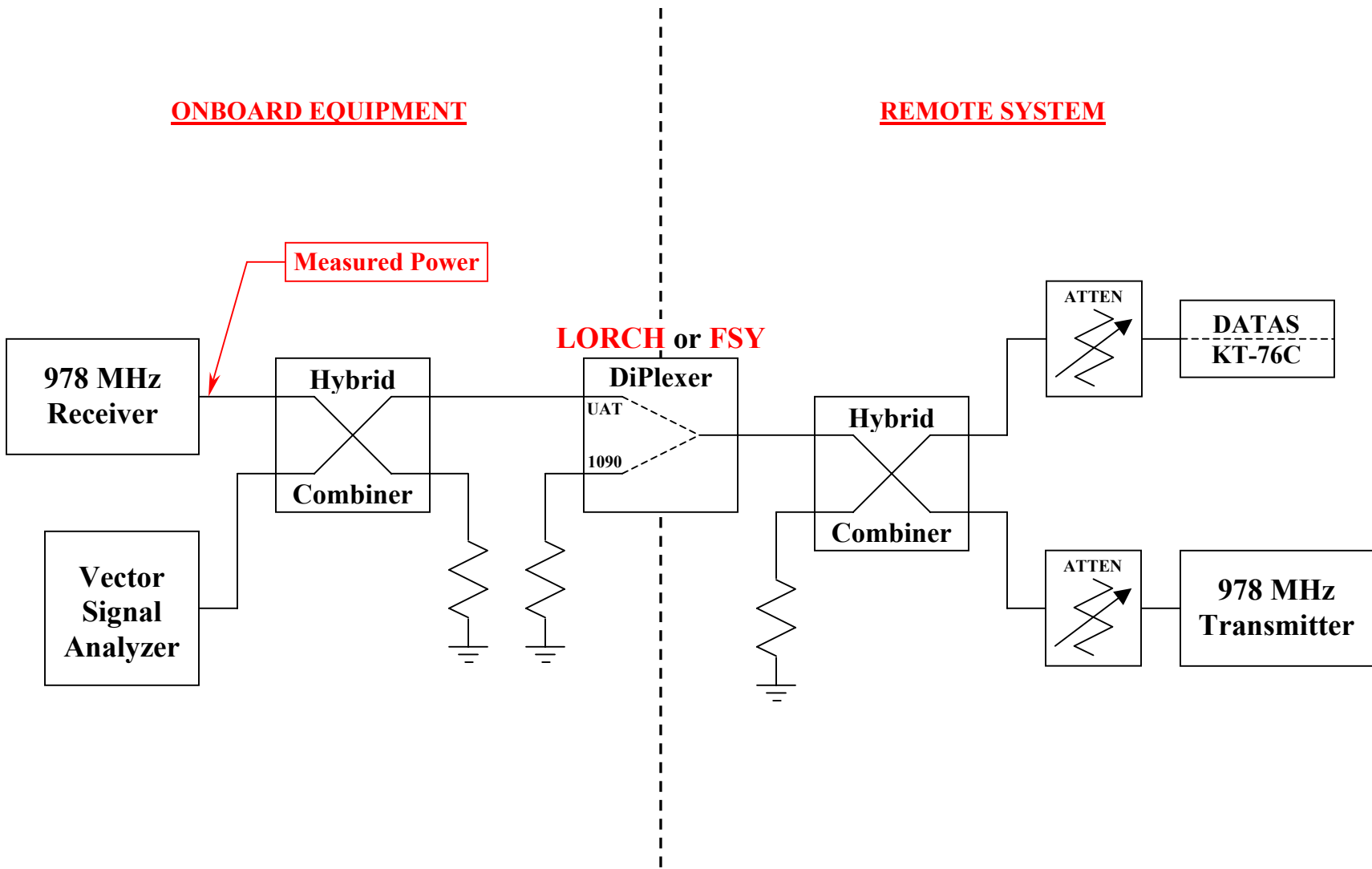
Diplexer Testing Issues (2)

- Loss Across Diplexer a Concern
 - Transponder manufacturer pointed out that allocated loss from transponder to antenna may not allow diplexer insertion
 - MOPS allot up to 3 dB cable loss but manufacturer can require lower loss allotment to trade equipment performance for installation requirements
 - Concern that some current installations even with 3 dB allowance may have used up allocation and not enough margin to insert diplexer

UAT DIPLEXER COMPARISON TEST CONFIGURATION



UAT DIPLEXER TESTING CONFIGURATION



FSY Diplexer – Channel 1 (UAT) Port to Antenna Port

Reference = -30dBm. Marker @ 1090 MHz.

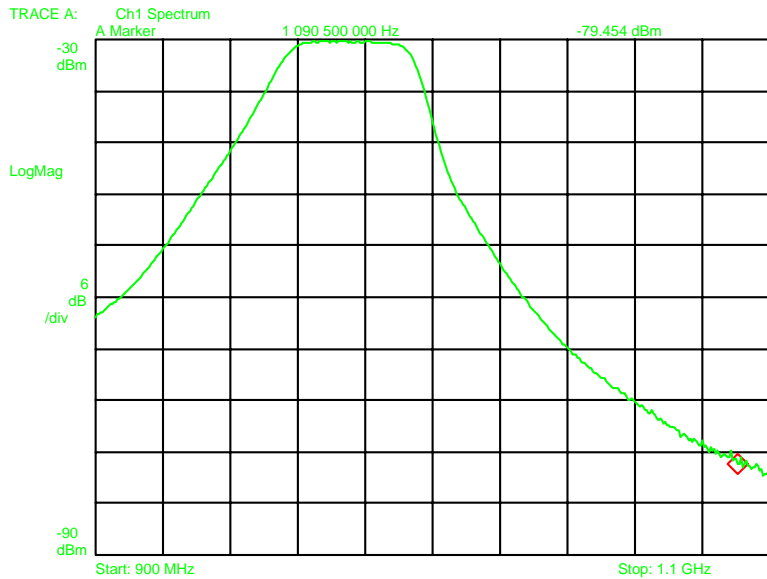
- Passband loss is about 0.30 dB

Lorch Diplexer – Channel 1 (UAT) Port to Antenna Port

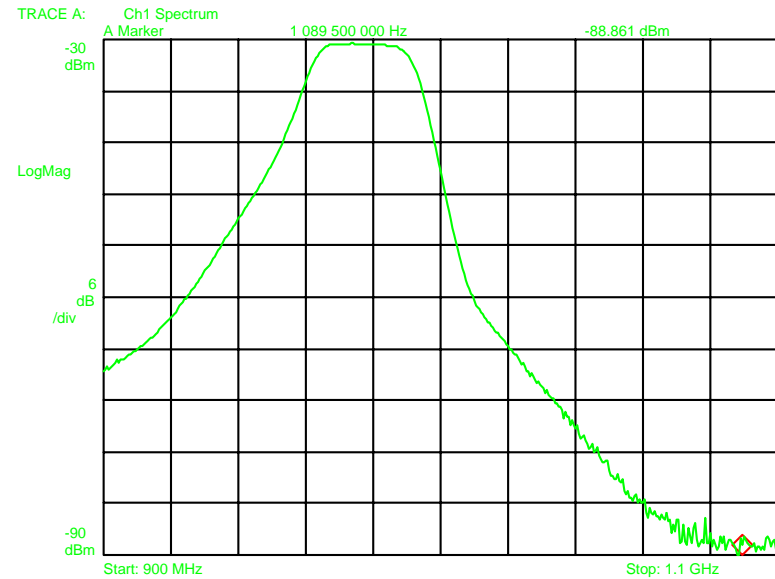
Reference = -30dBm. Marker @ 1090 MHz.

- Passband loss is about 0.57 dB

Date: 03-27-03 Time: 17:55



Date: 04-01-03 Time: 10:36



FSY Diplexer – Channel 2 (1090) Port to Antenna Port

Reference = -30dBm. Marker @ 978 MHz.

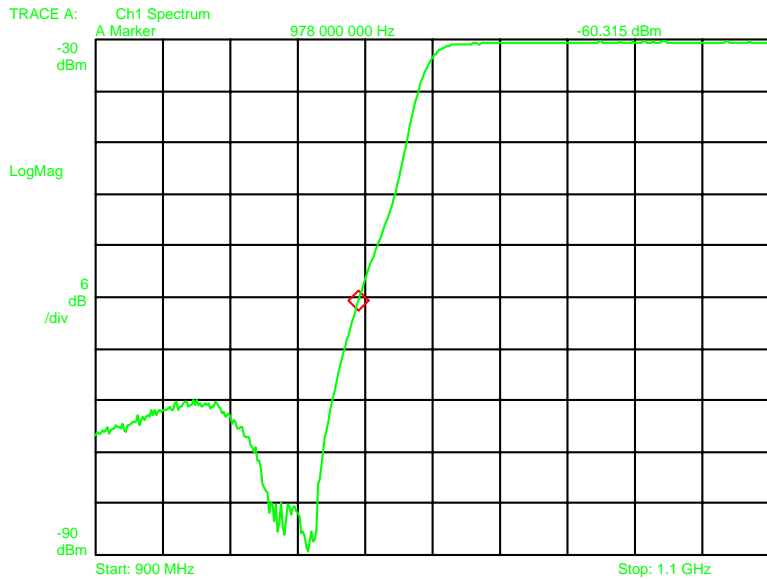
- Passband loss is about 0.40 dB

Lorch Diplexer – Channel 2 (1090) Port to Antenna Port

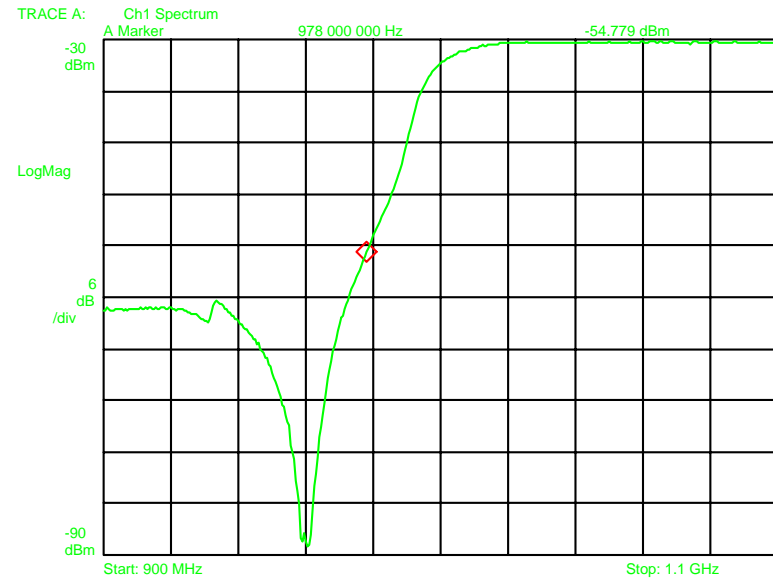
Reference = -30dBm. Marker @ 1090 MHz.

- Passband loss is about 0.42 dB

Date: 03-28-03 Time: 09:31



Date: 04-01-03 Time: 11:01



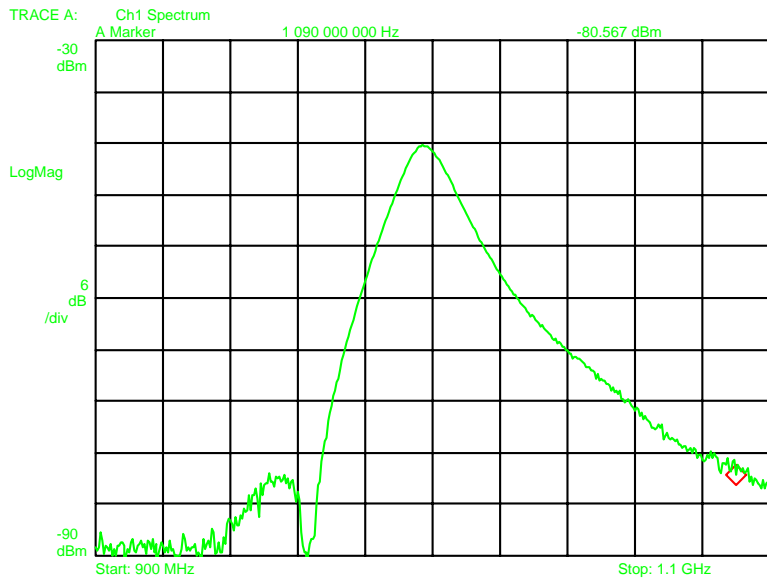
**FSY Diplexer – Channel 1 (UAT) Port to Channel 2 (1090) Port
Reference = -30dBm. Marker @ 1090 MHz.**

- ~31 dB Rejection of 978 MHz from Channel 2(1090) at Channel 1 (UAT)

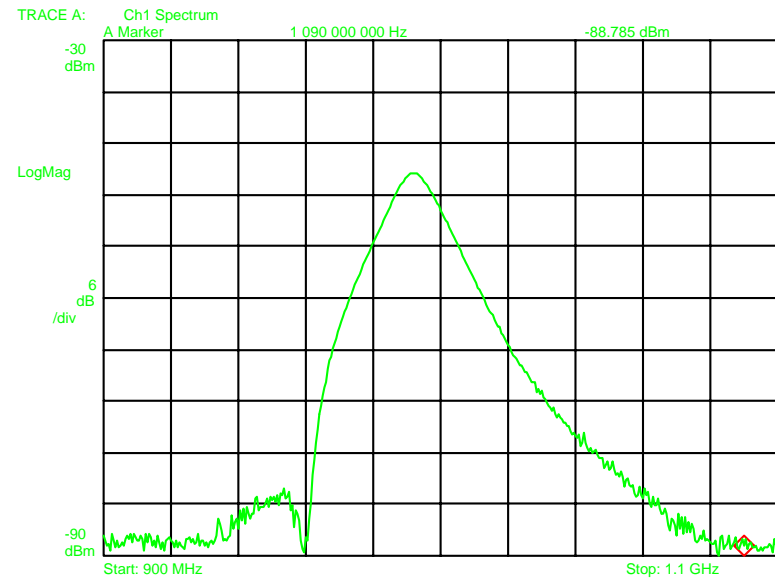
**Lorch Diplexer – Channel 1 (UAT) Port to Channel 2 (1090) Port
Reference = -30dBm. Marker @ 1090 MHz.**

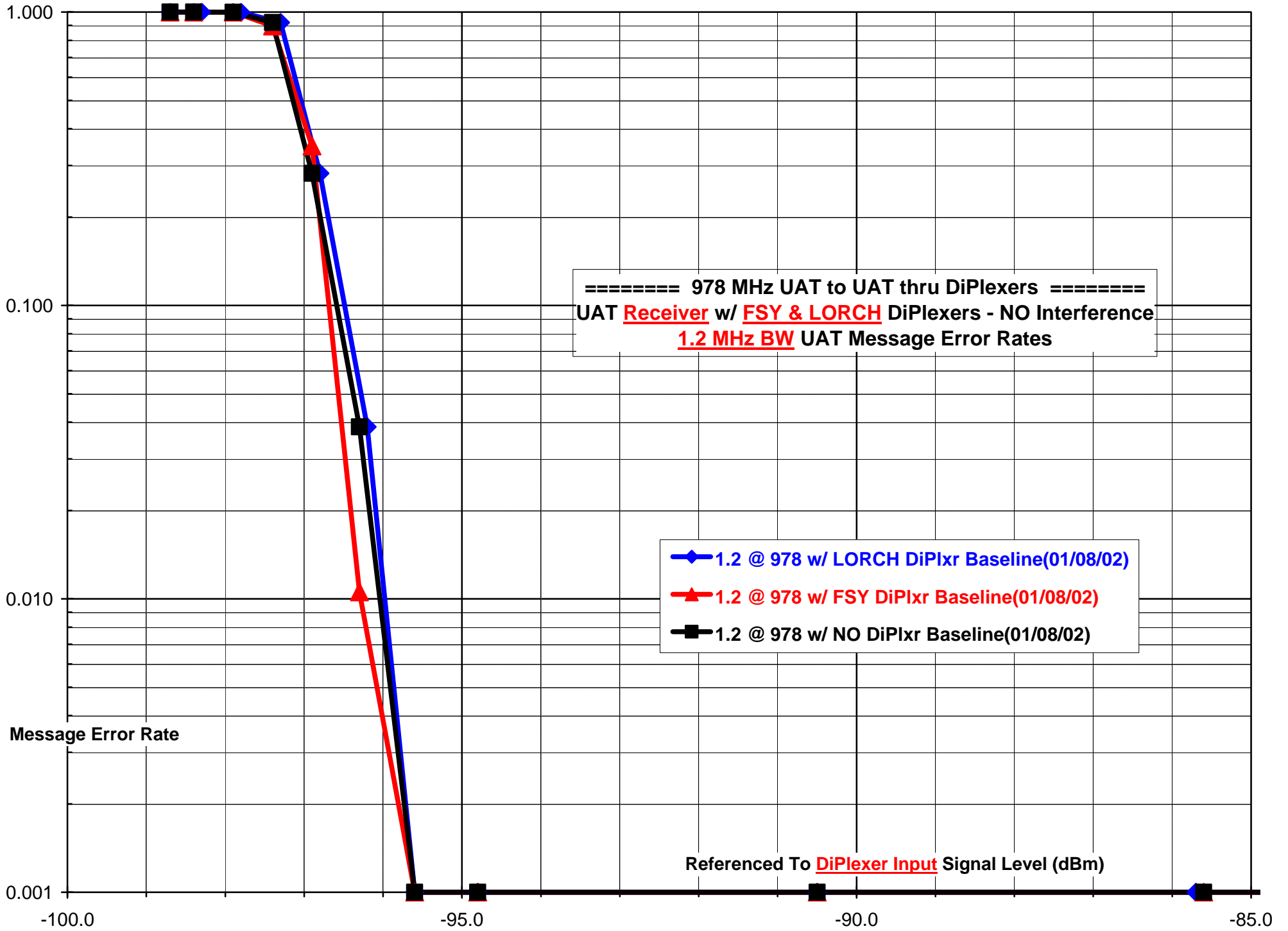
- ~25 dB Rejection of 978 MHz from Channel 2(1090) at Channel 1 (UAT)

Date: 03-28-03 Time: 10:08



Date: 04-01-03 Time: 11:23





=====**978 MHz UAT to UAT thru DiPlexers**=====

UAT Receiver w/ FSY & LORCH DiPlexers - NO Interference

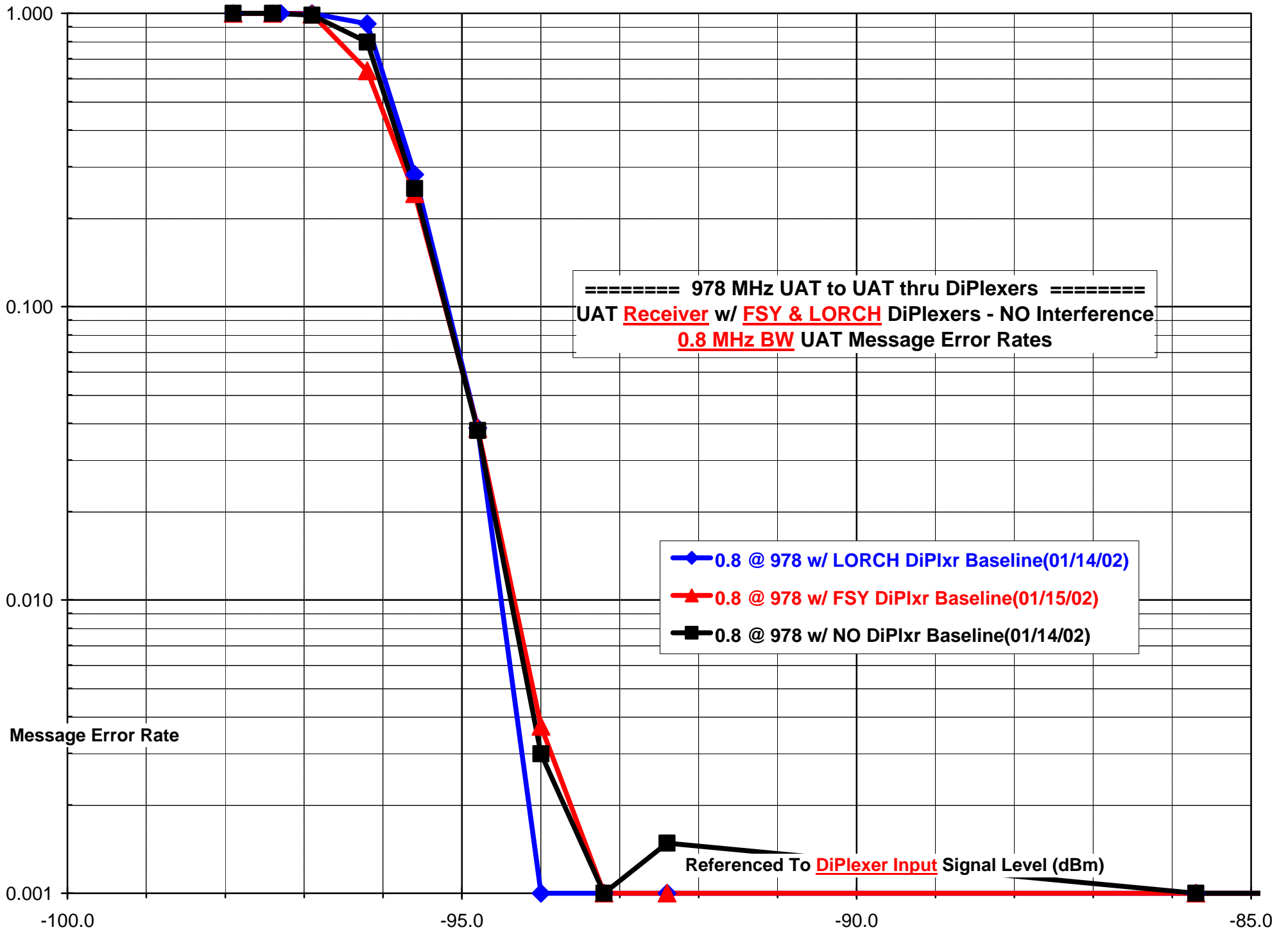
1.2 MHz BW UAT Message Error Rates

◆ 1.2 @ 978 w/ LORCH DiPlxr Baseline(01/08/02)

▲ 1.2 @ 978 w/ FSY DiPlxr Baseline(01/08/02)

■ 1.2 @ 978 w/ NO DiPlxr Baseline(01/08/02)

Referenced To **DiPlexer Input** Signal Level (dBm)

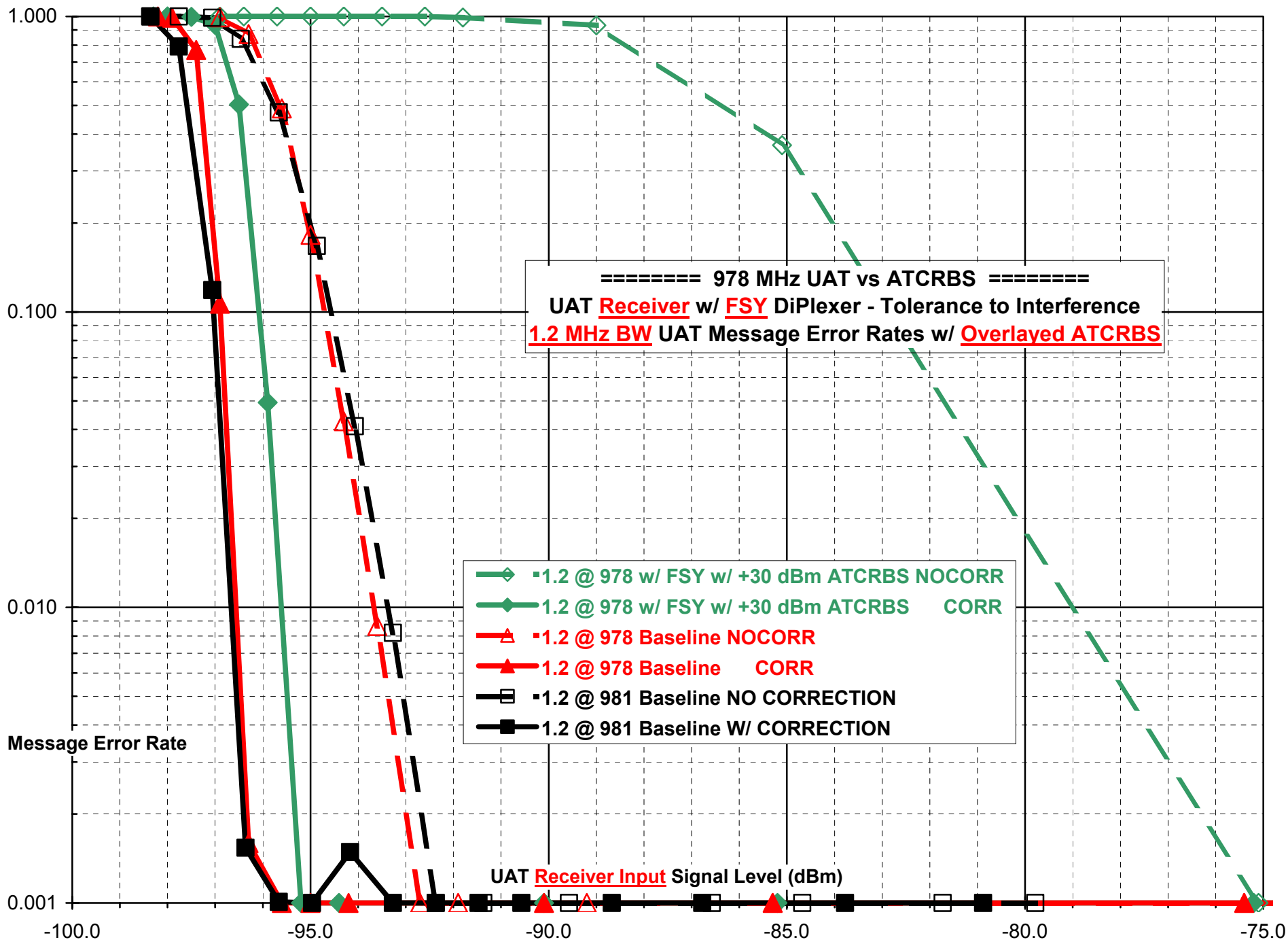


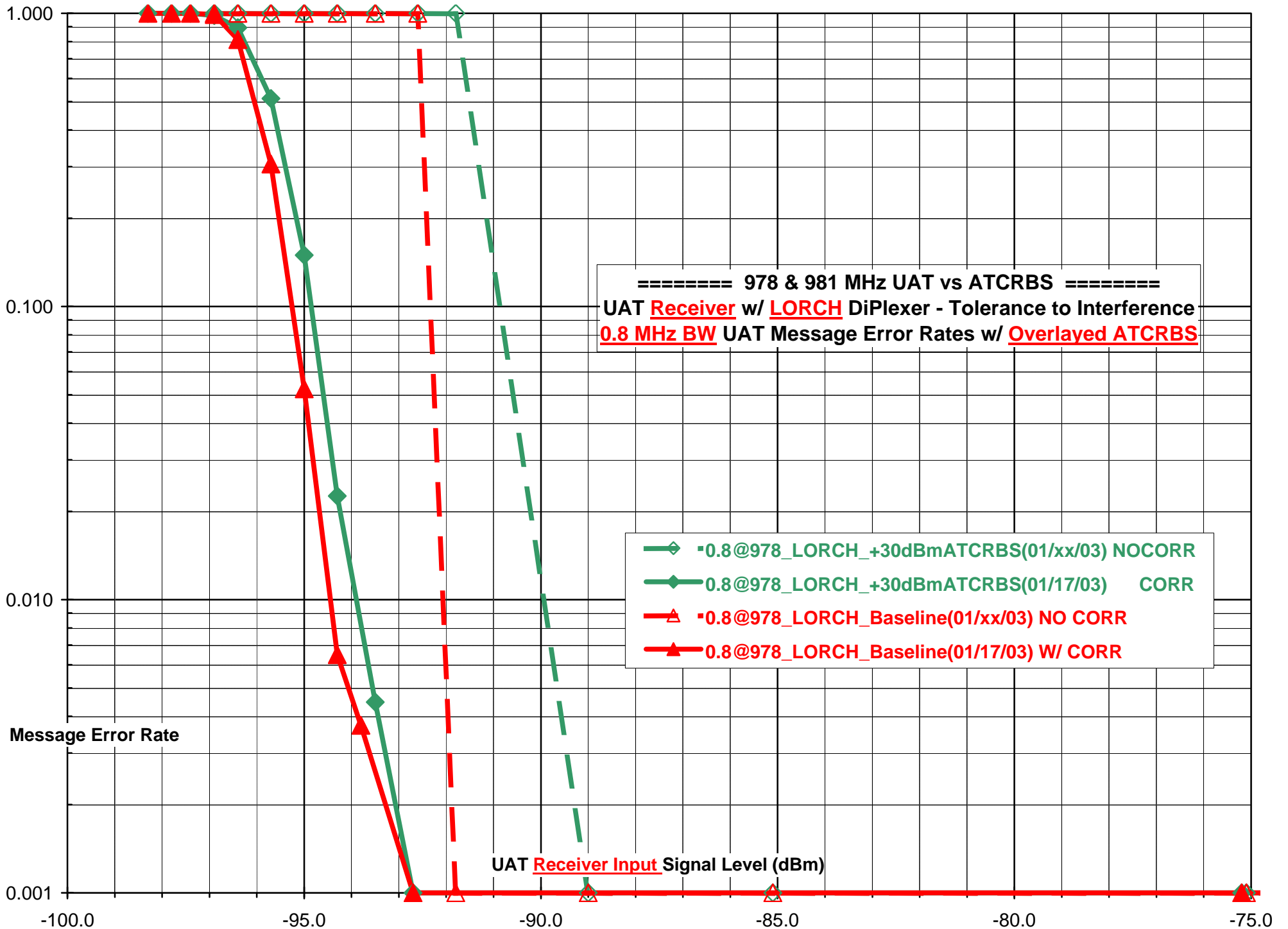
=====
978 MHz UAT to UAT thru DiPlexers
=====
UAT Receiver w/ FSY & LORCH DiPlexers - NO Interference
0.8 MHz BW UAT Message Error Rates

◆ 0.8 @ 978 w/ LORCH DiPlxr Baseline(01/14/02)
▲ 0.8 @ 978 w/ FSY DiPlxr Baseline(01/15/02)
■ 0.8 @ 978 w/ NO DiPlxr Baseline(01/14/02)

Message Error Rate

Referenced To DiPlexer Input Signal Level (dBm)





=====**978 & 981 MHz UAT vs ATCRBS**=====

UAT Receiver w/ LORCH DiPlexer - Tolerance to Interference

0.8 MHz BW UAT Message Error Rates w/ Overlaid ATCRBS

◆ 0.8@978_LORCH_+30dBmATCRBS(01/xx/03) NOCORR

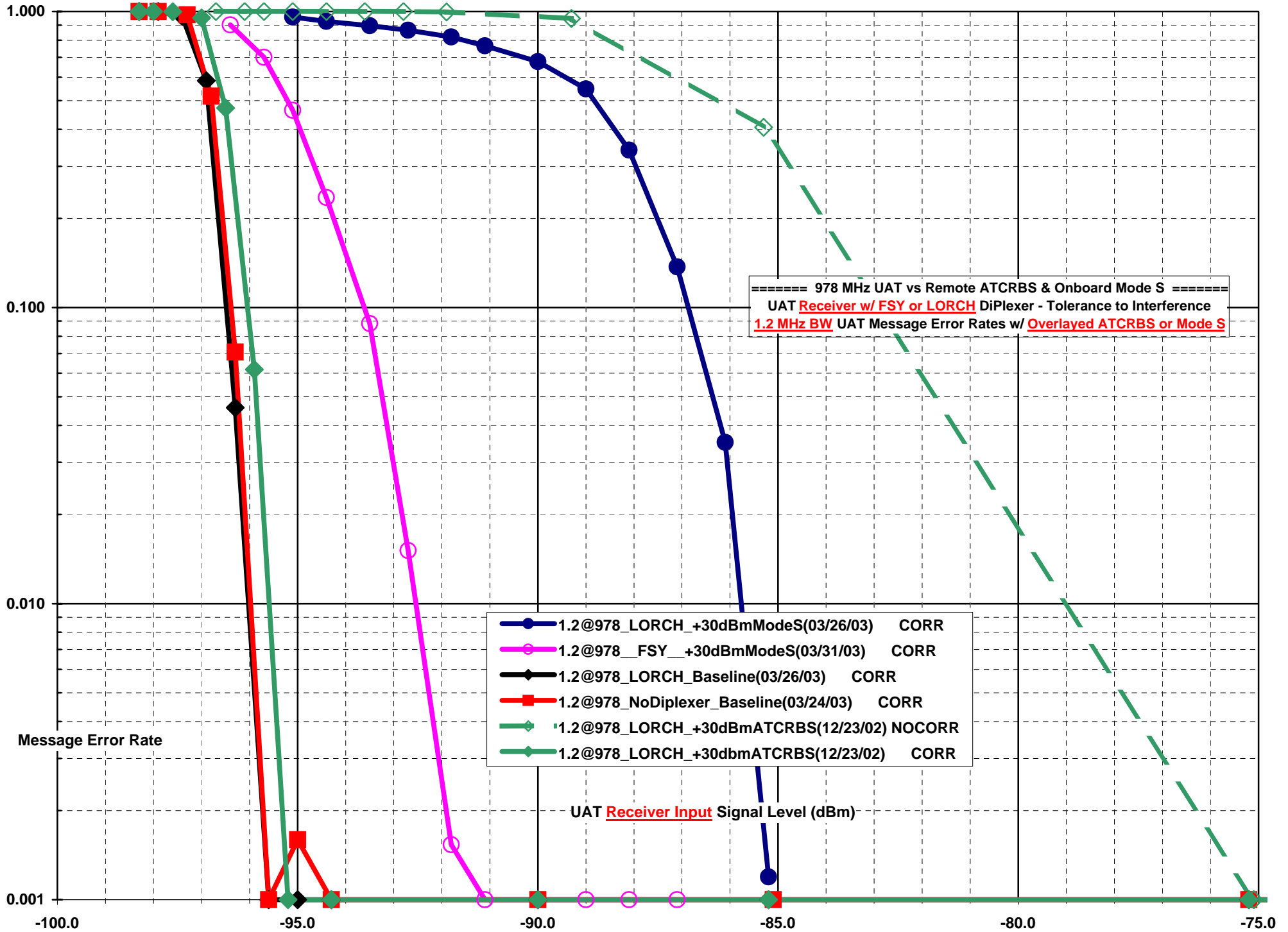
◆ 0.8@978_LORCH_+30dBmATCRBS(01/17/03) CORR

▲ 0.8@978_LORCH_Baseline(01/xx/03) NO CORR

▲ 0.8@978_LORCH_Baseline(01/17/03) W/ CORR

Message Error Rate

UAT Receiver Input Signal Level (dBm)



===== 978 MHz UAT vs Remote ATCRBS & Onboard Mode S =====
UAT Receiver w/ FSY or LORCH DiPlexer - Tolerance to Interference
1.2 MHz BW UAT Message Error Rates w/ Overlaid ATCRBS or Mode S

- 1.2@978_LORCH_+30dBmModeS(03/26/03) CORR
- 1.2@978_FSY_+30dBmModeS(03/31/03) CORR
- 1.2@978_LORCH_Baseline(03/26/03) CORR
- 1.2@978_NoDiplexer_Baseline(03/24/03) CORR
- 1.2@978_LORCH_+30dBmATCRBS(12/23/02) NOCORR
- 1.2@978_LORCH_+30dbmATCRBS(12/23/02) CORR

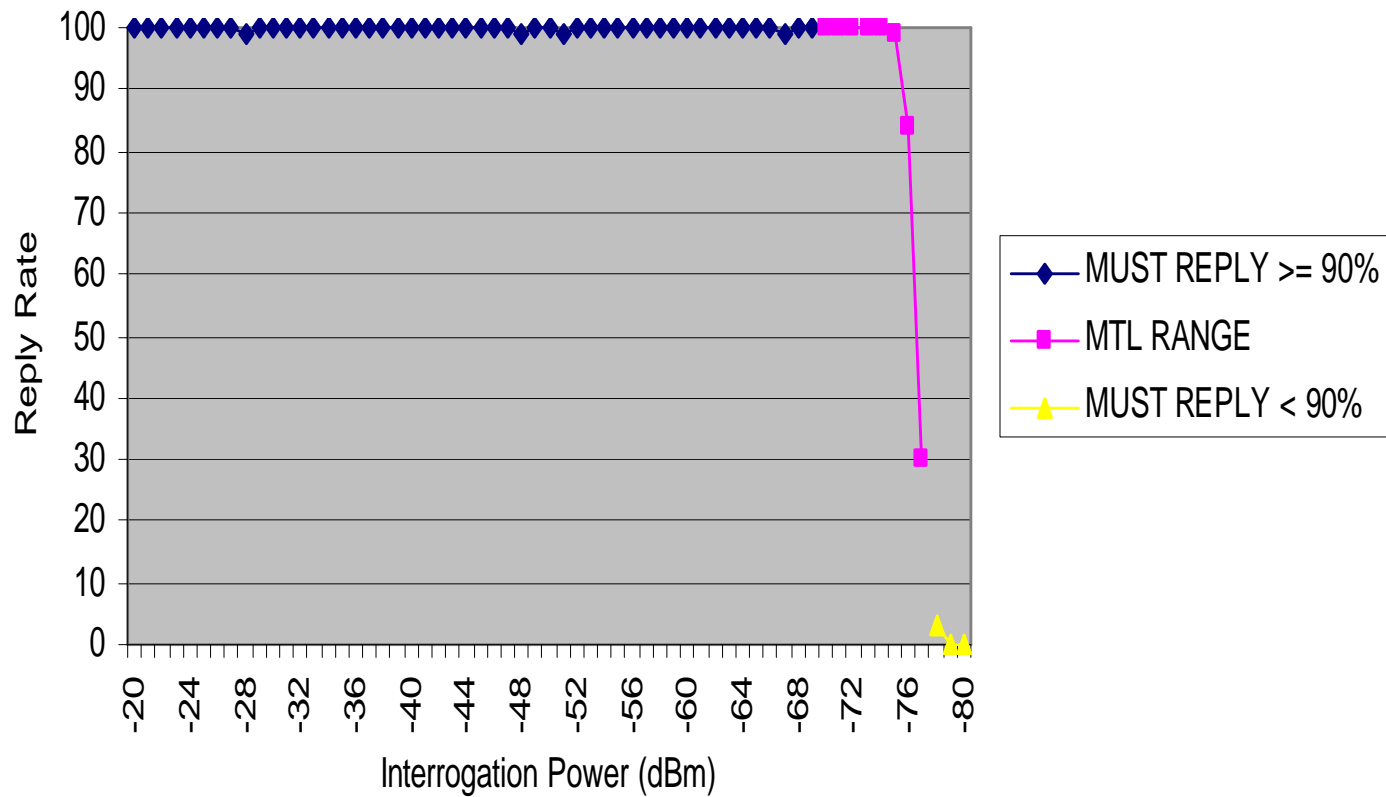
UAT Receiver Input Signal Level (dBm)

Message Error Rate

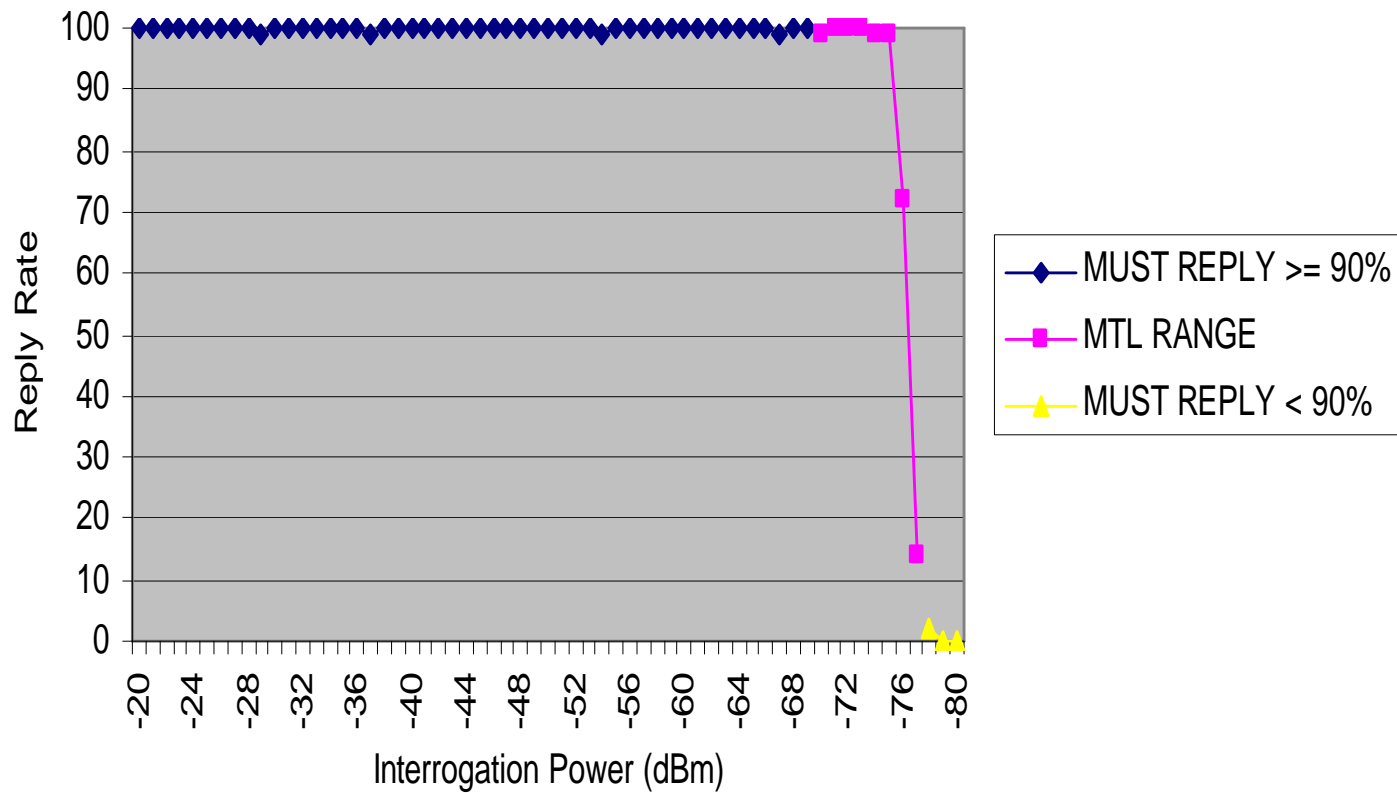
Diplexer Transponder Performance Results

April 23, 2003

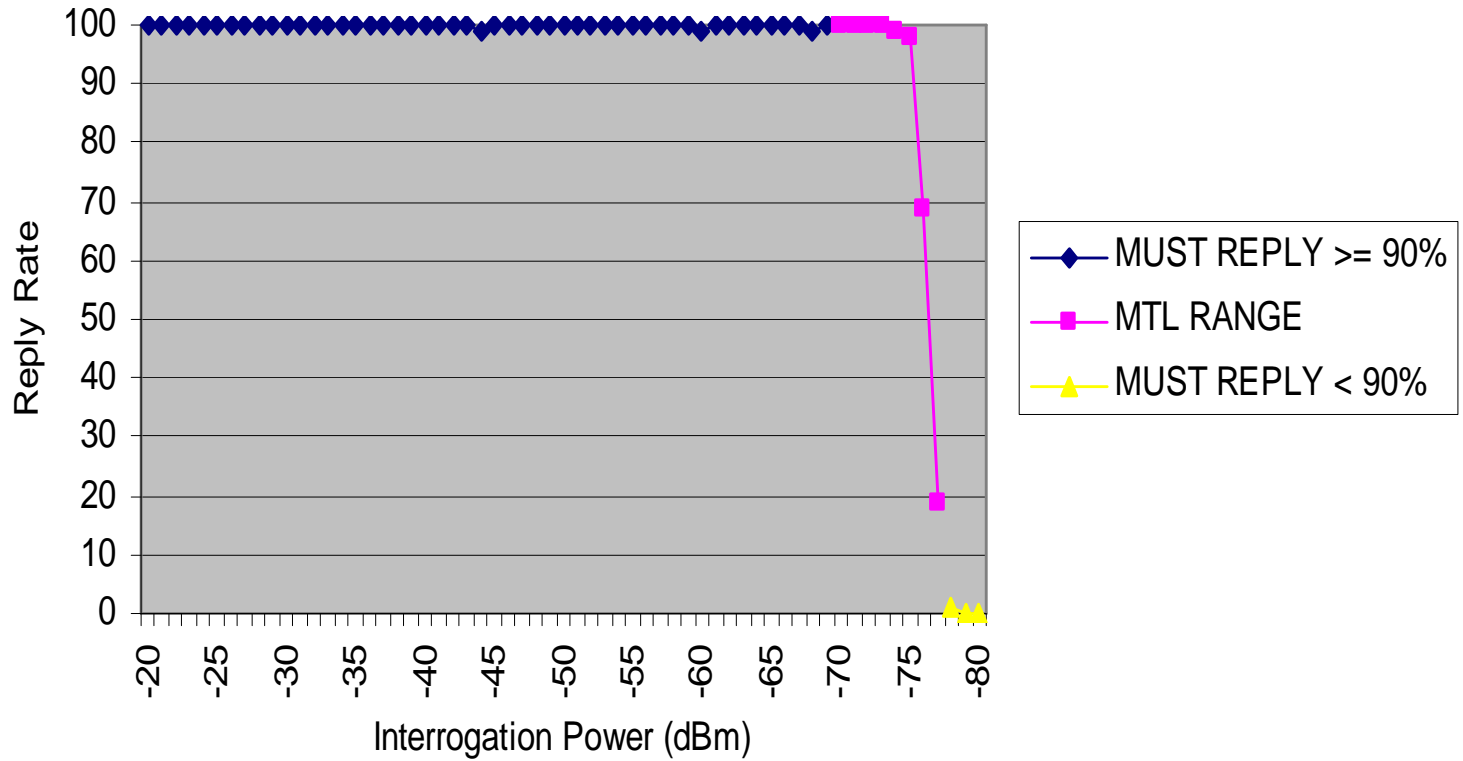
Mode A Dynamic Range Baseline



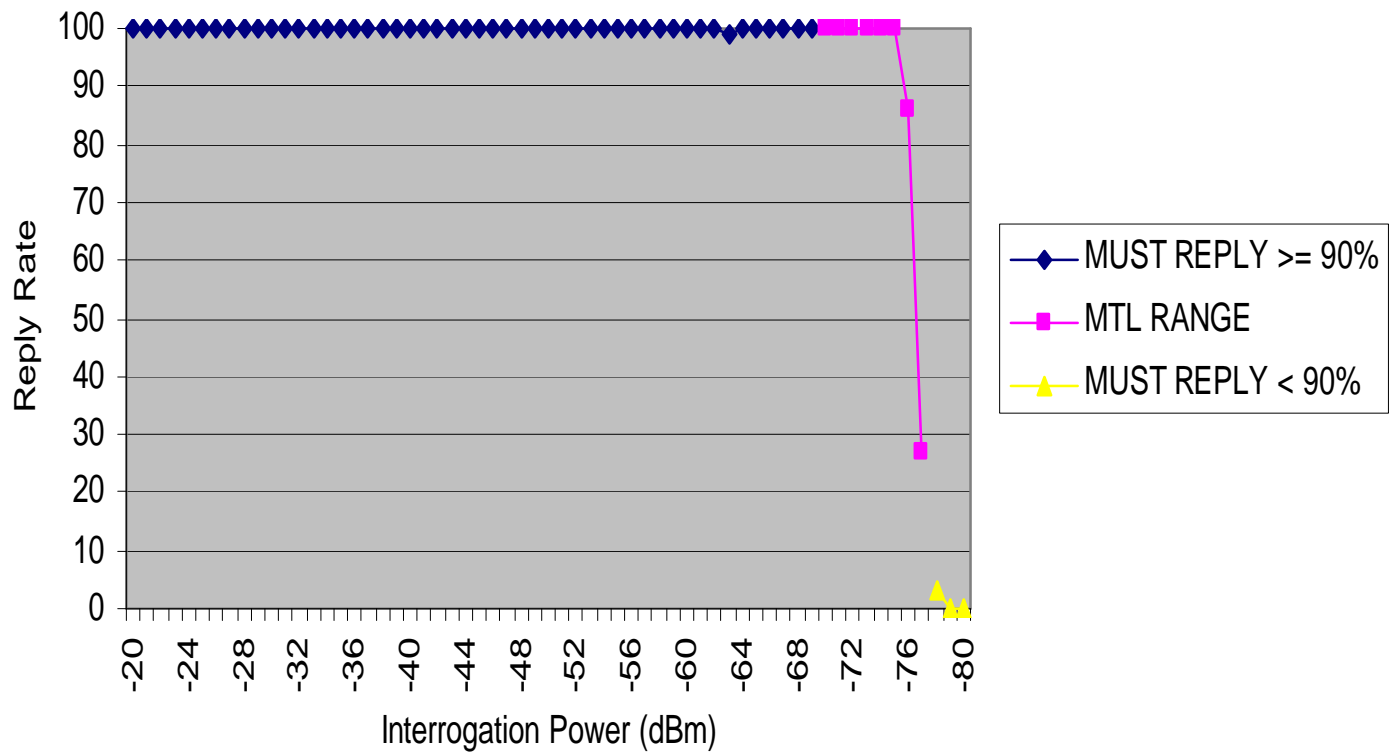
FSY Diplexer no UAT Mode A Dynamic Range



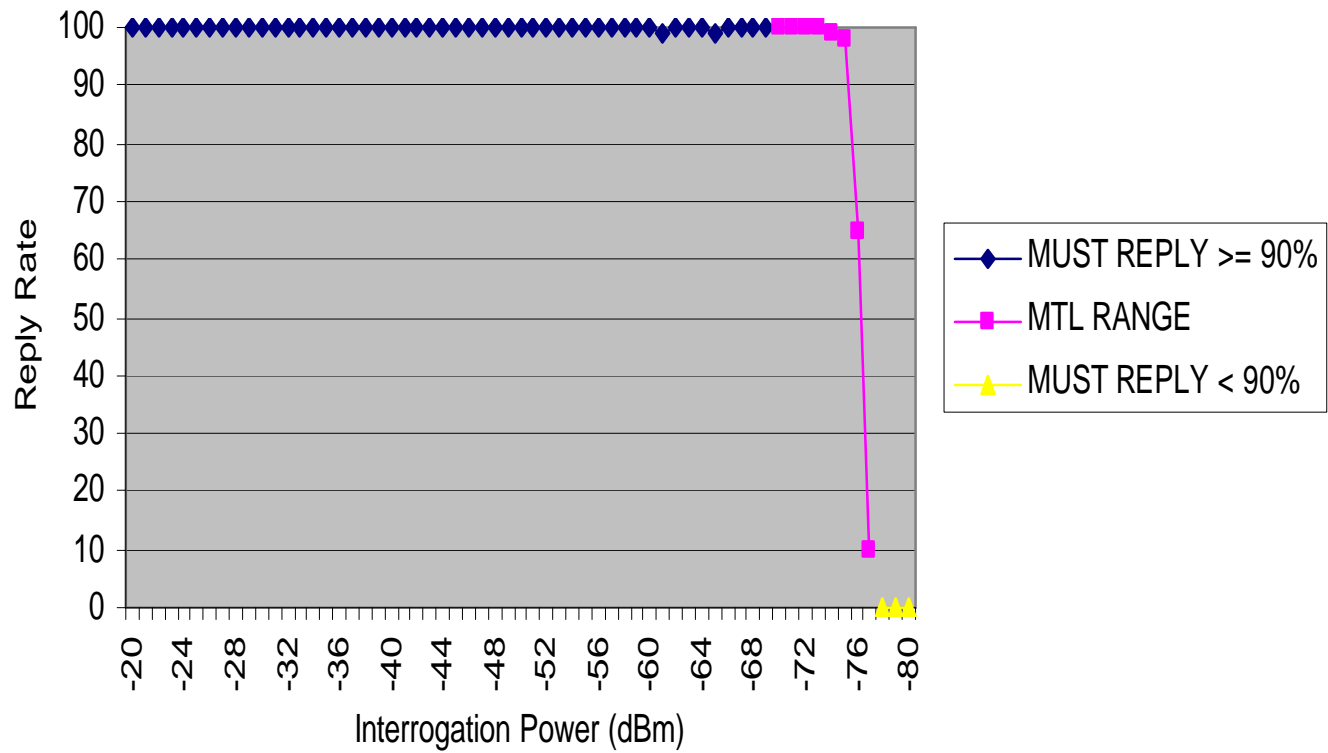
FSY Diplexer and UAT Mode A Dynamic Range



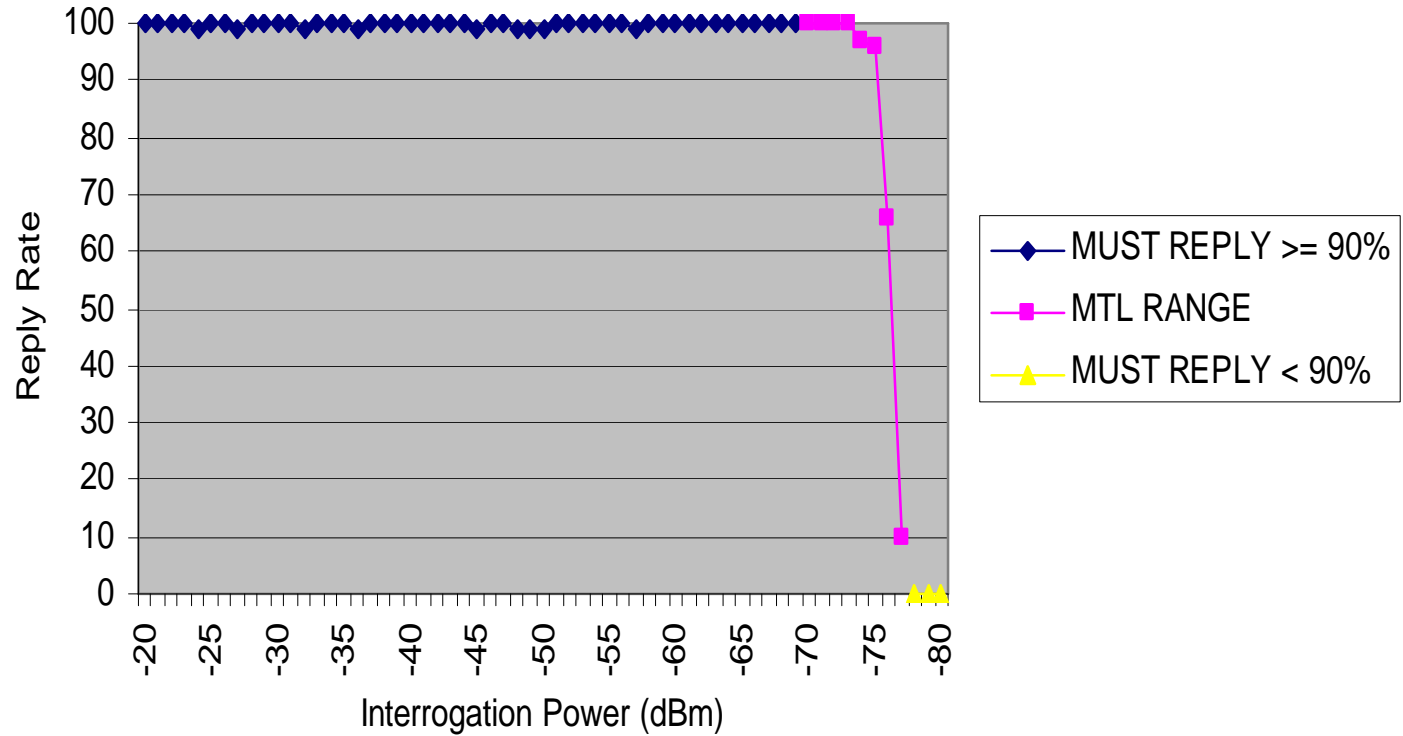
No Diplexer Mode C Dynamic Range



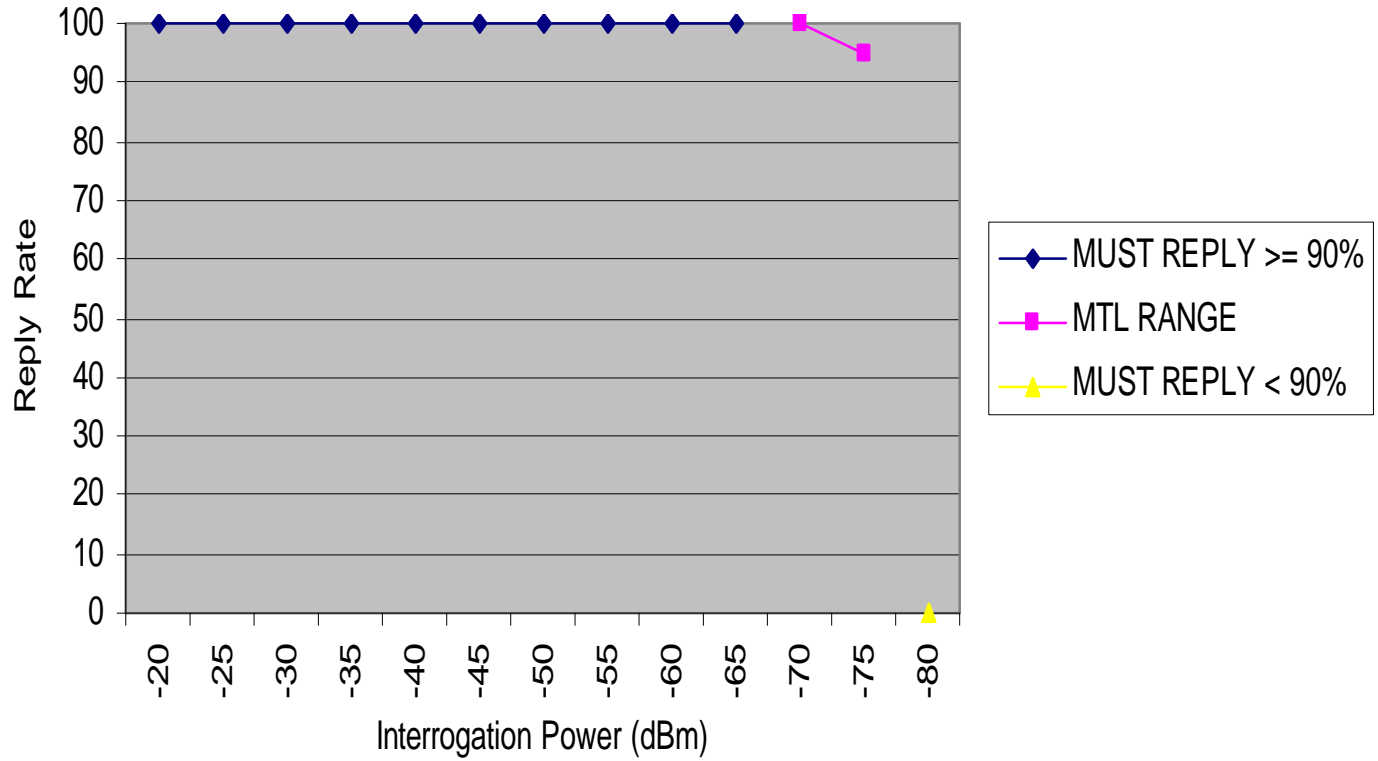
FSY Diplexer no UAT Mode C Dynamic Range



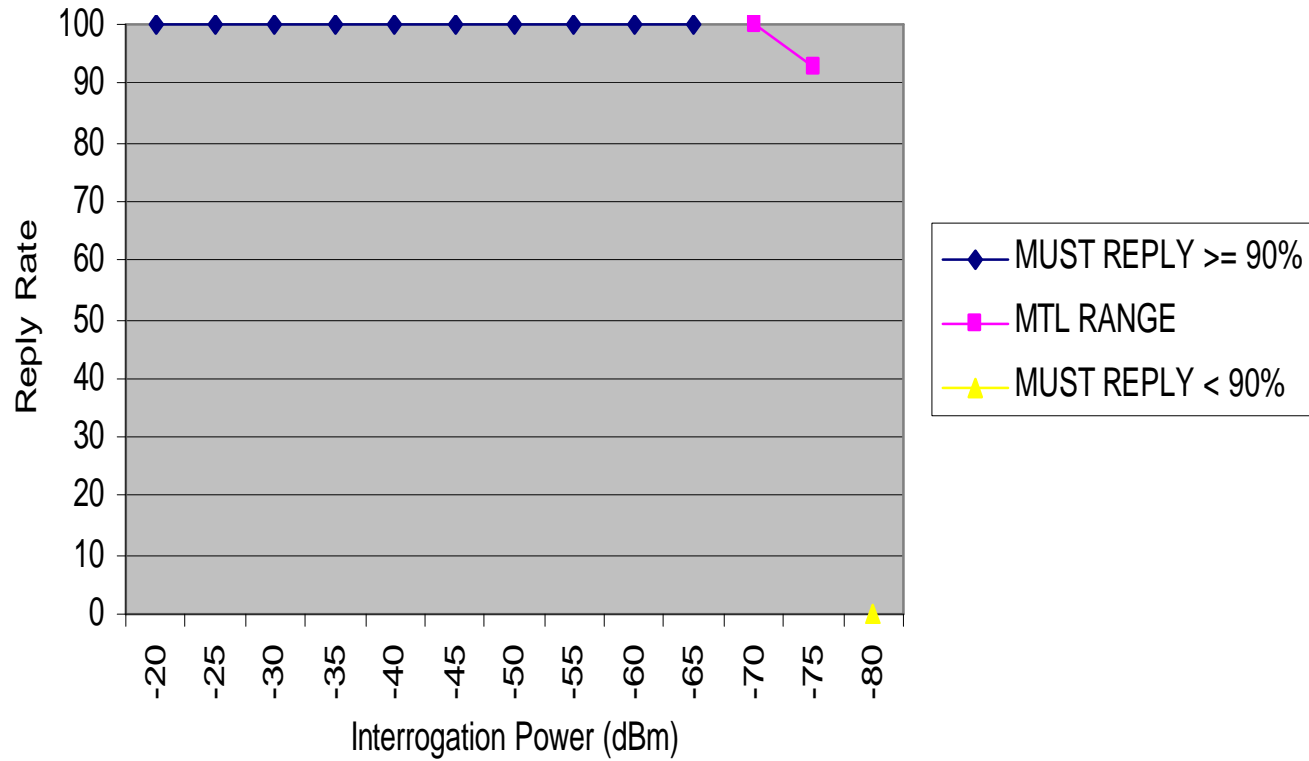
FSY Diplexer & UAT Mode C Dynamic Range



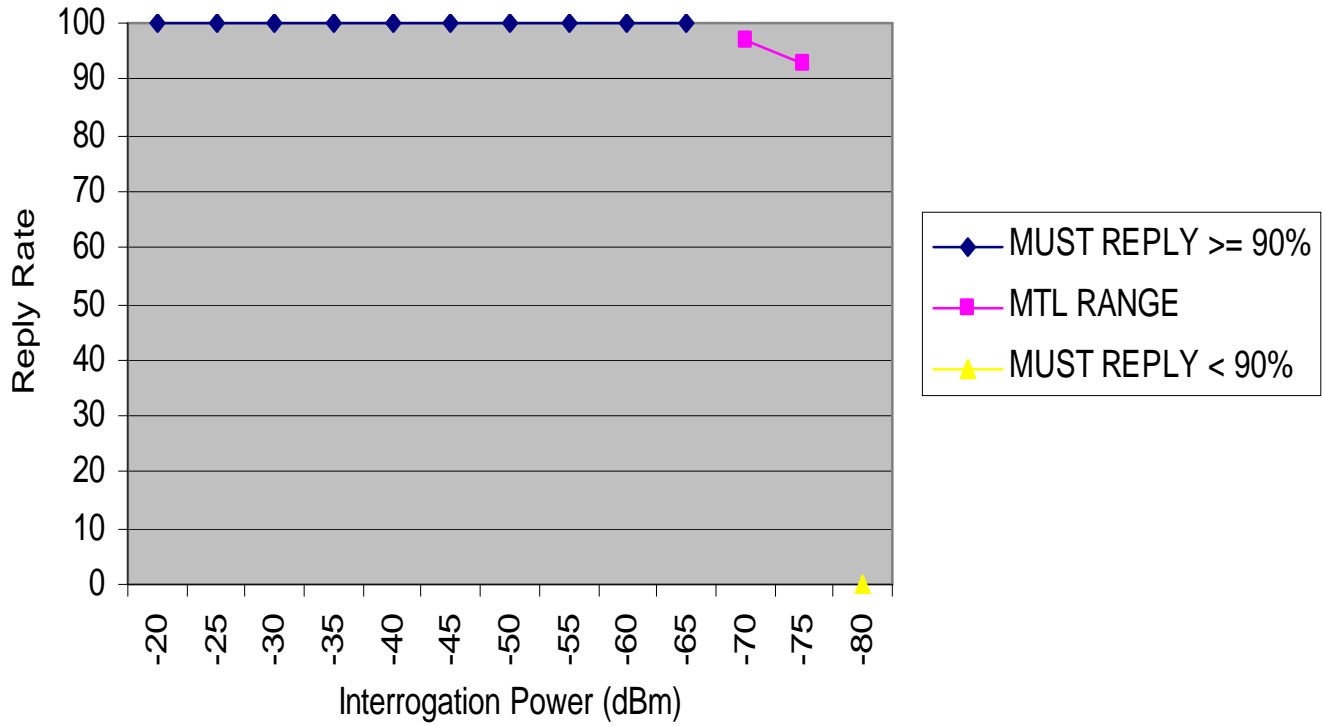
No Diplexer Mode A/Mode S Dynamic Range



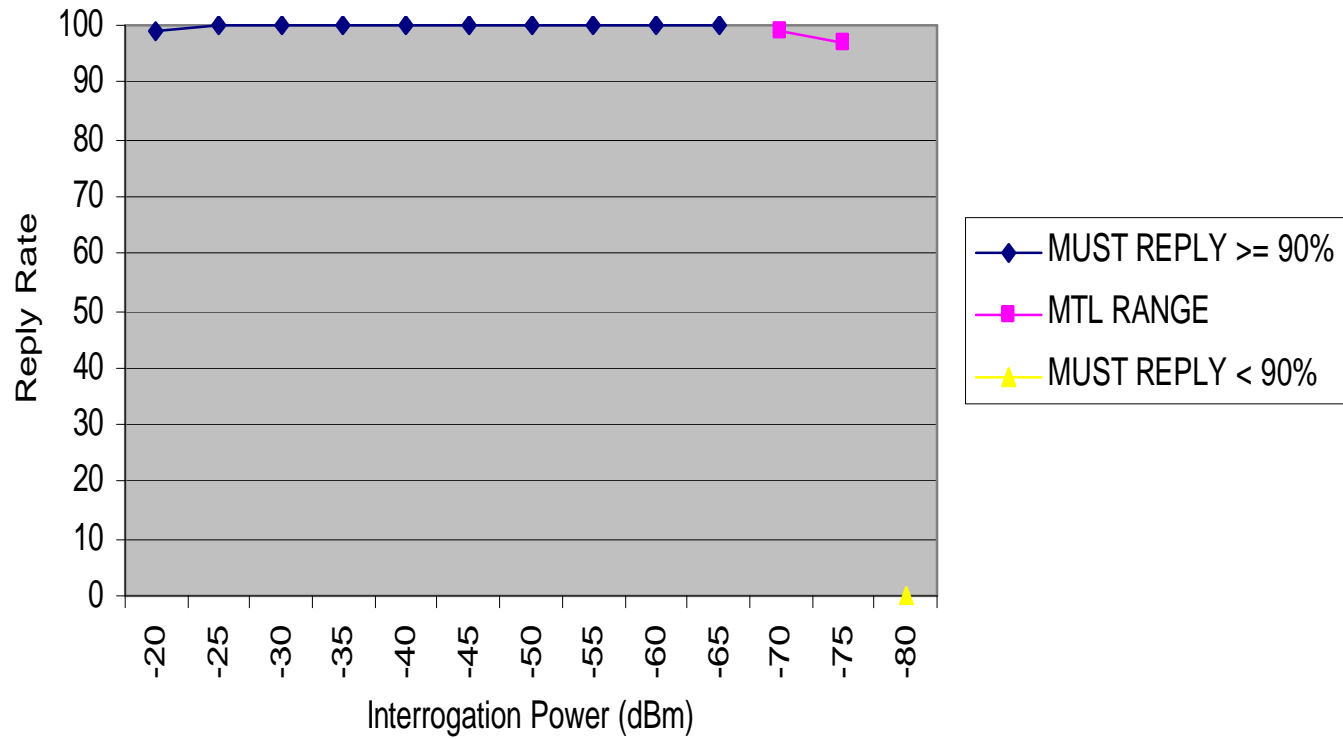
FSY Diplexer Mode A/Mode S Dynamic Range



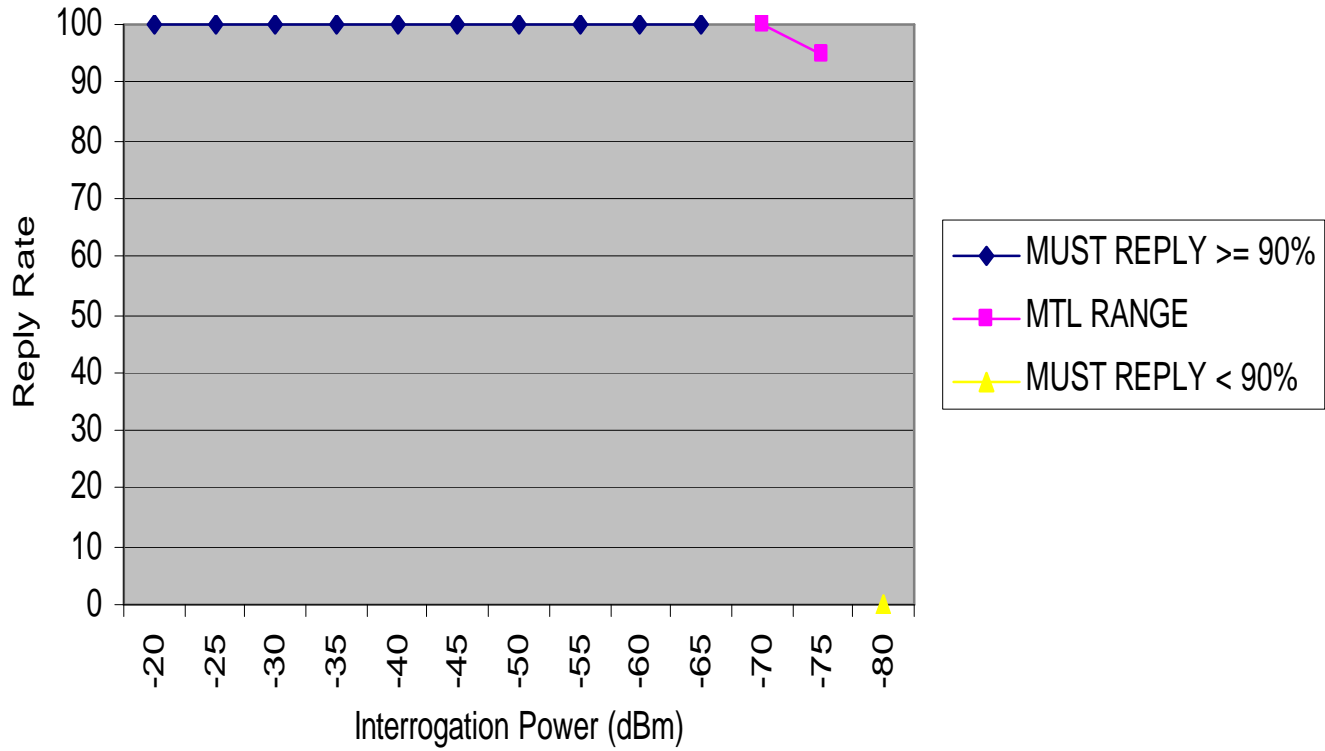
FSY Diplexer & UAT Mode A/Mode S Dynamic Range



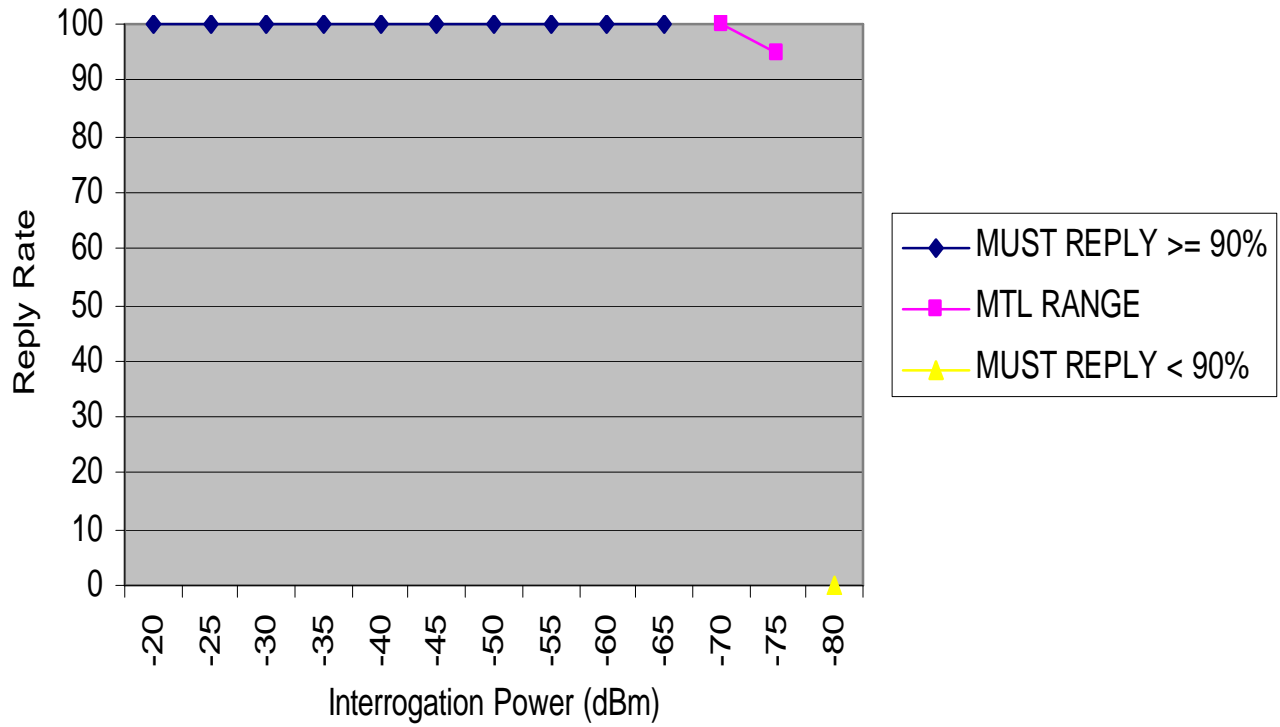
No Diplexer Mode C/Mode S Dynamic Range



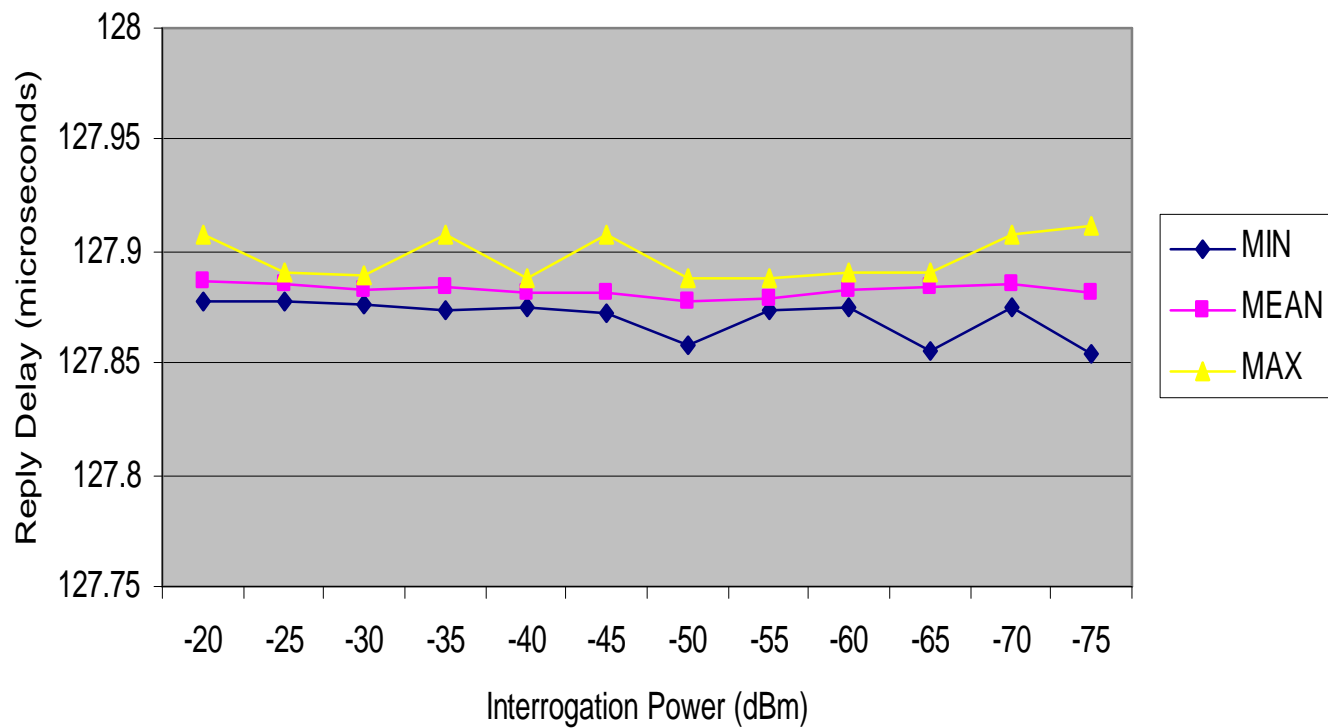
FSY Diplexer Mode C/Mode S Dynamic Range



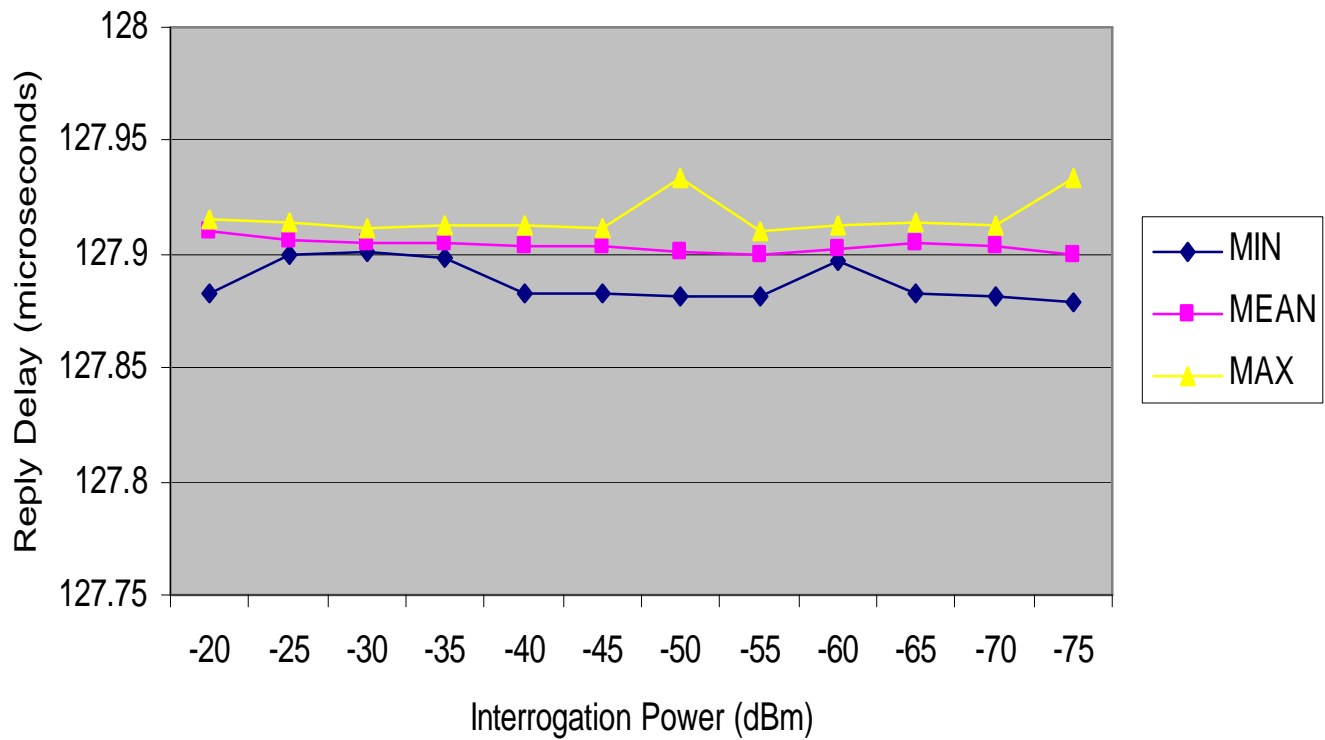
FSY Diplexer & UAT Mode C/Mode S Dynamic Range



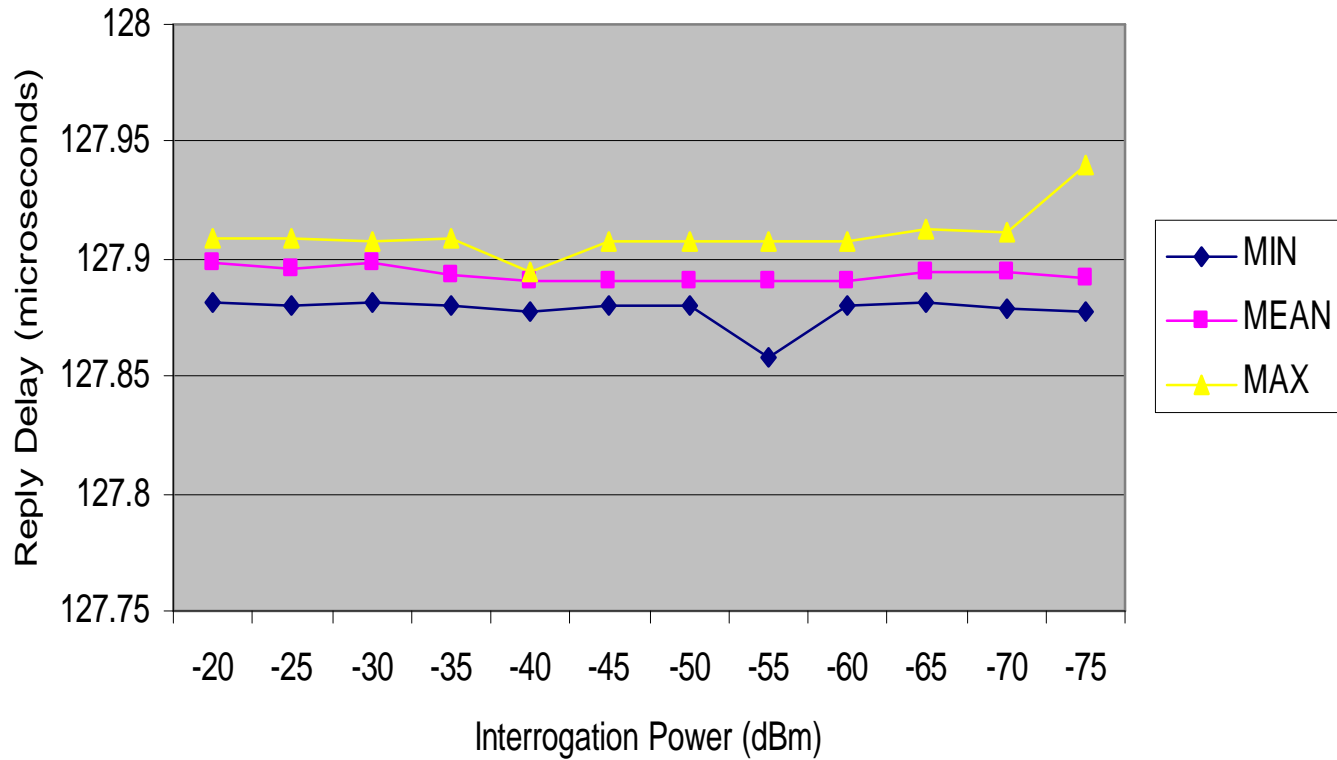
No Diplexer Mode A/Mode S Reply Delay and Jitter



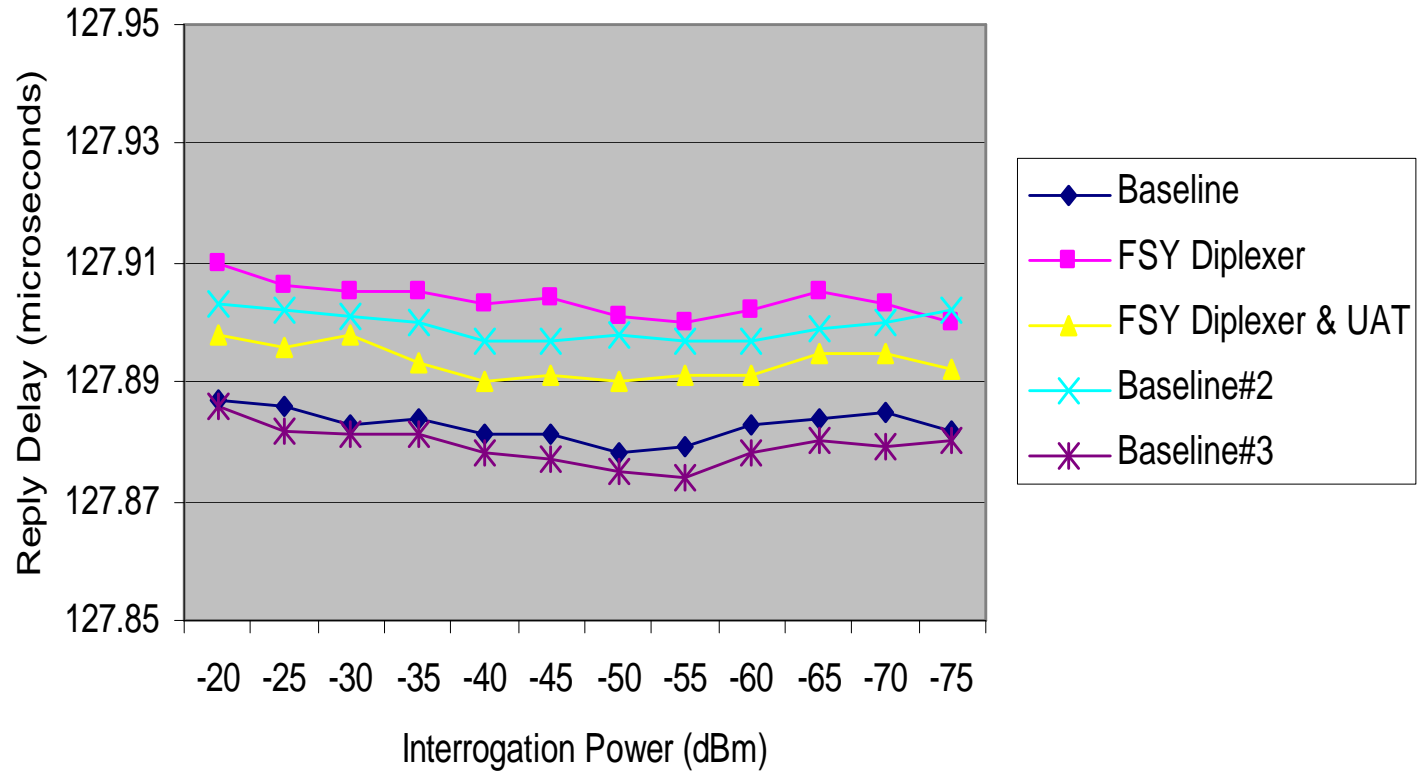
FSY Diplexer Mode A/Mode S Reply Delay and Jitter



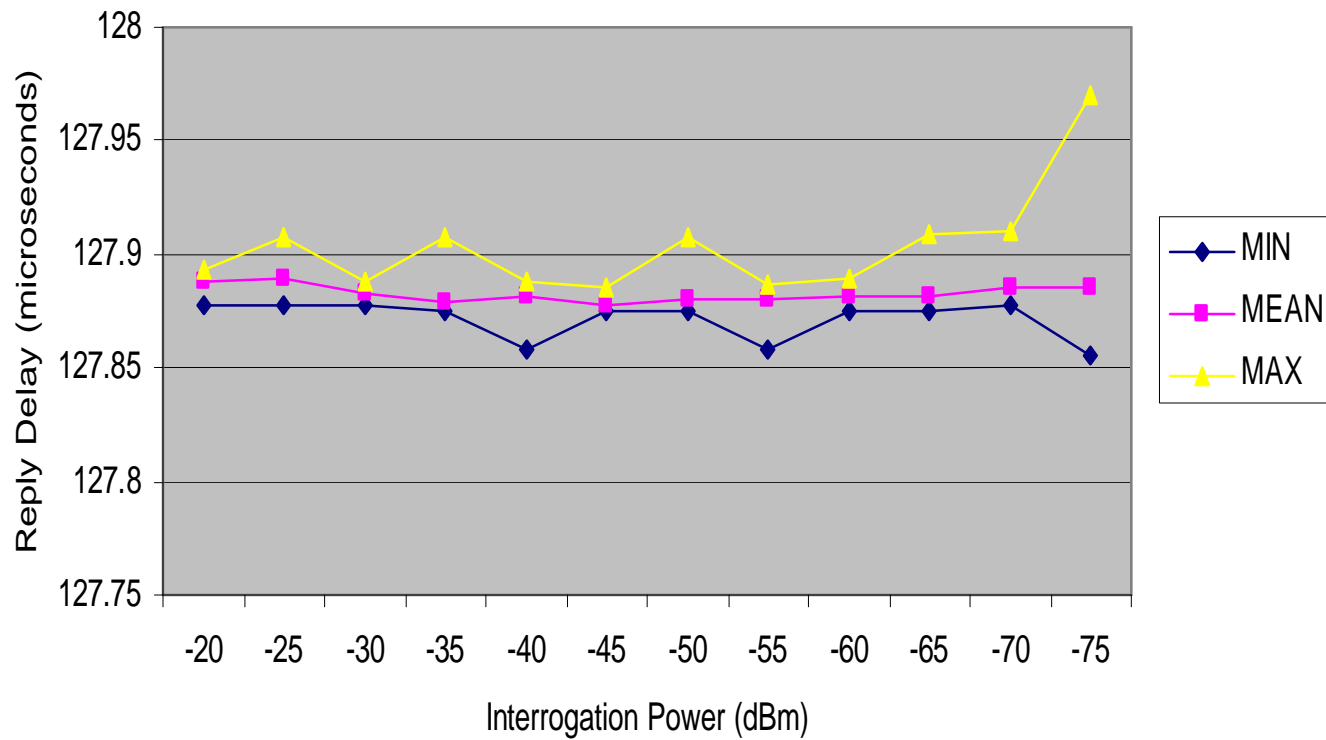
FSY Diplexer & UAT Mode A/Mode S Reply Delay and Jitter



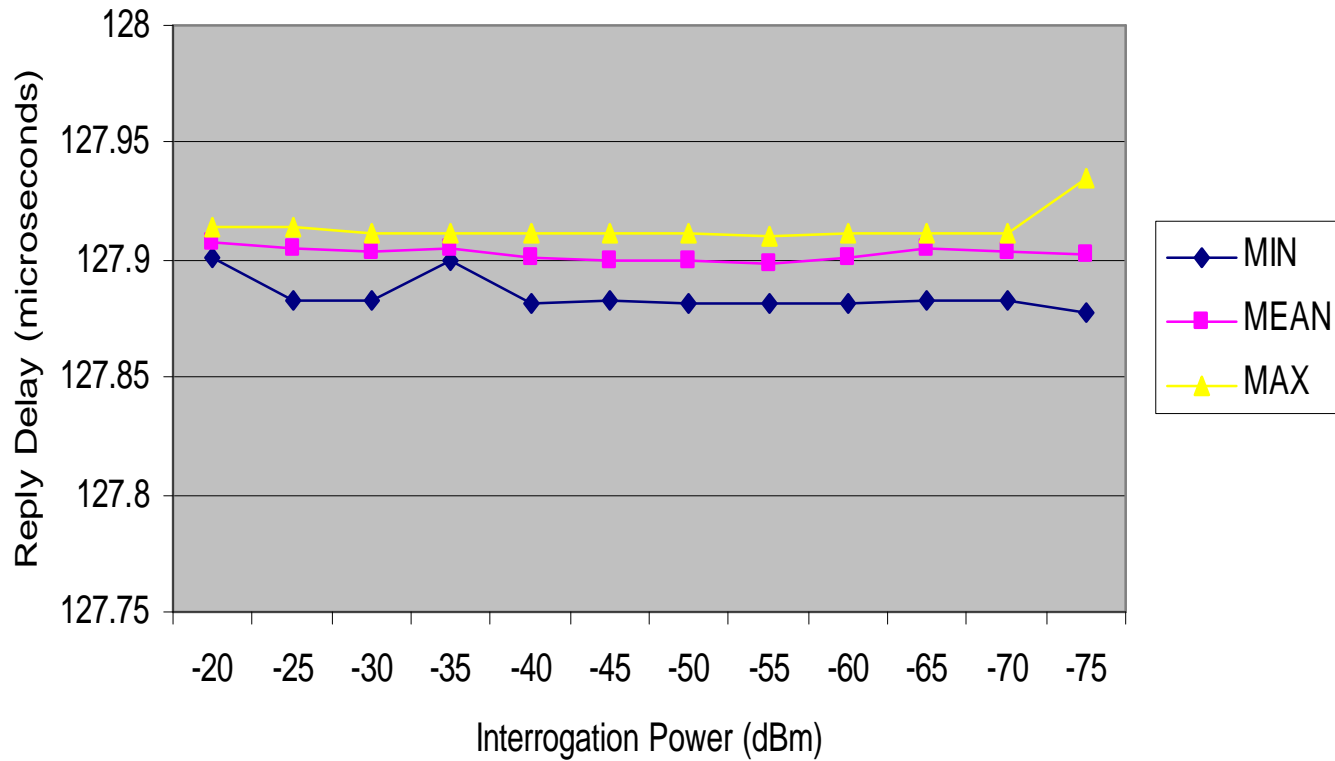
Mean Mode A/Mode S Reply Delay



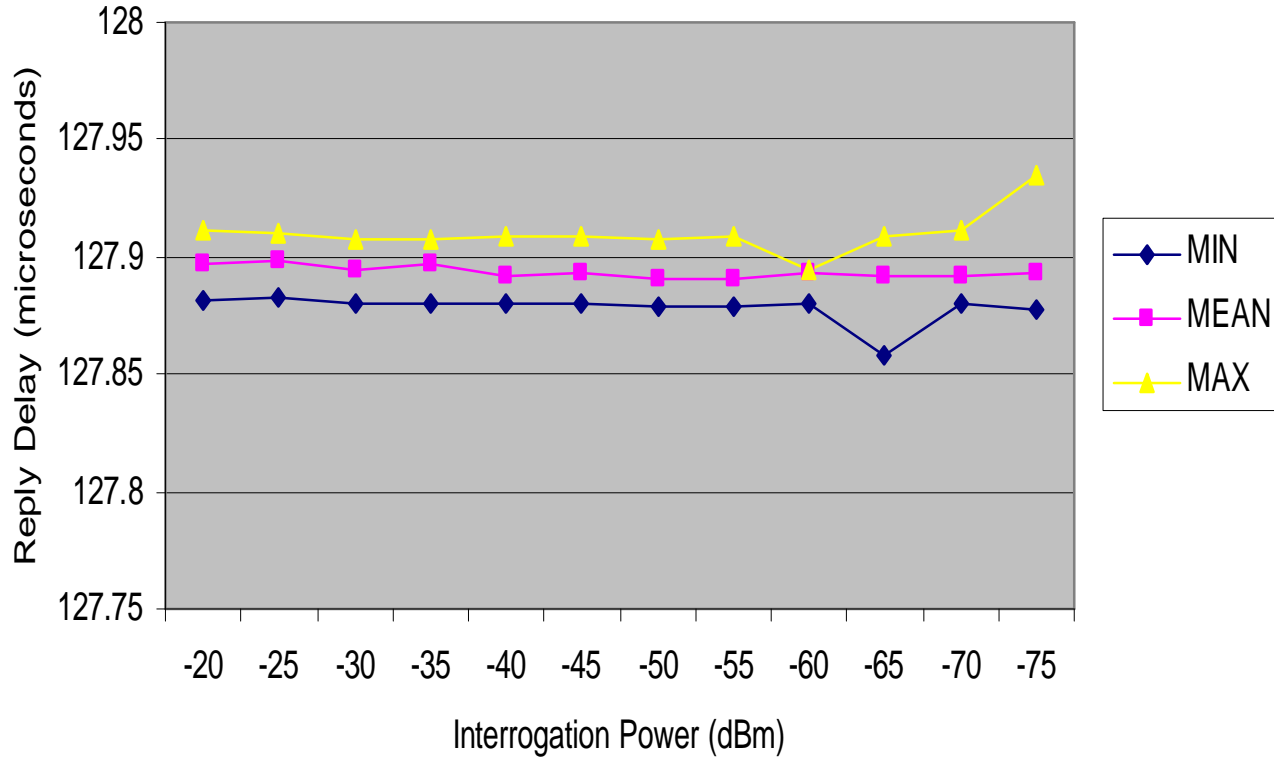
No Diplexer Mode C/Mode S Reply Delay and Jitter



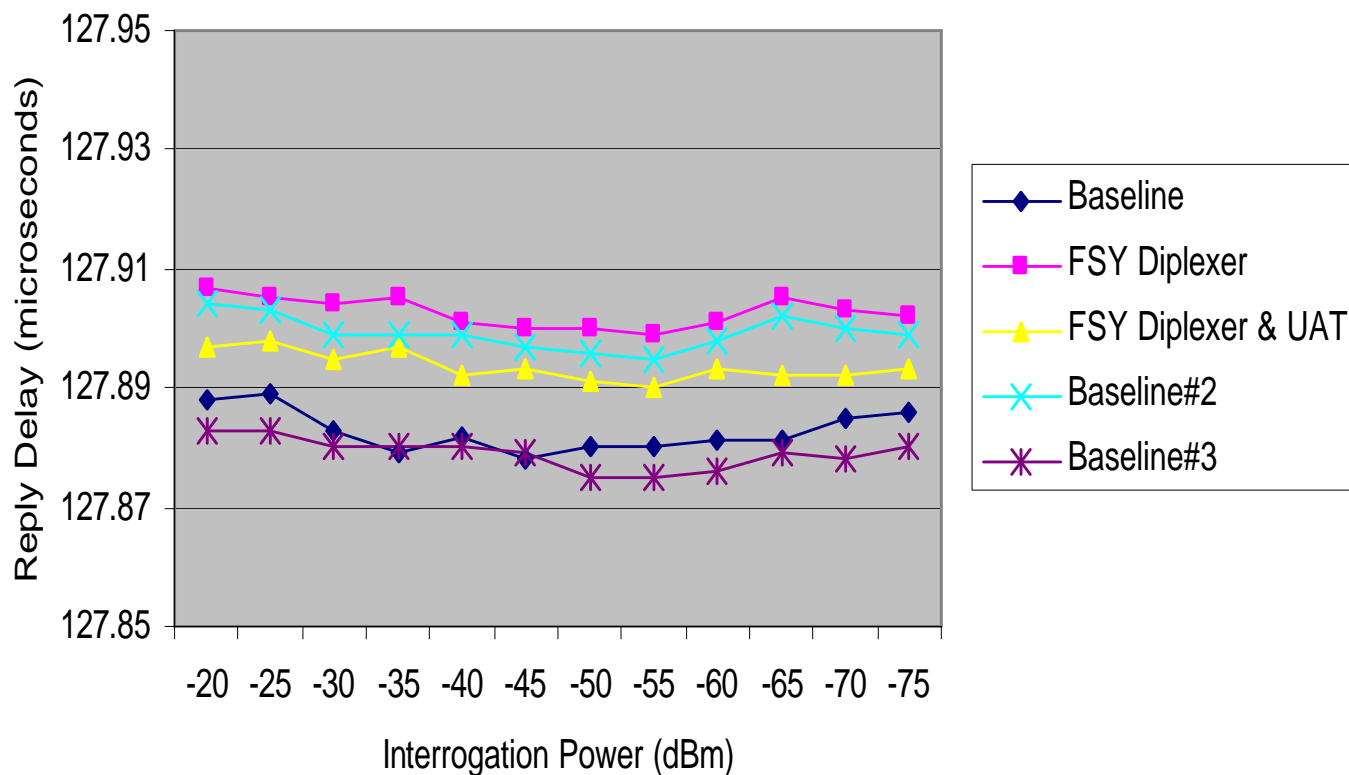
FSY Diplexer Mode C/Mode S Reply Delay and Jitter



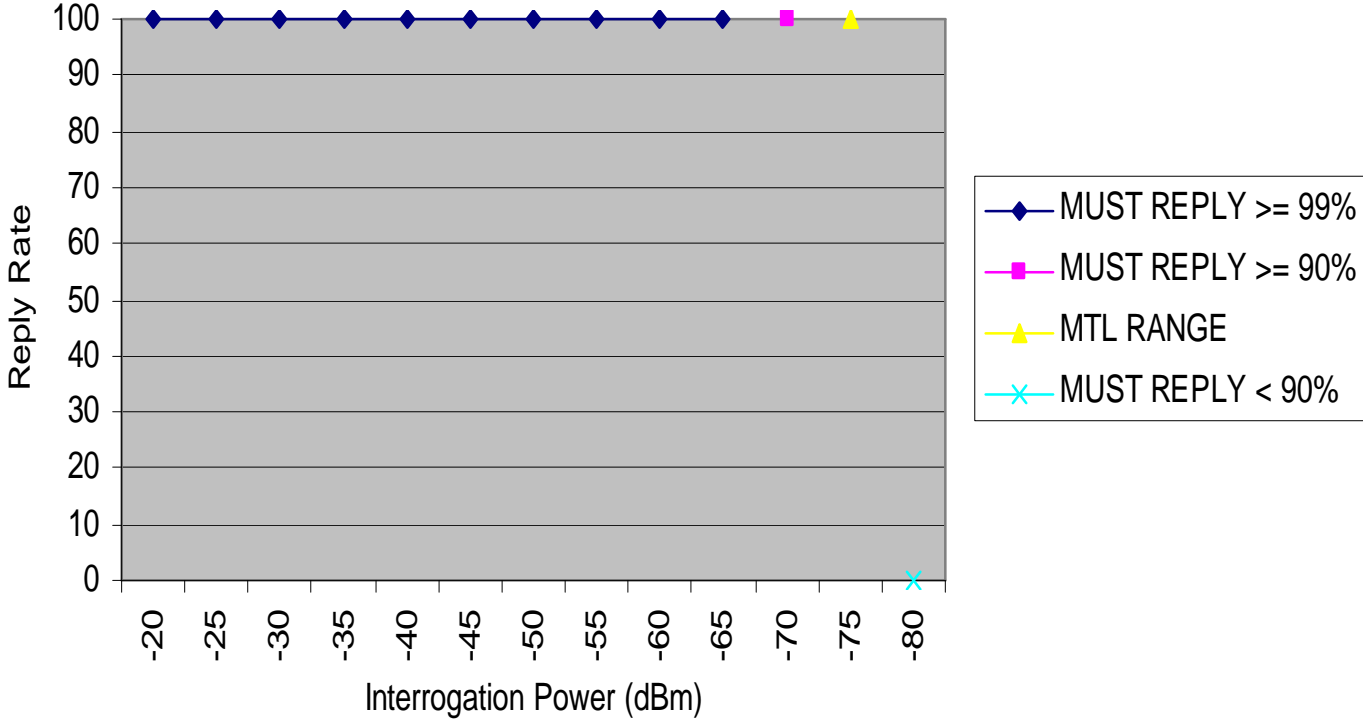
FSY Diplexer & UAT Mode C/Mode S Reply Delay and Jitter



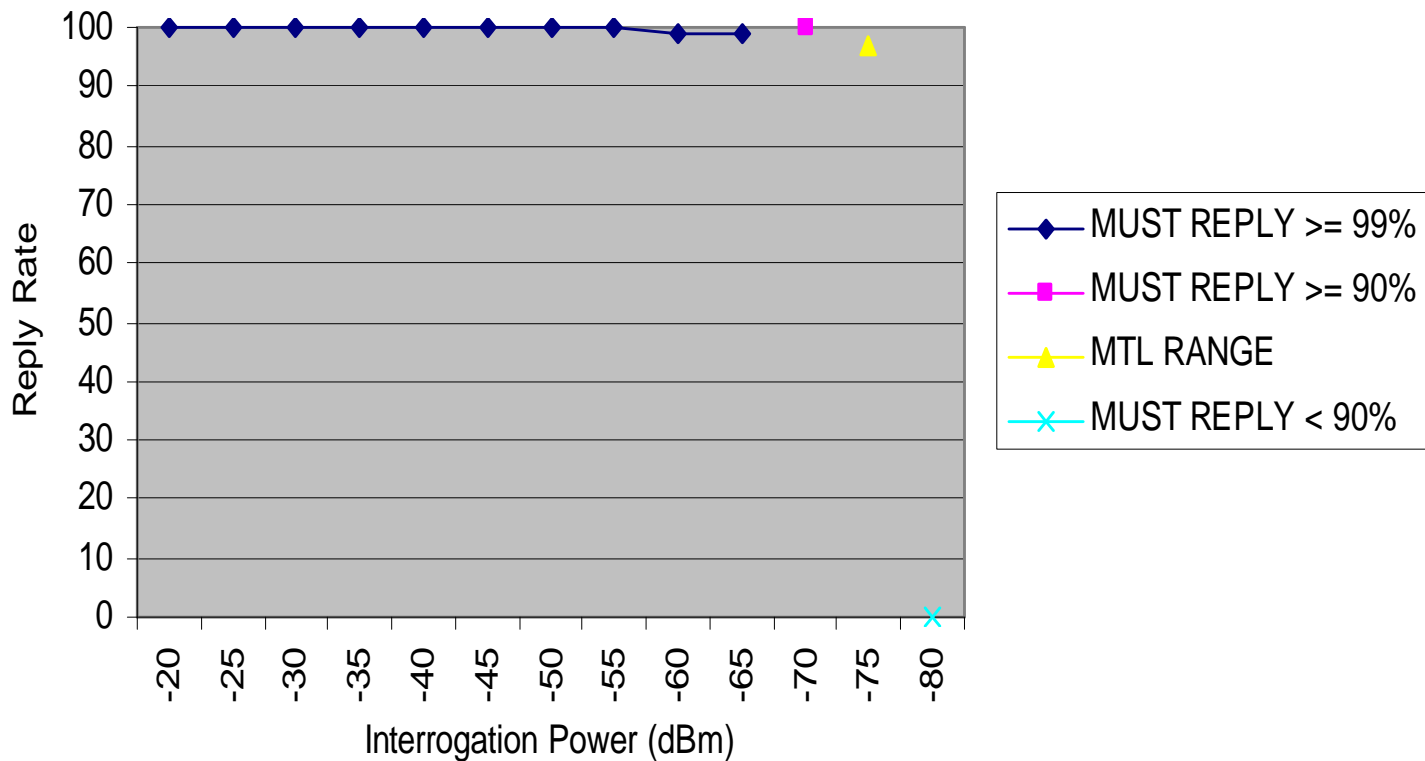
Mean Mode C/Mode S Reply Delay



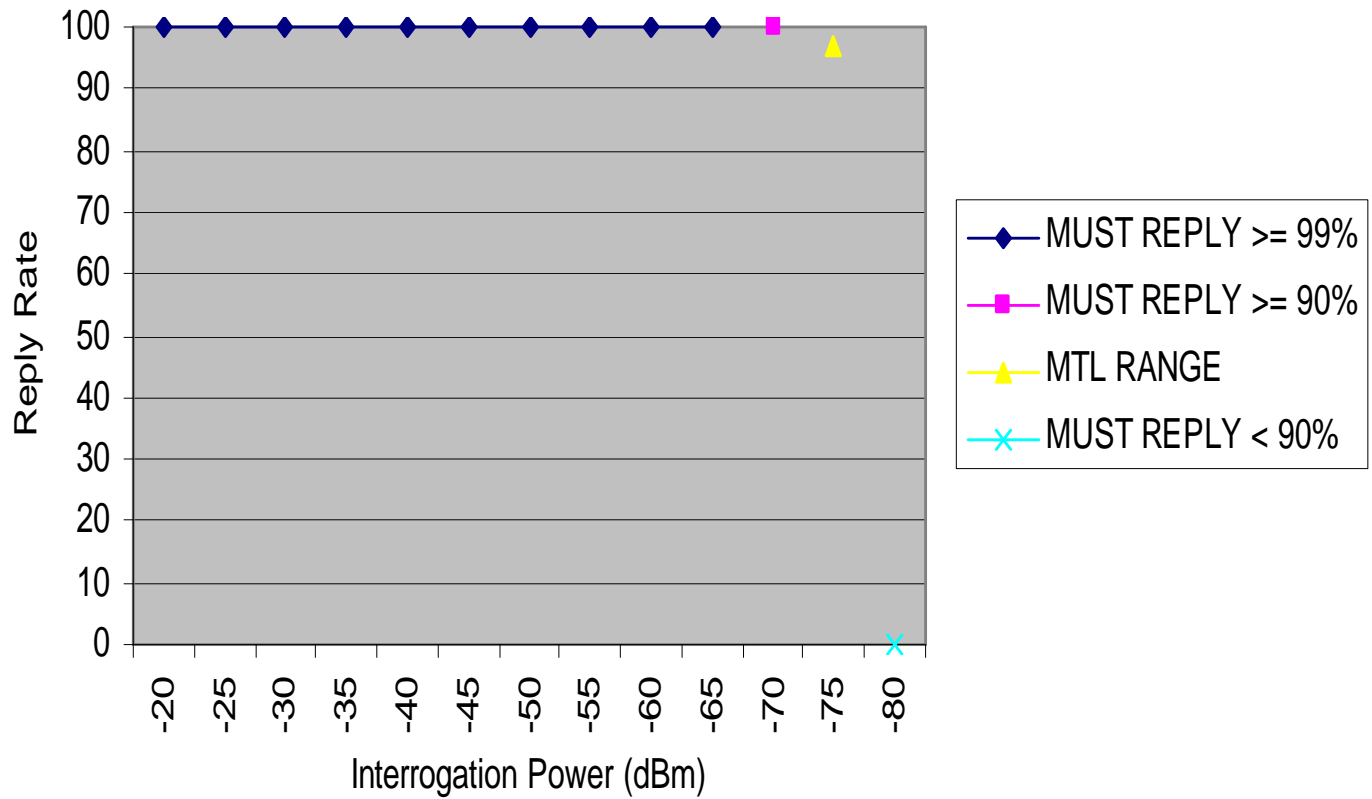
No Diplexer Mode S Dynamic Range



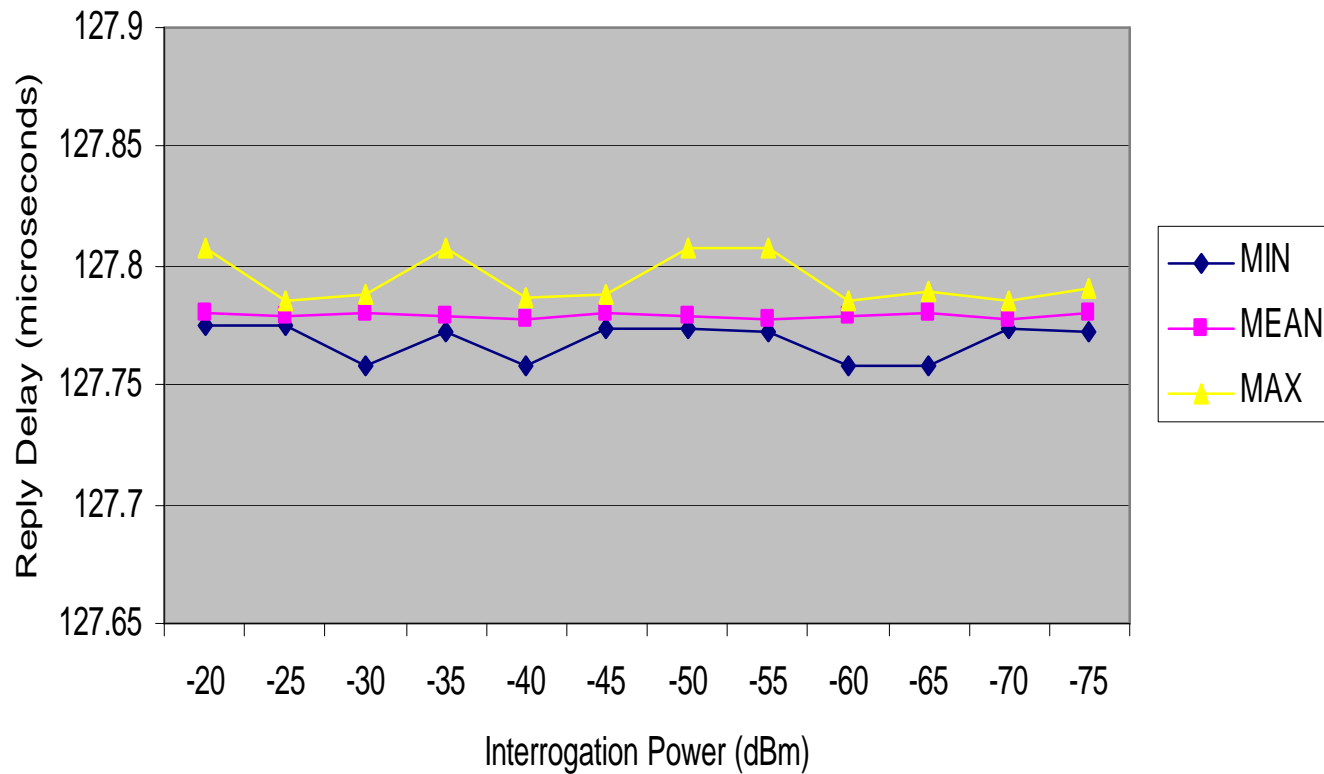
FSY Diplexer Mode S Dynamic Range



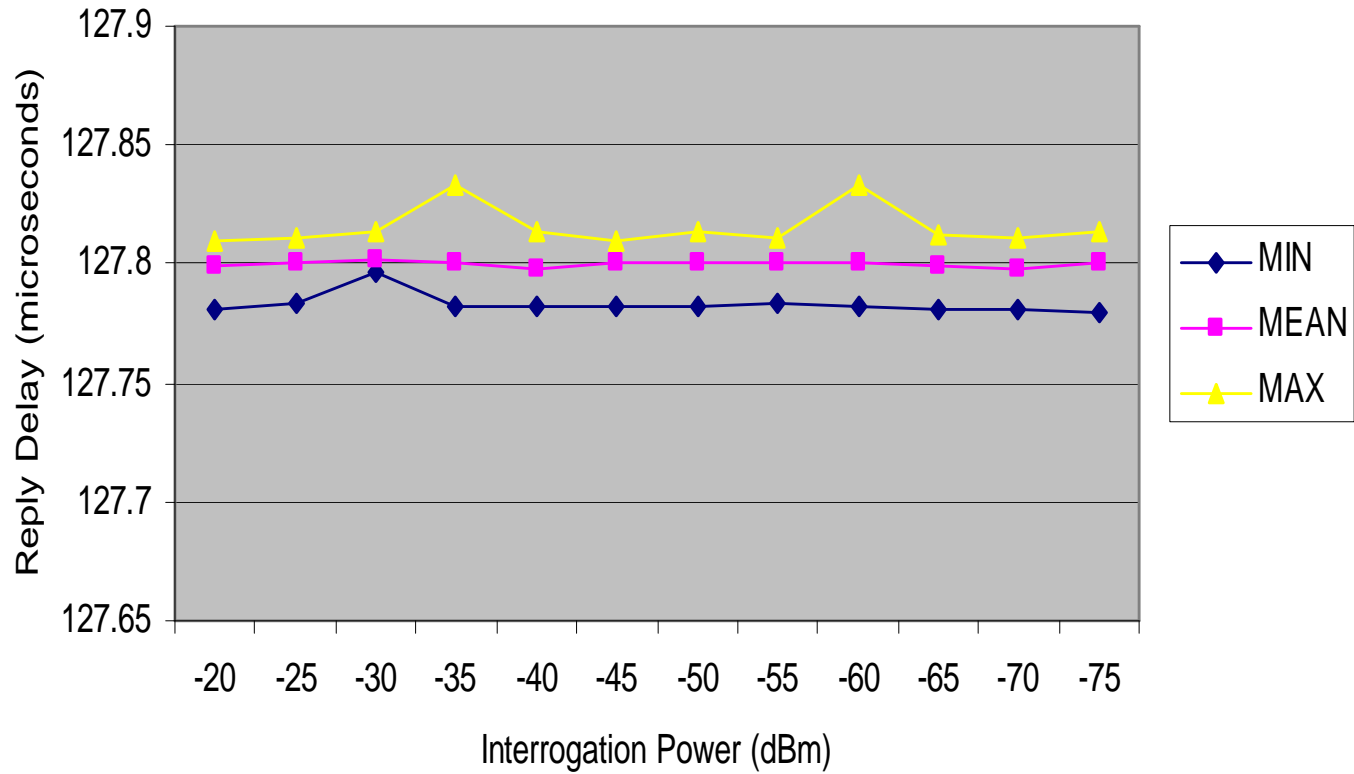
FSY Diplexer & UAT Mode S Dynamic Range



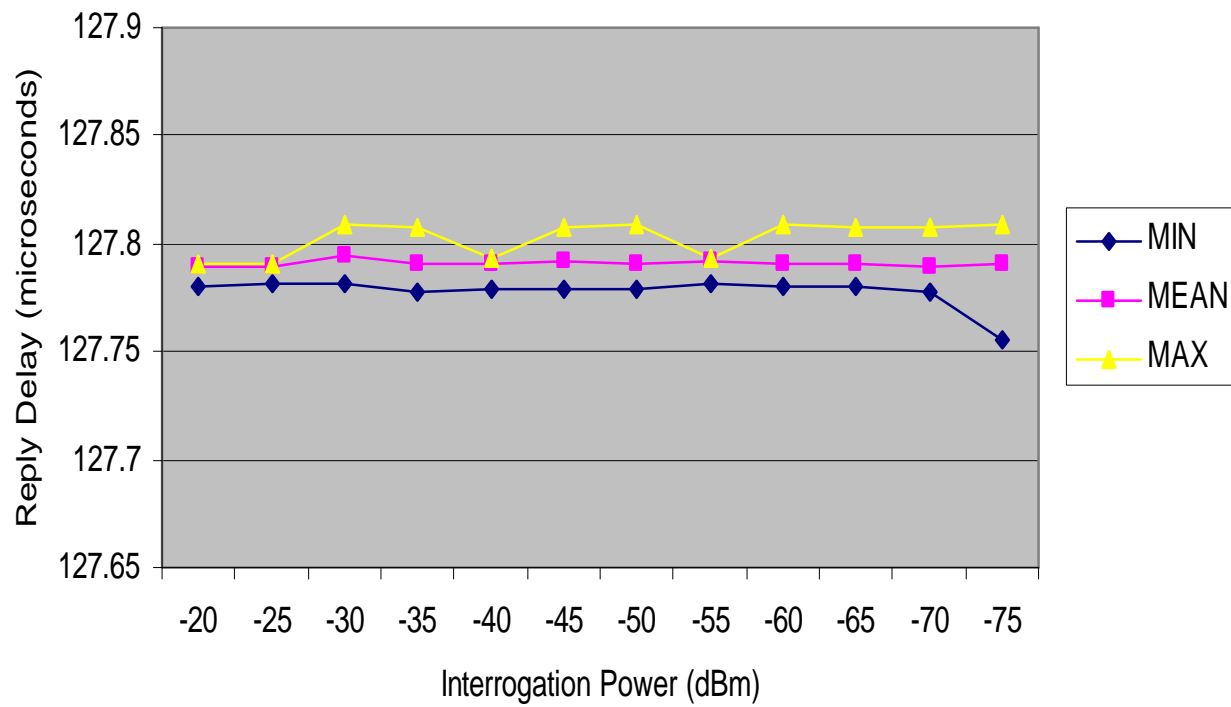
No Diplexer Mode S Reply Delay and Jitter



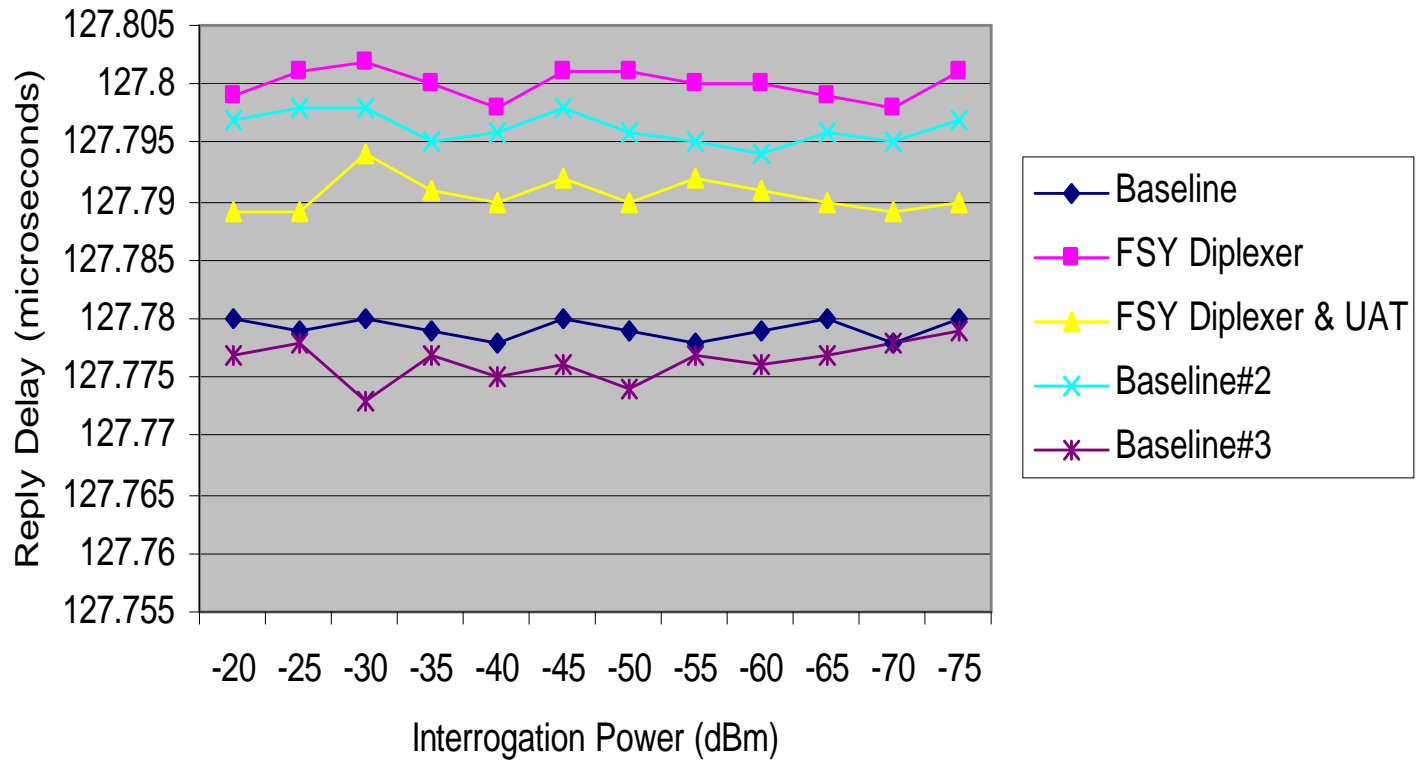
FSY Diplexer Mode S Reply Delay and Jitter



FSY Diplexer & UAT Mode S Reply Delay and Jitter

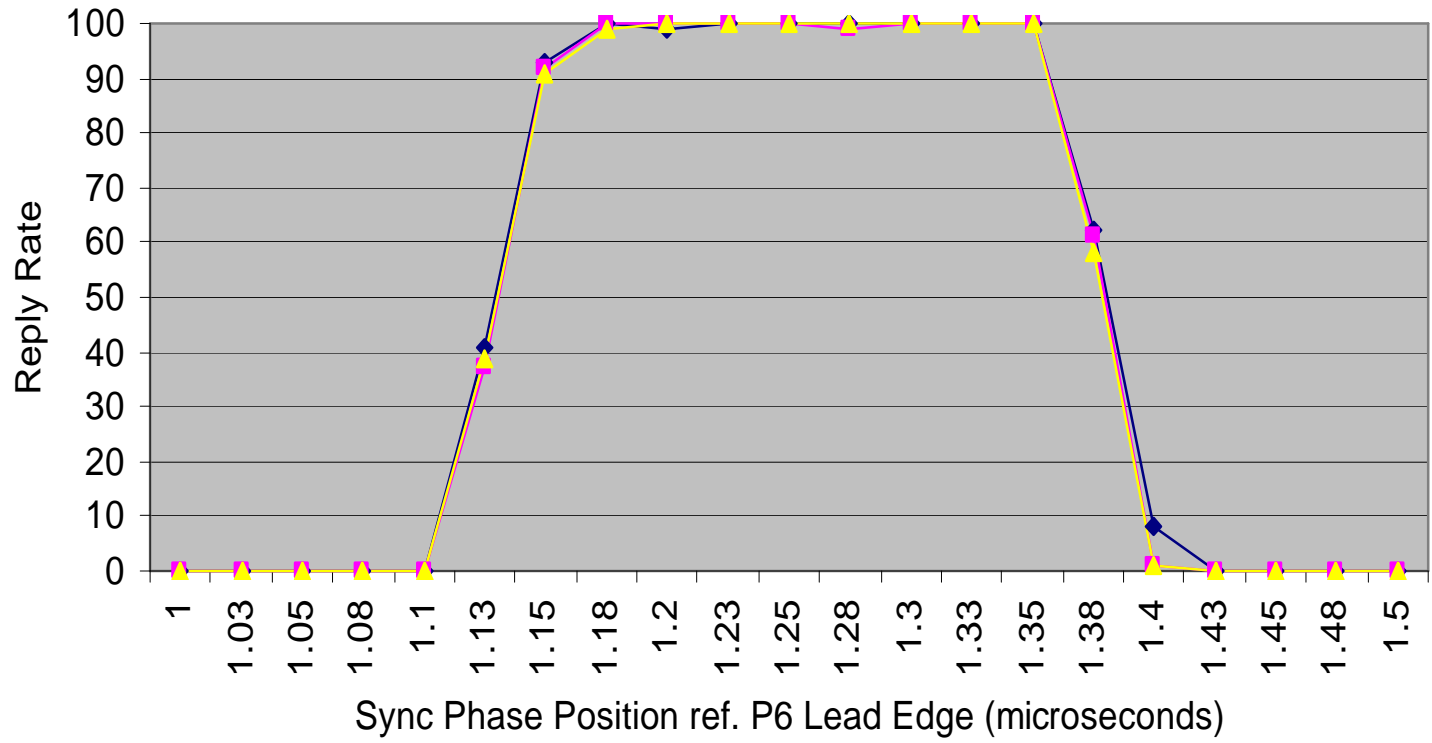


Mean Mode S Reply Delay

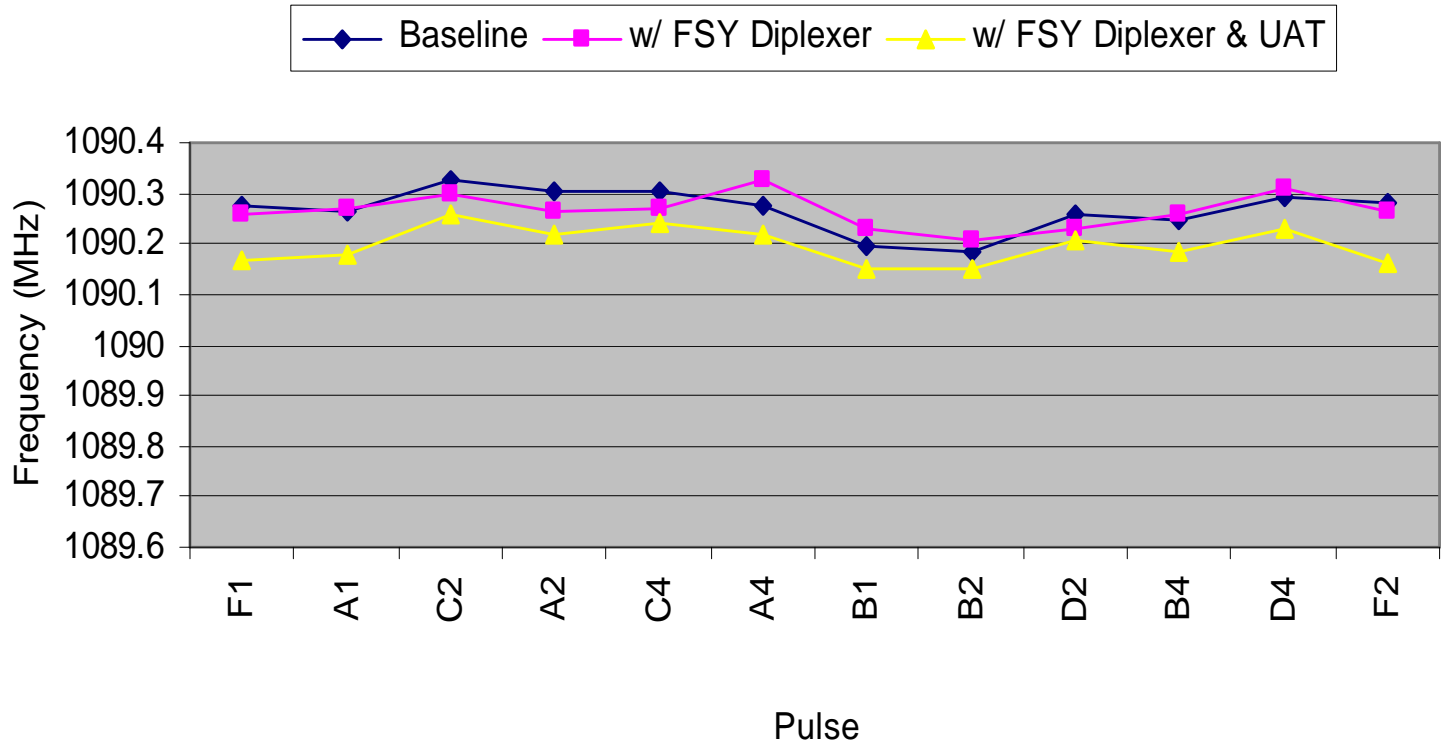


Mode S Sync Phase Position Tolerance

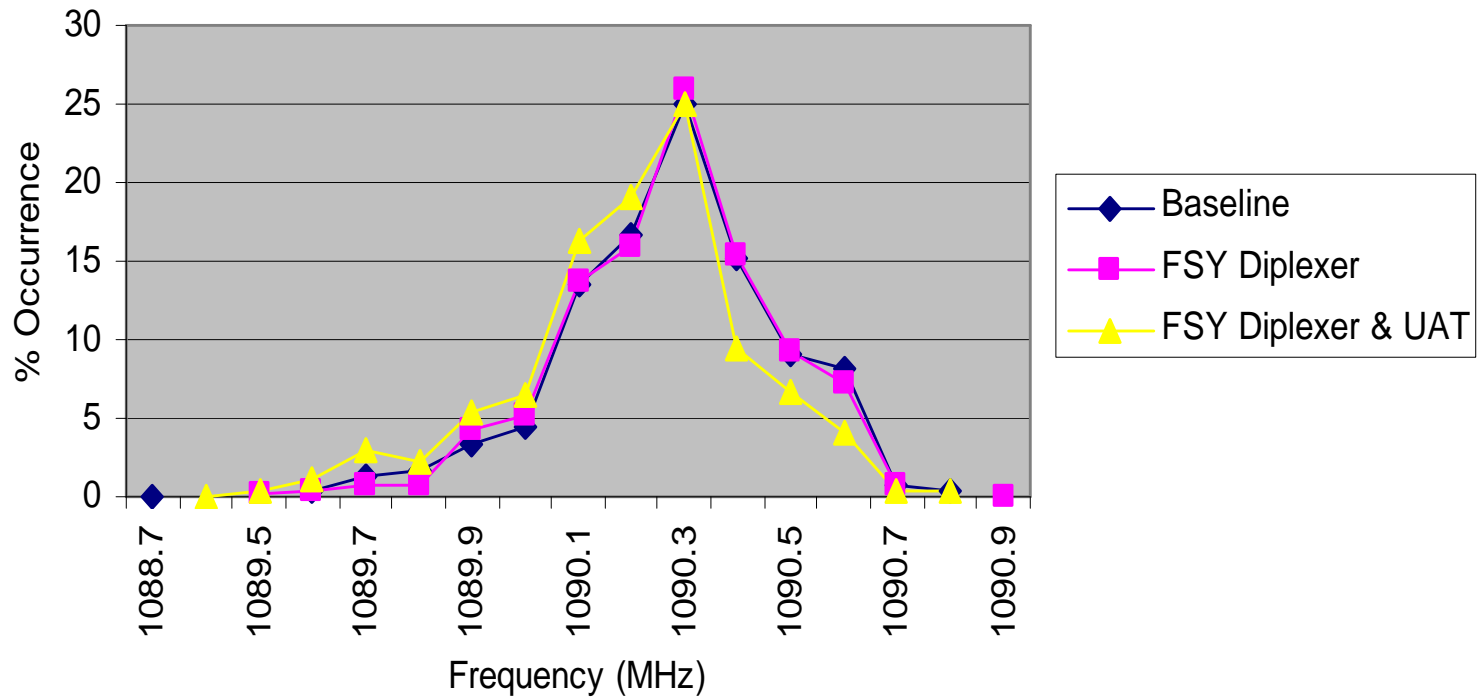
◆ Baseline ■ FSY Diplexer ▲ FSY Diplexer & UAT



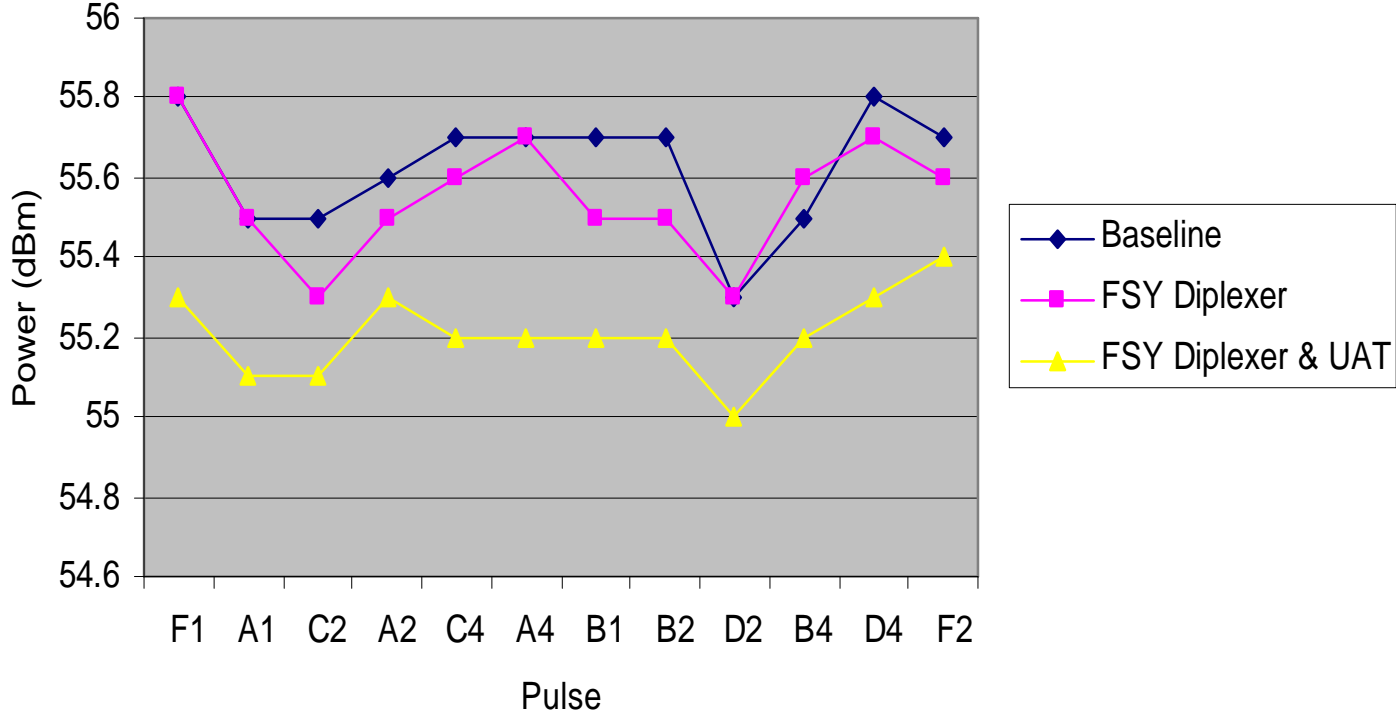
ATCRBS Mean Reply Frequency per Pulse



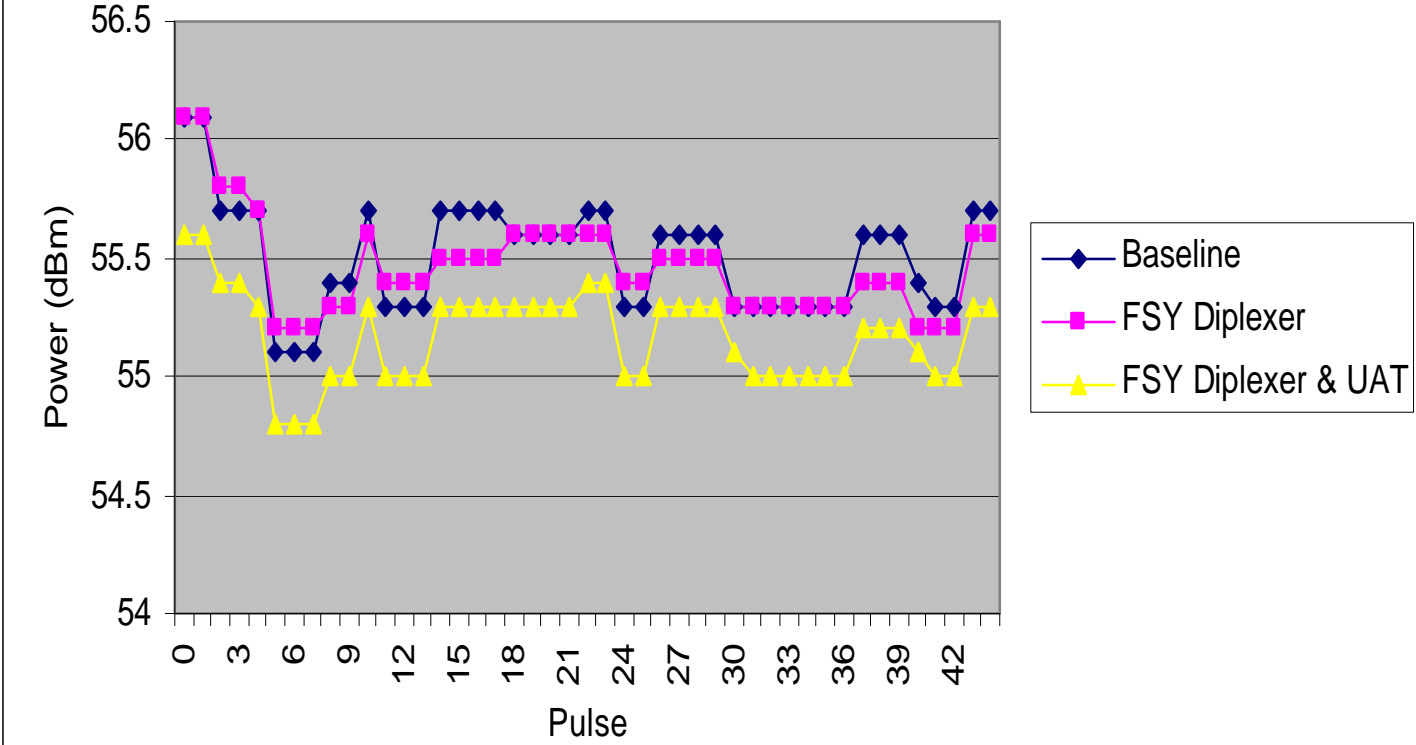
ATCRBS Reply Frequency Distribution



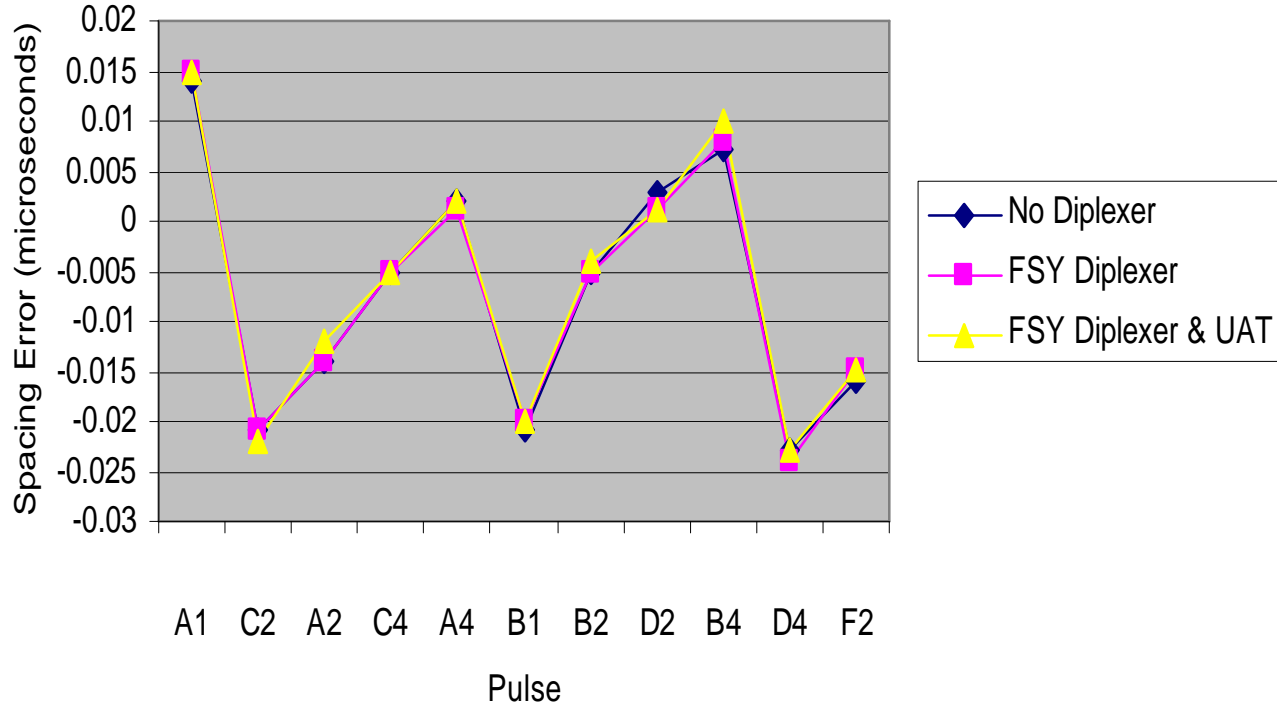
ATCRBS Reply Power Mean per Pulse



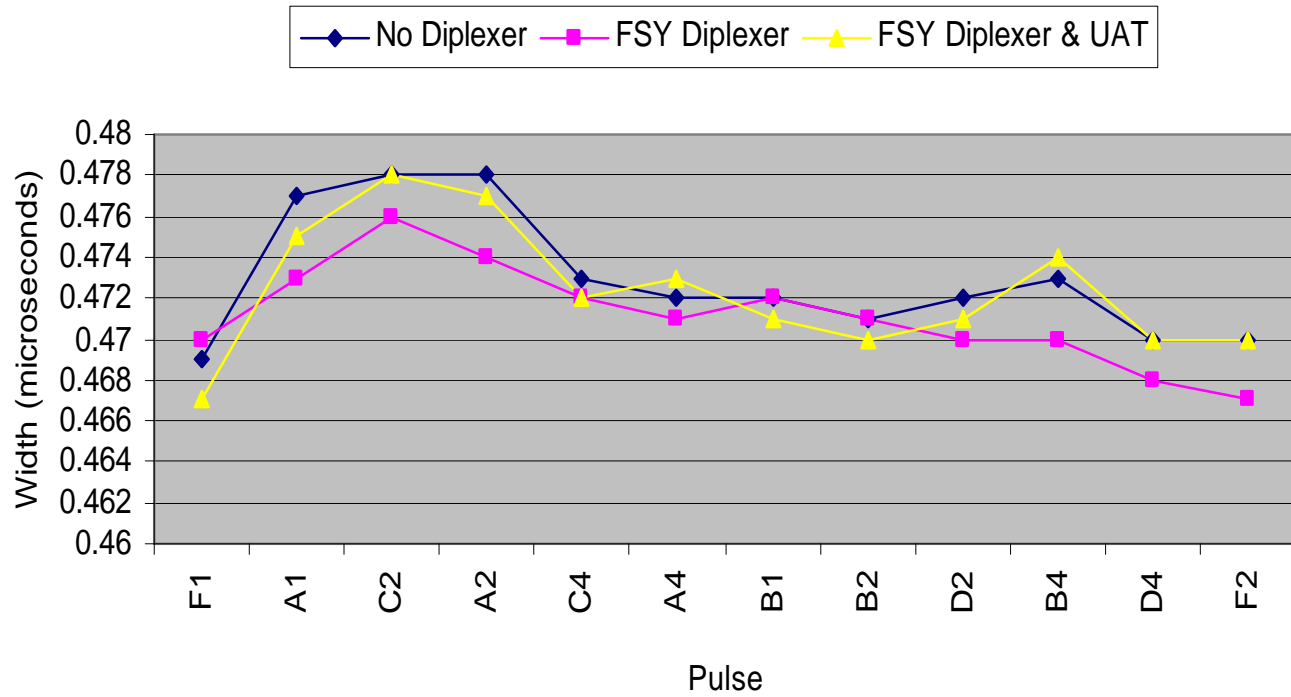
Mode S Reply Power Mean per Pulse



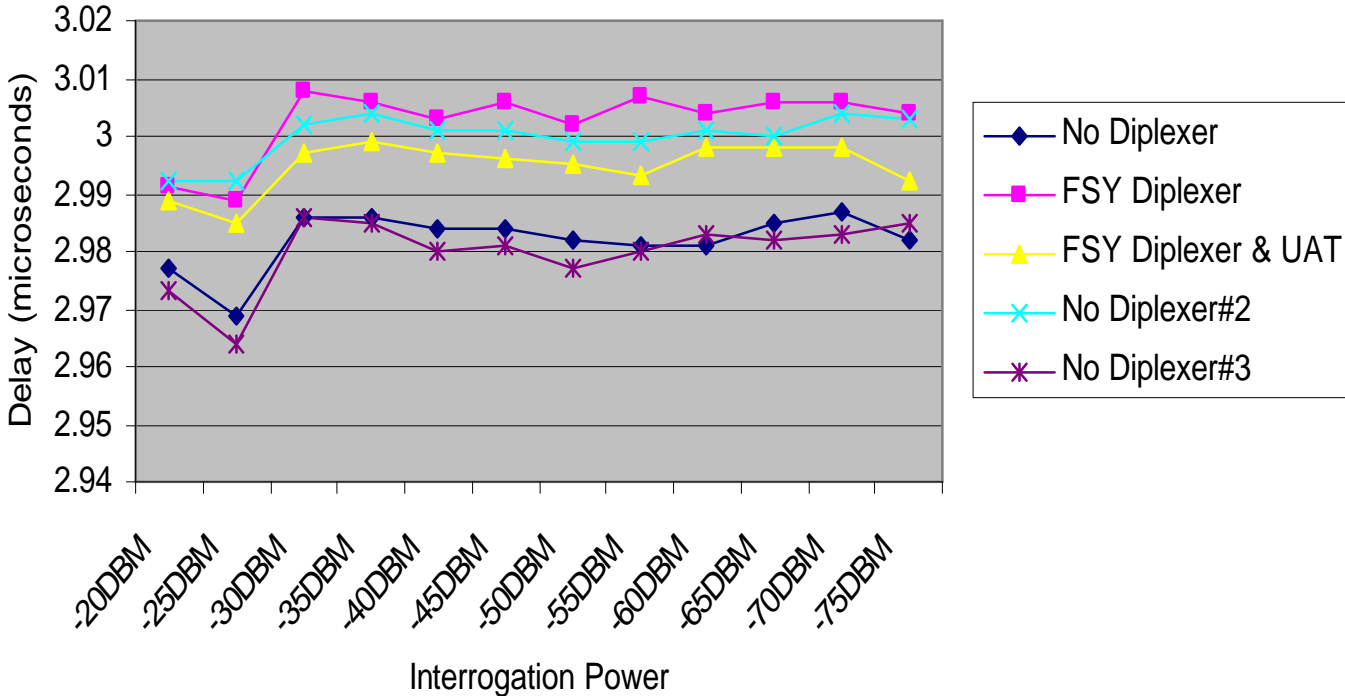
ATCRBS Reply Pulse Spacing



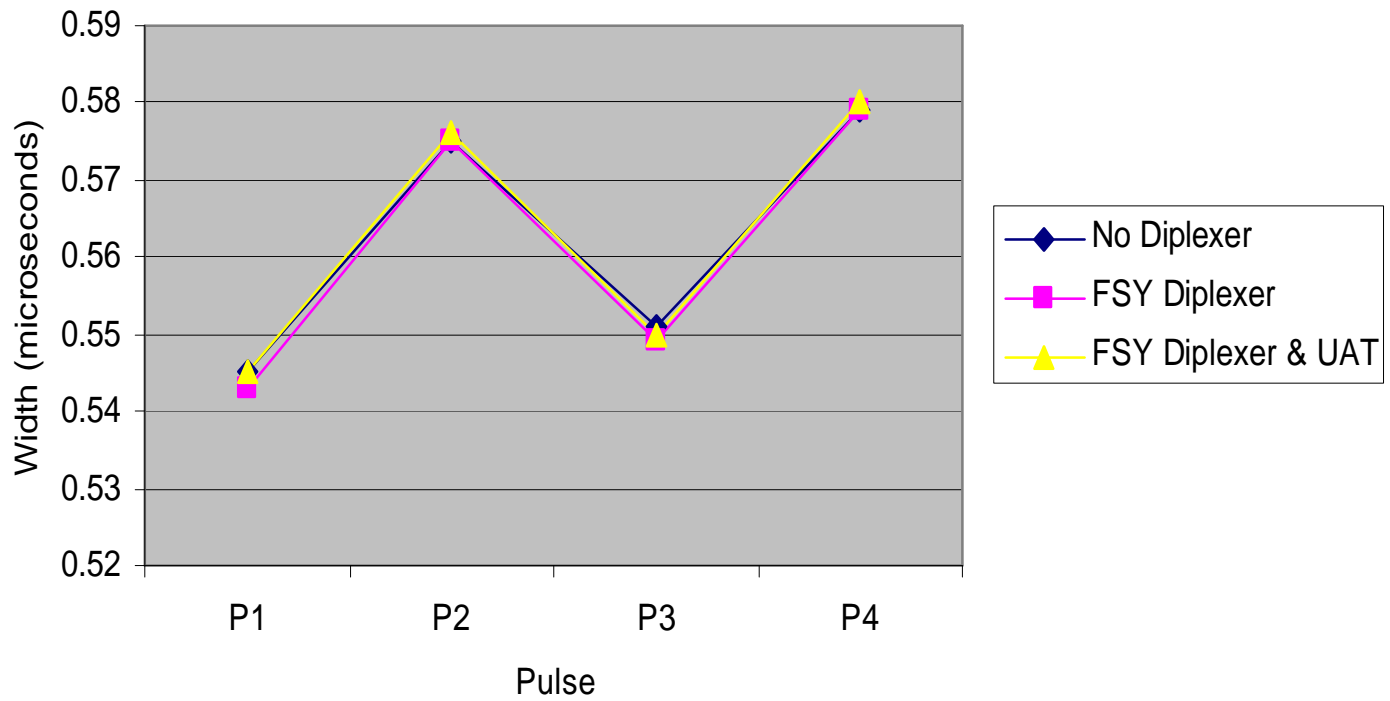
ATCRBS Reply Pulse Width



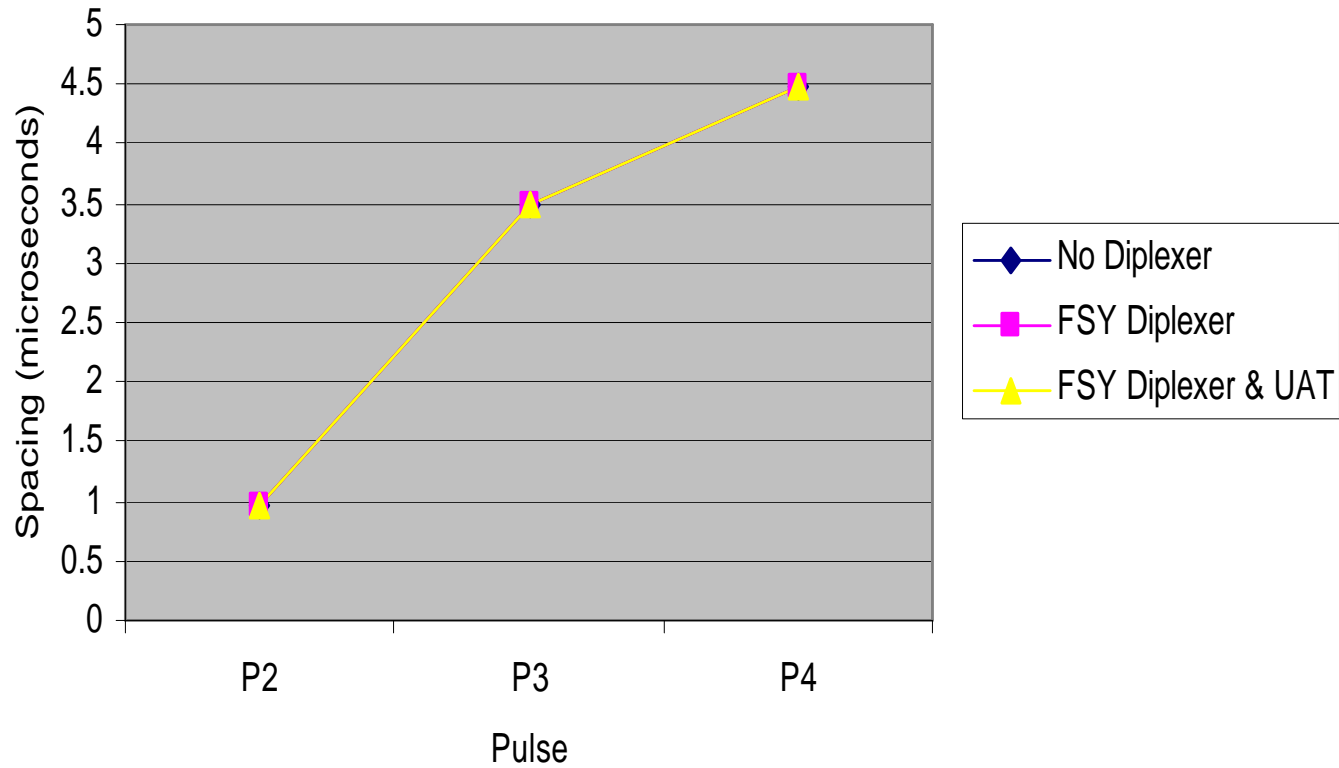
ATCRBS Reply Delay



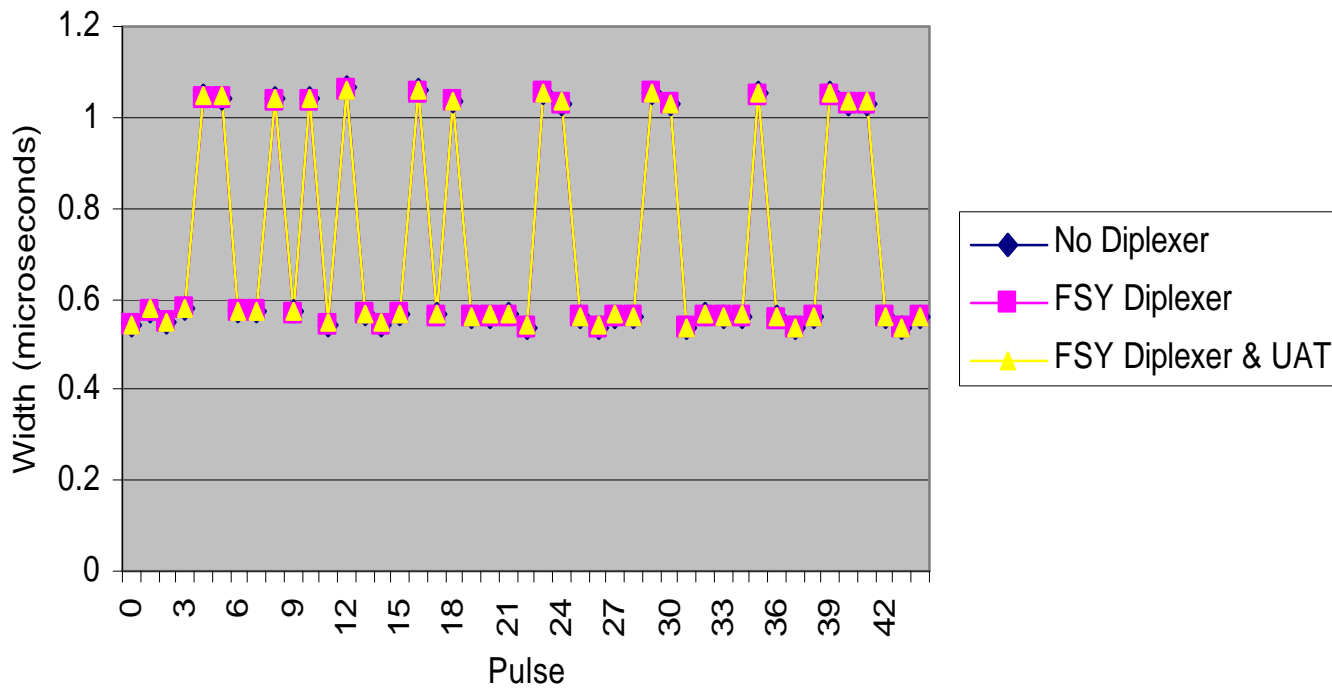
Mode S Preamble Pulse Widths



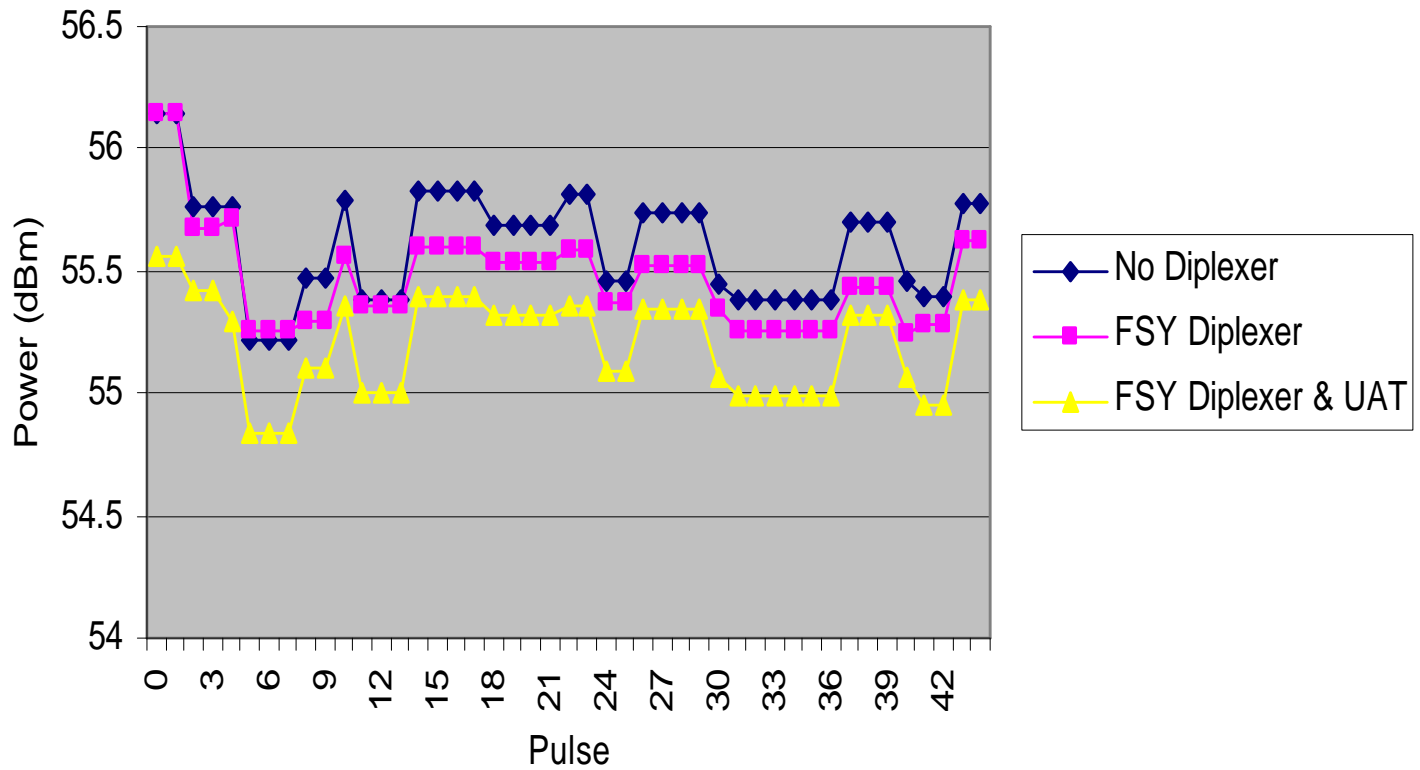
Mode S Preamble Pulse Spacing (ref. P1)



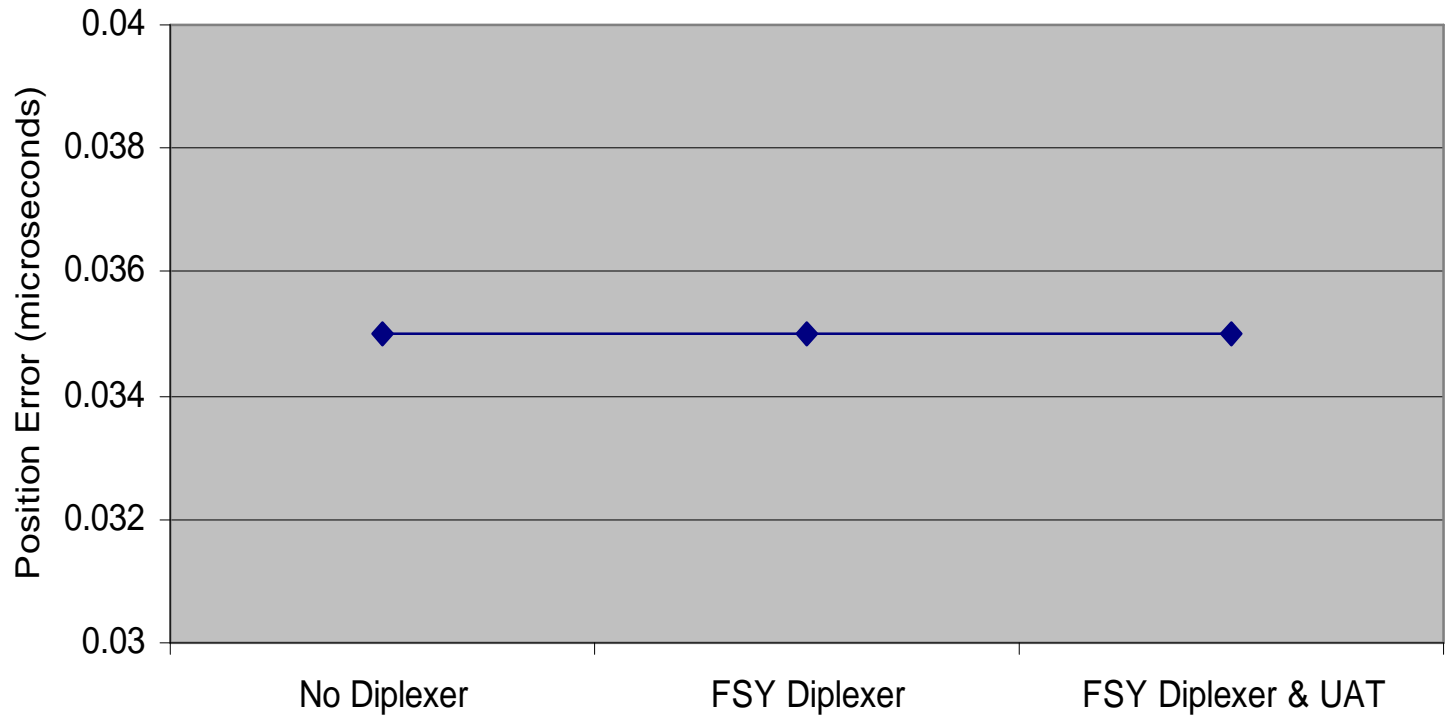
Mode S Reply Pulse Widths



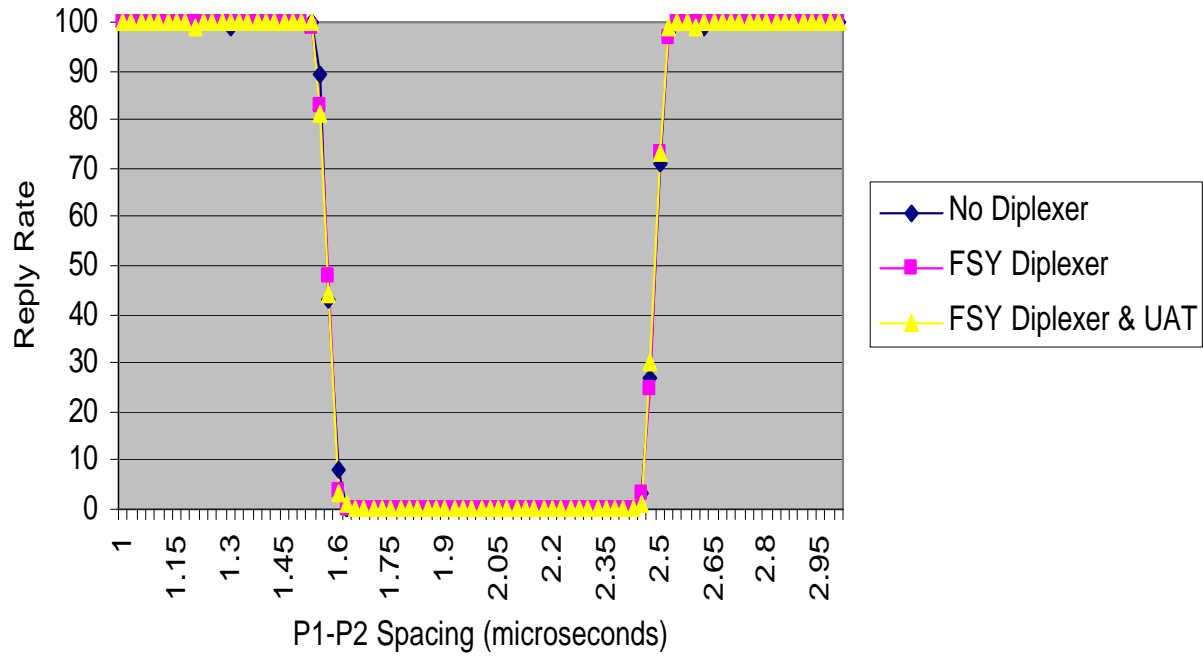
Mode S Reply Pulse Power



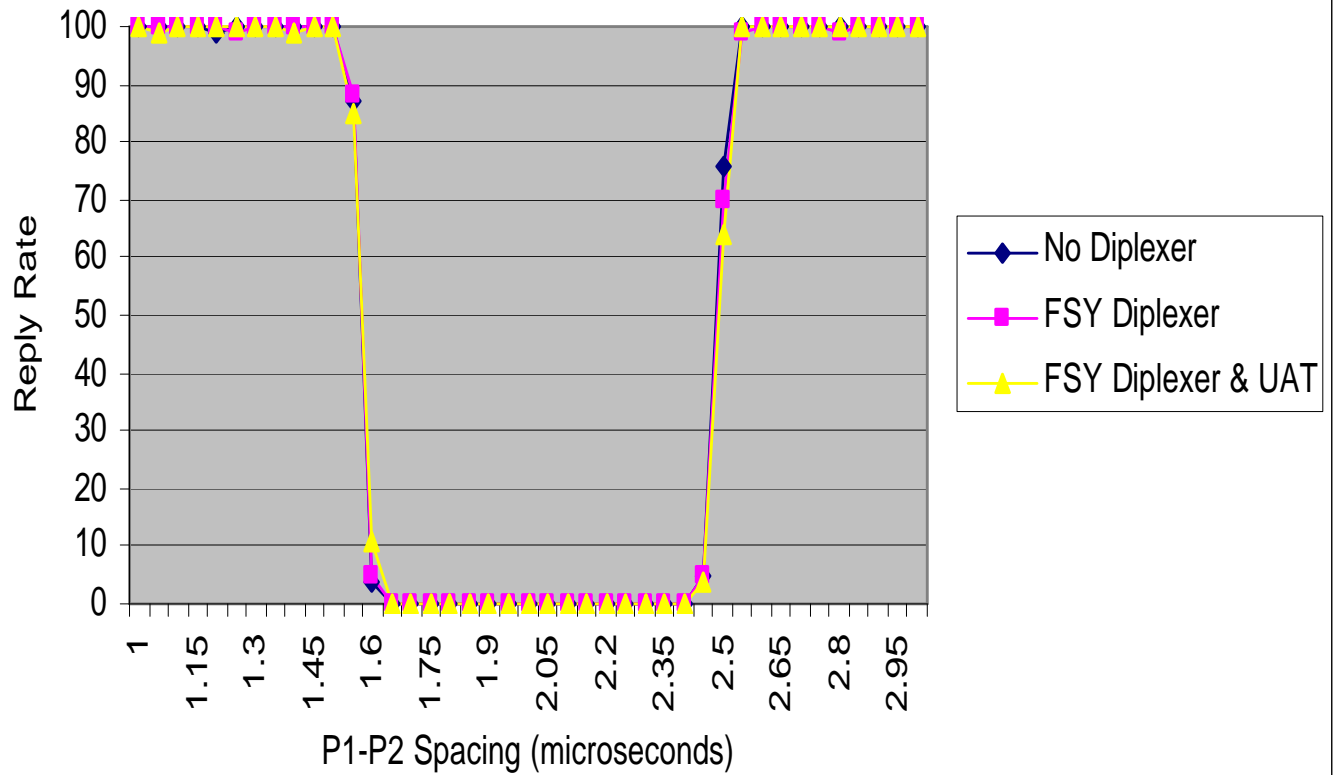
Maximum Mode S Reply Pulse Position Error



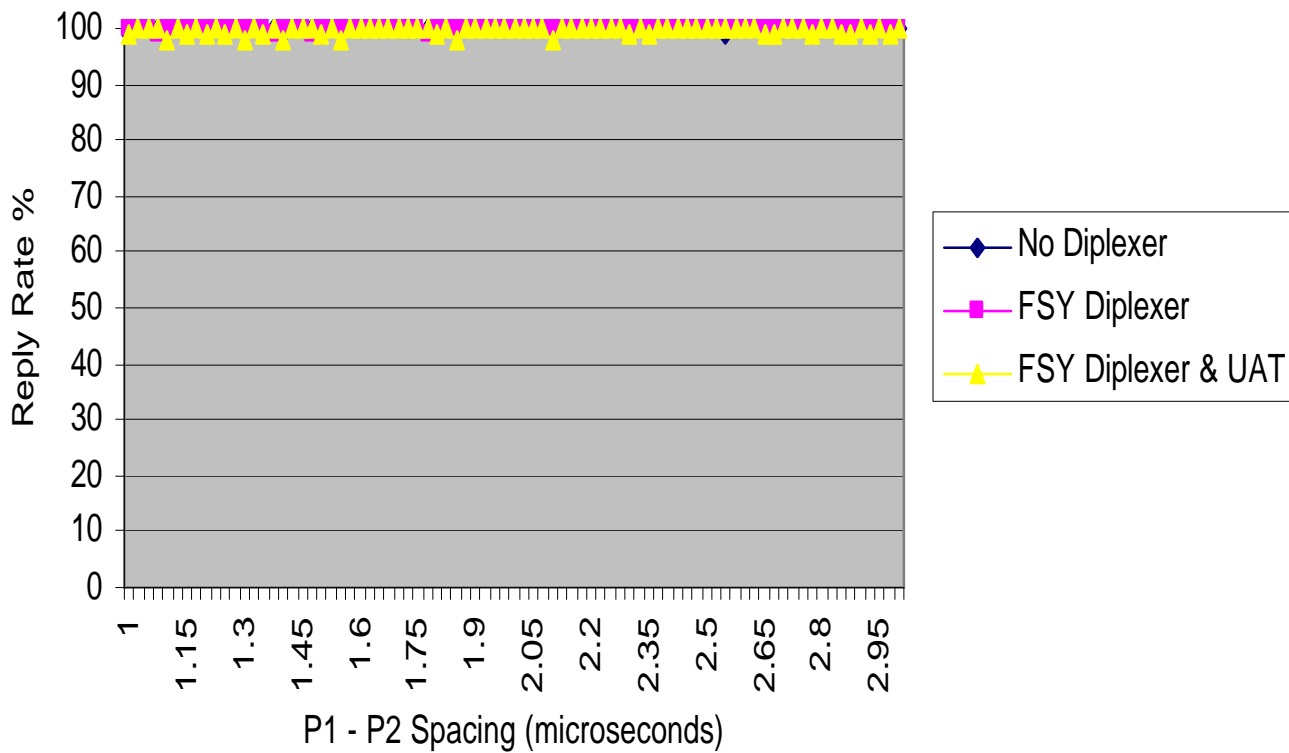
ATCRBS SLS Decoding (P2 Amp. = P1&P3)



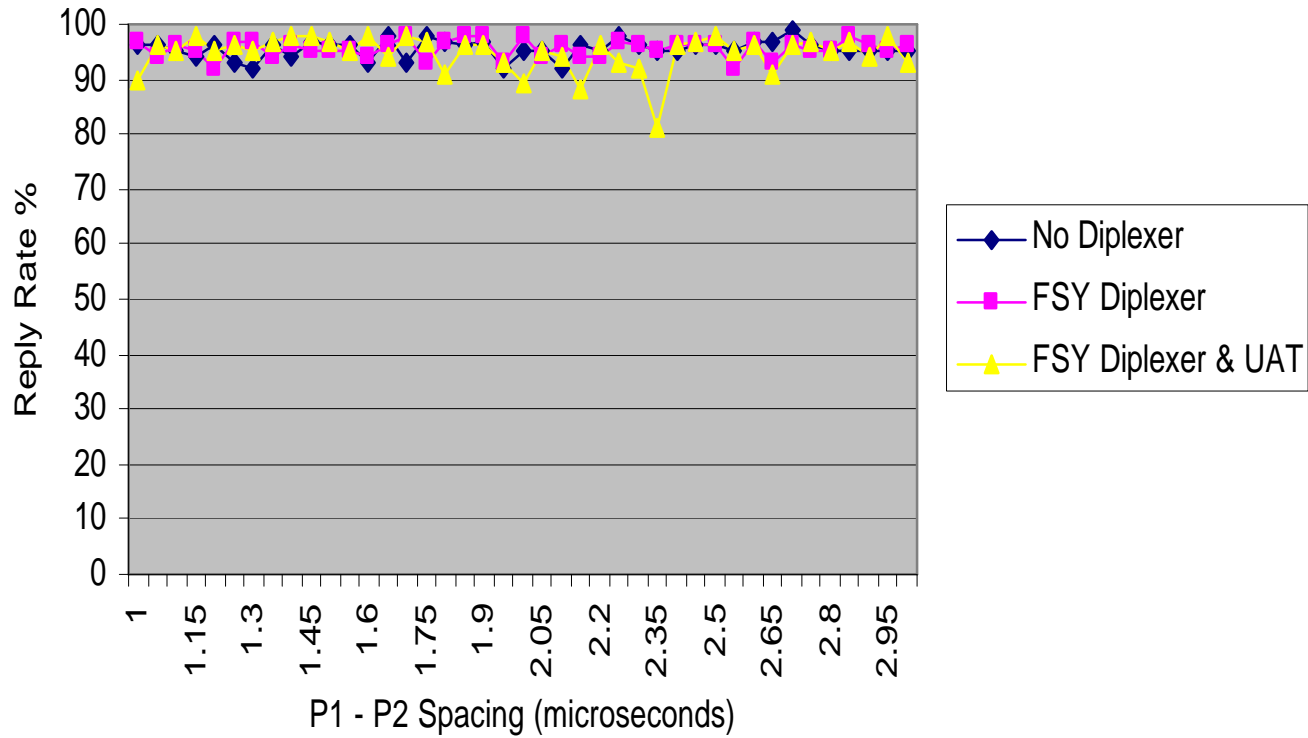
ATCRBS/Mode S SLS Decoding (P2 Amp. = P1,P3,&P4)



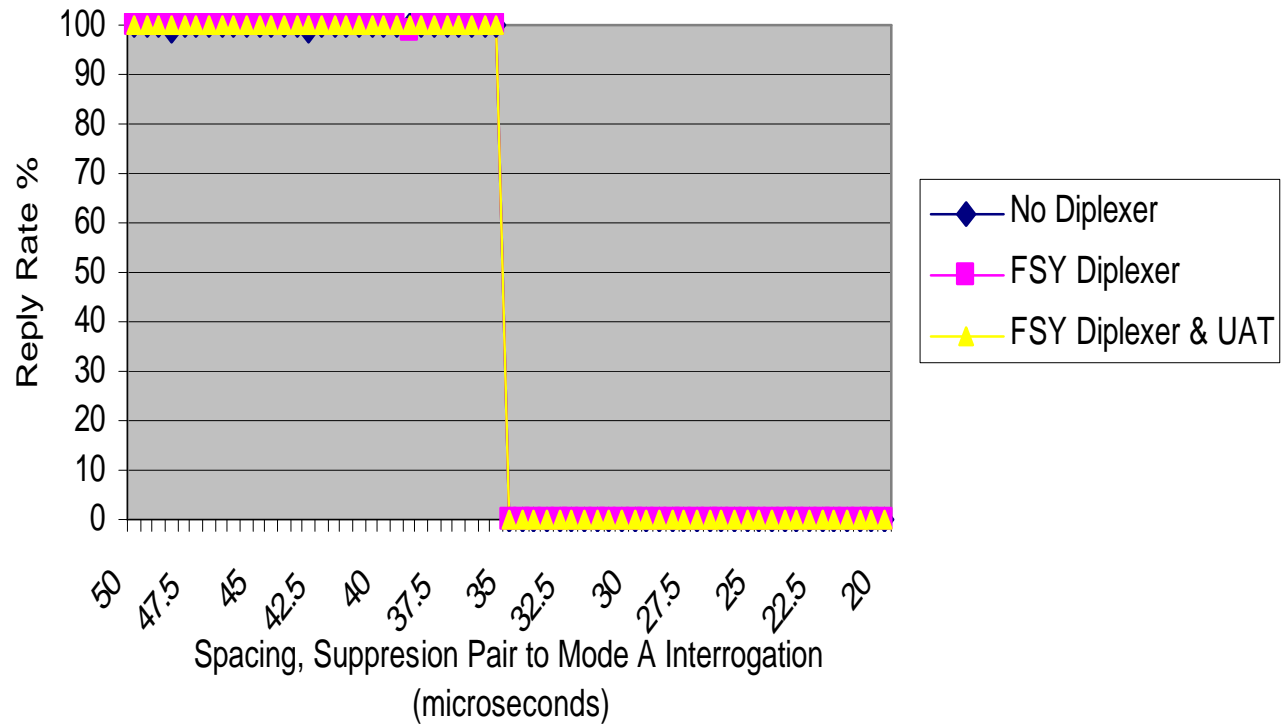
ATCRBS SLS Ratio (P2 9 dB Below P1 & P3)



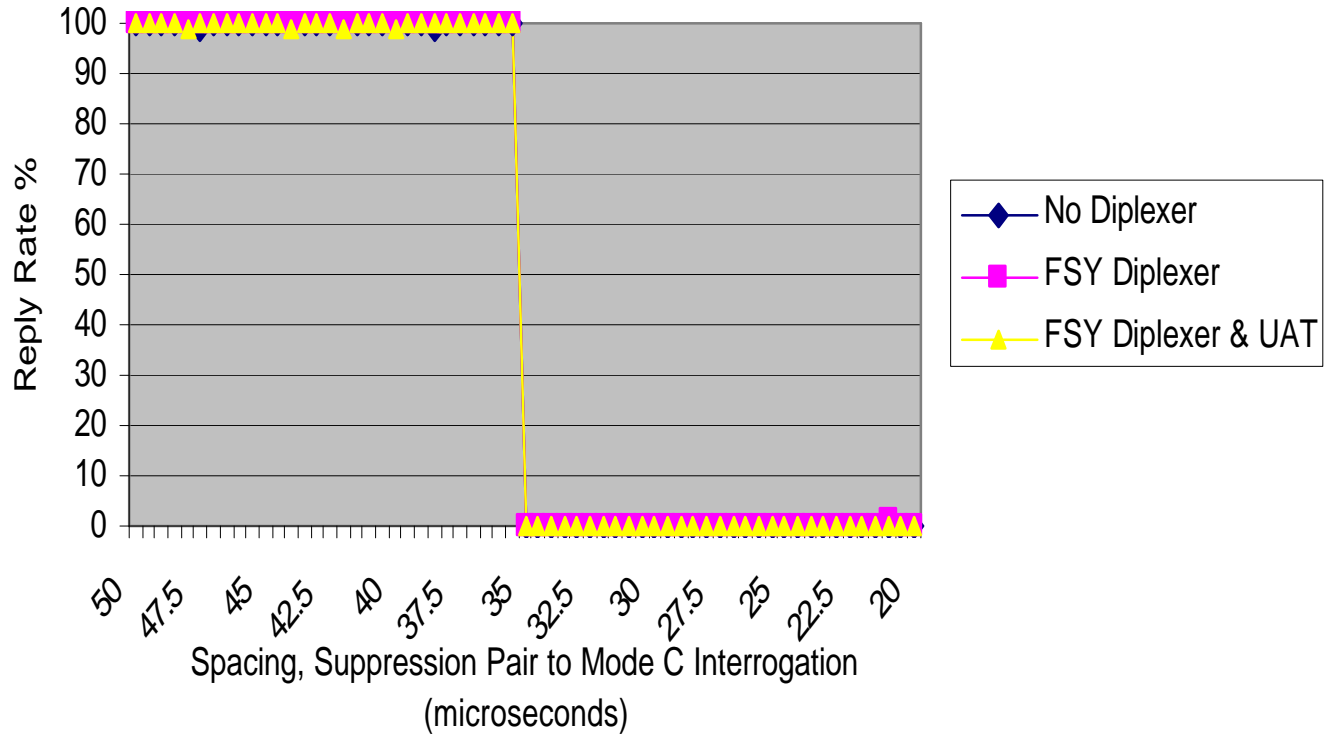
ATCRBS/Mode S SLS Ratio (P2 9 dB below P1, P3 & P4)



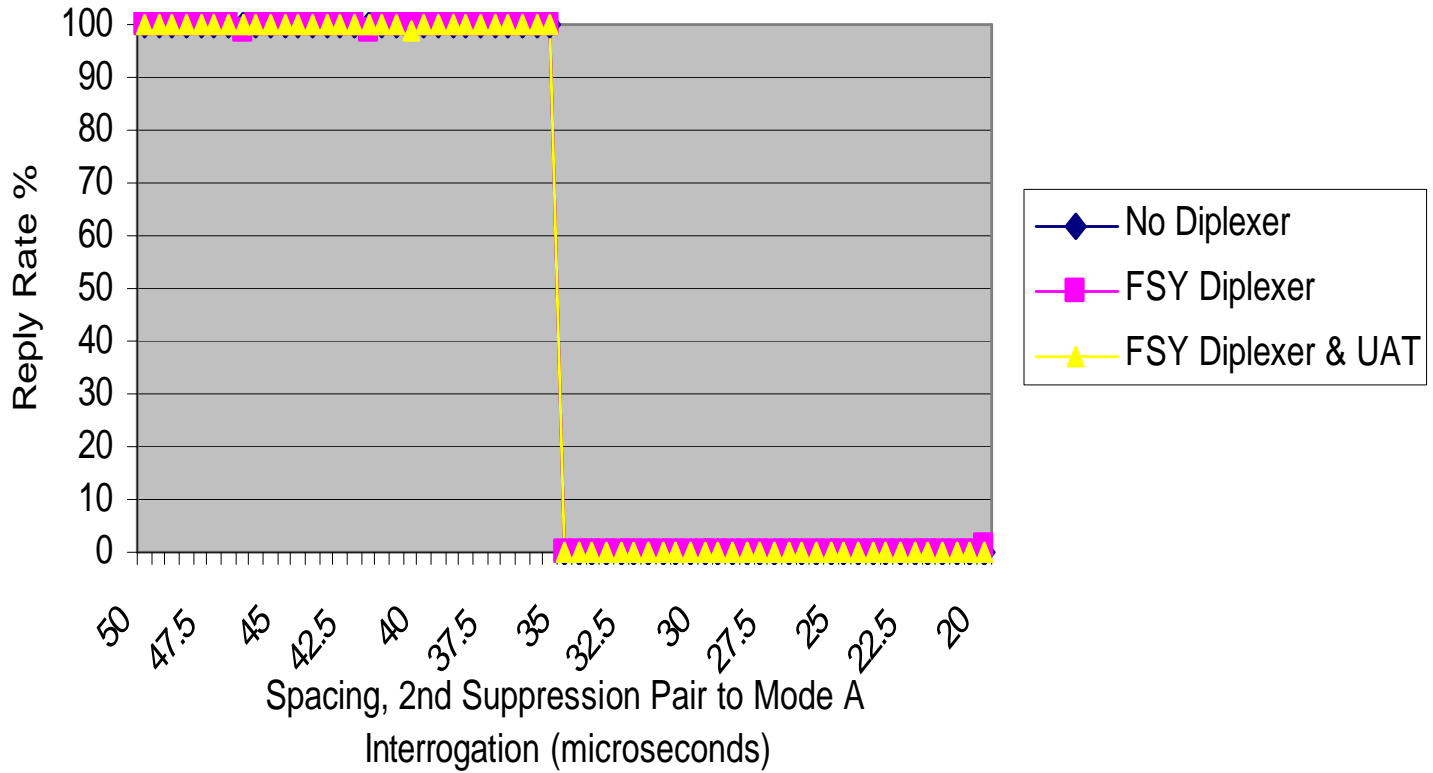
Mode A Suppression Duration



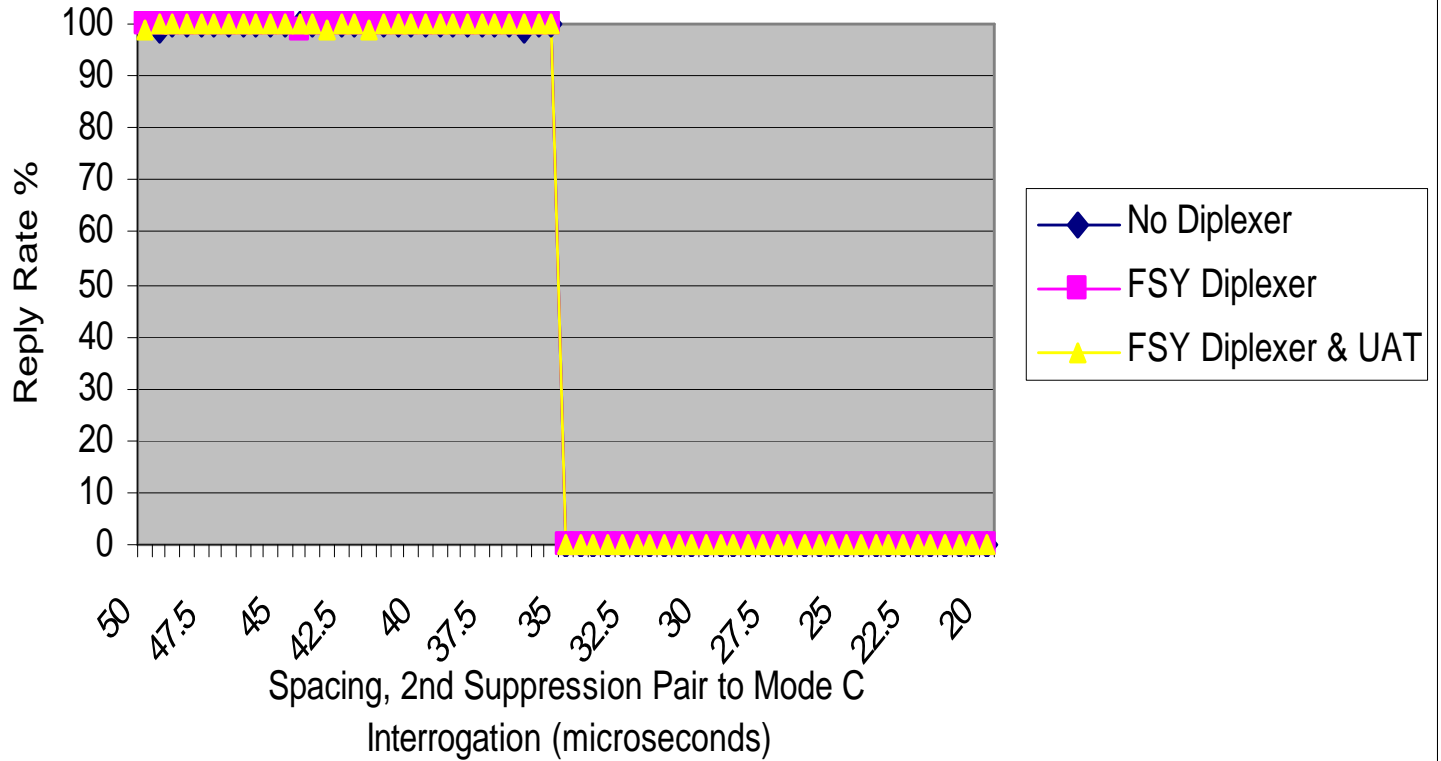
Mode C Suppression Duration



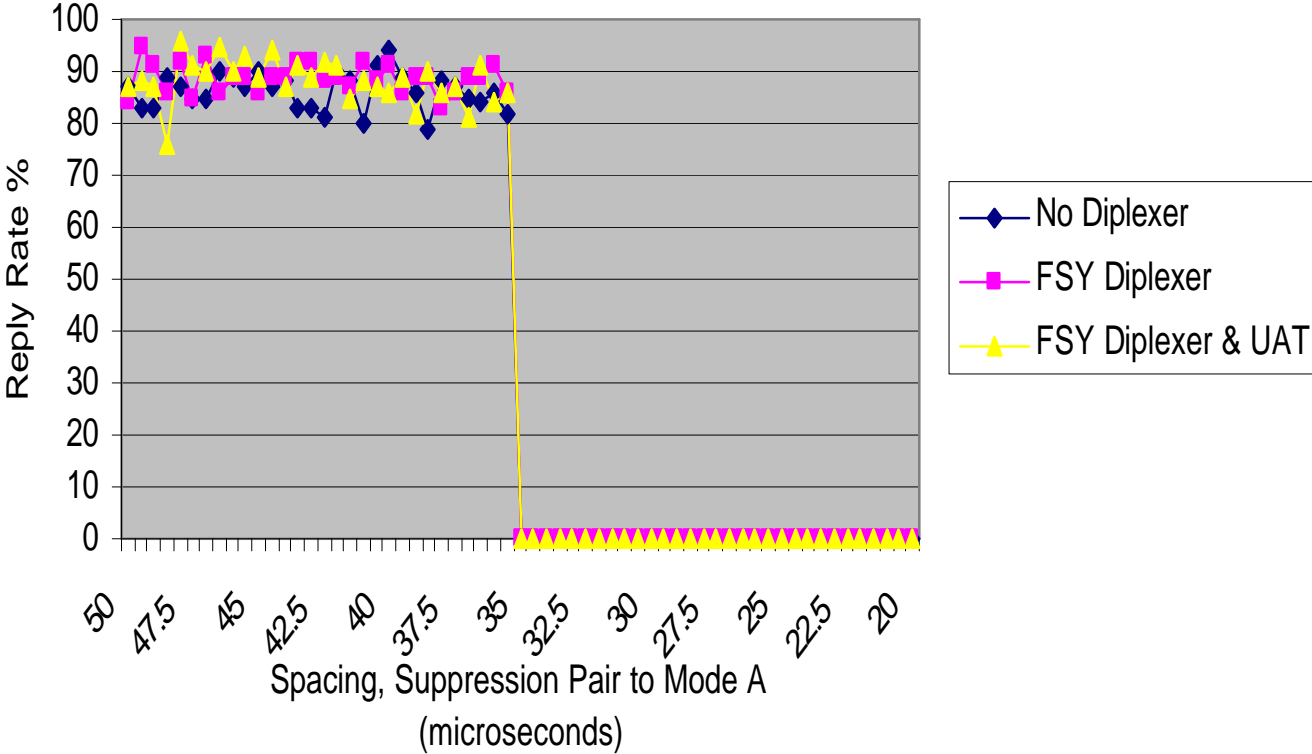
Mode A Suppression Reinitiation



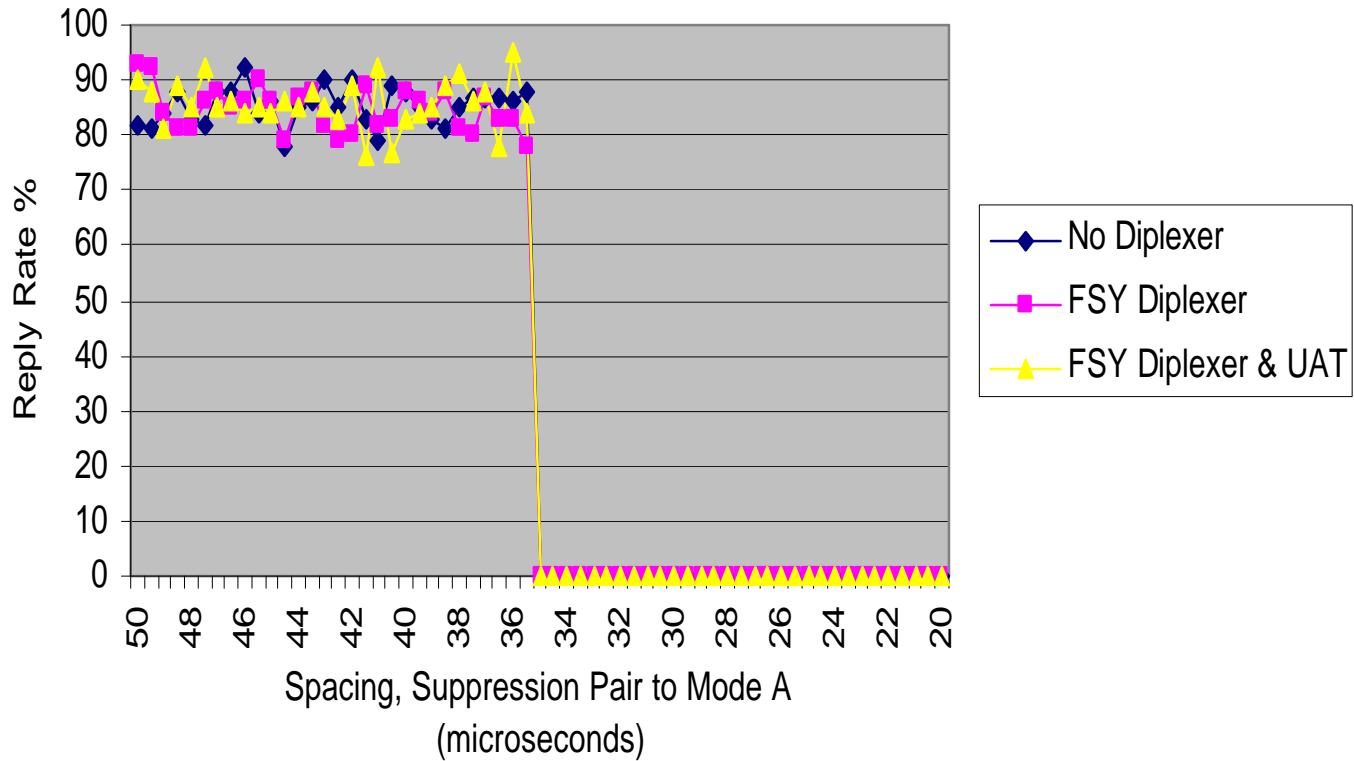
Mode C Suppression Reinitiation



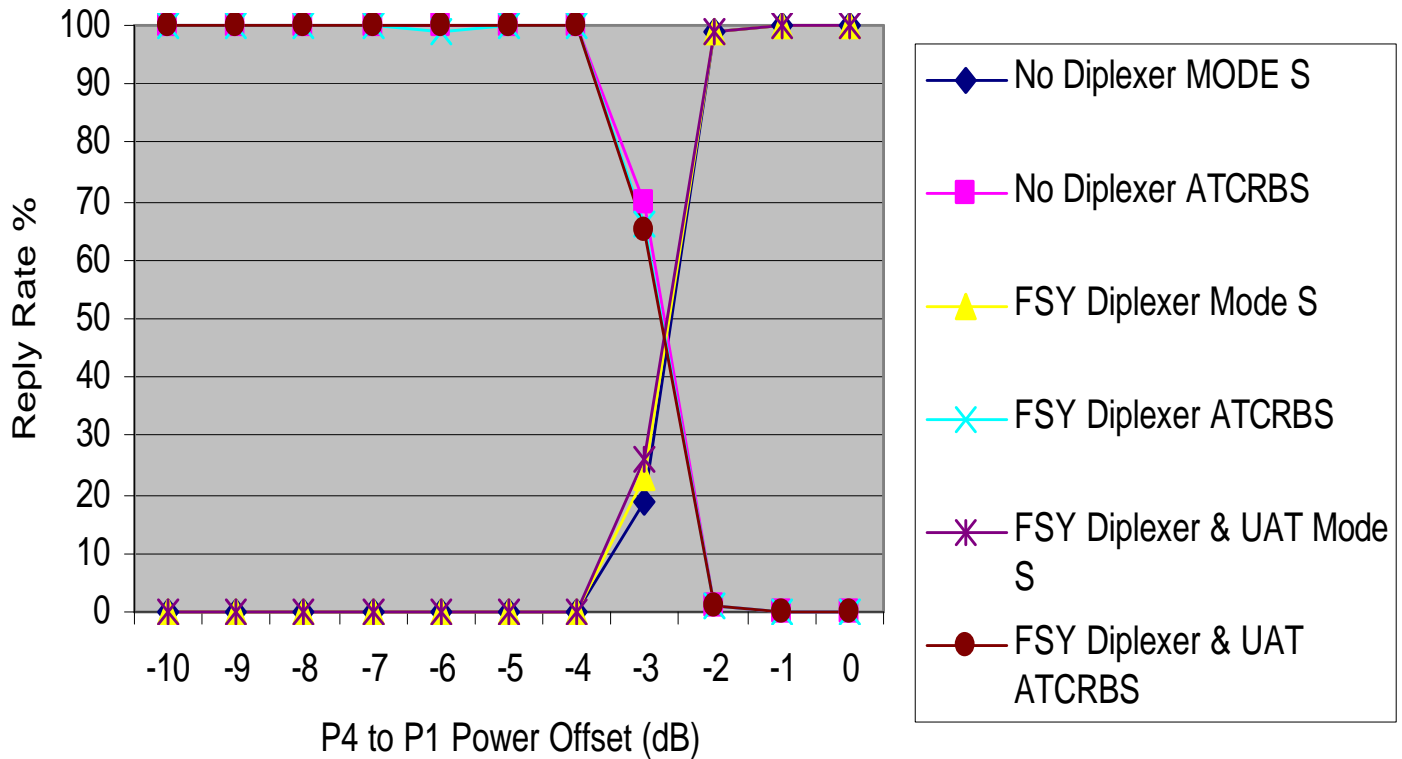
Mode A Recovery After Suppression (Mode A @ MTL)



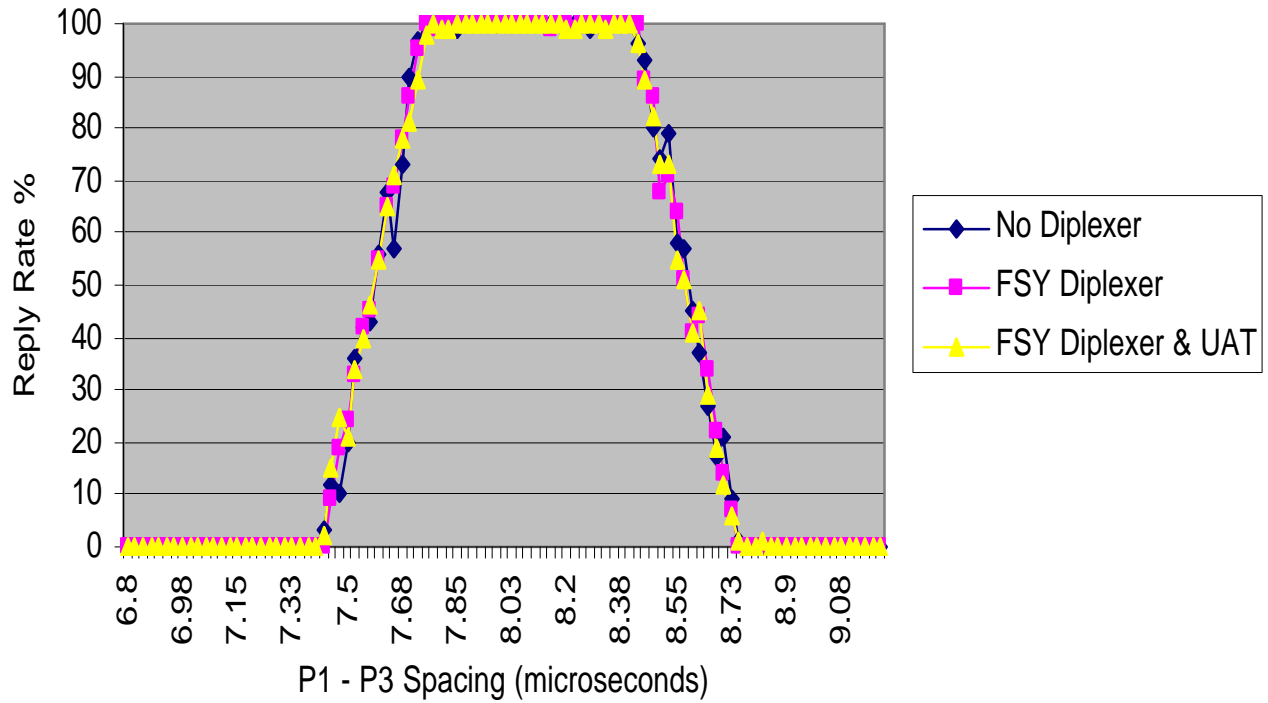
Mode A Recovery After Suppression (Mode A @ MTL)



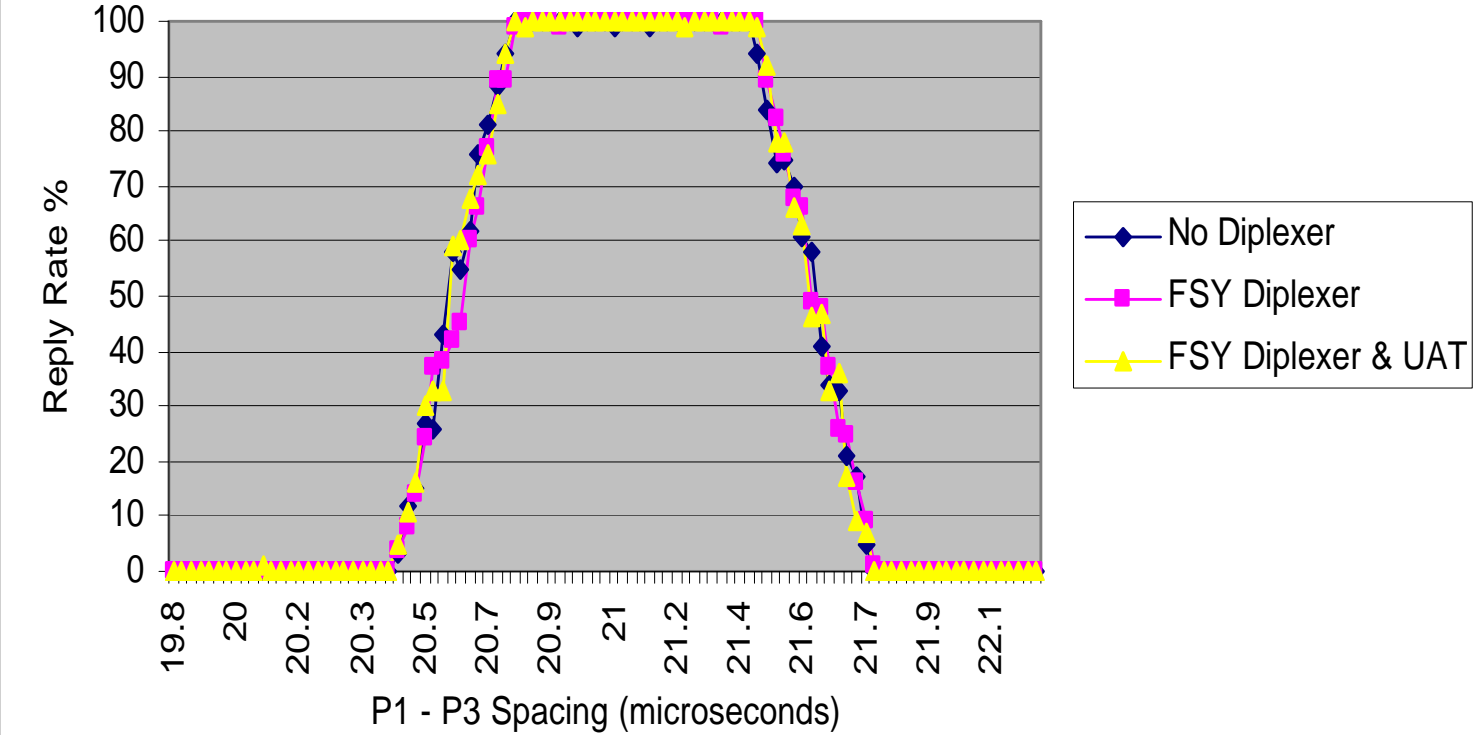
P4 Level Tolerances ATCRBS/Mode S



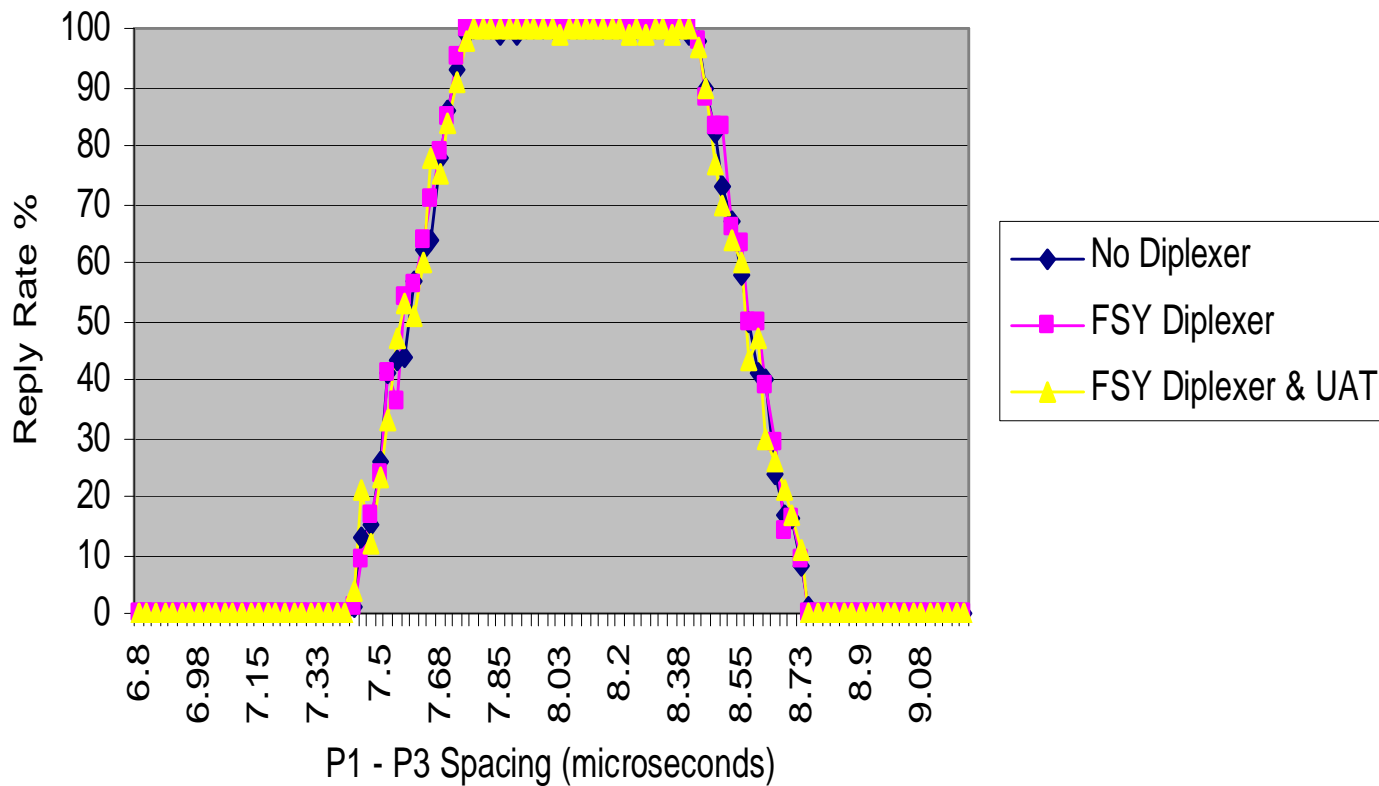
Pulse Position Tolerances P1,P3 Mode A



Pulse Position Tolerances P1,P3 Mode C



P1,P3 Position Tolerances, Mode A/Mode S



P1,P3 Position Tolerances, Mode C/Mode S

