DTC Communications

T2001S

TECHNICAL / ALLIGNMENT MANUAL

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T2001S

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The T2001S is miniature VHF narrow-band FM audio transmitter for application in Police Radio Service technical surveillance, and personnel protection. The T2001 features ten channel synthesized operation over the frequency range of 150 to 174 MHz with an RF output power of 1 Watt.

The T2001S is housed in a "hard" aluminum-cased assembly and incorporates an integral "AAA" 6-cell battery pack. The antenna is integrated into the microphone lead-wire, thus eliminating the need for a separate antenna assembly.

AUDIO CHARACTERISTICS

The T2001S utilizes linear audio compression with a 45dB dynamic range. This provides the end user excellent audio performance over a wide range of audio conditions and audio input levels.

BATTERY SUPPLY VOLTAGE

The T2001S operates on a power source of 3.5 to 9 VDC.

CHANNEL SELECTION

The T2001S incorporates a ten position rotary switch for channel selection. The ten frequencies are user programmable via a built in serial-data interface.

POWER SWITCH

The T2001S incorporates a power switch for control of the transmitter. The power is ON when the power switch is moved toward the GREEN dot. The power is OFF when the power switch is toward the RED dot. The T2001S will transmit approximately 1 second after application of power, allowing for the channel data to be read from the non-volatile memory and settling of the phase locked loop.

T2001S SPECIFICATIONS

ELECTRICAL

Frequency range	150 - 174 MHz
Channels	TEN (programmable)
Maximum channel separation	24 MHz
RF Power output	@9.0 VDC 1.0 < Po < 1.25 W
Frequency stability	+/- 2.5 ppm -30 to +65 deg C.
Modulation Type	NBFM type 11K2F3E
Deviation	+/-2.5 kHz peak (maximum)
Spurious and Harmonics (conducted)	-52 dBc
Audio frequency response	+2 to -6dB from a 6dB / octave pre-emphasis 300 Hz to 2500 Hz
AGC range	45 dB
Microphone (integral to antenna wire)	FET - electret

POWER SUPPLY ...

Voltage input range	3.5 - 9 VDC
Supply current	250 mA max

TX AUDIO

(ref schematic 1002901-1)

The TX Audio is capable of driving the FM modulator to constant peak deviation over an audio input range of 45 dB.

Microphone audio is routed to preamplifier stage Q1. Preamplified audio is fed to operational amplifier U1-A which functions as a high gain audio amplifier with frequency selective feedback. The feedback network results in a 6 dB per octave (pre-emphasis) frequency response over the range of 300 to 2500 Hz with the response peak centered at 2500 Hz.

The pre-emphasized audio is fed to operational amplifier U2-A and U1-D. Amplifier U1-D functions as an AGC amplifier and feeds a temperature compensated audio detector. The audio detector is implemented by silicon signal diodes CR1 and CR2 in conjunction with transistor Q3. The detected audio signal is fed to a voltage controlled attenuator implemented by FET Q2, and input resistor R6.

The negative feedback action of the overall AGC loop levels the audio present at the output of U1-A over a 45 dB range of input signal. The AGC maintains a constant deviation over the rated 45 dB audio input range. Input overload protection limiters are implemented by operational amplifiers U2A and U2B in conjunction with diodes CR3 and CR4. The AGC leveled audio is then routed to a two-pole lowpass filter implemented by op-amp U1-B. Circuit components C8, C9, R18 and R19 set the 3 dB cutoff frequency at 3,000 Hz.

TRANSMIT VOLTAGE CONTROLLED OSCILLATOR

The primary VHF transmit frequency is generated by a Colpitts oscillator implemented by integrated circuit U7 (MAX2620). The frequency is determined by a resonant tank circuit formed by capacitors C7, C7, and inductor L2. Frequency modulation is provided by a variable capacitance diode D1 placed in series with inductor L1. A dual output high isolation buffer amplifier contained within U7 splits the VCO signal into two output paths. The first output is fed to the synthesizer IC U9, while the second output is fed to the PA driver IC, U8.

PA DRIVER

The buffered VCO output signal is fed to a high gain broadband rf amplifier implemented by integrated circuit U8 (RF2361). The RF level at the input to U8 is amplified to a +15 dBm output level. This signal is then fed to the Power Amplifier stage.

The driver integrated circuit features a high isolation shutdown feature that is used to inhibit drive to the PA. The driver IC is inhibited under the following conditions:

1. When the Voltage supervisor circuit detects that the initial power-on battery Voltage is below 5.0 Volts

2. When the Voltage supervisor circuit detects that the battery Voltage has fallen below 3.5 Volts

3. During initial power-on synthesizer frequency lock-up

4. When the channel switch is moved to a new frequency

5. When the microcontroller detects that there is an external serial-port connection

POWER AMPLIFIER

The RF Power Amplifier (Q5) is implemented by a single metal-oxide field effect transistor. The +15dBm signal from the PA driver is fed to the FET gate via a broadband 9:1 impedance matching network implemented by transformer T1. Gate bias Voltage is supplied via the secondary side of transformer T1. PA drain impedance matching to 50 Ohms is provided via shunt inductor L5, series connected L6 - C6, and shunt capacitor C27. The PA output is then fed to a 5 section harmonic suppression low pass filter implemented by C28, L7, C30, L8, and C31. L9 provides a ground return for the microphone audio signal that is duplexed on the RF and RF-ground signal leads. Potentiometer RV1 provides a variable gate bias voltage that is use to set the output power level during factory test and alignment.

FREQUENCY SYNTHESIZER

Integrated circuit U9 (LMX2306) functions as a single component serial input PLL frequency synthesizer. It implements a dual modulus 8 / 9 prescaler, a 5 bit programmable swallow counter, a 13 bit programmable main counter, and a 14 bit reference divider. It also implements a charge-pump type phase detector. The main parameters of the PLL are:

Phase comparator reference frequency	variable 10 to 20 kHz
Main reference TCXO input frequency	9.600 MHz
Prescaler divider ratio	8 / 9
Reference divider ratio	variable 480 - 960

Counter parameters for a 161.050 MHz example are:

```
Main counter (N) = 201
Swallow counter  =  20
Ntotal = N * P + A where P = 64
       = 201 * 64 + 20
       = 12884
```

Output frequency = Ntotal * Fref
= 12884 * 12.5 kHz
= 161.050 MHz

PLL IC U9 is serially programmed via the microcontroller IC U10.

MICROCONTROLLER

The function of the microcontroller is:

1. Read the ten position channel switch to determine the desired rf channel frequency.

2. Read synthesizer frequency programming data from the non-volatile RAM contained within U10 at initial power-on and when the channel switch is rotated.

3. Inhibit drive to the power amplifier stage as described above.

4. Read (when connected) programming data from the serial programming port used to define the ten channel frequencies.

TRANSMITTER ALIGNMENT

The following section details the alignment of the T2001S transmitter.

TEST EQUIPMENT

o DC power supply
  : 3.5 to 9.0 VDC
  : metered current 0 - 300 mA DC

o DC Voltmeter
  : 10 meg Ohm input impedance
  : 0 to 5 volt range

o Audio frequency generator
  : 1,000 Hz
  : 50 mV rms output level

o FM deviation monitor
  : 150 - 174 MHz
  : 2.5 kHz peak full scale

o RF power meter
  : 50 Ohm, terminated or "thru-line"

o Frequency counter
  : 150 - 174 MHz
  : 0.1 ppm frequency accuracy

o 50 Ohm attenuator pads
  : as required

o Spectrum analyzer
  : 10 MHz to 2.0 GHz

PRELIMINARY

Preset the power supply to 8.0 VDC, and turn off the supply. Set the audio frequency generator to 1 kHz and adjust the output level to 50 mV RMS. Cable the transmitter under test per figure 1.

Preset the potentiometers RV1, RV2, and RV3 as follows:

RV1 (mic gain) to mid position
RV2 (deviation) to max CCW
RV3 (output power level) to max CCW

Note! The transmitter microcontroller NV RAM is loaded with initial frequencies used to test and align the device.
They are:

Chan	Frequency
1	150.025
2	153.025
3	157.025
4 - 7	161.025
8	165.025
9	170.025
10	174.025

VCO ADJUST

Set the channel switch to the highest frequency (channel 10).
Apply DC power to the transmitter and set the power switch to ON.
Monitor the voltage at the top of C12 with a DVM.
Adjust the core in L2 for 3.1 VDC as read on the DVM.

POWER AMPLIFIER

Set the channel switch to the mid-frequency (channel 4).
Adjust RV3 CW for an RF output power reading of 1.0 Watt.

*** 8.0 VDC Conditions of DC current and output power. ***

Idc < 240 milliamps
Pout = 1 Watt

Adjust the power supply to 9.0 VDC, note the output power and total supply current. Test output power and current at the lowest frequency (channel 1), the middle frequency (channel 4) and the highest frequency (channel 10).

*** 9.0 VDC Conditions of DC current and output power. ***

Idc < 260 milliamps
1.0 < Pout < 1.25 Watts

TRANSMITTER FREQUENCY

Set the channel select switch to channel 10 and note the exact specified channel frequency. Monitor the output of the transmitter with the frequency counter. Adjust the trimmer capacitor located on the TCXO module (U6) until the transmitter frequency error with respect to the specified channel frequency is less than .2 ppm.

MICROPHONE GAIN ADJUST

Monitor the Voltage at TP4 with the DVM.
Adjust RV1 for 1.4 VDC as read on the DVM.

TRANSMITTER DEVIATION

Set the channel select switch to channel 4. Monitor the transmitter output with the FM deviation monitor, and modulate the transmitter by connecting the audio frequency generator to the microphone input via the J1 accessory connector. Set the audio generator to a frequency of 1 kHz and the output level to 50 mV RMS. Set the deviation control (potentiometer RV2) for a peak deviation of 2 kHz.

Now set the channel select switch to channel 1, and then channel 10. Check that the deviation is:

1.8 kHz < FM Dev < 2.5 kHz

SPECTRUM CHECK

Cable the transmitter under test to the spectrum analyzer via appropriate attenuator pads. Perform a frequency sweep from 10 MHz to 2.0 GHz, and verify that the conducted spurious emissions are attenuated greater than 50 dB below the level of the carrier.

Vary the supply voltage over the range of 3.5 to 9.0 VDC. Verify that the output spectrum is clean and the conducted spurious emissions remain 50 dB or greater below the carrier.

Disconnect the transmitter under test from the spectrum analyzer and connect it to an appropriate electrically-short body worn antenna. Using a "sniffer" antenna attached to the spectrum analyzer verify that the transmitter remains stable when driving the external antenna.

Perform the above radiated stability audit while varying the supply voltage over the range of 3.5 to 9.0 VDC.

** END OF ALIGNMENT PROCEDURE **

FUNCTION OF EACH SEMICONDUCTOR DEVICE
T2001S

Module/circuit	#	Type	Ref	Part	Function
TX AUDIO					
	1	IC op-amp	U1-A	LM224	Audio amplifier
	2	IC op-amp	U1-B	"	Low pass filter
	3	IC op-amp	U1-C	"	Bias buffer
	4	IC op-amp	U1-D	"	AGC amplifier
	5	NPN tran.	Q1	BCW33	Audio preamp
	6	N chan FET	Q2	BFT46	Gain Control
	7	PNP tran.	Q3	BCW70	FET driver
	8	Sil. diode	CR1	BAW56	AGC detector
	9	Sil. diode	CR2	"	AGC detector
	10	Sil. diode	CR3	BAV99	Pos. peak clipper
	11	Sil. diode	CR4	"	Neg. peak clipper
	12	Sil. diode	CR5	"	Pre-clipper
	13	Sil. diode	CR6	"	Pre-clipper
TX VCO					
	1	IC, U1, MAXIM MAX2620			VCO / Buffer
	2	Varactor D1, SMV1236			VCO tuning diode
PA DRIVER					
	1	U8, IC, RFMD RF2361			Driver RF amp
POWER AMPLIFIER					
	1	NCHAN MOSFET Q5, TRF7003A			Power amplifier
SYNTHESIZER					
	1	TCXO	U6	T-1050-1B0	TCXO module
	2	Sil. IC	U9	LMX2306	Freq synthesizer
POWER CONTROL					
	1	Sil. diode	D4	MBRS140T3	Rev pol protect
	2	Sil. IC	U3	TK11435	3.5V regulator
	3	Sil. IC	U5	MAX6315	Reset generator
	4	Sil. IC	U4	MAX6315	0.2 Sec delay
U_PROCESSOR	1	Sil. IC	U9	PIC16LF84A	Controller
AGC Control	1	N-CHAN FET	Q1	VN0605T	Analog Switch
	2	"	"	"	"
	3	"	"	"	Logic Inverter