Theory of Operation: MTS10 10 Watt AM Transmitter

Referenced Documents: Attachment 1 Block Diagram
Attachment 2 Schematic Diagram
Attachment 3 Filter Schematic Diagram

Section 1.0 General Description

General

The MTS10 Transmitter is a 10 watt AM Broadcast band transmitter designed to comply with FCC Rules Part 97.242 Travelers Information Station Requirements.

The unit is synthesized and covers from 530 kHz to 1700 kHz in 10 kHz steps. The transmitter frequency is set by running a configuration utility on a personal computer connected to the unit. This USB connection is a one time connection for configuration purposes only and is not designed nor intended to remain connected at any time after the initial configuration.

The power level which is continuously adjustable from 0.1 to 10.0 watts is also set using the USB configuration utility. Additional features in the USB configuration utility include a visual indication of modulation, a display of the transmitters forward and reflected power to the antenna system, selection of which audio input is active, selection of which mode the audio selection is in, and a display of the DC input voltage to the unit.

The MTS10 employs a Class D RF amplifier and a Class S modulator which yields outstanding power efficiency and reduced operation costs. The efficiency is for a fully modulated output is 82% minimum and can be as high as 92% depending on frequency and the antenna characteristics.

Input Power

Input Power to the MTS10 is nominally 13.2 Volts DC at a maximum current of 2.5 amperes. The connection for the DC input power is at J7. MTS recommends that you use only the provided power cable with the unit as the current rating for this connector is for a specific model of the coaxial power connector.

Audio Input.

The MTS10 has two audio inputs, Primary and Alternate, at J4 and J5 respectively. J4 and J5 are monaural 3.5mm jacks and the inputs are both 600 ohm transformer coupled. The nominal audio input level is -10 dBm for full

modulation, however this level is not critical. The MTS10 has a compandor circuit that automatically adjusts the gain of the modulator to accommodate input levels from -30 dBm to +10 dBm. It is not possible to over modulate the transmitter regardless of the audio input level. This is due to the modulator employing a pulse width modulation that is generated by the microprocessor and having a maximum pulse duration of 99%.

RF Output
The RF output is at J3 on the rear panel which is a BNC type connector. The RF output is a 50 ohm output and should only be connected to 50 ohm antennae or 50 ohm loads. The transmitter is protected from large mismatches to the load. It will not damage the unit if the output is opened or shorted, repetitively. There are certain load conditions that may cause the unit to operate at higher than normal or desirable temperatures, but these conditions should not exist in normal serviceable installations.

LCD Display
The MTS10 has a front panel LCD display that displays various information about the condition of the unit. It displays the unit serial number on power up, frequency, forward and reflected power, and a visual indication of modulation.

RF Filters
The MTS10W has three 5^{th} order elliptical filters that are selected by the processor for RF Filtering. The filters are for 530-750 kHz, 760 kHz to 1100 kHz and 1110 kHz to 1700 kHz. The filters are located on the plug in Filter Assembly at P1.

Audio Filter
The MTS10 is equipped with the 3.4 kHz Modulation Filter as required by FCC Part 90.242.

Section 2.0 Micro Controller Circuitry

U2 is the embedded Micro Controller that controls the transmitter. U2 is operated from the regulated 5V supply. U2 has a 20 MHz crystal oscillator, X1, that provides its clock signal. U2 provides:

a. Programming data for the numerically controlled oscillator, U5

b. Data for the LCD Display

c. Control data for the Audio input selector switch, U4.

d. USB interface for user programming of the radio and firmware updates.

e. A pulse width modulated signal for the Power Control circuitry. This PWM is at 186 kHz and can be varied from 1% to 99%

f. A pulse width modulated signal for the Modulator circuitry. This PWM signal is at 186 kHz and can be varied from 1% to 99%.

g. Analog to Digital conversion for the Forward Power and Reflected Power signals from the bidirectional wattmeter circuitry.

h. Drive for LED D12 that is the 'operating' indicator for the processor.

i. Filter detection for determining what RF filter module is installed.

Section 3.0 Numerically Controlled Oscillator

The operating frequency of the transmitter is determined by programming U2 with the appropriate control and data words to divide its reference oscillator, 10 MHz temperature compensated crystal oscillator X2, to the correct frequency. The maximum error is less than 10 Hz, from either division error or temperature drift or the combination of both. X2 and U2 are powered by the 3.3 volt regulated DC supply, U11. Provisions for operating the synthesizer from an external reference source have been made at J6.

Section 3.1 RF Section

The output of the numerically controlled oscillator directly drives U3 a differential FET driver IC. This IC provides highly duty cycle accurate, current limited drive to the RF Final MOSFETs, Q4 and Q5. Q4 and Q5 are operated in the CLASS D Mode. RF Transformer T4 converts the low impedance of the amplifier (2.7 ohms) to nearly 50 ohms. The center tapped primary of the RF Transformer is output of the modulation filter. Note that the DC from the power control flows through the filter and provide the current which is switched to create the RF carrier in the primary. The modulator varies the DC to create high level AM.

Section 3.2 RF Filters

The RF Filter Module mount just above the main board at P1. The filter design is a 5^{th} order Cauer design which provides excellent in band loss characteristics as well as excellent attenuation to out of band signals. An approximate half octave filter scheme is employed resulting in three different filter circuits. The correct filter is selected by relays K1 and K2.

Each filter offers a minimum of 35 dB rejection to the second harmonic of the lowest frequency in its band.

Section 3.3 Power Control

The 186 kHz PWM Power Control output from Controller U2 directly drives the first gate in FET driver U1. This output drives the gate of MOSFET Q1. When Q1 is turned on it charges C3 thru L1. The inductive ring is clamped by schotkey diode D1. As the pulse width changes the resulting charge of C3 changes yielding a DC voltage that is proportional to the pulse duration. This DC voltage continuously variable from 0.1 volts to 12 volts DC.

Section 3.4 Modulator

The 186 kHz PWM modulation signal from Controller U2 directly drives the second gate in FET Driver IC U1. This output drives MOSFETS Q2 and Q3. Diodes D3 and D5 protect the gates of the MOSFETS. Q2 and Q3 are configured as a Class S amplifier and switch the Power Control DC from ON to OFF at the PWM rate which results in a audio modulated DC. This audio modulated DC drives the center tap of the RF output transformer T4.

Section 3.5 Modulation Filter

FCC Rules Section 90.242 requires that a filter be installed between the modulator and the RF stage in equipment authorized under 90.242. The filter Has to pass the current for the RF Final and has to meet the filter response required.

This filter has a source impedance of 0.1 ohm and a load impedance of 2.7 ohms. The cutoff frequency is 3.2 kHz. The filter is a 7^{th} order Chebychev Dual design and meets the requirements for the filter response. This filter consists of L2, C9, C10, C11, C12, L3, C13, C14 and L4.

Section 3.6 RF Watt Meter

The Bi-Directional wattmeter is a typical current sensing type using 3 transformers, T1, T2, and T3. The forward and reflected power is represented by the DC resulting from the rectified sum at D6 and D7 respectively. Vf and Vr and buffered by operational amplifer U6 and then routed to the controller A-D input where the DC level is digitized and available for display at either the LCD or USB ports.

Section 3.7 LCD Display

The LCD module is a typical 2 x 7 character display module and is driven directly by the controller. R76 is the contrast adjustment for the display module. The LCD module connects to the main board at J8 and J9. J9 has the connections for the backlight LED.

Section 3.8 USB Port

The Micro Controller, U2, has a USB port that is available at J2. D1 is a package of three protection diodes that protect the USB pins of the controller from ESD.

Section 3.9 Power Supply

There are several regulated supply voltages that are used in the MTS10.

+8V Three terminal regulator U12

+5V Three terminal regulator U9

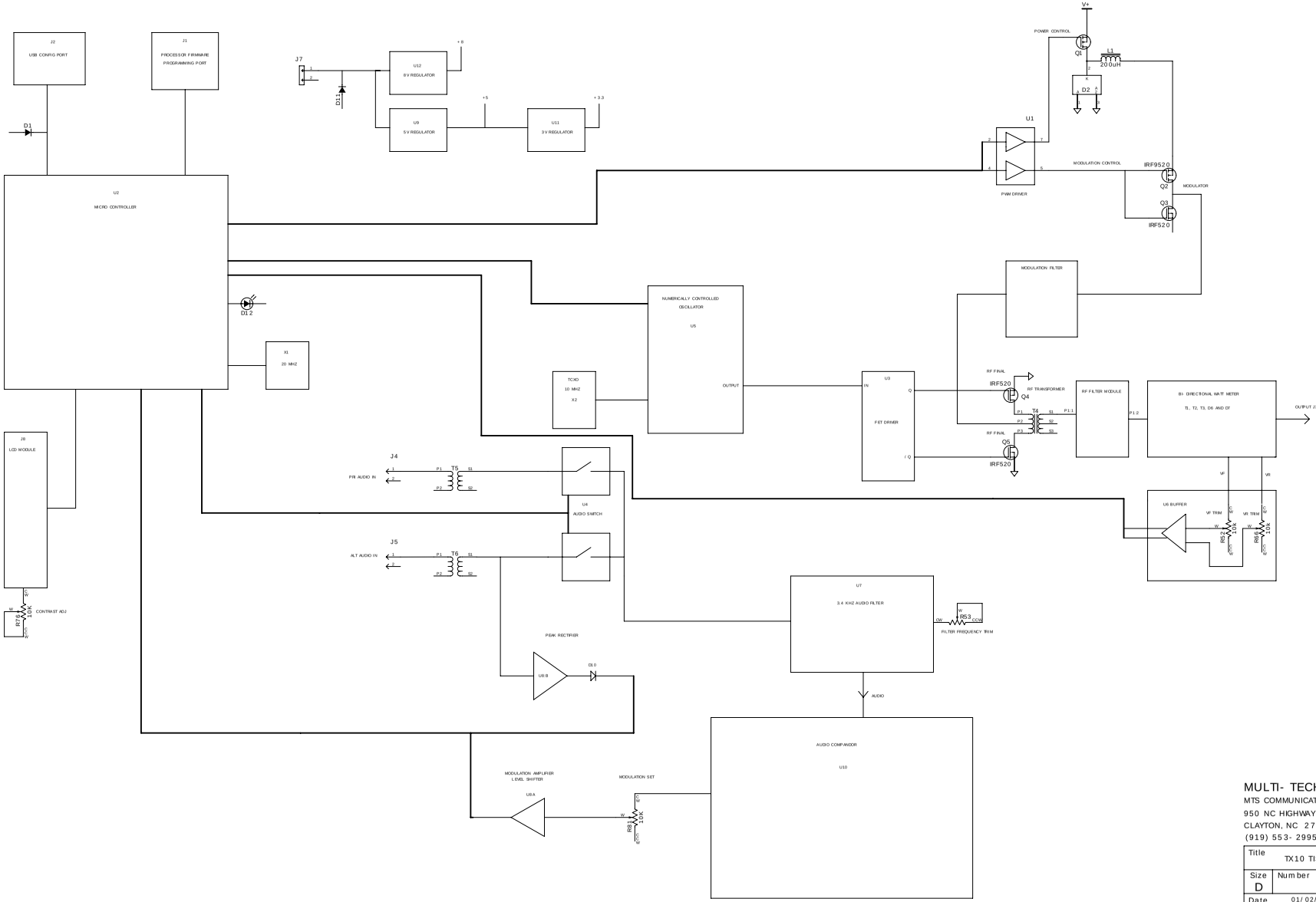
+3.3V Five terminal low drop out regulator U11

Note that each of the regulator IC's are bypassed and filtered with low ESR high frequency capacitors.

The DC input to the unit is filtered by C49. Polarity protection is provided by D11.

Section 4.0 Enclosure

The MTS10 Enclosure is fabricated from aluminum and plastic materials. Do not use any hardware but that supplied with unit to prevent damage to the unit.



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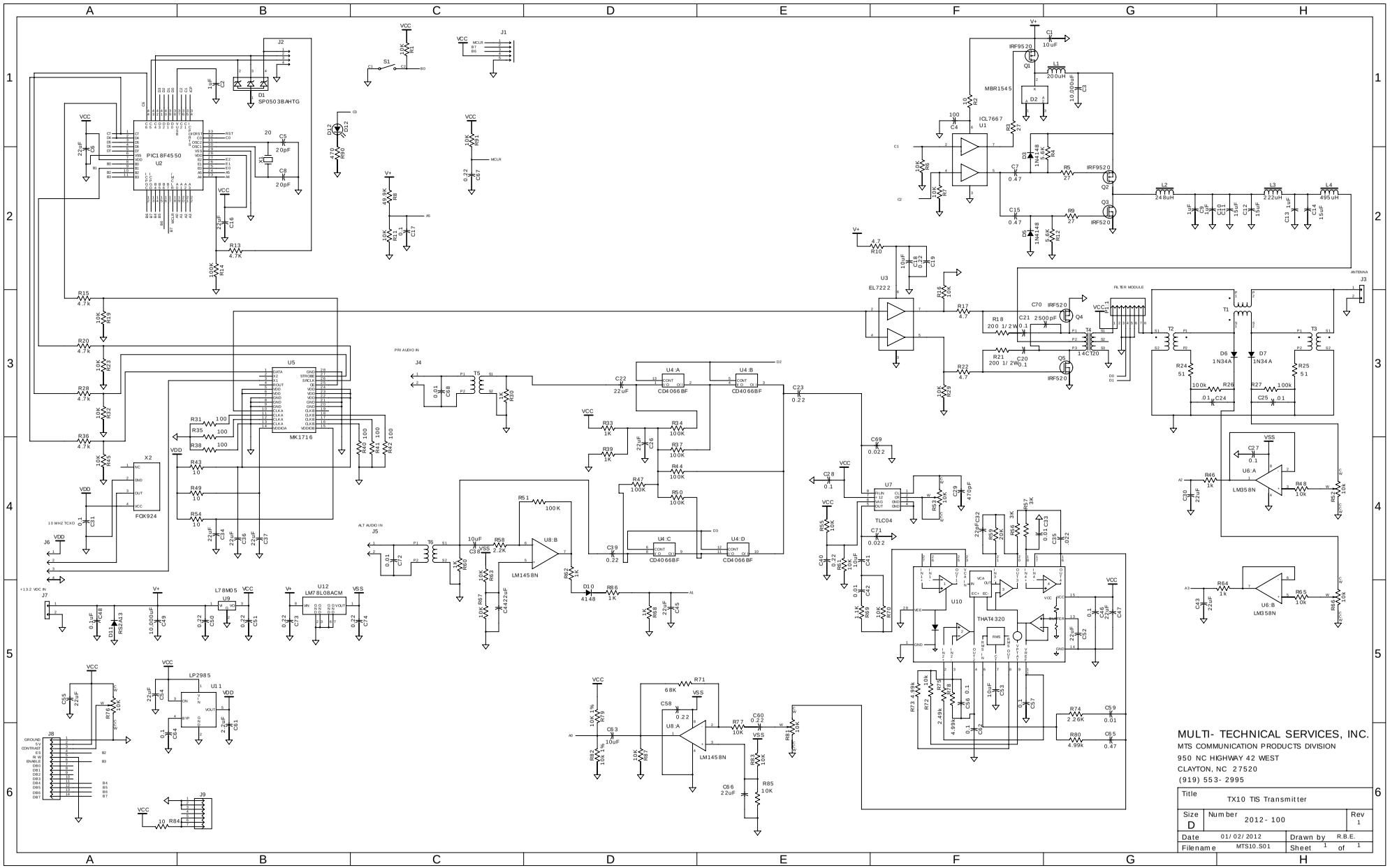
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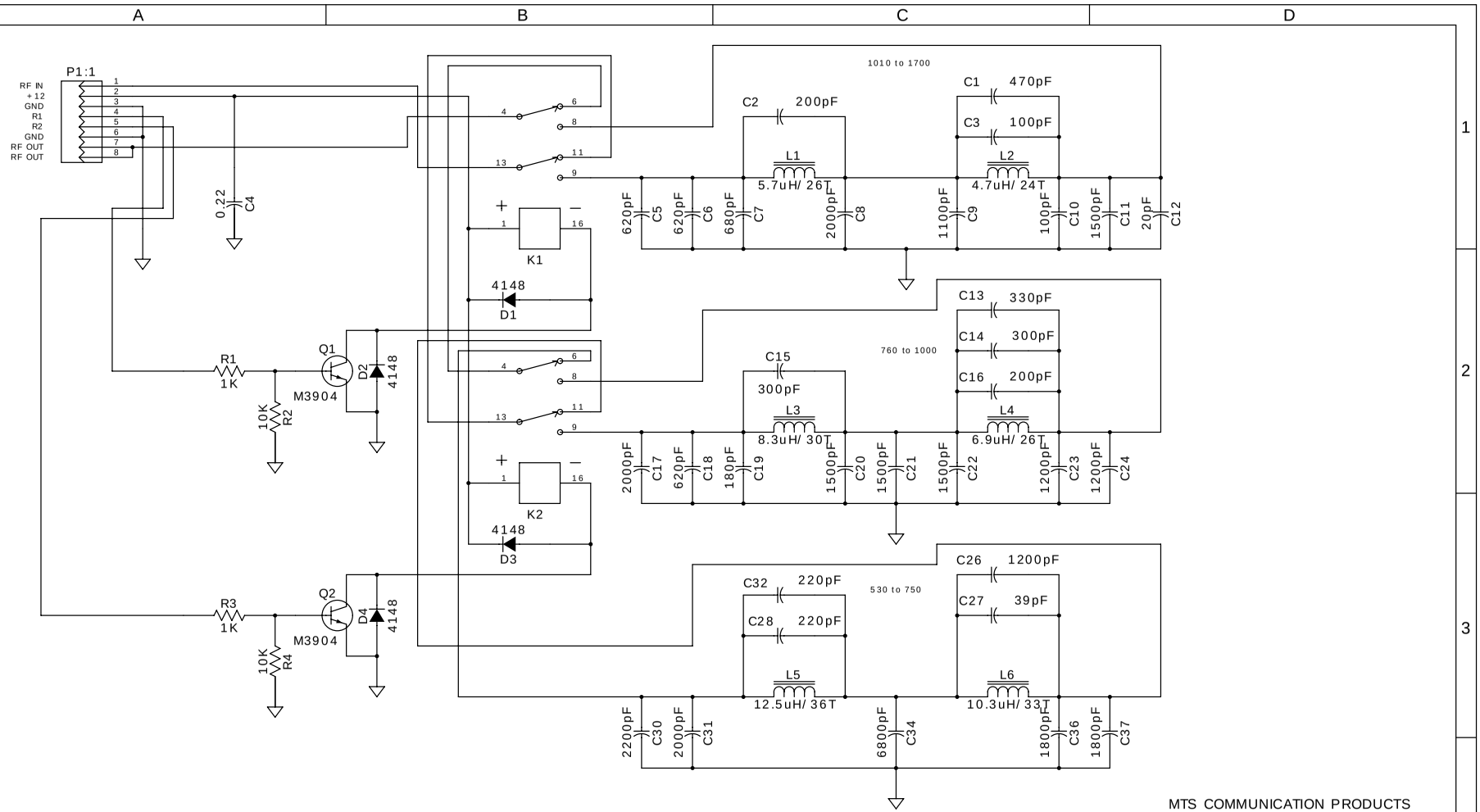

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Title: MTS- 10 AM FILTER		
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Date: 01- 27- 2012		Drawn by: LAW
Filename: MTS10FLT.S01		Sheet 1 of 1