CML Microcircuits

COMMUNICATION SEMICONDUCTORS

Application Note
PDT* Configuration for EV9910B/EV9920B

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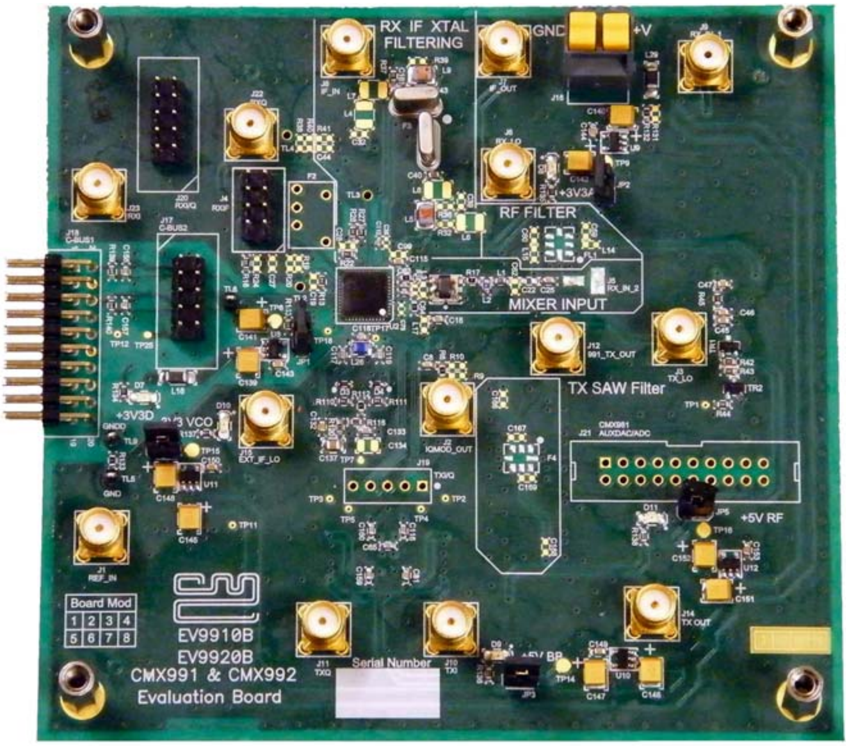


1 Introduction

The EV9910B allows the evaluation of the CMX991 RF Quadrature Transceiver IC and the EV9920B allows the evaluation of the CMX992 Quadrature/Low IF Receiver IC. Full details of these ICs and evaluation PCBs can be found in the relevant datasheets and manuals available from www.cmlmicro.com.

This Application Note describes the use of the EV9910B and EV9920B to evaluate the CMX991 and CMX992 RF ICs for the Chinese *Police Digital Trunking (PDT) system.
A brief outline of the relevant technical characteristics of the system are given in section 2, followed by configuration details in section 3.

This application note applies to EV9910B or EV9920B boards at mod state 2 (see Annex A for definition of ‘Mod State’ markings).

1.1 Contents

2 Introduction to PDT

On 20th April 2010 the Chinese Information and Communications Bureau of the Ministry of Public Security released the Chinese Police Digital Trunking standard (PDT) with the statement:

> "PDT is a fully patented and independently developed digital trunking standard. It will propel the growth of the police communications equipment industry and will bring more efficient and powerful communication solutions to the public security system…"

PDT is known for its all-IP architecture, flexible and convenient networking, quality audio and data applications, responsiveness and encryption. Highly interoperable with the current GIS dispatching platform, the PDT system functions with the requirements from users of different levels, including national, provincial, municipal etc. While it is designed for the contingency of public security, PDT also serves professional communication users and operators in sectors like transportation, port/airport, and energy.

Note:
The PDT standard is a local Chinese standard so there has been limited information available to study concerning the potential application of CML IC devices for PDT. CML's current understanding of the PDT RF requirements is detailed in the following subsections.

2.1 General Requirements

Duplex spacing (Tx to Rx)	10MHz
Channel Spacing	12.5kHz
Multi-address Access Mode	TDMA
Modulation	4-FSK, 9.6kbps
Frequency Stability	1.5kHz (Mobile Station / Portable Radio - Normal conditions) 2.5kHz (Mobile Station / Portable Radio – Extreme conditions)
Operation Temperature	-30 °C to 60 °C

2.2 Transmit

Tx frequency range	351MHz to 356MHz
Output power (portable)	1 W or 4 W ±1.5dB (Normal conditions) +2/-3 dB (Extreme conditions)
Effective radiated power	±6dB
Adjacent channel power	≤-60dB
Alternate channel power	≤-70dB
Switching transient power	≤-50dB (±12.5kHz)
	≤-60dB (±25kHz)
Unwanted emissions	≤-36dBm (9kHz to 1GHz) ≤-30dBm (1GHz to 12.75GHz)

2.3 Receiver

Rx Frequency Range	361MHz to 366MHz
Sensitivity	-120dBm @5% BER
Rx unwanted emissions	≤ -57dBm (30MHz to 1GHz) ≤ -47dBm (1GHz to 12.75GHz)

3 EV9910B and EV9920B for PDT

The EV9910B evaluation card is a platform for investigating the CMX991 RF transceiver IC. The EV9920B supports the CMX992 receiver IC. The EV9910B and EV9920B use a common PCB with the appropriate IC fitted. The CMX992 functionality is essentially the same as the receiver sections of the CMX991.

The CMX991 and CMX992 are excellent devices to support the requirements of PDT. The EV9910B/EV9920B can be used to evaluate the devices for PDT applications by making a number of modifications to the standard component values.

3.1 Frequency Plan

The EV9910B/EV9920B has a default receiver IF of 45MHz. An analysis of receiver spurious responses shows there are relatively few; for example with a LO at 406MHz (RF = 361MHz) spurious responses could potentially be found at:

360.875MHz (8 x RF - 7 x LO)
360.9MHz (-0 x RF + 9 x LO)

These have however been measured on a modified EV9910B and found to be rejected by better than 80dB.

On transmit, some high-order in-band spurs could be expected with a 45MHz IF, however measurements have suggested[1] the levels are well below the required 72dB. A change to 47MHz IF would eliminate the spurs but this does not appear to be necessary.

So the suggested frequency plan for PDT operation is:

Receiver:

Rx band is 361MHz to 366MHz using 45MHz IF.

Therefore: LO range = (361 + 45) x 2 = 812MHz
to (366 + 45) x 2 = 822MHz.

Transmitter:

Tx band is 351MHz to 356MHz using 45MHz IF.

Therefore: LO range = (351 + 45) x 2 = 792MHz
to (396 + 45) x 2 = 802MHz.

[1] See section 3.5.2.

3.2 Receive Path Considerations

The following sections details changes to the EV9910B/EV9920B receiver sections and typical performance with the changes implemented.

3.2.1 LNA

Typical performance of the EV9910B/EV9920B LNA is shown in Figure 1. The LNA can be re-tuned for 350MHz operation with the following changes:

- C50 = 8.2pF
- C51 = 8.2pF
- C52 = 12pF
- C57 = 15pF
- C58 = 15pF
- L10 = 22nH (0805HQ type)
- L11 = 33nH (0805CS type)
- L12 = 33nH (0805CS type)
- L13 = 27nH
- R46 = 18ohms

Typical performance of the modified design is shown in Figure 2 and Figure 3, the results being measured between J9 and the output of C52.

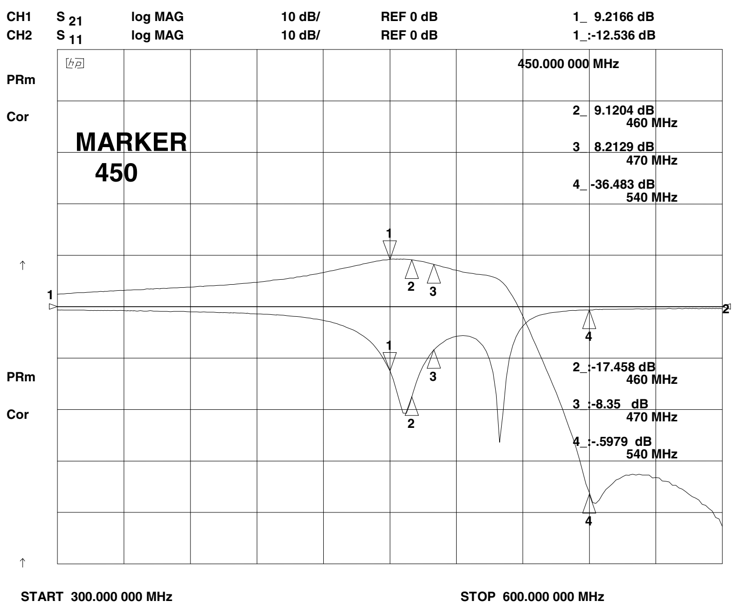


Figure 1 – Typical 460MHz LNA S_{21} and S_{11} response (including attenuator) prior to modification

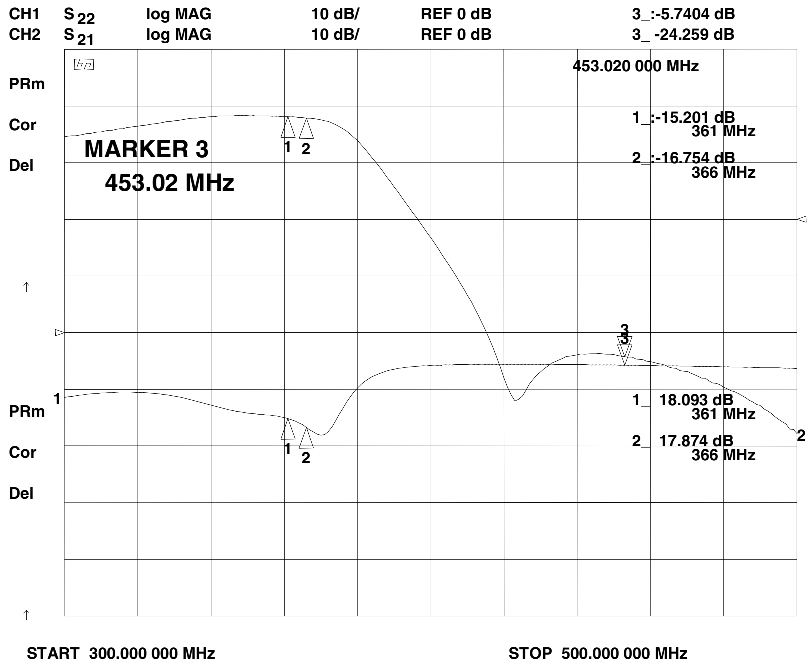


Figure 2 – LNA modified for 350MHz operation showing typical S_{21} and S_{22}

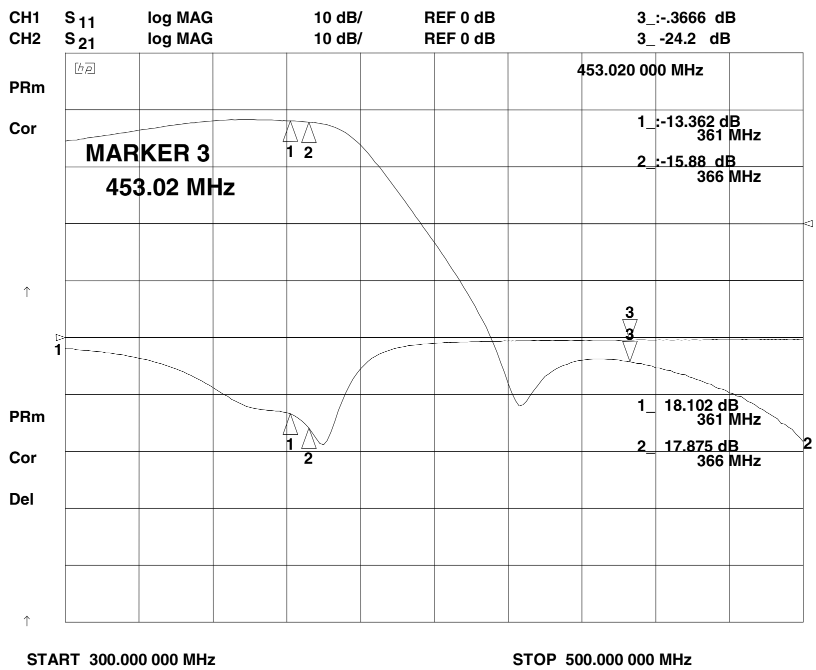


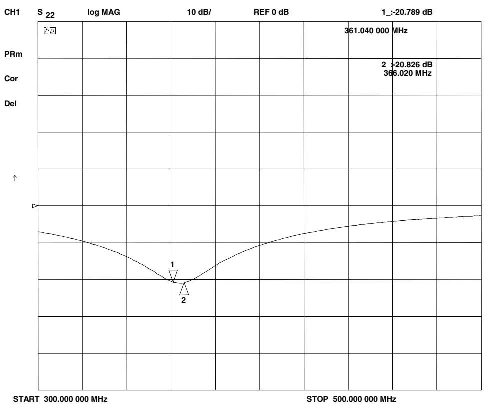
Figure 3 – LNA modified for 350MHz operation showing typical S_{21} and S_{11}

3.2.2 CMX991/CMX992 Rx Mixer

The Rx mixer input (J5) can be matched to 361MHz – 366MHz using the existing EV9910B/9910B circuit values (including balun transformer T1) with the following changes:

- C25 =0R
- L1 = 43nH (0603CS type)
- L2 = 68nH (0603CS type)
- R49 = NF

Results are shown in Figure 4.



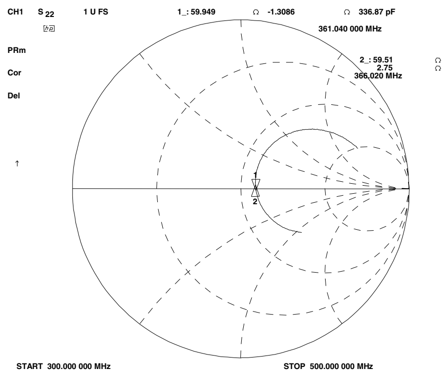


Figure 4 - J5/Rx mixer input match to 361-366 MHz

3.2.3 Crystal Filter

For PDT evaluation use, the IF crystal filter would need to be changed from the current 25kHz channel part to a filter for 12.5kHz channel operation (e.g. use part 45G7B1). This will necessitate a change in the matching values.

3.3 Transmit Path Considerations

3.3.1 T Filtering

An examination of the requirements in section 2.2 shows that all transmitter spurious products should be below –72dBc (-36dBm – (+36dBm)).

Measurements of the CMX991 transmitter output using the arrangements described in section 3.5.1 show that the worst spurious product is typically the Tx Local Oscillator at 45MHz above the wanted signal. A typical level measured at J12 this is –28dBc[2].

As a result, filtering after the CMX991 needs to provide at least another 44 dB (preferably nearer 50dB) of rejection. The existing EV9910B transmit filter plus buffer amplifier achieves approximately 20dB rejection at +60MHz (Figure 5).

Re-designing the filter using notches to improve the rejection suggests circa 50 dB rejection is possible at +45 MHz. Tolerances have been included in the simulation and appear to be satisfactory, however 0.1pF tolerance capacitors are recommended for the small values (below 10pF).

[2] CMX991 worst case level is –25dB.

Other mixing products may still cause a problem (e.g. –45MHz, where around 30dB rejection needed).

An alternative to an LC type filter is a SAW filter. Suitable SAW filters are available from a number of manufacturers such as the TaiSAW TA1209A and TA1210A which are available through Golledge Electronics (www.Golledge.com).

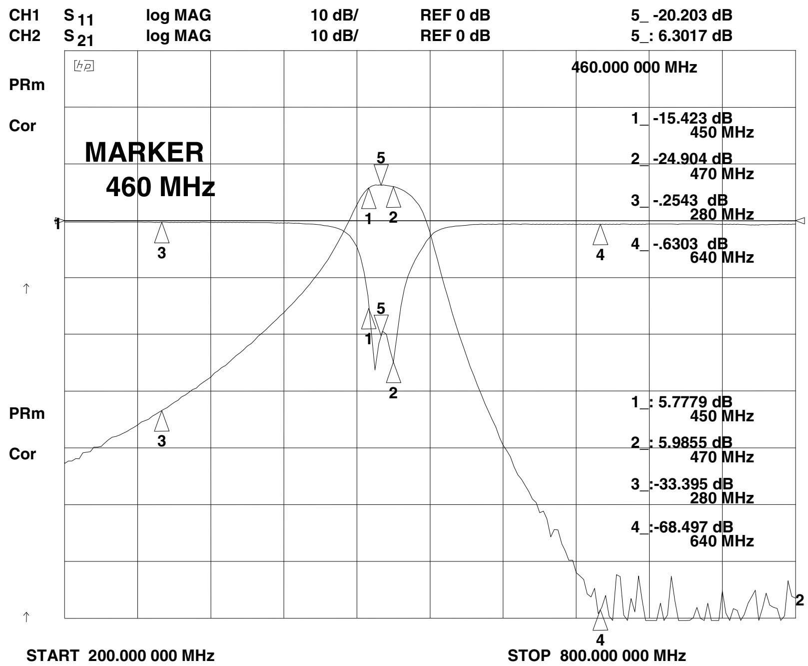


Figure 5 – EV9910B 460MHz default build, typical response of optional Tx filter + buffer

3.4 Receiver Performance

As a result of the modifications in section 3.2, the receiver was found to have slightly higher gain (+1.6dB) than previously found at 460 MHz. Results are summarised in Table 1; note that the rejection figures refer to output tone levels with respect to a wanted signal at -104dBm - they do not include required signal-to-interferer ratios.

Parameter	Level
Receiver Gain (Including LNA)	63.6dB
Image rejection	42dB
Half IF rejection	79dB
Spurious response rejection: 360.875MHz (361MHz Rx) 360.9MHz (361MHz Rx)	 >95dB 93dB
Overall system NF	7.3dB
Input IIP3	-0.5dBm

Table 1 – EV9910B/EV9920B receiver performance summary

The image rejection is dominated by the response of the pre-LNA filter and as the EV9910B/EV9920B only uses a simple LC, design performance is less than might be required. A post LNA SAW filter is recommended to achieve better performance. The EV9910B/EV9920B includes a footprint for a filter (FL1). In the PCB as supplied a resistive pad (R48/R49/R51) emulates the attenuation of the filter.

3.5 Transmitter Performance

3.5.1 CMX991 Output Match

The transmitter output (J12) can be matched using original EV9910B circuit values with the following changes:

- C80 = 100nH (0603CS)
- L27 = 36nH (0603CS).

Results are shown in Figure 6.

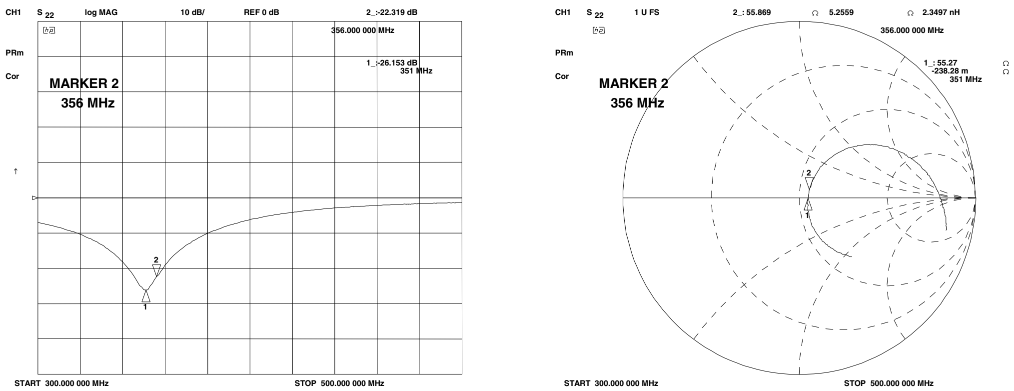


Figure 6 – J12/Tx mixer output match to 351 - 356 MHz

3.5.2 Tx Filter and Buffer

The EV9910B filter can be modified as discussed in section 3.2 as follows.

Tx Filter:

Ref	Previous Value	360 MHz Value
C121	DNF	12pF
C131	5.6pF	8.2pF
C165	56pF	8.2pF
C136	DNF	27pF
C162	DNF	27pF
L28	22nH	39nH (1008CS)
L32	22nH	39nH (1008CS)
L33	22nH	39nH (1008CS)
C122	1.0pF	2.7pF
C127	1.0pF	2.7pF
C123	5.6pF	3.3pF
C125	5.6pF	3.3pF
C128	5.6pF	3.3pF
C170	DNF	1.0nF

Amplifier:

Ref	Previous Value	360 MHz Value
L34	15nH	33nH.
C174	18pF	27pF
C175	6.8pF	4.7pF
C178	18pF	33pF

The results from the filter are shown in Figure 7 to 13 inclusive. The overall performance of the transmitter chain is shown in Figure 14 and Figure 15. As expected the only product above the –72dBc limit is the +45 MHz product. A further stage of filtering, or possibly a little attenuation from the transmitter harmonic filter, should be enough to bring this product within the overall requirement. The in-band performance, as shown in Figure 15, is excellent with no products observable close to the -72dBc limit. A further plot showing the absence of spurs is shown in Figure 16, users should note that if the PE0002 card is being used to control the EV9910B it can generate a spur at 360MHz. Once the EV9910B has been programmed the PE0002 can be disconnected and powered down.

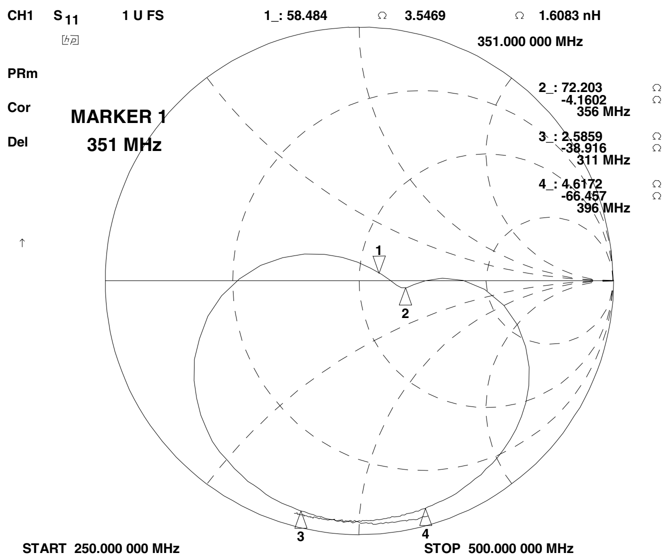


Figure 7 - 355MHz Tx filter input

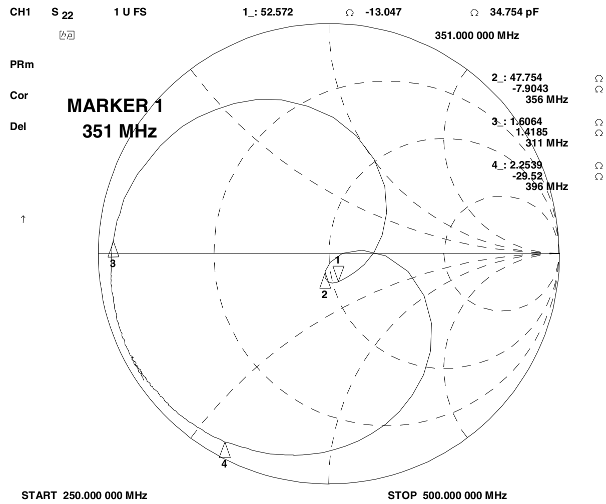


Figure 8 - 355MHz Tx filter output

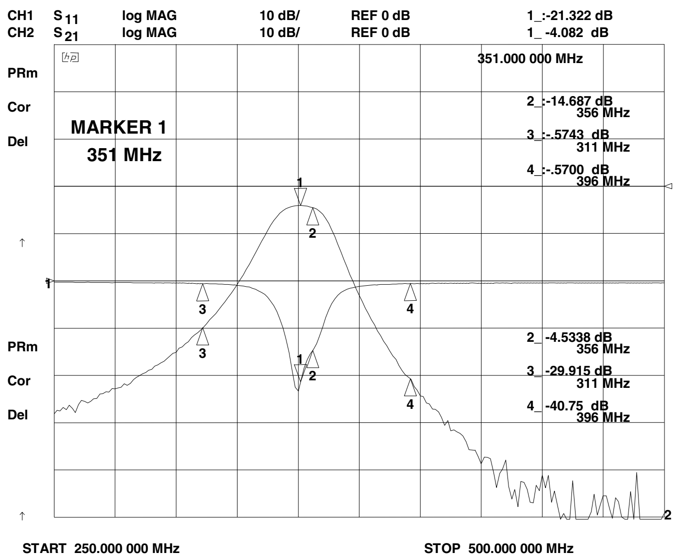


Figure 9 - 355MHz Tx filter , response and S11

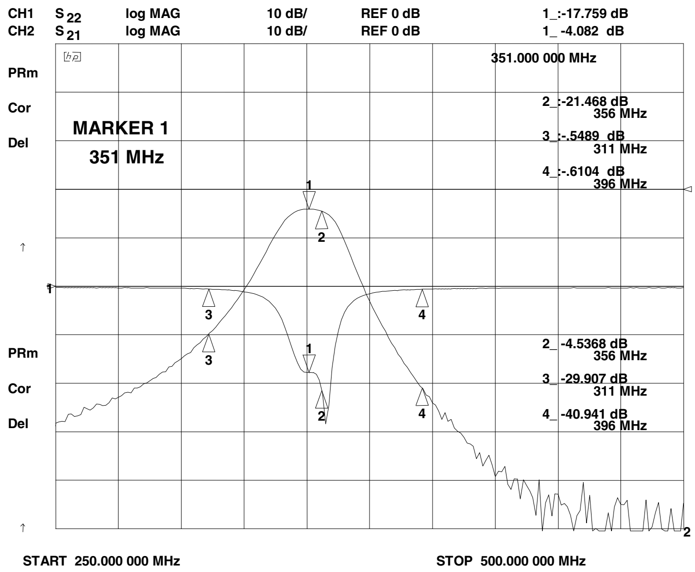


Figure 10 - 355MHz Tx filter , response and S22

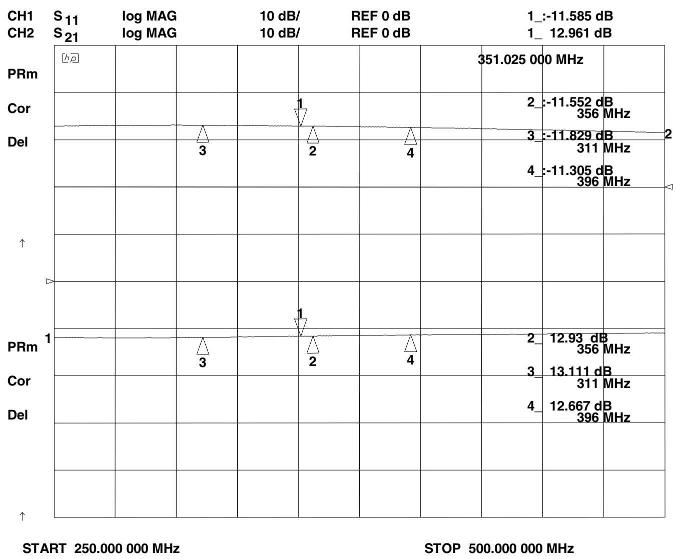


Figure 11 - Tx amp S21, S11

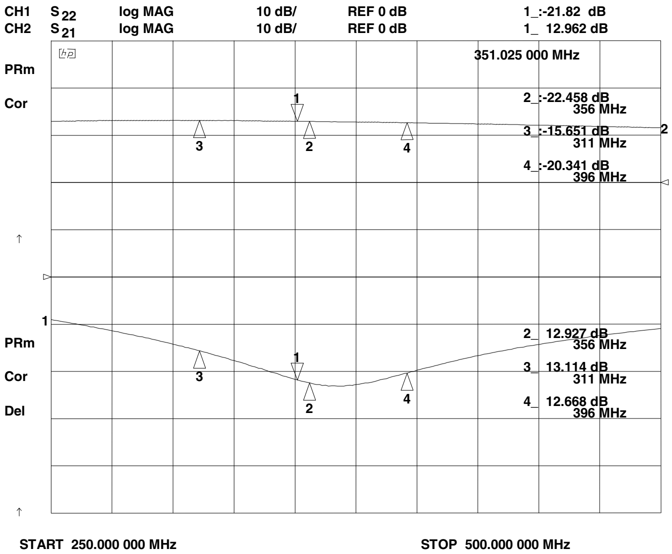


Figure 12 - Tx amp S21, S22

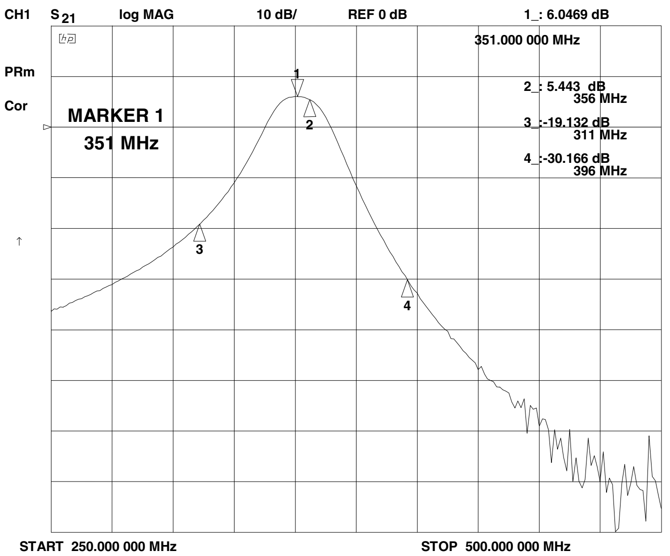


Figure 13 - Overall plot of Tx filter, amp and attenuator.

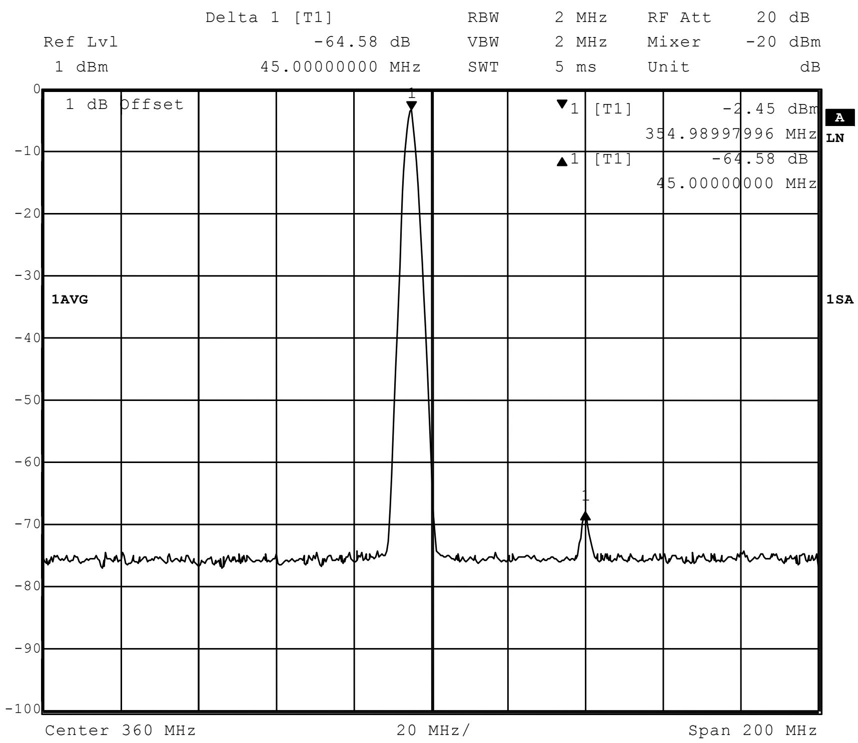


Figure 14 - Modified EV9910B Tx output with 200MHz span and 355MHz carrier; the spur at +45MHz is -64dBc

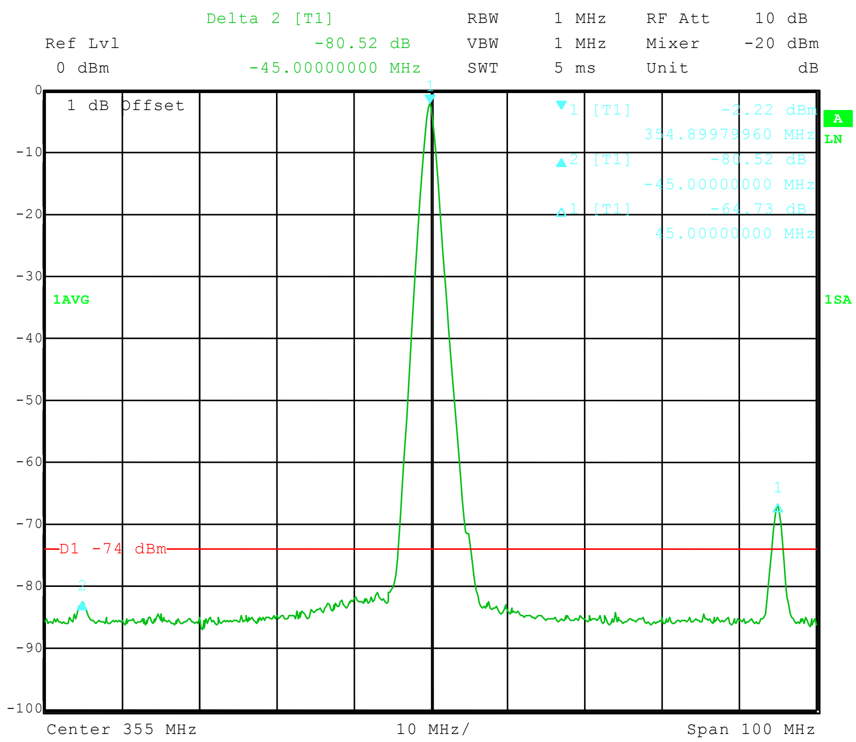


Figure 15 – Modified EV9910B Tx output with 100MHz span showing no other spurri above –74dBc

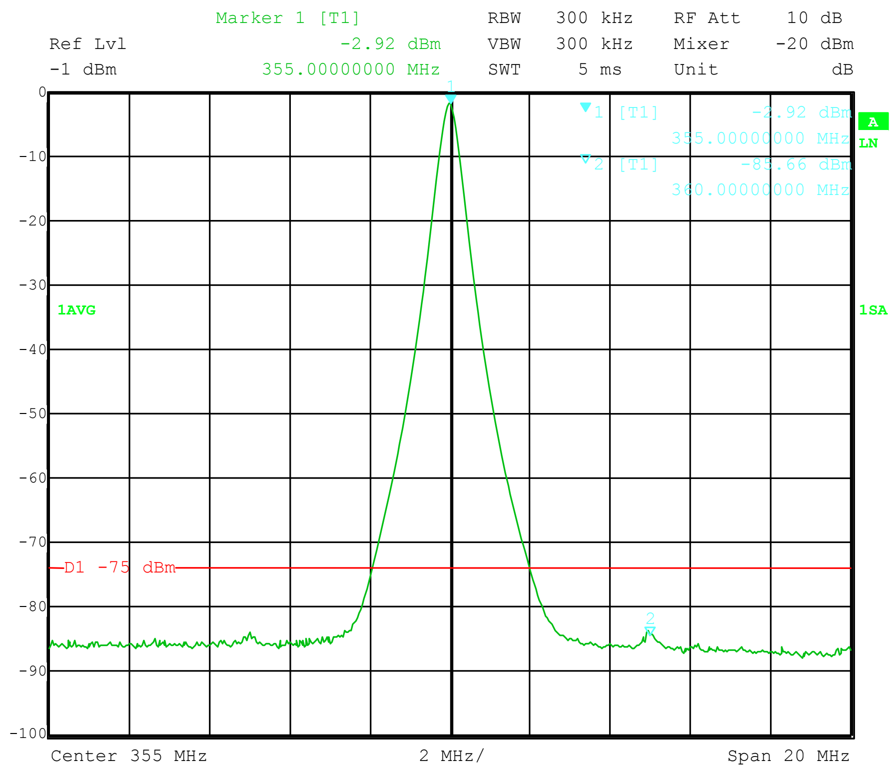


Figure 16 – Modified EV9910B Tx output with 20MHz span showing no other spurii above –74dBc

Annex A Identifying the mod state and board revision

The mod state (modification state) of a particular EV9910B can be determined from the ‘Board Mod’ box printed on the PCB silkscreen. The number of figures that is blacked out gives the mod state. The following examples indicate a mod state of 3.

Figure 17 – Mod state illustrations

The letter that follows the PCB reference gives the board revision. The EV9910B is marked “PCB570D”, indicating the board is revision D. The first production release was PCB570D Mod state 2.

Annex B Glossary of Terms

ACP	Adjacent Channel Power
ACR	Adjacent Channel Rejection
DNF	Do Not Fit
GIS	Geographic information systems (or geospatial information systems)
LO	Local Oscillator
PCB	Printed Circuit Board
PDT	Police Digital Trunking
PER	Packet Error Rate
PLL	Phase Locked Loop
RF	Radio Frequency
Rx	Receiver
SAW	Surface Acoustic Wave Filter
Tx	Transmitter
VCO	Voltage Controlled Oscillator

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