

# TM9300/TM9400

## Interface Specifications Manual

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# 1 Preface

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## Scope of Manual

This manual provides detailed information on the audio interface DSP signal TAP points for TM9300/TM9400 radios. It includes frequency response curves, AC and DC signal characteristics, and signal delay information for the audio TAP-IN and TAP-OUT paths of the Auxiliary and Internal Options Interfaces.

This manual is supplementary to the ‘TM8100/TM8200 Mobiles 3DK Hardware Developer’s Kit Application Manual’ (**MMA-00011-xx**).

## Document Conventions

Please follow exactly any instruction that appears in the text as an ‘alert’. An alert provides necessary safety information as well as instruction in the proper use of the product. This manual uses the following types of alert:

-  This icon is used to draw your attention to information that may improve your understanding of the equipment or procedure.

## Associated Documentation

- **MMA-00011-xx** - TM8100/TM8200 Mobiles 3DK Hardware Developer’s Kit Application Manual
- **MMB-00002-xx** - TM9300 DMR Mobile Radios/TM9400 P25 Mobile Radios Installation Guide
- **MMB-00001-xx** - TM9300 DMR Mobile Radios User’s Guide
- **MMB-00003-xx** - TM9400 P25 Mobile Radios User’s Guide

## Publication Record

Issue	Date	Description
1	June 2020	First release



# 2 Frequency Response Plots

The following diagrams show the frequency response plots of the following:

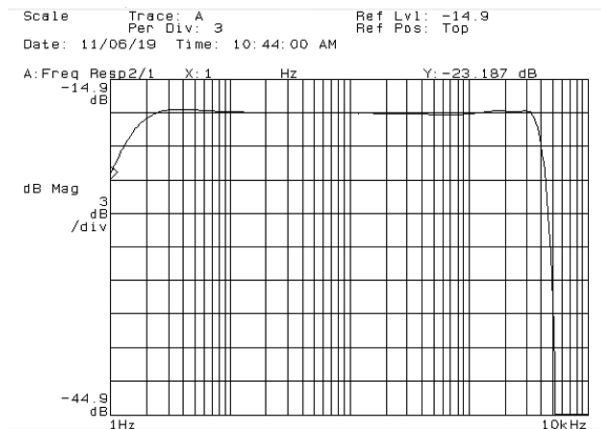
**Receiver (Rx)** Rx PATH TAP-OUT, Rx PATH TAP-IN and Rx\_AUD.

**Transmitter (Tx)** Tx PATH TAP-IN, Tx PATH TAP-OUT and AUX\_MIC\_AUD.

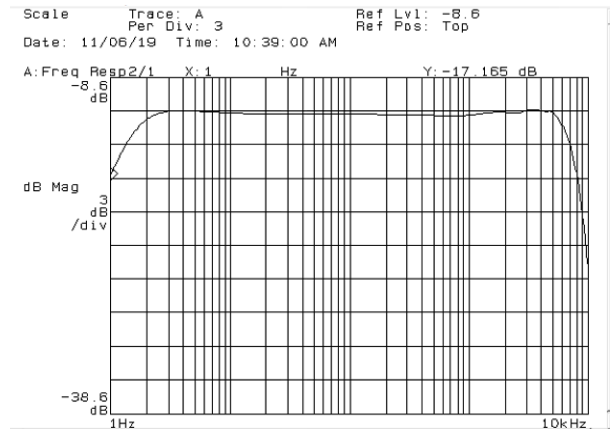
## Receiver

### Rx PATH TAP-OUT frequency response plots

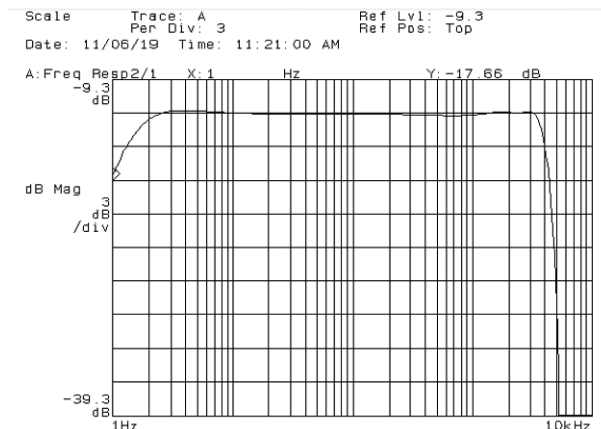
TAP-OUT R1 (NB)



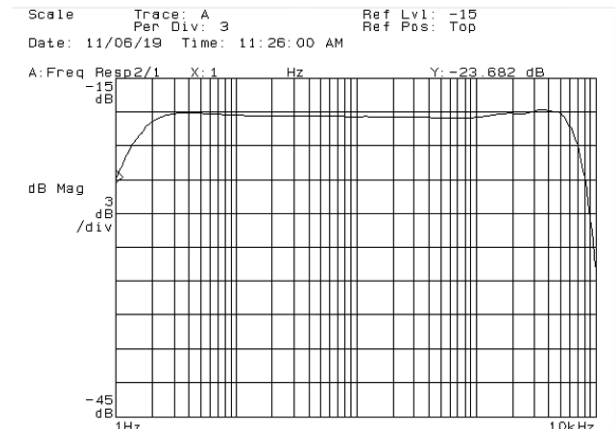
TAP-OUT R1 (WB)



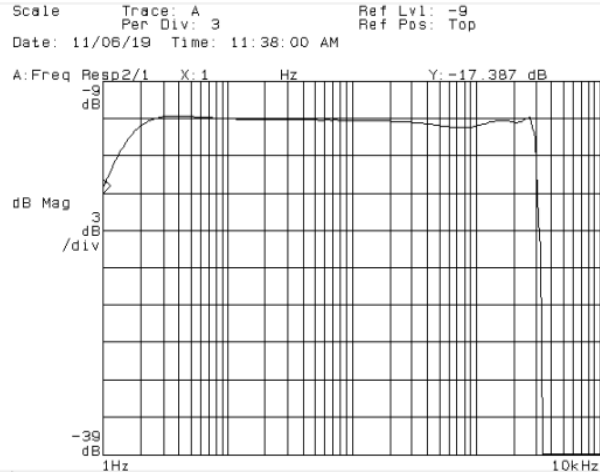
TAP-OUT R2 (NB)



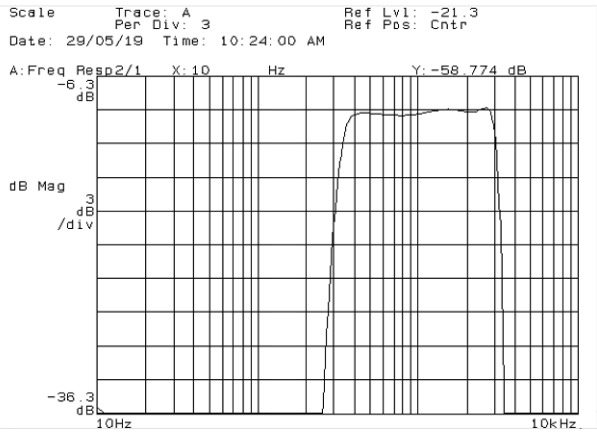
TAP-OUT R2 (WB)



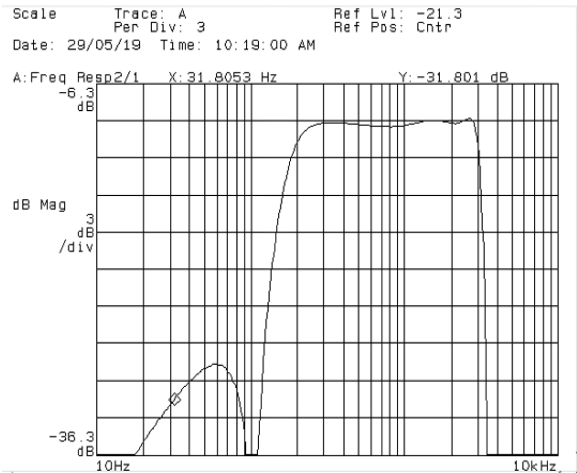
**TAP-OUT R4 (NB) only shown**



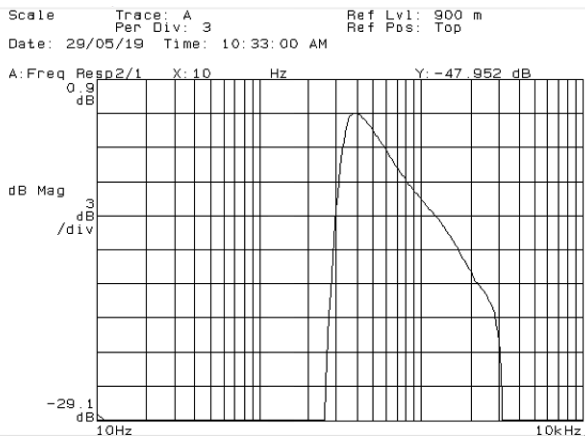
**TAP-OUT R5 CTCSS ON**



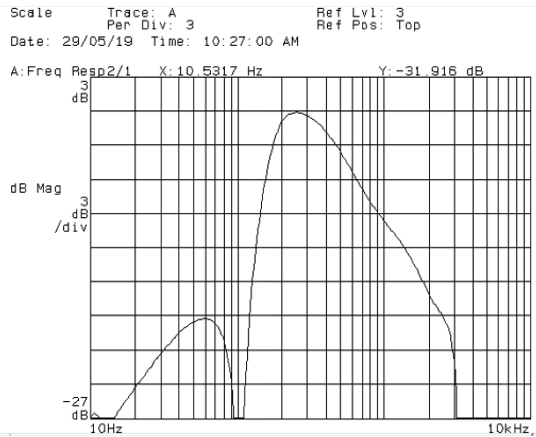
**TAP-OUT R5 CTCSS OFF**



**TAP-OUT R7 CTCSS ON (de-emphasis on)**

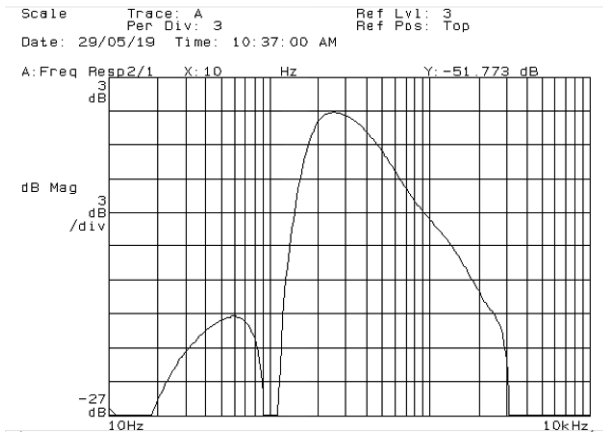


**TAP-OUT R7 CTCSS OFF (de-emphasis on)**

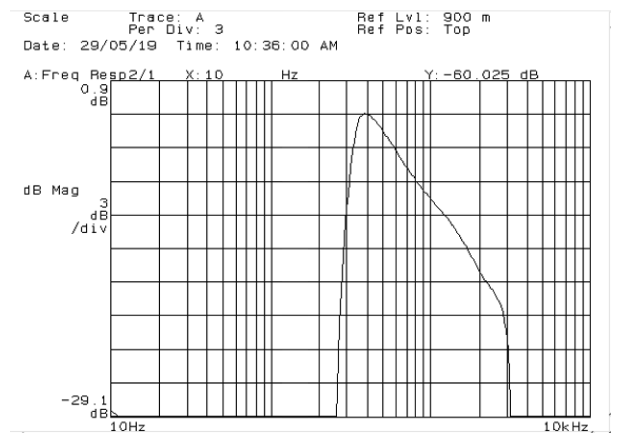




**TAP-OUT R10 CTCSS OFF (de-emphasis on)**



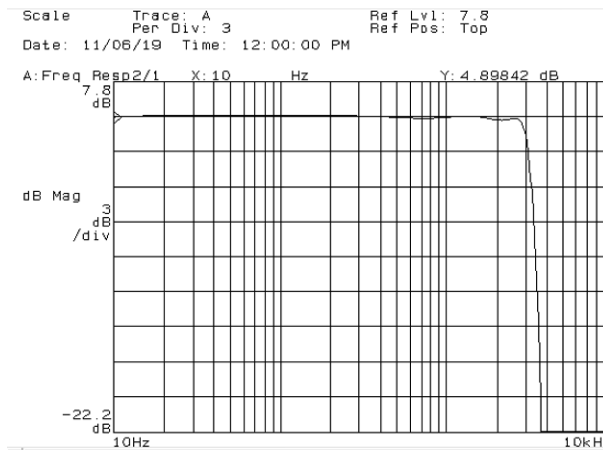
**TAP-OUT R10 CTCSS ON (de-emphasis on)**



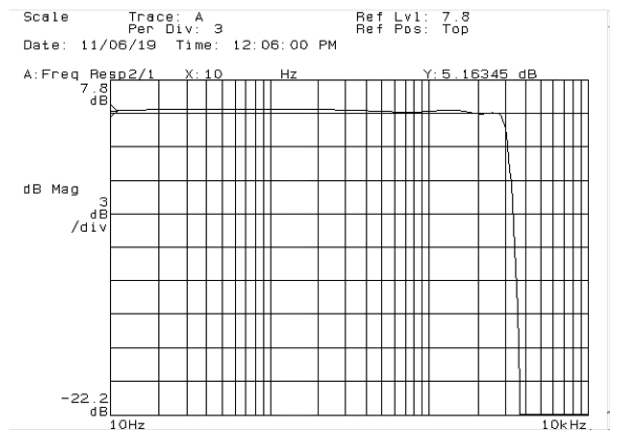
audio response output is based on tests at 60% deviation

**Rx PATH TAP-IN frequency response plots**

**TAP-IN R7 response TM9300**

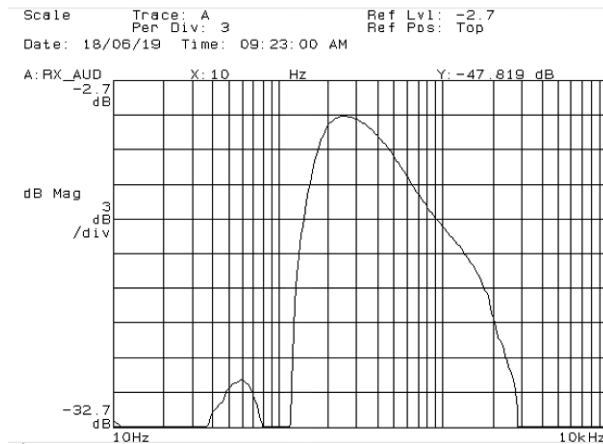


**TAP-IN R10 response TM9300**

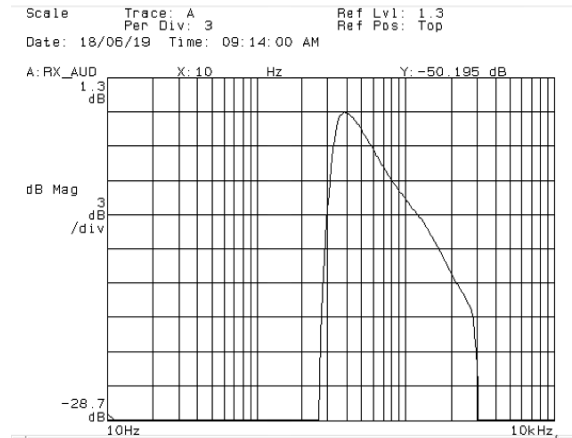


**Rx\_AUD frequency response plots**

**Rx\_AUD NO CTCSS filter**



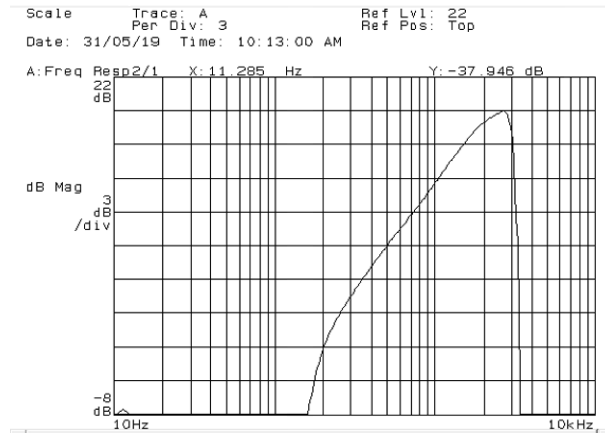
**Rx\_AUD CTCSS filter**



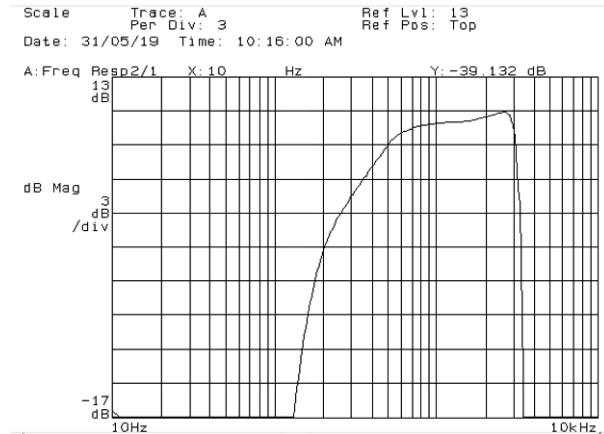
# Transmitter

## Tx PATH TAP-IN frequency response plots

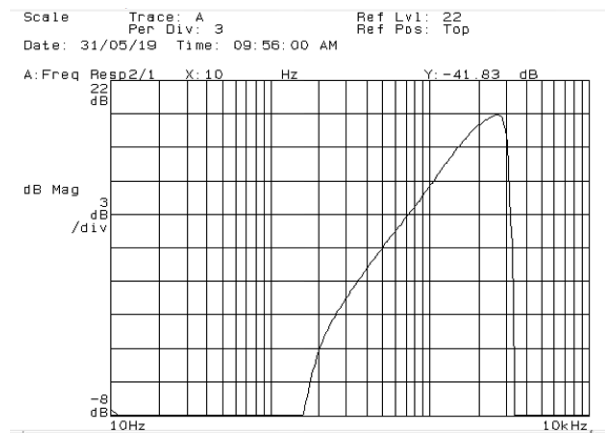
TAP-IN T3 sub limiting (pre-emphasis on)



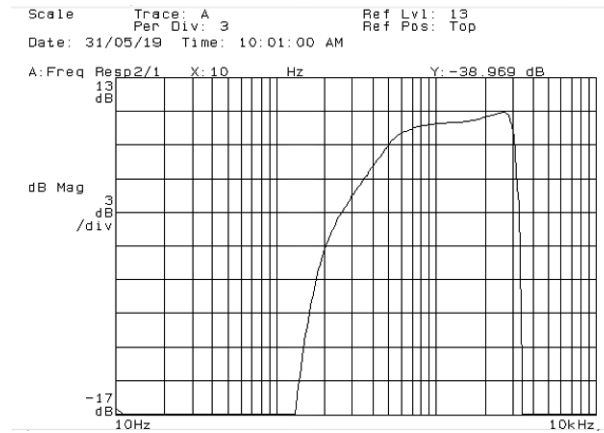
TAP-IN T3 limiting (pre-emphasis on)



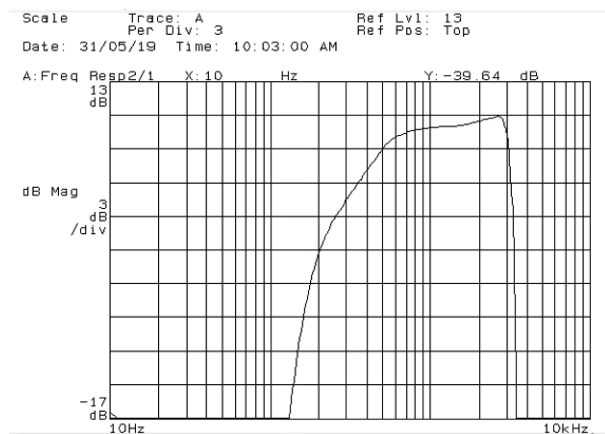
TAP-IN T4 sub limiting (pre-emphasis on)



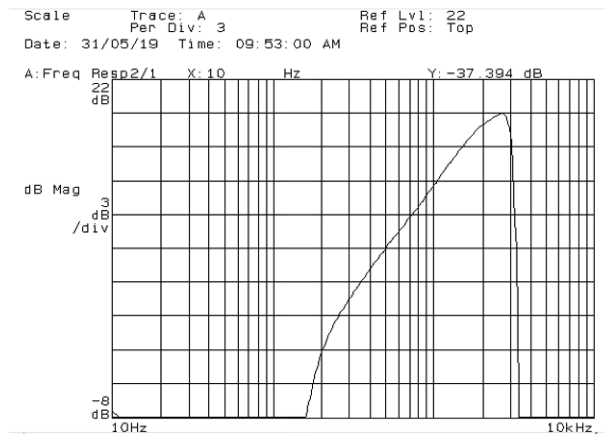
TAP-IN T4 limiting (pre-emphasis on)



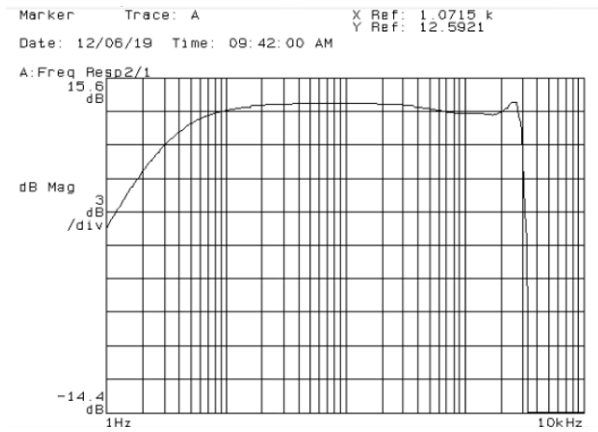
TAP-IN T5 limiting (pre-emphasis on)



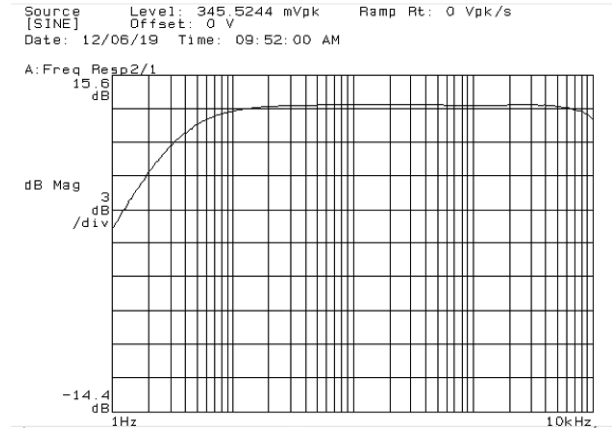
TAP-IN T5 sub limiting (pre-emphasis on)



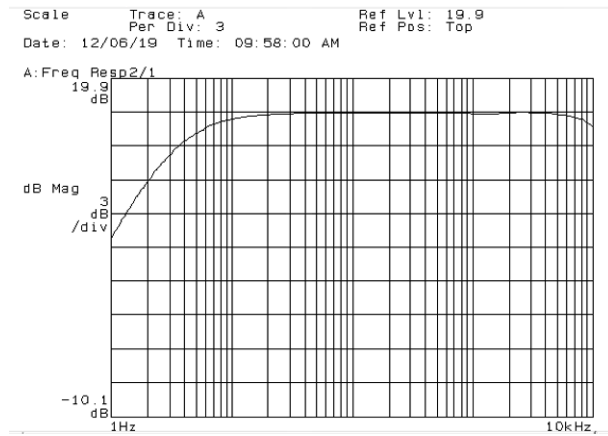
**TAP-IN T8**



**TAP-IN T12**

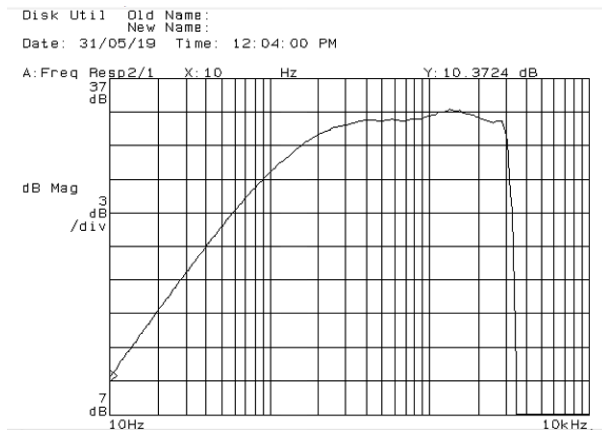


**TAP-IN T13**



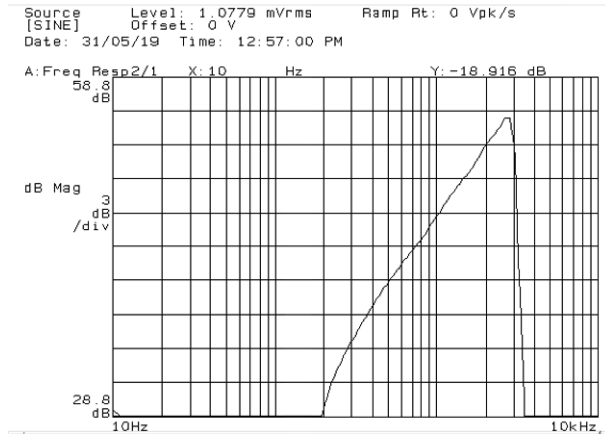
**Tx PATH TAP-OUT frequency response plots**

**TAP-OUT T3 (cannot select TAP-OUT T4 in analog mode)**



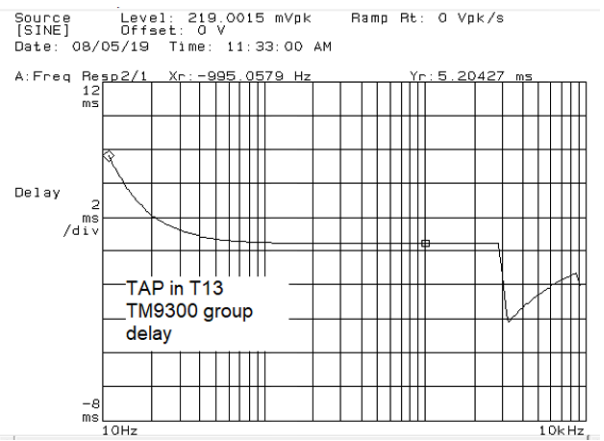
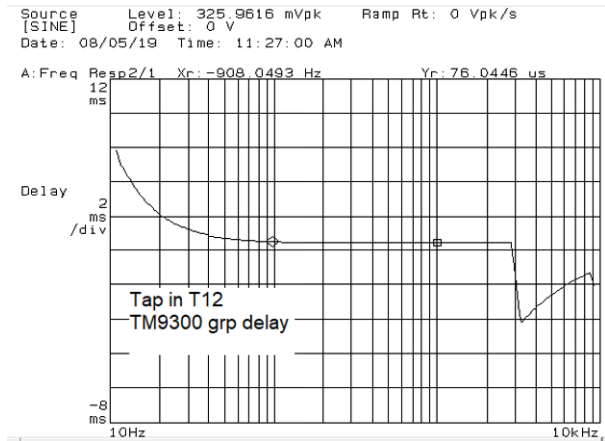
# AUX\_MIC\_AUD frequency response plots

## AUX\_MIC\_AUD frequency response plot

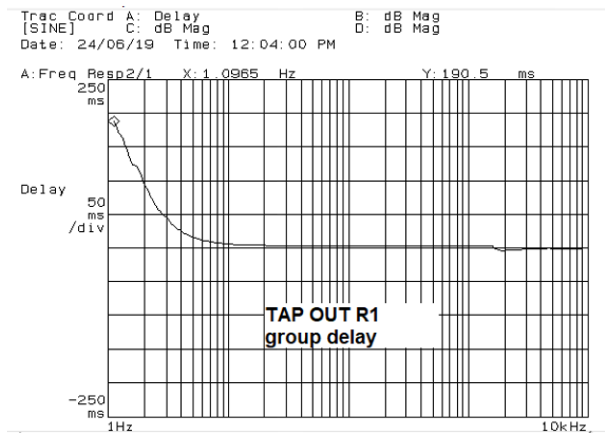


# TAP-IN and TAP-OUT delay as measured on a storage oscilloscope

## TAP-IN T12 and T13 group delay distortion



## TAP-OUT R1 group delay



# 3 Signal Delays

## Time Plots (TAP-IN delay absolute) Transmit path

The following section illustrates the time plots.

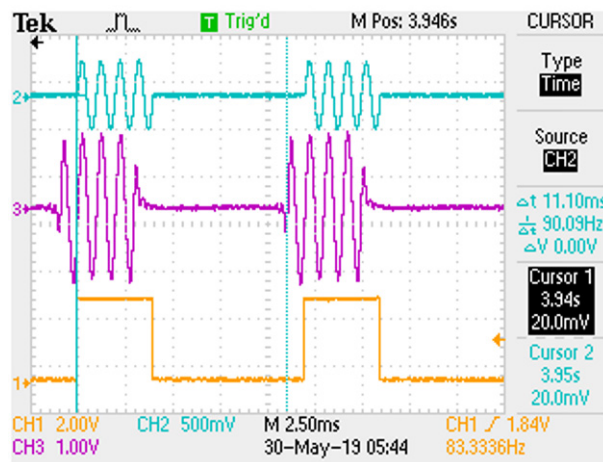
Note that the signals are colored to signify the following:

- **Orange:** PTT
- **Purple:** Observed signal
- **Light blue:** Test signal

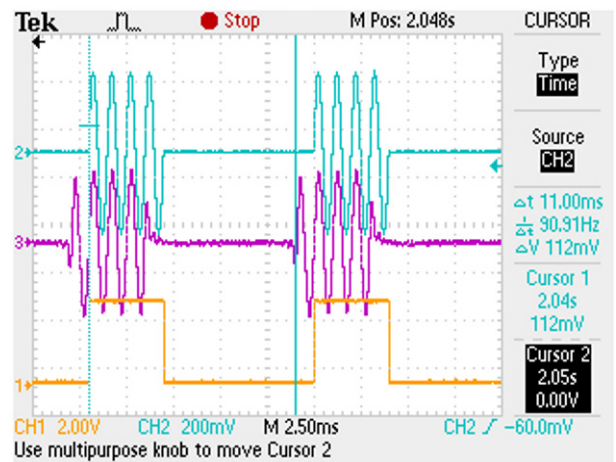
ⓘ TAP-IN's T8, T12 and T13 do not distort the audio signal. T12 and T13 have the shortest delay. The FSD (full scale deviation) is  $\pm 7$  kHz with a  $2V_{pk-pk}$  input modulation signal. The maximum modulation frequency at which  $\pm 7$  kHz deviation occurs is with a 4.224 kHz signal, and at 10 kHz the maximum deviation is  $\pm 5.98$  kHz.

ⓘ For T13, the input level to AUX TAP-IN for  $\pm 3$  kHz deviation at 1 kHz is typically  $435mV_{pk}$ . The TAP-IN level for all other nodes are for 60% system deviation at 1 kHz, =  $345mV_{pk}$ . The input level at 1 kHz for the SUB limiting response = 40% or 1 kHz deviation in a  $\pm 2.5$  kHz peak deviation =  $((345/6) \times 4) = 230$  mV peak. The input level for limiting is 6db above the 60% level or  $2 \times 345mV_{pk} = 690mV_{pk}$ .  
Time plots (TAP-OUT delay absolute).

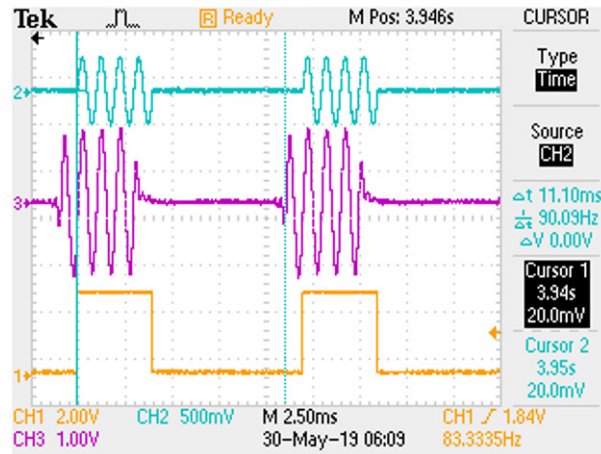
DELAY T3 (11.1msec)



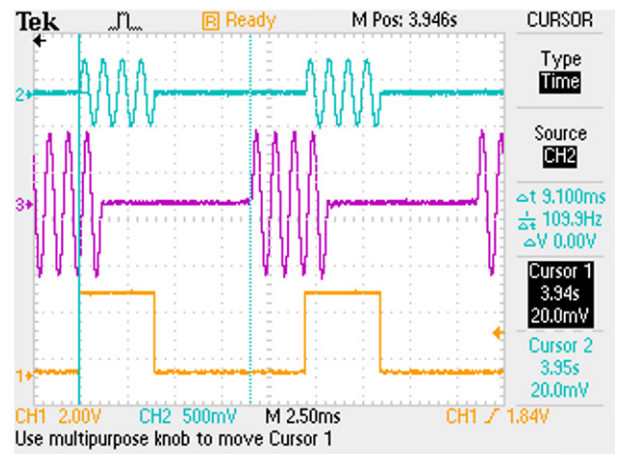
DELAY T4 (11.1msec)



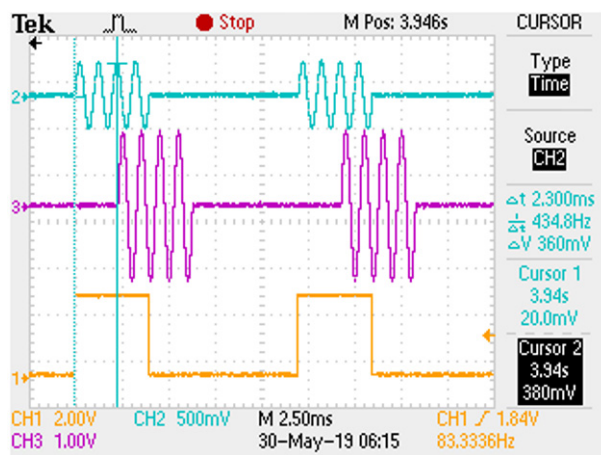
DELAY T5 (11.1msec)



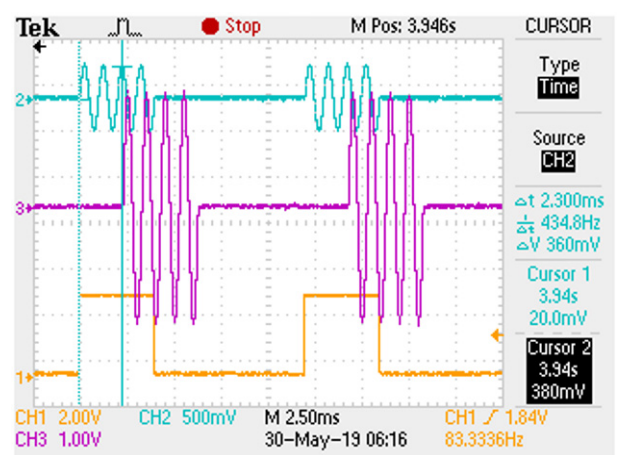
DELAY T8 (9.1msec)



DELAY T12 (2.3msec)

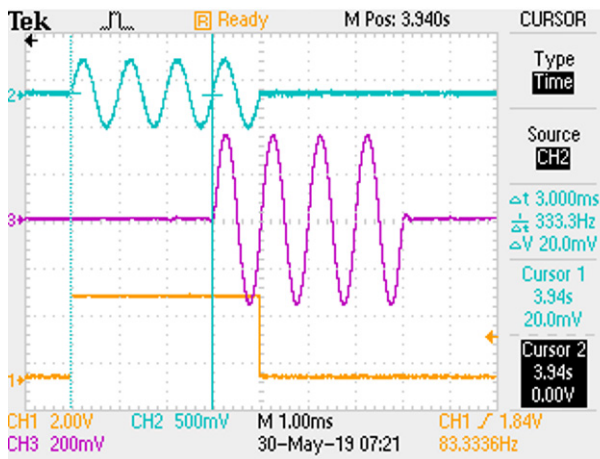


DELAY T13 (2.3msec)

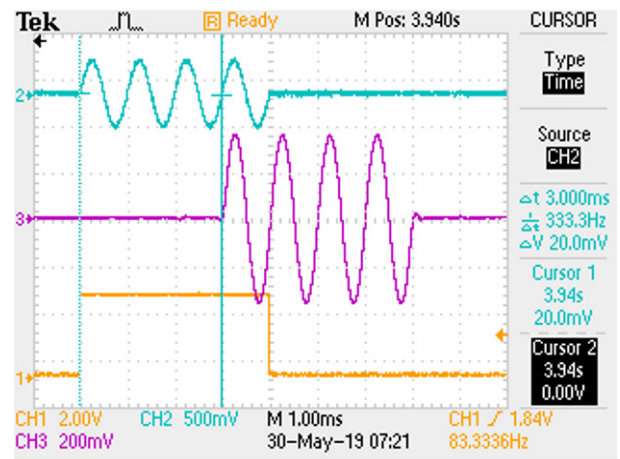


# Time Plots (TAP-OUT delay absolute) Receive path

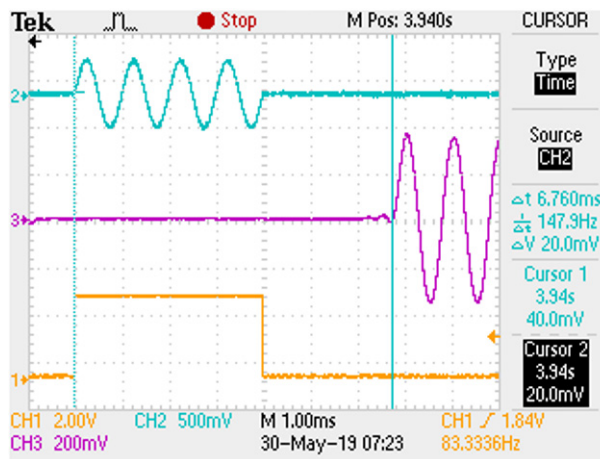
Delay R1 (3msec)



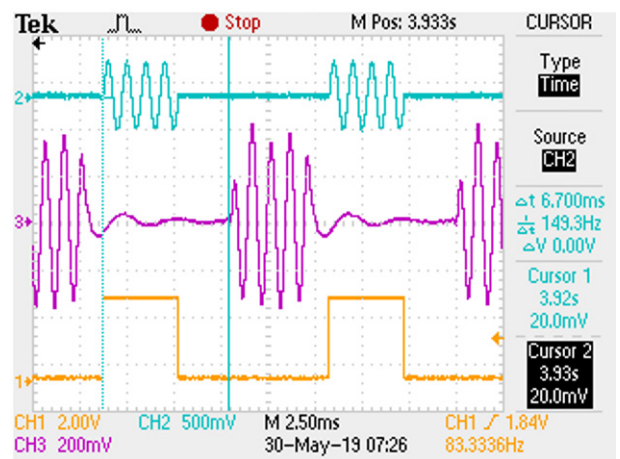
Delay R2 (3msec)



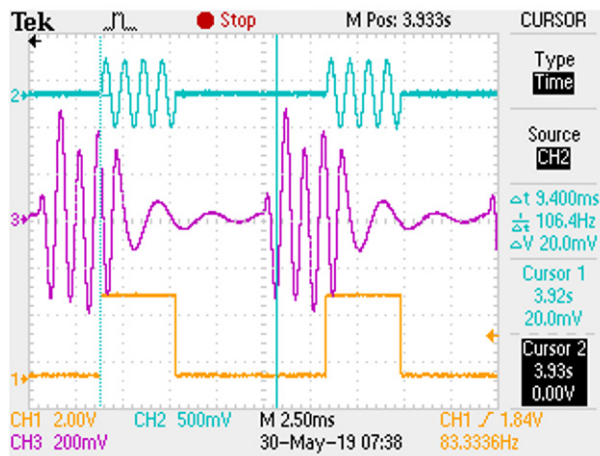
Delay R4 (6.76msec)



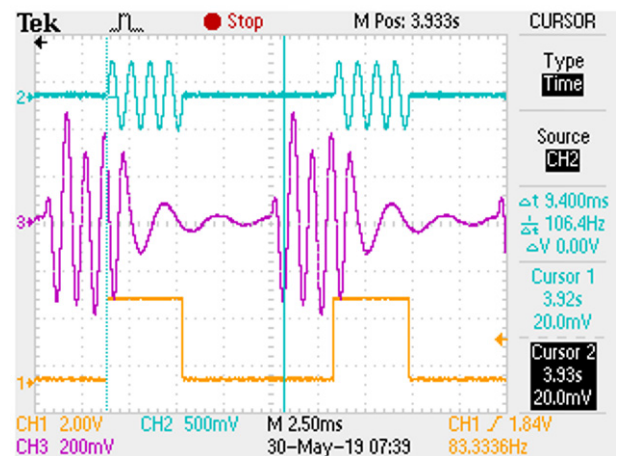
Delay R5 (6.76msec)



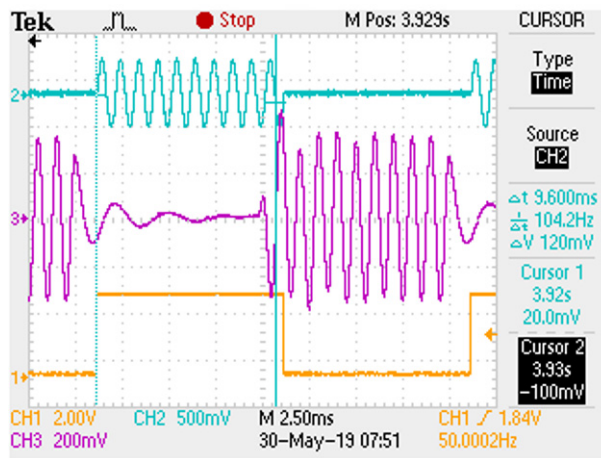
Delay R7 (9.4msec)



Delay R10 (9.4msec)



TAP-OUT R10 showing extended modulation cycles at 1 kHz





# 4 System Timing Measurements

## Tx-Rx, Rx-Tx, Rx-Rx timing

The timing delays between states are not always the same due to jitter, therefore the worst case delay caused by the jitter measured is the most reliable for setting up a system.

## Measured Times

The following diagrams show the measured times with EPTT-1 configured on the AUX connector and a UHF band Tx/Rx channel separation of 5MHz.

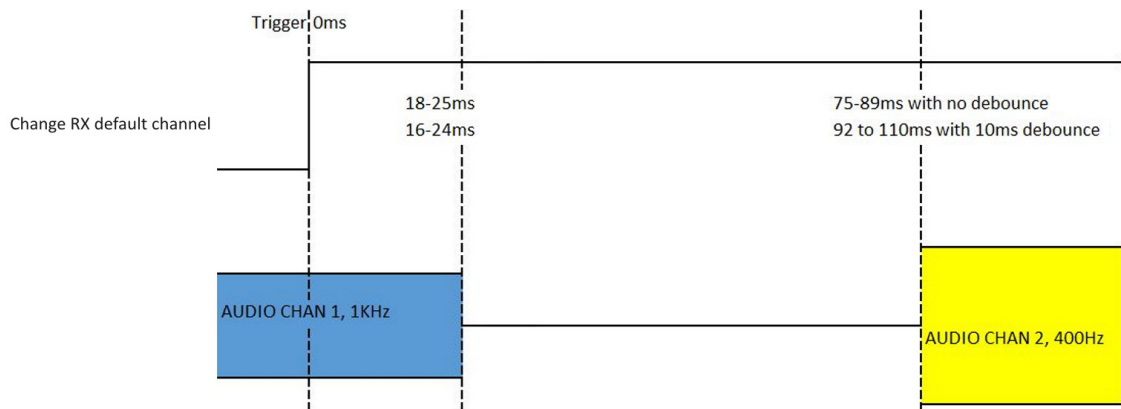
This shows that from when EPTT-1 is released, it takes up to 6ms for Tx to cease, and from that point, 39ms for Rx to be valid.

Rx to Tx takes about 6ms max for Rx to cease and between 16 to 31ms for valid transmission to start.

**i** “Valid transmission” is when the transmitted information is available on a receiver on the same channel frequency as the transmitter.

**Diagram 1: Change Rx Default Channel**

TM9300 H5 400-470MHz band, analogue channels only.  
Rx to Rx channel change, triggered using AUX GPIO default channel state.  
Channel 1 = 430.1MHz Channel 2 =435.1 MHz.  
Longest observed times from trigger low to high default channel.  
Longest observed times from trigger high to low previous channel.

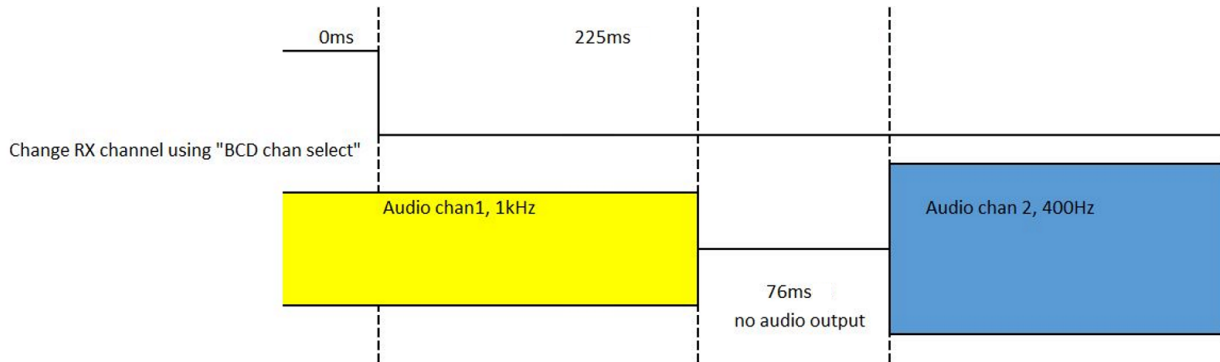


**Diagram 2: Change Rx channel using "BCD chan select"**

Timing of channel change using AUX\_GPIO BCD Chan select with 10ms debounce.

The debounce can be set up to 60ms, and the timing would increase correspondingly.

Trigger line is high to low, notice how much longer it takes than the previous timings using the default channel select.

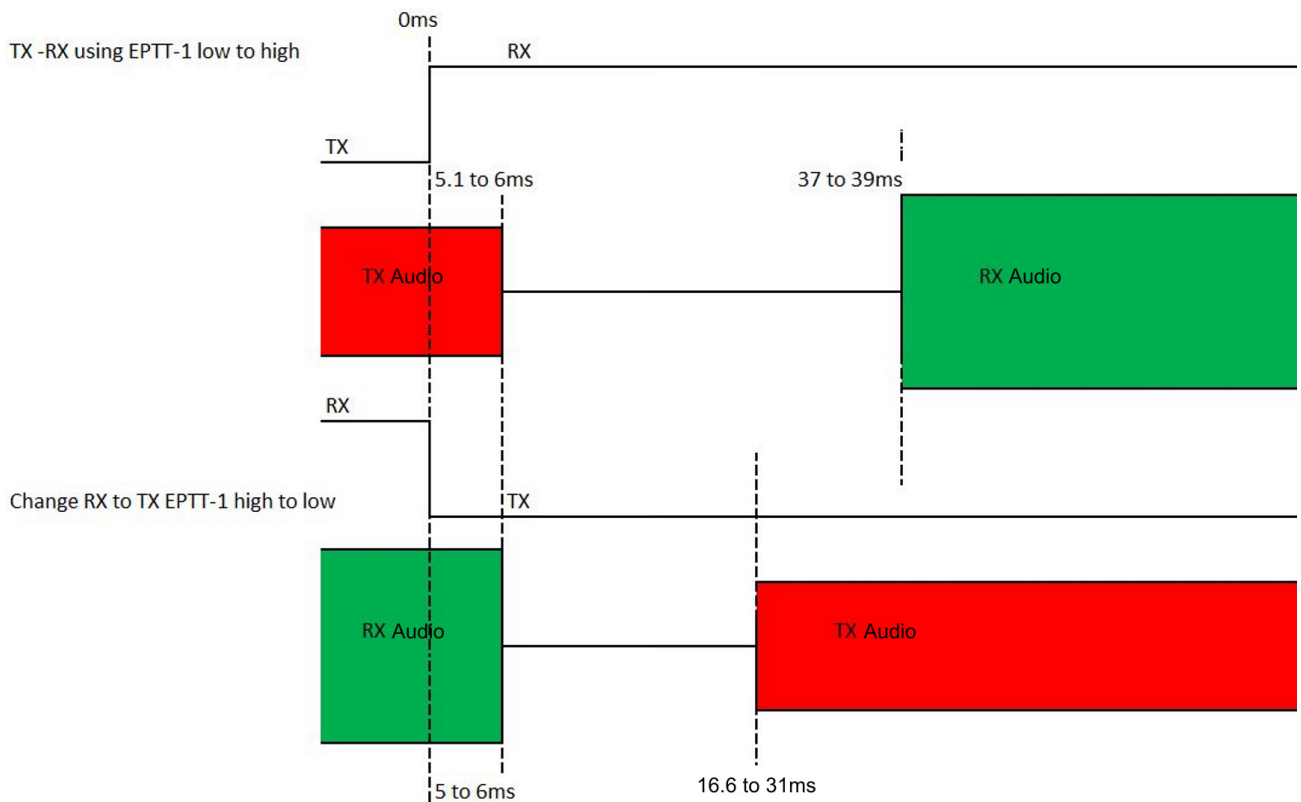


**Diagram 3: Tx-Rx Using EPTT-1 Low to High**

Tx to Rx using EPTT-1 no debounce time 37 to 39ms, with 10ms debounce up to 55ms.

Low to High transition, 5MHz channel separation, simplex analog mode, 430.1 -> 435.1MHz

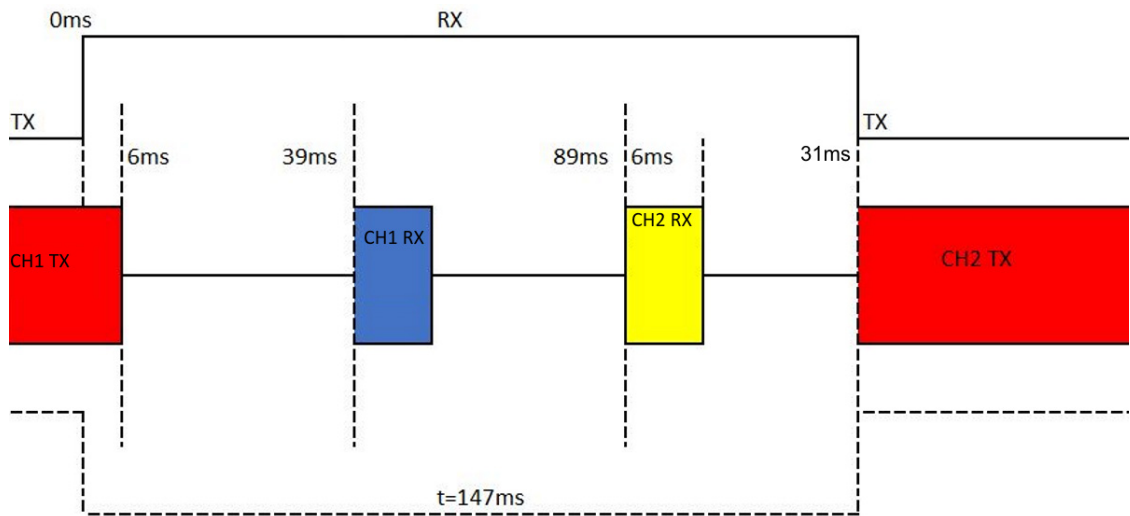
In the diagram below, the Tx PA is ramped up to power and the modulation is applied:



**Diagram 4: Change Tx ch1 to Tx ch2**

Tx to Tx use AUX\_GPIO 0ms with debounce.

Chan1 Tx to Chan 2 Tx. Tx to Tx= t(Tx to Rx) + t(Rx to Rx) + t(Rx to Tx)



**Ramp measurement**

Measured Rx to Tx ramp-up time <800usec, Tx to Rx ramp down time = <1.15ms

This is only the power control ramp, other times are the PA bias set up. PLL lock time Rx or Tx < 8ms to 100Hz final frequency.



# 5 Auxiliary Connector Signal Characteristics

The following tables show the auxiliary connector AC and DC characteristics:

## Auxiliary Connector - DC Characteristics

Parameter	Standard				Test method and conditions	Comments
	min.	typ.	max.	units		
<b>Digital signals</b>						
Input low level: All inputs AUX_GPI2			0.7 $V_S-4$	V V	No hardware links fitted. LK3 fitted.	Includes AUX_GPI3 with LK1/2 fitted. Configured as emergency power sense input.
Input high level: All inputs AUX_GPI2	1.7 $V_S-1.5$			V V	No hardware links fitted. LK3 fitted.	Configured as emergency power sense input.
AUX_GPI3	2.6			V	LK1 and/or LK2 fitted.	Configured as power sense input.
Input low current: All other inputs AUX_GPI2 AUX_GPI3 AUX_RXD		-100	-120 -13 <sup>b</sup> -500 -1	$\mu$ A mA $\mu$ A mA	No links fitted <sup>a</sup> . Default pullups <sup>c</sup> . LK3 fitted. $V_S=13.8V$ LK1 and 2 fitted. -8 V input.	Default pullup resistance is 33k $\Omega$ . Configured as emerg. power sense input. Configured as power sense input.
Input high current: AUX_RXD All other inputs			1 10 100	mA $\mu$ A $\mu$ A	No links fitted <sup>a</sup> . Default pullups <sup>c</sup> . +8 V input. 3.3 V input. 5 V input.	Default pullup resistance is 33k $\Omega$ .
Output low level: AUX_GPIO4-7 AUX_TXD			50 600 200	mV mV mV	100 $\mu$ A sink current. 10 mA sink current. 100 $\mu$ A sink current.	Current limit occurs at 20mA typ.
Output high level: AUX_GPIO4-7 AUX_TXD	3.1 2.4			V V	No load. Default pullups. 3k $\Omega$ load.	
Safe DC input limits: AUX_GPI1-3 AUX_GPIO4-7 AUX_RXD AUX_TXD <sup>d</sup>	-0.5 -0.5 -25V -10		$V_S+0.5$ $V_S+0.5$ $V_S+0.5$ $V_S+0.5$	V V V V		Input current must not exceed $\pm 50$ mA. This is the rating of the clamping diodes.
<b>Analog signals</b>						
DC output range: RSSI 13V8_SW	0 9.7		3 17.2	V V	Follows $V_S$ .	

DC bias: AUD_TAP_IN AUD_TAP_OUT AUX_MIC_AUD	1.55 2.1 2.9	1.65 2.3 3.0	1.75 2.5 3.1	V V V	No load. Zero Rx frequency error. Via 2.2k $\Omega$ .	Bias for electret microphone.
Input impedance: AUD_TAP_IN AUX_MIC_AUD	50 2.1	100 2.2	150 2.3	k $\Omega$ k $\Omega$	DC to 10 kHz	
Output impedance: AUD_TAP_OUT RSSI	590 950	600 1000	650 1050	$\Omega$ $\Omega$	DC to 10 kHz	
Safe DC input limits: AUD_TAP_IN AUD_TAP_OUT <sup>d</sup> AUX_MIC_AUD RSSI	-17 -0.5 -17 -17		+17 +17 +17 +17	V V V V		Short circuit-safe. Input current <math>\leq \pm 20\text{ mA}</math>
Output load: 13V8_SW (switched) 13V8_SW (switched) 13V8_SW (unswitched) 13V8_SW (unswitched)			1 2 1 2	A A A A	Continuous load Peak for <math>< 1\text{ sec}</math> Continuous load Peak for <math>< 1\text{ sec}</math>	Specification must be derated by the load amount drawn from the control head and internal options interfaces

- For more information on hardware links, refer to chapter 3 of the TM9300/TM9400 Installation Guide (**MMB-00002-xx**).
- We recommend this input is driven by a mechanical switch or an open collector/drain output.
- For more information on pullups, refer to the 'Digital Input Lines' section of the TM8100/TM8200 3DK Hardware Developer's Kit Application Manual (**MMA-00011-xx**).
- These outputs are protected against accidental input to the limits specified.

## Auxiliary Connector - AC Characteristics

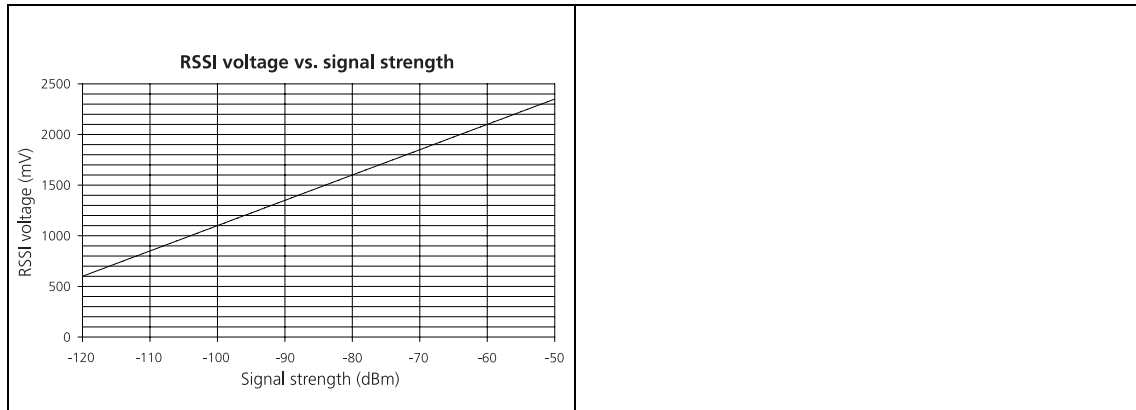
Parameter	Standard				Test method and conditions	Comments
	min.	typ.	max.	units		
<b>AUD_TAP_IN<sup>a</sup></b>						
Nominal input level: Tap T3, T4, T5, T8, T12 Tap T13 Tap R7, R10	0.62 0.78 0.62	0.69 0.87 0.69	0.76 0.96 0.76	V <sub>p-p</sub> V <sub>p-p</sub> V <sub>p-p</sub>	Level for 60% RSD @ 1 kHz Level for 3 kHz dev. @ 1 kHz <sup>b</sup>	Equivalent to -10 dBm into 600 $\Omega$ .
Full scale input level		2.0		V <sub>p-p</sub>		
Frequency response: All tap-points	<b>See "Frequency Response Plots" on page 7</b>					
Group delay - absolute: Tap T13 Tap T12 Tap T8 Tap T5 Tap T4 Tap T3		1.8 1.8 9.6 11.6 11.7 11.7		ms ms ms ms ms ms	At 1 kHz <b>See oscilloscope time delay plots</b>	
Group delay - distortion: Tap T12 and Tap T13	<b>See "TAP-IN and TAP-OUT delay as measured on a storage oscilloscope" on page 12</b>					
<b>AUD_TAP_OUT</b>						

Nominal output level: All Rx tap-points except R1 Tap R1 Tap T3	0.62 0.54 0.62	0.69 0.60 0.69	0.76 0.66 0.76	$V_{p-p}$ $V_{p-p}$ $V_{p-p}$	Rload = 600Ω. Level at 60% RSD @ 1 kHz. Level at 3kHz dev. @ 1 kHz <b>See</b> "AUX_MIC_AUD frequency response plots".	Equivalent to -10 dBm into 600Ω.
Full scale output level		2.0		$V_{p-p}$	Rload = 600Ω.	
Frequency response: All tap-points	<b>See "Frequency Response Plots" on page 7</b>					
Group delay - absolute: Tap R1 Tap R2 Tap R4 Tap R5 Tap R7 Tap R10 <sup>c</sup>		3 3 6.76 6.76 9.4 9.4		ms ms ms ms ms ms	At 1 kHz <sup>d</sup> <b>See oscilloscope time delay plots</b>	
Group delay - distortion: Tap R1 and Tap R2	<b>See "TAP-IN and TAP-OUT delay as measured on a storage oscilloscope" on page 12</b>					
<b>AUX_MIC_AUD</b>						
Rated System Deviation NB MB WB	-2.5 -4.0 -5.0		+2.5 +4.0 +5.0	kHz kHz kHz	EIA-603E	Units are peak frequency deviation from nominal carrier frequency in kHz.
Modulation frequency response	<b>See "AUX_MIC_AUD frequency response plots" on page 12</b>				EIA-603E	
Microphone sensitivity	6.0	7.5	9.0	mV rms	EIA-603E	

- a. AUD\_TAP\_IN uses a DC-coupled analog-to-digital converter and the bias voltage specified in Auxiliary Connector - DC characteristics should be used to maximise dynamic range. The DC bias is removed internally by a digital high-pass filter so the Tx carrier frequency will not be affected by any bias error. It is recommended to use external AC-coupling for applications that do not require modulation to very low frequencies.
- b. For tap into the Rx path, nominal level refers to the level required to give output at Rx\_AUD that is the same as the 60% dev level from the receiver. The level specified applies at 1kHz only.
- c. Optional processing blocks are bypassed in the above specification.
- d. For AUD\_TAP\_IN and AUD\_TAP\_OUT specifications the following signal paths apply:

Case	Input	Output
Tap into Rx chain	AUD_TAP_IN	Rx_AUD
Tap out of Rx chain	Modulation at antenna	AUD_TAP_OUT
Tap into Tx chain	AUD_TAP_IN	Modulation at antenna
Tap out of Tx chain	AUX_MIC_AUD	AUD_TAP_OUT

Parameter	Standard				Test method and conditions	Comments
	min.	typ.	max.	units		
Serial port						
Baud rate:	1200, 2400, 4800, 9600, 14400, 19200, 28800, 38400, 115200			bit/s		All UART parameters are fixed and common to all UARTs except for the baud rate which is configurable and different for different modes/applications
Data bits:	8					
Start bit:	1					
Stop bit:	1					
Parity:	None					
Protocol:	CCDI3					
Flow control: Software	XON/XOFF					
GPIO						
Delays: I/O mirror to IOP UI key delay			500 50	$\mu$ s ms		





## 6 Internal Options Connector

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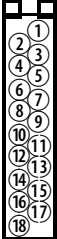
When installing an internal options board, the internal options connector is the electrical interface to the main board of the radio body. The internal options connector provides similar I/O to the auxiliary connector. The digital signals and the serial port are independent of the auxiliary connector signals, but the AUD\_TAP\_IN, AUD\_TAP\_OUT, and RSSI signals are shared with the auxiliary connector. The internal options connector is an 18-pin, 0.1in pitch Micro-MaTch connector.

Examples of internal options boards:

- T02-00007-ABAA Line-Interface Board.  
See TM8100/TM8200 Service Manual (**MMA-00005-06**)
- T02-00007-BAAA RS-232 Interface Board.
- T02-00007-ACAA TeamPTT Line-Interface Board.

For information on how to create your own internal options board, refer to “Internal Options Board” on page 129 of the “TM8100 mobiles/TM8200 mobiles 3DK Hardware Developer’s Kit Application Manual” (**MMA-00011-03**).

## Internal Options Connector - Pins and Signals

Pinout	Pin	Signal	Description	Signal type
	1	13V8_SW <sup>a</sup>	Switched 13V8 supply. Supply is switched off when the Radio Body is switched off.	Power
	2	AUD_TAP_OUT	Programmable tap point out of the Rx or Tx audio chain. DC-coupled.	Analog
	3	AGND	Analog ground.	Ground
	4	IOP_MIC_AUD	Internal options microphone input. Electret microphone biasing provided. Dynamic microphones are not supported.	Analog IOP_MIC_AUD
	5	RX_BEEP_IN	Receive sidetone input. AC-coupled.	Analog
	6	AUD_TAP_IN	Programmable tap point into the Rx or Tx audio chain. DC-coupled.	Analog
	7	RX_AUD	Receive audio output. Post volume control. AC-coupled.	Analog
	8	RSSI	Analog RSSI output.	Analog
	9...15	IOP_GPIO1...7	Programmable function and direction. With LK4 fitted, GPIO7 is a power sense input <sup>b</sup> .	Digital. 3V3 CMOS
	16	DGND	Digital ground.	Ground
	17	IOP_RXD	Asynchronous serial port - Receive data.	Digital. 3V3 CMOS
	18	IOP_TXD	Asynchronous serial port - Transmit data.	Digital. 3V3 CMOS

a. Can be switched or unswitched. For more information, refer to the service manual (**MMB-00004-xx**)

b. For more information on hardware links refer to the service manual (**MMB-00004-xx**)

**Notice** The digital I/O signals are intended to interface directly with compatible logic signals only. **Do not** connect these signals to external devices without appropriate signal conditioning and ESD protection.

## Internal Options Connector - DC Characteristics

Parameter	Standard				Test method and conditions	Comments
	min.	typ.	max.	units		
<b>Digital signals</b>						
Input low level: All inputs			0.7	V	No hardware links fitted <sup>a</sup> .	Also applies to IOP_GPIO7 with LK4 fitted.
Input high level: All inputs IOP_GPIO7	1.7 2.8			V V	No hardware links fitted. LK4 fitted.	Configured as power sense input.
Input low current: All inputs			-120	µA	No hardware links fitted.	Also applies to IOP_GPIO7 with LK4 fitted.
Input high current: All inputs IOP_GPIO7			±10 2000 250	µA µA µA	3.3 V input. 5 V input. 3.3 V input. LK4 fitted.	Configured as power sense input.
Output low level: All outputs			120	mV	100 µA sink current.	1 kΩ series R on all outputs.

Output high level: All outputs	3.1			V	100 $\mu$ A source current.	1 k $\Omega$ series R on all outputs.
Safe DC input limits: All inputs/outputs	-0.5		+5.5	V		Input current must not exceed $\pm$ 10 mA.
Analog signals (for signals not listed here refer to the auxiliary connector specification)						
Safe DC input limits: RX_AUD RX_BEEP_IN	-17 -17		+7 +17	V V		
Output load: 13V8_SW (switched) 13V8_SW (switched) 13V8_SW (unswitched) 13V8_SW (unswitched)			1 2 1 2	A A A A	Continuous load Peak for <1sec Continuous load Peak for <1sec	Specification must be derated by the load amount drawn from the auxiliary interfaces. See Service Manual.

a. For more information on hardware links refer to the service manual (MMB-00004-xx).

## Internal Options Connector - AC Characteristics

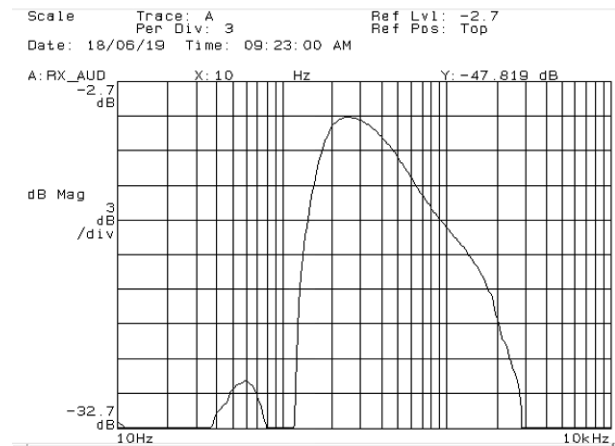
Parameter	Standard				Test method and conditions	Comments
	min.	typ.	max.	units		
<b>RX_BEEP_IN</b>						
Nominal input level		0.76		V <sub>p-p</sub>	For 6.2V <sub>p-p</sub> at speaker @1kHz.	Level for 10dB below rated power.
Full scale input level			2.5	V <sub>p-p</sub>	For onset of clipping at 13.8V.	
Frequency response	0.3 to 3 kHz				-3dB with respect to level at 1kHz.	
Parameter	Standard				Test method and conditions	Comments
	min.	typ.	max.	units		
Input impedance	1			k $\Omega$	DC-10kHz	
<b>RX_AUD</b>						
Nominal output level		1.0		V <sub>p-p</sub>	At 1kHz, 60% dev. Full volume	
Full scale output level:		2.0		V <sub>p-p</sub>	At 1kHz, 120% dev. Full volume	
Output impedance:		100		$\Omega$	At 1kHz.	
Frequency response:	See <a href="#">"RX_AUD Frequency Response Plot"</a> on page 28.					

## Internal Options Connector - Data Characteristics

Parameter	Standard				Test method and conditions	Comments
	min.	typ.	max.	units		
Serial port						
Baud rate:	1200, 2400, 4800, 9600, 14400, 19200, 28800, 38400, 115200			bit/s		All UART parameters are fixed and common to all UARTs except for the baud rate which is configurable and different for different modes/applications
Data bits:	8					
Start bit:	1					
Stop bit:	1					
Parity:	None					
Protocol:	CCDI3					
Flow control: Software	XON/XOFF					
GPIO						
Delays: I/O mirror to AUX UI key delay			500 50	$\mu$ s ms		

## RX\_AUD Frequency Response Plot

Rx\_AUD NO CTCSS filter



Rx\_AUD CTCSS filter

