DT6000
SCALABLE LPAM TRANSMITTER
PLANS, ASSEMBLY,
AND
OWNERS MANUAL

Version 002

With Patent Pending Under / Over Modulation Eye Indicator Circuit

520-1720 kHz Inclusive

FOR REQUIRED PCB and PROGRAMMED CHIP CONTACT:

TransmitterPlans@GMAIL.com

Allow Up To 24-48 hours for a response, closed weekends, and Holidays

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Preliminaries

What You Should Agree To

By building these plans you agree to be within a group of hobbyists, inventors, and other parties that design and build Part 15 transmitters with no intention of ever marketing them as complete units. The reason for this is that if completed kits are sold, the design needs to be tested by a certified laboratory to show the final product is in compliance with FCC regulations. As plans for those individuals described above, this testing requirement is precluded saving considerable expense. Many assembled transmitters are being sold without FCC certification, these are all illegal to use despite meeting the advertised 100 milliwatt power rating. Without FCC certification, only plans and kits such as this are legal to build and use. You also agree to to employ good engineering practices in order to ensure compliance with the Part 15 standards during their construction or if ever modified. The suggested electronics are similar to or based on existing or past Part 15 compliant transmitters and should not be altered, particularly with a different antenna unless the antenna configuration is in accordance with FCC regulations.

For specific information and fines for non compliance may be found at:

https://transition.fcc.gov/Bureaus/Engineering_Technology/Documents/bulletins/oet63/oet63rev.pdf

To fully comply with FCC regulations, you must permanently solder the antenna to the PCB board to prevent using other antenna configurations which are not approved.

https://transition.fcc.gov/oet/ea/presentations/files/may17/32-Part-15-Antennas-Consolidated-KDB-Pub-353028-v2b_r1-TH.pdf

Why These Plans Are Available

The these instructions provide a basis to start or advance your knowledge in the field of FCC compliant Part 15 Low Power AM (LPAM) transmitters in compliance with FCC regulations. This is accomplished primarily by building the plan per these instructions and taking the time to investigate how the circuits work operate. Learning to program the transmitter with an Arduino Nano will increase your programming skills as well.

Warranty

No warranty is written or implied as plans being assembled by individuals of varying skill level results can not be guaranteed. However the information herein is correct and accurate and created in good faith to create a quality transmitter when built with specified parts when created by a reasonably skilled electronic enthusiast. Technical support is not provided, and shouldn't be needed.

About The Design

Some aspects of this transmitter are based on the no longer available but well performing, popular, and durable SSTRAN AMT3000 and AMT5000. At least one of these transmitters has been in constant use for over 20 years. The pre-emphasis filter and the noise gate expander are based on posted improvements to the transmitters by a generous fellow enthusiast professionally working in the field.

Key Transmitter Features

Time progresses as does the electronic industry and associated technologies (as have component prices). Likewise, some parts are no longer available or not readily attainable. This transmitter plan offers some of the past milestones and several improvements over the original SSTRAN transmitters. Notably:

- Digital frequency generation instead of a crystal and PLL circuit (NEW)
- An over modulation detection circuit when using the built in audio processing providing a visual indication via a bi-color LED providing peak modulation without the risk of audio distortion and an FCC lower sideband noise violation.(NEW)
- An isolated audio input suitable for MP3 players and IPODs, the entire audio section may be bypassed if desired by using jumpers. (NEW)
- Pre-Emphasis high pass filter located before the audio chip and if desired, the original post audio high pass filter is still available. (NEW)
- Balanced audio input via a THAT1200 IC reducing audio signal noise for long audio runs from a studio to the antenna allowing remote outdoor transmitter mounting for an audio studio. An antenna surge protector is also available. (AMT5000 FEATURE)
- Audio chip exclusion for your own audio processing if desired (NEW)
- Additional noise gate / expander adjustment if desired (NEW)
- An OLED display indicating the frequency adjusted by a knob instead of the cumbersome dip switch frequency changing system (NEW)
- Basic antenna tuning / peaking via a front panel knob. Adjustment results are shown as VDC on the OLED readout on the front of the transmitter. This is an improvement over a capacitor on the board and using a voltmeter for peaking. However, this feature is not needed as the transmitter covers the range allowed by the FCC, 200' in one direction without adjustment subject to local conditions and setup. (Original AMT3000 tuning inductor circuit still included.) (NEW)

- Use an Arduino Nano or ATMEL chip to reprogram the display and frequencies. Two digital pins may be set high or low via jumpers for additional programming versatility. (NEW)

- Easily configurable for a loaded base antenna to the original designed base antenna (AMT3000 FEATURE)

- GDT tube for antenna safety (AMT5000 FEATURE)

- Optional self-reseting fuse rated at .25 amps to protect the transmitter circuit should a component fail causing a short. (NEW)

T DT6000 combines functionality of both the AMT3000 and AMT5000 plus the many new innovative features above. Generally the DT6000 uses the AMT3000 audio / RF sections and the AMT5000 balanced audio input using a THAT1200 chip.

If desired, more extensive antenna tuning / peaking may still be performed as with the original AMT3000 via jumpers instead of a dip switch, the same as the original transmitter. Depending on your desired range, changing the inductor jumpers may not be needed and this feature is not typically available on other transmitters. Most other specifications remain the same including similar transmission distance to the AMT3000. It was found by the designer of the AMT 3000, Mr. Phil Bolyn that usable range was well over one mile and could be received over 2 miles by car radio under his local conditions in southeastern Pennsylvania. While the SSTRAN website still operates, plans for a high performance base-loaded vertical antenna may be found at the following link and is included in this manual at the end.

http://www.sstran.com/pages/COMMON/sstran_buildant.html

Keep in mind however, the FCC indicates the maximum transmission distance should be no more than about 200 feet from the antenna. https://www.fcc.gov/media/radio/low-power-radio-general-information

Part 15 Devices

Unlicensed operation on the AM and FM radio broadcast bands is permitted for some extremely low powered devices covered under Part 15 of the FCC's rules. On FM frequencies, these devices are limited to an effective service range of approximately 200 feet (61 meters). See 47 CFR (Code of Federal Regulations) Section 15.239, and the July 24, 1991 *Public Notice* (still in effect). On the AM broadcast band, these devices are limited to an effective service range of approximately 200 feet (61 meters). See 47 CFR Sections 15.207, 15.209, 15.219, and 15.221. These devices must accept any interference caused by any other operation, which may further limit the effective service range.

For more information on Part 15 devices, please see OET Bulletin No. 63 ("Understanding the FCC Regulations for Low-Power, Non-Licensed Transmitters"). Questions not answered by this Bulletin can be directed to the FCC's Office of Engineering and Technology, Customer Service Branch, at the Columbia, Maryland office, phone (301) 362 - 3000.

This manual discusses features available at time of writing, however some features may be removed or

not available as time progresses due to several reasons such as popularity, cost, and part availability.

Configurations and Options

The DT6000 is scalable offering multiple configurations to satisfy even the most demanding transmitter requirements for enthusiasts of all levels.

The basic configuration essentially offers the capabilities of the original AMT3000 plus digital tuning, audio isolation, pre-emphasis audio processing before the audio chip, and noise gate expansion. If desired, the audio chip may be bypassed as well. The two noise filtering power inductors are also optional. Simply install the jumpers as explained in the assembly instructions or use a solder bridge. These may always be installed later if you believe you have line noise.

Optional additions include, an over modulation detector, balanced audio input using the THAT1200 IC and an antenna surge protector.

The average user will likely find the basic configuration and the over-modulation detector a nice combination providing excellent audio quality while more dedicated enthusiasts will include the all of the additional options for their transmitting studio, or for mounting the transmitter on an exterior loaded antenna.

If you plan on having an outdoor antenna and will be mounting the transmitter on the antenna mast, and will be supplying the audio from a considerable distance from perhaps inside your home or studio, the balanced audio will help eliminate noise from the audio transmission on the wires between your house and the antenna. If you will be placing the transmitter inside your home with the antenna, or using something such as an MP3 player located with your transmitter on an external antenna outdoors, the balanced audio is not needed.

Balanced audio is an involved subject, with specialized equipment, and it is beyond the scope of this manual to provide a tutorial. As such balanced audio is left to those familiar with the subject to look at the schematics and use them as needed to implement this feature if the components are installed.

Most be people will find the standard setup using the on board audio processing as both simple and effective also allowing the use of the modulation indicator.

Manual Errors

Though it is hoped this plan is perfect and has no errors, like most things in life, probably it is not free of errors. Kindly report them to the email on the front cover with a subject for the email “Manual Error”. Improvements and suggestions will be considered as well for the next release.

Manual Overview

Congratulations on deciding to build the most advanced LPAM legal transmitter available, regardless of price.

This manual contains sections which will lead you along the journey of ordering the additional parts required and instructions to build your Part 15 compliant LPAM transmitter.

Section 1 provides information on purchasing the parts you need

Section 2 contains information for organizing and identifying your parts

Section 3 contains a list of tools to build the transmitter

Section 4 provides instructions for inserting and soldering components, be sure to read this sections as some parts require specific orientation.

Section 5 contains information about the circuit board and locate where parts belong

Section 6 contains the step by step assembly instructions based on the transmitter components,; power supply, audio, digital display / frequency synthesis, and modulator / RF power output. This is the longest section with many steps containing check boxes to mark. Each section should be tested after assembly using the provided test procedure.

Section 7 contains final assembly checks

Section 8 contains some checks with power applied and some troubleshooting information should you have any problems

Section 9 contains information about mounting the assembled board and connecting the end panels to the connectors

Section 10 contains information on using the adjustments and setting the frequency, gain, modulation, compression, and peak voltage.

Section 11 contains information on manually tuning the conductors using peak voltage to obtain the possibly obtain better output signal

Section 12 contains information on the final installation, a reminder about the FCC rules, antenna considerations, grounding, and closing the case

Section 13 contains information about performance specifications as constructed and other related matters.

To get the most out of this manual and making the build as smooth as possible, it would be a good idea to read the entire manual before doing anything associated with the transmitter parts.

Refer to the table of contents for specific page numbers as needed.

Purchasing the Parts

This section contains about purchasing the required parts. First the basic configuration parts are listed, then the optional parts are listed and should be included in your order if selected. Be for to read the parts notes before ordering any parts as there are a few options to consider.

There are 4 main sources for the parts:

The plans designer – Specialized parts required for building the transmitter, the PCB and programmed chip or Arduino.

Mouser and Digikey– Electronics part suppliers for the majority of the electronic parts easily ordered using their cart / BOM tools as explained. Be sure to read the section and review the alternative parts list for preferred parts, particularly L2, and L3.

Amazon – Internet market place for non specialized electrical components such as the OLED display, peaking capacitor, and other common parts.

Any 3D Printing Service – The custom 3D face plate stl file may be printed by anyone with a 3D printer.

Feel free to use your own excess components or other suppliers should you find better prices and the parts may be interchanged. Be sure to verify your resistors and capacitors with a meter however.

The including these plans, the total cost to build the transmitter is roughly $200 plus relevant taxes and shipping. The price breakdown is as follows:

REQUIRED: PCB and programmed chip, approximately $69 + shipping (Ebay and Etsy prices will be higher)

REQUIRED: Basic configuration electronics parts, Mouser / Digikey $100 - $120 depending on options

OPTIONAL: Overmodulation detection parts, Mouser / Digikey $10 - $15

OPTIONAL: Balanced audio input parts and surge protector, Mouser / Digikey $30 - $35

REQUIRED : Amazon Parts, $35

REQUIRED: Printed 3D face plate and 5 knobs, print your own from supplied STL files or, $15-30 from https://www.etsy.com/shop/MakerChamber?ref=seller-platform-mcnav

Purchasing Custom Parts From The Plans Designer

To purchase the custom parts from the designer, send an email to:

TransmitterPlans@GMAIL.com

From the plans designer you will purchase:

- Required PCB
- Programmed computer chip

Schematics will be posted for easy download at sites such as GrabCAD. Other parts from the suppliers below on a limited basis may also be available at extra charge through the designer.

The designer may also use PayPal or similar billing as the payment method. You will receive a link in the email to make the payment via PayPal or similar service, the parts usually ship priority or first class mail in a few days but may take up to a week or more depending on availability. Or purchase through Ebay or Etsy as usually available.

Having The Face Plate and Knobs Made

Contact https://www.etsy.com/shop/MakerChamber?ref=seller-platform-mcnav to order the desired part quality you want for the face plate and other components. Much more information is found below in a few pages ahead.

Purchasing Parts From Mouser and Digikey

It is best to select Mouser or Digikey but not both due to the extra postage if two suppliers are used unless you must use both due to an availability issue. Both have outstanding customer service. Mouser and Digikey have all the parts not ordered from the designer (only the ATMEGA programmed chip and PCB) and Amazon. Verify parts availability and price from both before ordering. Always refer to the manufacturer number as DigiKey and Mouser also have different part numbers for the same part but the manufacturer part is always the same. The download spreadsheet has parts from only Mouser with the manufacturer codes. When you receive the parts from Mouser and order the parts with the supplied spreadsheet, the component numbers on the part bags will match the components in this kit in the customer number section. This makes assembly quite simple, almost enjoyable.

BE SURE TO CHECK THE PARTS YOU REQUIRE BELOW AGAINST THE SPREADHEETS BEFORE USING THE SPREADSHEETS

Digikey Parts

If you prefer Digikey, use the manufacturer part numbers as the cross reference to the Digikey part numbers. Digikey does not carry the THAT1200 IC required for the balanced audio circuit. Digikey provides excellent customer service and is an excellent alternate parts source.

Mouser Parts

Below is a list of parts to order from Mouser with the manufacturer part number and specifications. Total cost is roughly $100 plus tax and shipping. The optional parts list for the modulation monitoring and balanced audio are also presented below.

This may be uploaded as an xls file to Mouser to create a shopping cart using their BOM tool and creating a shopping cart to order from saving having to type in the part numbers. If some parts are not available after creating your shopping cart, see the section on Alternate Suppliers and Parts below. The board is designed to use more than one footprint in some instances for maximum flexibility in ordering parts, particularly for capacitors.

As an overview, to create your Mouser shopping cart and order the parts:

1. Create you Mouser account
2. Select Service and Tools on the webpage
3. Select the Forte BOM tool
4. Select Upload spreadsheet
5. Import the spreadsheet.
6. Select the mapping headers for Customer Number, Quantity1, and Manufacturer Number, should be automatic, but verify the headers.
7. Verify that the mapping tool worked properly and the correct parts are selected. The only known mismatch are the 1/4" PCB screws, rematch to select the screws in place of the Klein screwdriver shown below.

Figure 1: Mouser Part Mapping Screen

Make the indicated replacement shown.

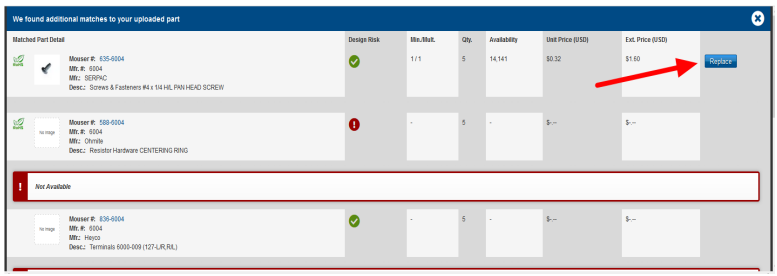


Figure 2: Mouser Part Selection Screen

8. Once the BOM is complete, click on the Add To Cart x 1. Then make the shopping cart and verify the parts are in stock indicated by "Ships Now" in the Availability column. If a part is not available, refer to the Alternate Parts section and search for the part in Mouser and replace the missing part with the part in stock making sure the leads are spaced properly, especially for capacitors. In some instances such as for the bipolar electrolytic capacitors, the alternative parts are less expensive than those in the BOM shopping cart, make changes as needed.

Mouser has excellent customer support, if you have problems creating the cart, or finding substitute parts, call them for assistance. 800-346-6873.

Mouser Parts List

Be sure to use the attached spreadsheet file and BOM tool when ordering. The customer number will be on the parts bag with the components and identifies the part number for the board and reference in this plan. Make sure you map the fields to Mouser correctly, take your time, it will save confusion when all the parts arrive. See the Mouser parts notes below, in some instances other parts are preferred if available.

Basic Configuration Parts - MOUSER

Mfr. #	Manufacturer	Instructions #	Description
CF1/4CT52R220J	KOA Speer	R8	22 ohm Carbon Film Resistors - Through Hole 5%, ¼ Watt
CF1/4CT52R101J	KOA Speer	R3	100 ohms Carbon Film Resistors - Through Hole 5%, ¼ Watt
CF1/4C221J	KOA Speer	R28 R29	220 ohm Carbon Film Resistors - Through Hole 5%, ¼ Watt
CF1/4CT52R511J	KOA Speer	R7	510 ohm Carbon Film Resistors - Through Hole 5%, ¼ Watt
CFP1/4CT52R821J	KOA Speer	R18	820 ohm Carbon Film Resistors - Through Hole 5%, ¼ Watt
CF1/4CT52R102J	KOA Speer	R21 R31	Carbon Film Resistors - Through Hole 1K ohm 5%, ¼ Watt
CF1/4CT52R152J	KOA Speer	R17	1.5k ohm Carbon Film Resistors - Through Hole 5%, ¼ Watt
CF1/4CT52R182J	KOA Speer	R27	1.8k ohm Carbon Film Resistors - Through Hole 5%, ¼ Watt
CF1/4CT52R272J	KOA Speer	R4	2.7k ohm Carbon Film Resistors - Through Hole 5%, ¼ Watt
CF1/4CT52R472J (See Note 11)	KOA Speer	R30 R37 R38 R12	4.7K ohm Carbon Film Resistors - Through Hole 5%, ¼ Watt
CF1/4CT26A682J	KOA Speer	R10	6.8k ohm Carbon Film Resistors - Through Hole 5%, ¼ Watt
CF1/4CT52R103J	KOA Speer	R19 R22 R32	10k ohm Carbon Film Resistors - Through Hole 5%, ¼ Watt
CF1/4C153J	KOA Speer	R6 R13 R16	15k ohms Carbon Film Resistors - Through Hole 5%, ¼ Watt
CF1/4CT52R273J	KOA Speer	R5	27k ohm Carbon Film Resistors - Through Hole 5%, ¼ Watt
CF1/4CT52R303J	KOA Speer	R33	30k ohm Carbon Film Resistors - Through Hole 5%, ¼ Watt
CF1/4CT52R473J	KOA Speer	R1 R2 R9	47k ohm Carbon Film Resistors - Through Hole 5%, ¼ Watt
CF1/4CT52R224J	KOA Speer	R14	220k ohm Carbon Film Resistors - Through Hole 5%, ¼ Watt

Mfr. #	Manufacturer	Instructions #	Description
CF1/4CT52R105J	KOA Speer	R15 R20 R39	1M ohm Carbon Film Resistors - Through Hole 5%, ¼ Watt
P160KN2-0EC15B100K	TT Electronics	R34G R36C FRONT	Potentiometers 16mm Rotary Panel Potentiometer 0-100 k ohms
P160KN2-0EC15B50K	TT Electronics	R35M FRONT	Potentiometers 16mm Rotary Panel Potentiometer 0-50 k ohms
K220J15C0GF5TL2	Vishay	C12 C13	22pF Multilayer Ceramic Capacitors MLCC - Leaded 50V 5% C0G 2.54mm LS
K221J15C0GF5TL2	Vishay	C15 C27	220pF Multilayer Ceramic Capacitors MLCC - Leaded 50V 5% C0G 2.54mm LS
K561J15C0GF5TL2 (See Note 13)	Vishay	C23A	560pF Multilayer Ceramic Capacitors MLCC - Leaded 50volts 5% C0G 2.54mm LS
C315C821J1G5TA	KEMET	C23	820pF Multilayer Ceramic Capacitors MLCC - Leaded 100V C0G 5% LS=2.54mm
K102J15C0GF5TL2	Vishay	C17	1000pF (1nF, .001uF) Multilayer Ceramic Capacitors MLCC - Leaded 25V 5% C0G 2.54mm LS
C315C103K5R5TA 7303	KEMET	C14 C16	0.01uF Multilayer Ceramic Capacitors MLCC - Leaded 50V X7R 10% LS=2.54mm
C315C473K5R5TA 7303	KEMET	C19	0.047uF (47 nF)Multilayer Ceramic Capacitors MLCC - Leaded 50V X7R 10% LS=2.54mm
C320C104K5R5TA 7301	KEMET	C1-3 C6-11 C22 C28 C31 C100-C103	0.1uF Multilayer Ceramic Capacitors MLCC - Leaded 50V X7R 10% LS=2.54mm LL=7mm
UES1V4R7MDM	Nichicon	C18 C21	4.7uF Aluminum Electrolytic Capacitors - Radial Leaded 35volts 4.7uF 85c 5x11 2LS
UES1V100MEM	Nichicon	C24 C25 C26 C29	10uF Aluminum Electrolytic Capacitors - Radial Leaded 2.5mm LS, 35volts 10uF 6.3x11
25NA100MEFC8X11.5	Rubycon	C32	100uF Aluminum Electrolytic Capacitors - Radial Leaded 25volts, .138" (3.50mm) LS
UES1V471MHM	Nichicon	C4	470uF Aluminum Electrolytic Capacitors - Radial Leaded 35volts 85c 16x25 7.5LS

Mfr. #	Manufacturer	Instructions #	Description
L7815CV	STMicroElec.	Q1	Linear Voltage Regulators 15V 1.0A Positive
L7805CV	STMicroElec.	Q7	Linear Voltage Regulators 5.0V 1.0A Positive
PN2222TA	Onsemi	Q2 Q3 Q4 Q5	Bipolar (BJT) Transistor NPN 30 V 600 mA 300MHz 625 mW Through Hole TO-92-3
2N4403BU	Onsemi	Q6	Bipolar Transistors - BJT PNP Transistor General Purpose 2N3906 or 2N4403BU PNP
SSA-115-S-T (See Note 3)	Samtec	IC1 NANO HEADER (2)	Headers & Wire Housings .100 Low Cost Socket Strip
1-2199298-9	TE Connectivity	IC1 BRD SOCKET for ATMEGA chip	IC & Component Sockets 28P DIP SKT 300 CL LADDER
SSM2166SZ-REEL7 (See Note 4)	Analog Devices Inc.	IC3_AUDIO	Microphone Preamplifiers MICROPHONE PREAMP W/VAR COMPRESS
LCQT-SOIC14 (See Note 7)	Aries Electronics	IC3 AUDIO ADAPTER	Sockets & Adapters SO Prototyp Adaptor 14 contact SOIC
SSA-107-S-T (See Note 9)	Samtec	AUDIO / DDL HEADER (3)	Headers & Wire Housings .100 Low Cost Socket Strip
ECS-160-S-1X (See Note 11)	ECS	XTAL	Crystals 16MHz SERIES
1N4002-TP	Micro Commercial Components (MCC)	D1 D2 D3 D4	Rectifiers 1A 200V 140Vrms 200V 30A 1.0Vf 5.0uA 15p, Through Hole DO-41
1N4148 (See Note 8)	Onsemi	D5 D6	Diodes - General Purpose, Power, Switching Hi Conductance Fast, 100 V 200mA Through Hole DO-35
TY-142P	Triad Magnetics	T1	Audio Transformers / Signal Transformers AUDIO XFMR 10Kct:2Kct 4mADC 100mW PCB MOUNT/TY-142P
78F102J-RC	Bourns	L8	Fixed Inductors 1.0mH 5%
78F560J-RC	Bourns	L4	Fixed Inductors RF CHOKE 56uH 5%
78F820J-RC	Bourns	L5	Fixed Inductors 82uH 5%
78F181J-RC	Bourns	L6	Fixed Inductors RF CHOKE 180uH 5%
78F471J-RC	Bourns	L7	Fixed Inductors 470uH 5%
7447480102 (See Note 1)	Wurth Elektronik	L2 L3	Fixed Inductors WE-TI RadXtnd Ld1014 WW1000uH .8A 1.15Ohm

Mfr. #	Manufacturer	Instructions #	Description
MF-RX025/72-2 (See Note 12)	Bourns	Self Resetting Fuse	Resettable Fuses - PPTC PTC RESETTABLE 0.25A (250 mA) 72V
151-8003-E	Kobiconn	JUMPER	Headers & Wire Housings MINI JUMPER GF 6.0MM OPEN TYPE RED
2340-6211TG 3 Required	3M	MALE PIN HEADER	Headers & Wire Housings 40P STRT 1 ROW GOLD
PEC11R-4015KN0018	Bourns	ENC1 FRONT	Encoder 12MM, L=15mm SHAFT NO SWITCH, NO DETENT
R1-23B	Shin Chin	CN8 PWR CASE BACK	DC Power Connectors DC POWER JACK PANEL MOUNT 2.1MM
RCJ-034	CUI Devices	CN9 ANT CASE	RCA Phono Connectors RCA Connectors YELLOW
RCP-024	CUI Devices	ANT MALE	RCA Phono Connectors Plastic-Handled w/Strain Relief, Modular RCA Plug Connector
RCJ-032 (See Note 10)	CUI Devices	CN6 AUDIO CASE BACK	RCA Phono Connectors RCA Connectors RED
RCJ-033 (See Note 10)	CUI Devices	CN7 AUDIO CASE BACK	RCA Phono Connectors RCA Connectors WHITE
4832.2300 (See Note 5)	Schurter	CN4 AUDIO CASE	Phone Connectors AUDIO SOCKET 3.5MM 3P SOL
PC-11478	BUD Industries	CASE	Enclosures, Boxes, & Cases Plasticase Style I Plastic Case (1.6 X 7.9 X 4.8 In)
24283	Keystone Electronics	STANDOFF (1)	Standoffs & Spacers 4.5 HEX 10.0mm SS for peaking capacitor knob mount
29301	Keystone Electronics	PEAK CAP SCREWS (2)	Screws & Fasteners M2.5 6.0mm Screw Zinc Plated Steel
6004	SERPAC	PCB screws (6)	Screws & Fasteners #4 x 1/4 H/L PAN HEAD SCREW
WAU20-500 (See Note 2)	Triad Magnetics	AC ADAPTER	Wall Mount AC Adapters Wall Plug-In Pwr Supply, 20VAC@500mA, cULus, Center POS: 2.1mm diameter.

Figure 3: Mouser Standard Transmitter Parts List

NOTE (1): Fastron 77A-102M-01 preferred if available. If you want to save some money and not bother with this additional filtering simply leave them out and use jumpers for S2, and S3 and be sure to use the antenna ground. (L1 is not used and is not necessary and has been replaced with the transformer).

NOTE (2): Most any 500 mA or similarly rated, 18-20v VAC or VDC 2.1mm plug diameter will work. Check surplus / thrift stores or your own stock to save money. The lower priced WSU180-0450-R available at both Mouser and Digikey as well.

NOTE (3): Not required if an Arduino NANO will not be used to try programming.

NOTE (4): A good supplier that seems well stocked with these chips.
https://www.heisener.com/ProductDetail/SSM2166SZ

NOTE(5): In practice the female audio plug is not needed if you decide to use an audio cable with a male plug on the end to plug into the audio device. Simply solder the conductor that matches the part the jack furthest from the tip, the ground to the ground on the PCB as explained in the audio instructions and the positive conductors per the instructions as well. Tie a pigtail inside the case as to prevent stressing the connections if pulled. This way you will never have to search for a double male patch cord.

NOTE (6): Any of the Bourns 12mm or 15mm encoders should work, however encoders with the detent such as the 652-PEC11R-4215K-S24 appear to have more obvious missed pulses due to encoder errors for changing the frequency than the non detent encoders when they occur.

NOTE (7): This part may be omitted if you are comfortable soldering the chip directly on the board which is not particularly difficult as thoroughly explained in this manual.

NOTE (8): Or, use an N914

NOTE (9): Alternatively, rather than using these components which allow easy component removal, solder the component into the board.

NOTE (10): If not using audio cables with RCA jacks, these may be omitted. See note 5.

NOTE (11): If you are not planning to program the microchip, XTAL, SW4, SW8, CN15, CN16, R37, and R38 may be omitted.

NOTE (12): Optional, in place of a jumper

NOTE (13): Only required if using the base loaded antenna

Modulation Indicator Parts - MOUSER

Mfr. #	Manufacturer	Instructions #	Description
CF1/4CT52R331J	KOA Speer	R43 R47	330 ohm Carbon Film Resistors - Through Hole 5%, ¼ Watt
CF1/4CT52R511J	KOA Speer	R45	510 ohm Carbon Film Resistors - Through Hole 5%
CF1/4CT52R102J	KOA Speer	R48	1K ohm Carbon Film Resistors - Through Hole 5%, ¼ Watt
CF1/4CT52R473J	KOA Speer	R41	47K ohm Carbon Film Resistors - Through Hole 5%, ¼ Watt
CF1/4CT52R104J	KOA Speer	R44	100k ohm Carbon Film Resistors - Through Hole 5%, ¼ Watt
CF1/4CT52R154J	KOA Speer	R40 R46 R49	150k Carbon Film Resistors - Through Hole ohm 5%, ¼ Watt
CF1/4CT52R205J	KOA Speer	R42	2 mega ohms Carbon Film Resistors - Through Hole 5%, ¼ Watt
RDEC71E226K3P1H03B	Murata Electronics	C40	22 µF ±10% 25V Ceramic Capacitor X7S Radial, LS 0.098" (2.50mm)
1N4148 (See Note 3)	Onsemi	D7	200mA Diodes - General Purpose, Power, Switching Hi Conductance Fast, 100 V 200mA Through Hole DO-35
MC1458P See Note (1)	TI	IC4	General Purpose Amplifier 2 Circuit 8-PDIP 8-DIP (0.300", 7.62mm), pin spacing . 100” (2.54mm)
1-2199298-2	TE Connectivity	IC4 Socket	8 (2 x 4) Pos DIP, 0.3"

Mfr. #	Manufacturer	Instructions #	Description
	AMP Connectors		(7.62mm) Row Spacing Socket pin spacing . 100” (2.54mm)Tin Through Hole
2306-6211TG (Partial) See Note (2) 3 required	3M	CN17_M_LEDS	Headers & Wire Housings 40P STRT 1 ROW GOLD
PN2222TA	Onsemi	Q8	Bipolar (BJT) Transistor NPN 30 V 600 mA 300MHz 625 mW Through Hole TO-92-3
WP59SURKCGKW 700 / 200 mcd WP59EGW 60/60 mcd W59EGC 200/120 mcd	Kingbright	LED	Green, Red 568nm Green, 617nm Red LED Indication - Discrete 2.2V Green, 2V Red, 20mA, Radial - 3 Leads, common cathode (center), 5mm, T-1 ¾ Lens

Figure 4: Mouser Modulation Indicator Parts List

NOTE (1): Any similar DIP 8 pin 2 circuit op amp may be substituted with a slew rate >=.5 V/us.

NOTE(2): Three pieces required, likely you will have enough with the basic configuration parts. Also 3 female breadboard connectors are required, but not listed.

NOTE(3): Or, use N914

Balanced Audio Parts - MOUSER

Mfr. #	Manufacturer	Instructions #	Description
CF1/4CT52R101J	KOA Speer	R50 R53	100 Ohms Carbon Film Resistors - Through Hole 5%, ¼ Watt
CFS1/4CT52R114J	KOA Speer	R51 R52	110k Ohms Carbon Film Resistors - Through Hole 5%, ¼ Watt
CF1/4CT52R472J	KOA Speer	R54	4.7K Ohms Carbon Film Resistors - Through Hole 5%, ¼ Watt
CF1/4CT52R224J	KOA Speer	R55	220K Ohms Carbon Film Resistors - Through Hole 5%, ¼ Watt
1N4148 (See Note 3)	Onsemi	D8 D9 D10 D11	200mA Diodes - General Purpose, Power, Switching Hi Conductance Fast, 100 V Through Hole DO-35
SMR5474J50J04L16.5C BULK	Kemet	C50 C53 C56	0.47µF Film Capacitor 50V DC Polyphenylene Sulfide (PPS), Metallized Radial %5, LS 0.197" (5.00mm)
SMR5223J50J01L16.5C BULK	Kemet	C51 C52	0.022µF Film Capacitor 50V DC Polyphenylene Sulfide (PPS), Metallized Radial 5%, LS 0.197" (5.00mm)
K471J15C0GF5TL2	Vishay	C54	470pF Multilayer Ceramic Capacitors MLCC - Leaded 50volts 5% C0G, LS 0.098" (2.50mm)
UES1C221MPM See note (2)	Nichicon	C55	220µF 16 V Aluminum Electrolytic Capacitors Radial, Can 1000 Hrs @ 85°C, LS 0.197" (5.00mm)
	TI	Q9	Ground Reference (Virtual)

Mfr. #	Manufacturer	Instructions #	Description
TLE2426ILP			Voltage Reference IC Adjustable 2V 20 VV ±1% 20 mA TO-92-3
L7812CV	ST MICRO	Q10	Linear Voltage Regulator IC Positive Fixed 1 Output 1.5A TO-220
1200P08-U	THAT	IC2	Audio Amplifiers High-CMRR Bal Input Line Rec. -6dB DIP-8 .100” (2.54mm) pin pitch, 0.320/0.370 “ (8.13/9.40mm) pin spread
1-2199298-2	TE Connectivity AMP Connectors	IC2 SOCKET	8 (2 x 4) Pos DIP, 0.3" (7.62mm) Row Spacing Socket Tin Through Hole, Pin Pitch 0.100" (2.54mm)
1729050	Phoenix Contact	CN_18BAL	6 Position Wire to Board Terminal Block Horizontal with Board 0.197" (5.00mm) Through Hole
B88069X2023B252	EPCOS - TDK Electronics	GDT	Surge Protector - Gas Discharge Tube 2500 V 3000A (3kA) ±20% 2 Pole Through Hole
L7812CV	STMicroelectronics	Q10	Linear Voltage Regulators 12V 1.5A Positive

Figure 5: Mouser Balanced Audio Parts List

NOTE(1) Two pieces required, likely you will have enough with the basic configuration parts.

NOTE(2) May be polarized if required, follow instructions for leads observing +/- pins. 2.5mm lead spacing may be used as well.

NOTE(3): Or, use N914

Amazon Parts

The following parts may be found on Amazon, total cost about $35 excluding tax, shipping should be included.

QUANTITY	DESCRIPTION	MFG	PART NUMBERS
1	223P capacitor 60 pF / 140 pF 	ACXIO	NONE LISTED
1	BNTECHGO 22 Gauge Silicone Wire 10 ft red and 10 ft Black Flexible 22 AWG Stranded Copper Wire	BNTECHGO	SW22G6008F10C2
1	FEMALE TO FEMALE BREADBOARD JUMPER WIRES BOTH ENDS 80 PIECES	GENBASIC	4330127279 B01L5ULRUA
1	0.96 Inch OLED Module 12864 128x64 Yellow Blue SSD1306 Driver I2C Serial Self-Luminous Display Board for Arduino Raspberry Pi Pico 0x3C address 	UTRONICS	U602602 B072Q2X2LL
1	AD9833 Sine Square Wave DDS Signal Generator Programmable Microprocessors Serial Interface Module 1Pcs. Be sure to match picture in these plans.	XIMIMARK	8523715509

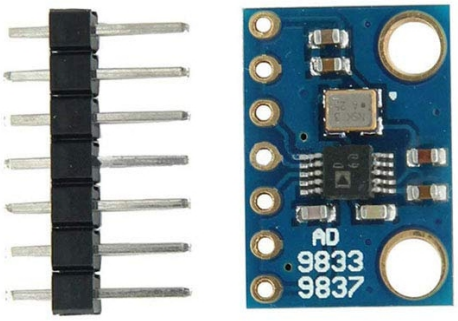
QUANTITY	DESCRIPTION	MFG	PART NUMBERS
			

Figure 6: Amazon Parts List

Case Front (Face Plate) Supplier and Knobs Details

The transmitter case uses some 3D printed case components in addition to the BUD box. There are two common methods of 3D printing, FDM and SLA. Essentially FDM uses a spool of plastic material passing through a heated nozzle resulting in a thin string of hot plastic precisely positioned to build up the object. SLA uses a liquid resin in a tank cured by ultraviolet lights to build up a model as the model is drawn up vertically.

SLA is more expensive than FDM and produces a smoother surface. Depending on your budget you may select either SLA or FDM for your face plate. Using FDM is the best price and finish trade off though upon close examination a uniform spaghetti / fingerprint appearance is visible and the resolution level can lose detail for letters. Knobs are usually FDM printed while the face plate, if budget allows is worth using SLA.

You will need 5 knobs and one face plate. Due to 3D printing variation some chamfering or opening of the inside diameter for accepting the knob shafts may be required to fit the knobs. A .240 drill bit seems to make a nice snug fit on the shafts. A drop of silicon glue may be used to secure the knobs as needed. There is also an option to use the white letters for the face plate, but this is often not worth the extra expense as most FDM printers do not use the small nozzle required for the detail and the result is not satisfactory.

There are several face plate and case options in order of expense from low to high:

1) If you wish to forego the expense of the 3D printing for the face plate and have a small rotary tool such as a Dremmel, have the knobs printed and use the rotary tool and a small file to cut a window to mount the OLED using the existing face plate which comes with the BUD case, but the process is time consuming. You will also need to drill .25” holes for the shaft of each control to protrude through the face plate and a total of 3 holes for the peaking capacitor. If this method is selected, be sure to look at the files using the slicer software below to provide an example of machining your face plate.

2) Same as #1 above but also have the printer make the bezel in FDM or SLA.

3) Print the face plate using FDM.

4) Print the face plate using SLA.

5) Do not use the BUD box and have the custom box top, bottom, and back printed FDM and the front printed with SLA .

With all options you will need to drill holes in the rear face plate in the spot toy want to mount the jacks as well in the front for the modulation indicator LED sizing the hole for the LED drill bit using the LED. You will also be required to drill 3 holes in the back plate, for the audio connector .25” diameter, power .430”, and antenna .25” jacks. Of course if you use the RCA audio jacks, those will need to be drilled as well. And, of course you will need the 5 knobs previously discussed.

From an economics and time standpoint, the FDM face plate and knob print combination without the white letters is likely the best combination. Order the SLA face plate if looks are important to you however. All the face plates and knobs may be painted in a color of your choice as well. Flat black or a medium gray are usually a good selection.

The printer may be contacted at: sales@makerchamber.com

The prices offered are as follows and subject to revision:

SLA face plate alone $13.50 + $5.00 shipping (Shipping is $4.00 through Etsy)

FDM face plate alone $8.00 + $5.00 shipping (Shipping is $4.00 through Etsy)

Clam shell case in all FDM $21.00 + $8.00 shipping

Clam shell FDM top, bottom, and back with SLA face plate $31.00+$8.00 shipping

5 knobs $2.00 no additional shipping charged if part of clam shell or face plate order

5 knobs knobs alone $4.00 + $5.00 shipping (Shipping is $3.80 if they order through Etsy)

Bezel price – contact MakerChamber.

Or, contact through Etsy: https://www.etsy.com/shop/MakerChamber?ref=seller-platform-mcnav

Face Plate and Knobs

The SLA printed front is free of spaghetti / fingerprint effect as would be expected, a fine face plate for the transmitter described in option #4.

Figure 7: SLA Printed Face Plate

The following image allows a comparison between the FDM and SLA printing results. The FDM is the black face plate while the gray is the SLA face plate.

Figure 8: Face Plate Print Comparison

As discussed in option 2, the bezel for the BUD box face plate is shown below, remember, you will still have to be careful cutting the edges of the OLED window but you have the sides of the bezel to cover the cut. Each side is about 1/8” wide.

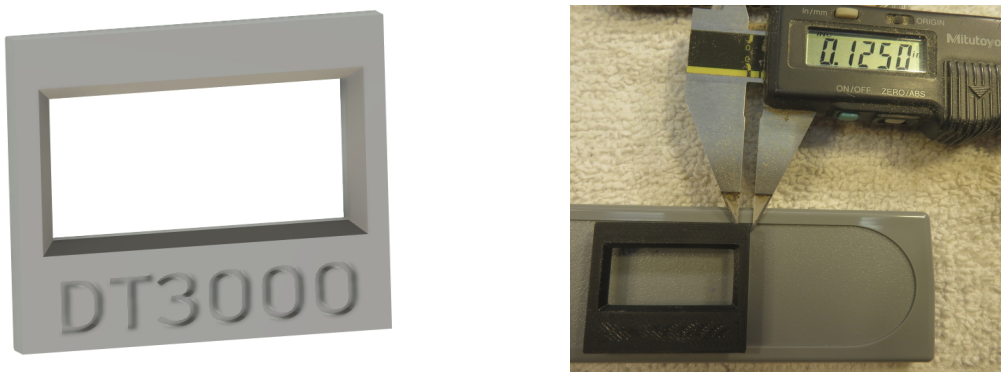


Figure 9: BUD Face Plate Inset

Option 5 is the completely printed custom case using FDM for the bottom, top and back while using SLA for the face. This is shown below with the clam shell top and bottom exploded.

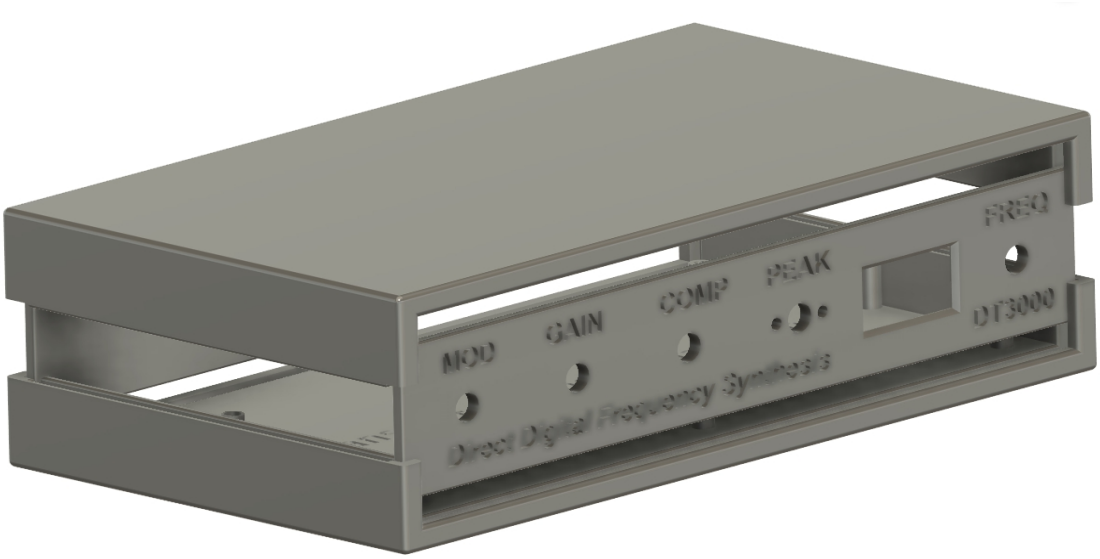


Figure 10: Fully Printed Case

Alternate Suppliers and Parts

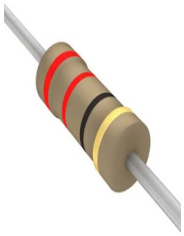
Make use of any parts you currently have. Other sources include Jameco, Newark, and Arrow to name a few for any out of stock parts at Mouser or to find better pricing. Component prices will vary, but one supplier is best due to the extra shipping costs which usually negate any cost savings between suppliers. Ebay may be a good alternative to Amazon and in some cases to the electronic supply houses, particularly for the SSM2166SZ-REEL7 which is in limited supply at times through the supply houses.

Component Organization and Identification

Components from Mouser or DigiKey will be shipped in bags with the plan numbers (Customer ID).

Some inductors and resistors are similar in appearance, keep all parts on their respective sheets / parts bag until required per the instructions.

If you are unfamiliar with components, below are some enlarged examples similar (shape and color may vary) to the parts.



Resistor

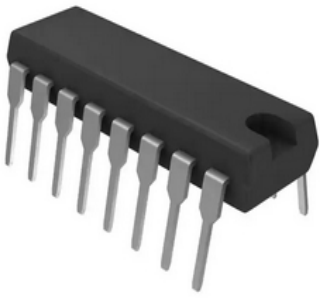
Multilayer capacitor

Ceramic Capacitor

Bipolar Electrolytic Capacitor

Polar Electrolytic Capacitor

Header



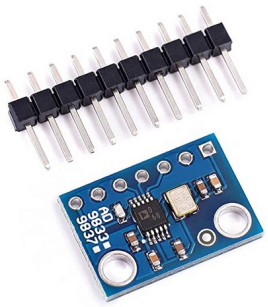
IC Chip

Audio Decoupling Transformer

Voltage Peaking Capacitor

Fixed Inductor

Female Header



AD9833 Module

Figure 11: Component Identification Graphics

Tools and Supplies You Will Need

To assemble the components on the board, verify you have the following tools at your bench. Order them off the internet or purchase them from a local supplier, even Micheal's or Hobby Lobby may have some of them.

- Low wattage (15-25) soldering with a fine pencil style tip
- fine rosin core solder, no acid core solder, or acid flux
- flux pen, desoldering wick
- Small long nose pliers, two pair
- Flush cutting dykes or nipping cutters
- Multi stripping tool
- Small flat screwdriver with about a 1/8” flat blade
- Small #1 phillips screwdriver
- Solder suction desoldering tool and perhaps braided copper soldering wick
- Silicone or similar glue for attaching the OLED display to the bezel or case end
- Electric hand drill and some bits about .25”
- Small diameter heat shrink and heat gun

Some Useful Information and Instructions

This section contains information to help you populate the board with the components in the best way possible assuring success in building your transmitter.

General Considerations

With the exception of transistors, all components should be seated flush with the board, pushed through until the base makes contact with the board. A few components such as diodes and transistors require proper orientation, these requirements are noted in the instructions. With the exception of the IC chip there are two styles of components, axial where the leads generally pass through the axis of a cylinder and radial where radiate out of one side of the component.

Examples of axial components are typically resistors and chokes, you'll need to carefully bend the leads at right angles to fit through the PCB holes using your small needle nose pliers. For the resistors you will need to bend a 180 degree radius on one end using a small screw driver as a mandrel. This soldering configuration is shown below.

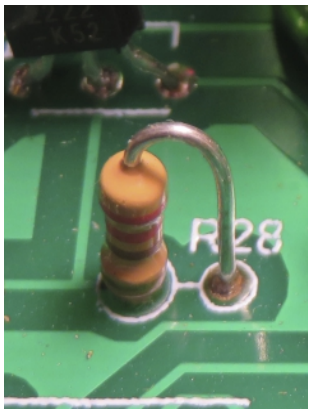


Figure 12: Vertical Resistor With Bent Leads

Other components typically include condensers and transistors. These components will only require minor bending of the legs to get through the holes in the PCB.

Soldering

If you are unfamiliar with good soldering technique, search for NASA-STD-8739.3.pdf. This is a good document to review. You'll need to solder similar to page 8-12 figure 8-18 in this document, the straight through termination.

To solder three conditions are required; the parts must be physically clean, chemically clean, and the correct heat. The parts come physically clean of corrosion and dirt. The flux in the solder makes the two parts to be soldered chemically clean removing oxides exposing the bare metals. The proper heat melts the solder and heats the two parts so the solder bonds to the two metals usually the PCB connection and the component.

Be sure to clean the tip of your soldering iron frequently on a sponge soaked in plain water and wrung out and reapply solder to the tip to promote good heat transfer to the components being soldered. To learn more about soldering in addition to the above guide if desired search the internet for “NASA soldering guide.”

If you have a problem with the transmitter working, it is likely a component was not soldered, or soldered poorly.

Generally placing a little excess solder on the soldering tip and placing the tip to the board / component connection on the bottom of the inverted board works best. The solder wicks into the hole and solders the component lead to the board usually without any excess solder.

Placing Components Into The PCB

Select the component as instructed to place in the board first by bending the leads to go through the PCB holes using proper orientation if needed. If the component does not easily slide through the holes, rebend the leads as needed ensuring the component, except transistors are flush or very close to the board.

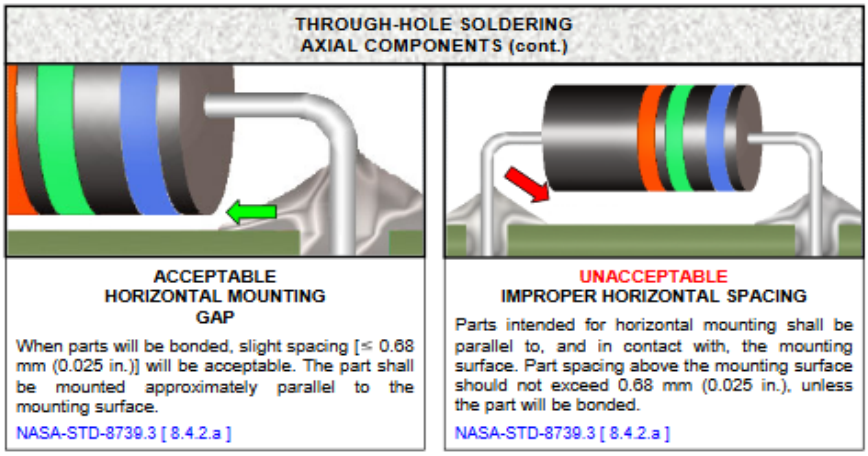


Figure 13: Axial Soldering Standard

Once inserted through the board gently press the lead about 30 degrees from vertical outward. This will hold the component in place until soldered. It is wise not to place too many components at once as some soldering connections may be missed in the mass soldering. Perhaps 3 or 4 is a good quantity of components to place counting the number of connections to be sure the count matches the number required. Most board problems may be traced back to missed soldering connections.

Tacking is another method of soldering to hold a component in place while the other connections are soldered. With a small bead of solder on the iron, lightly touch one lead with soldering iron to the PCB with the component in place, essentially forming a weak solder joint. Solder the other connections well, then go back and resolder the tacked connection.

Use the soldering technique s described above to solder the leads to the pass similar to as shown in the NASA pdf on page 8-12 figure 8-18. Once given a few seconds to cool, the flush cutting dykes are used to remove the excess lead material.

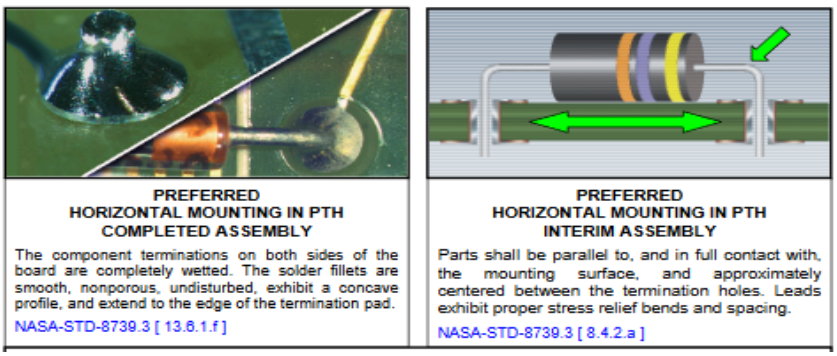


Figure 14: Soldering Fillet Standard

The Soldering NASA 609.pdf document has some good graphics of preferred work standards for

soldering.

If a solder bridge is accidentally created, use the soldering tools or wick to remove the solder and resolder the connection if necessary.

Though none of the transmitter components are particularly sensitive to the heat while soldering, if you ever have such a component on another project you can hold the component above the soldering location with the needle nose pliers to absorb the heat before it enters the component.

Eye Safety

Be sure to wear a pair of glasses particularly when cutting component leads off the back of the PCB after soldering them.

Getting To Know The Circuit Board

Your circuit board when populated is similar to the computer model shown below. The silk screening identifies the locations where you will place the components. Generally the components are located by transmitter function in the instructions below. Generally. Audio is the bottom left, frequency and the displays are mid center, RF / filter related components in the top right, and finally the power / filters section is the top center. Connections are on the lower and upper top side of the board sections as shown.

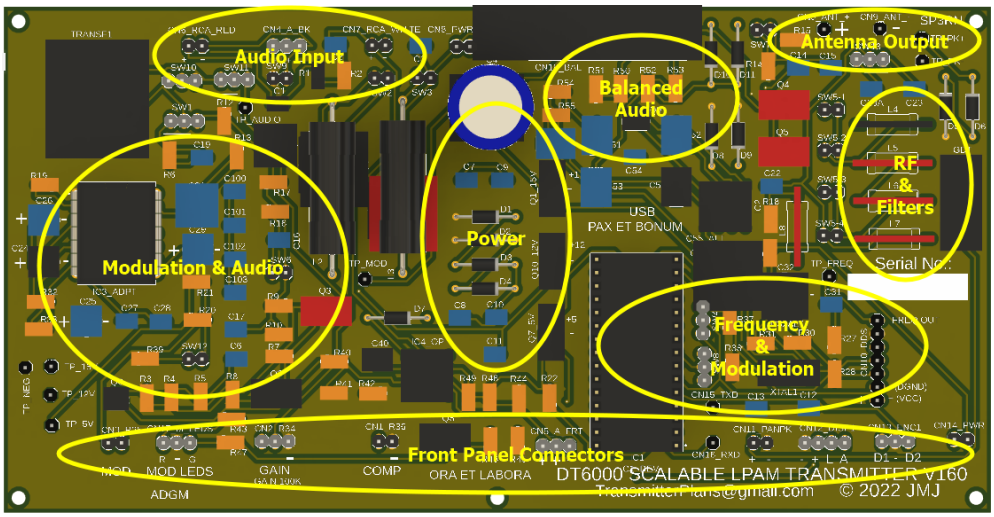


Figure 15: Functional Circuit Board Layout

The locations you will solder the components are on the bottom of the board. You'll put the component through to and solder then on the bottom of the PCB.

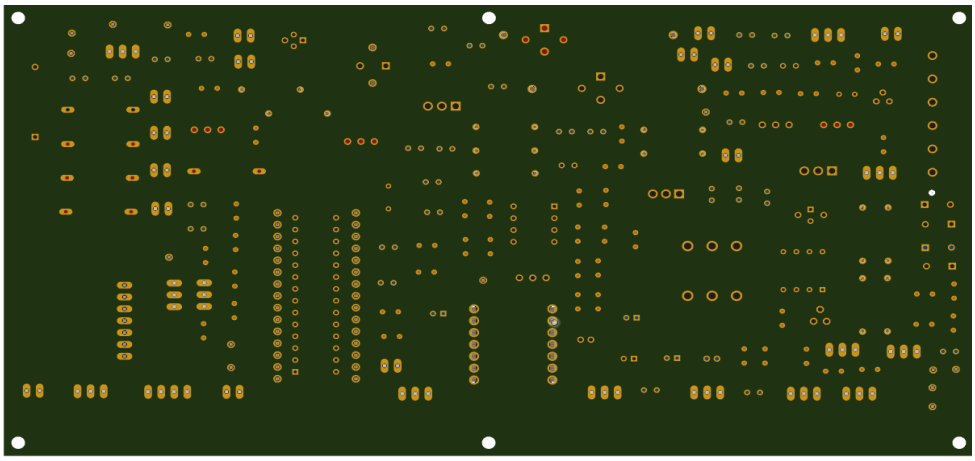


Figure 16: Circuit Board Back

Assembly Related Information

When you start the assembly you'll find that the abbreviations found in the instructions match the board. For example placing capacitor 17, C17 in the instructions corresponds to C17 on the PCB which also corresponds to the labeling on the bag from Mouser. Take the components out of the bags one at a time and place them one at a time soldering each component to prevent confusion. Some components, the diodes are easily installed backwards / reversed. Be sure to read the instructions carefully and look at the component and board to make sure you have the correct orientation. The plan specifies non polar electrolytic capacitors where orientation does not matter, but proper orientation is a good habit to develop for electrolytic capacitors. Due to availability, polarized capacitors may have to be substituted.

In these instructions, resistors are generally but not always shown in gold color and capacitors as blue. The actual PCB does not color code the components.

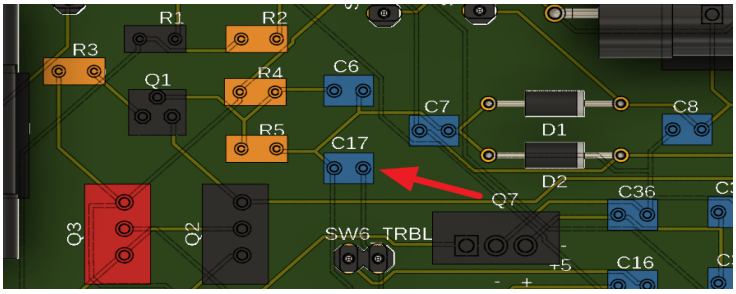


Figure 17: Component Coloring

On the PCB resistors are mounted as shown as below, the lead for the body of the resistor is inserted into the wide circle while the formed lead is inserted into the smaller circle. However, the orientation if reversed will not affect operation.

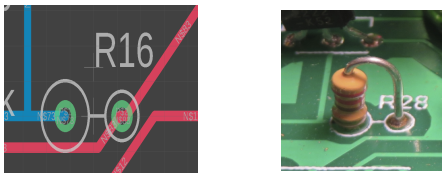


Figure 18: Instructions Component Coloring

All resistors are ¼ watt, and if by chance they become mixed up, verify them first with an ohm meter or by color bands. If you use your own resistors be sure first to verify the value before using it.

Likewise orientation for the electrolytic capacitors are indicated by the +/- signs on the board. You will notice one lead is longer than the other, the long lead is positive and should be inserted into the + hole and the short leg into the – hole. To minimize problems, use bipolar electrolytic capacitors and the orientation does not matter. None the less, to form good habits, insert the electrolytic capacitors as described to prevent problems using polarized capacitors on another project.

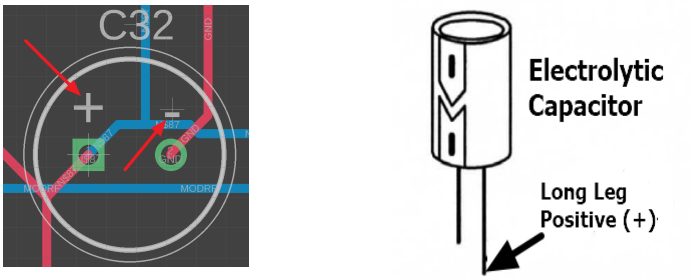


Figure 19: Capacitor Polarity

Insert diodes using the orientation for the band to match the circuit board using a vertical mounting like the resistors. Reversing a diode will cause the transmitter not to work. The inductors are mounted horizontally.

The transmitter uses female / male bread board wire connectors to connect between the case ends with the controls and connectors to the PCB board headers.

You will need to cut off and discard the male ends, strip the insulation, and solder the wire to the control or connector which will go on a case end. The female end may then be slid over the header pin when assembling the case. Be sure to keep track of the wire colors you use and their connection location on the corresponding PCB header. This method is used as a cost savings over dedicated connectors and to assure easy case assembly and disassembly if needed.

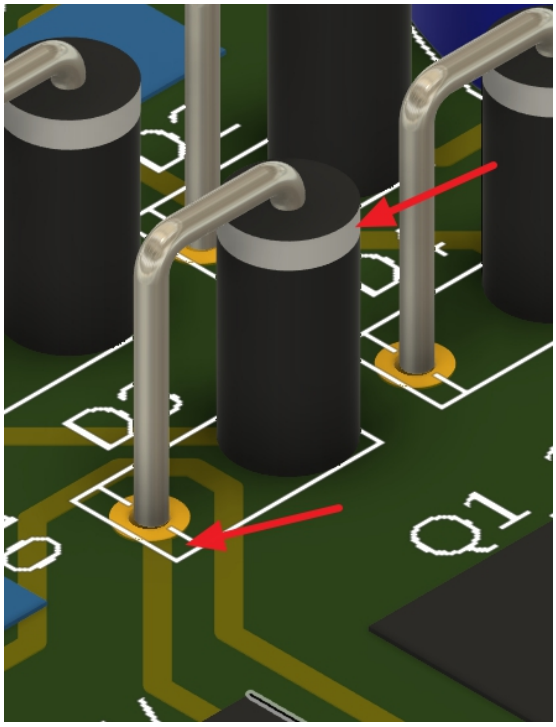


Figure 20: Diode Orientation To Band

The case uses small ears on the case ends to snap in place on the case body. Before using the case, practice putting it together and taking it apart a few times to become familiar with using it.

The IC chips for the audio and frequency control are static sensitive, be sure to work in static free environments and work with a grounding strap if available. If a ground strap in not available, frequently touch a grounded surface or device which uses a three prong plug which is in the receptacle such as the metal parts of a computer printer or a PC case. Work in a carpet free room if possible.

If the frequency control chip requires minor adjustment because the legs are splayed out, place one side of the legs of a flat surface and bending the entire row of legs at once. Then repeat for the other side. Work slowly and carefully taking care not to over bend the legs. Check the fit into the socket to gage additional bending if required.

After adjusting the legs gently and evenly push the chip into the socket. Once aligned properly, the chip will slide in.

If you need to remove the IC, use a small flat blade screw driver to pry up each end a little at a time as to not bend the pins on either end.

Finally, there is no need to force any components, if a component does not fit after bending, rebend the component leads so it easily fits in the holes on the PCB. Take the time to do your work neatly and professionally.

Other instructions and reminders are include in the step by step instructions which follow, and some are repeated several times.

Step By Step Assembly Instructions

This section contains the step by step instructions you'll following placing the various components on the PCB. Be sure to read the prior sections to ensure you create a well built transmitter.

Some pictures of generic instructions may be different than your board because they are from a previous model.

The transmitter has two additional options, the modulation indicator LED and the balanced audio. The modulation indicator instructions are included with the audio assembly instructions while the balanced audio has a separate assembly section. The reason being the modulation indicator LED will likely be installed in all transmitters while the balanced audio option is included for with more in-depth audio demands, which the average person will not likely desire...or need. If you plan on having an outdoor antenna and will be mounting the transmitter on the antenna mast, and will be supplying the audio from a considerable distance from perhaps inside your home, the balanced audio will help eliminate noise from the audio transmission. If you will be placing the transmitter inside your home with the antenna, or using something like an MP3 player located with your transmitter on an external antenna outdoors, the balanced audio is not needed.

Leave each component taped or in the bag until you place it on the board and solder it in place.

Check off each component as you progress while installing the components. To aide in assembly, graphics are provided with component locations. As PCB revisions take place, some components may not be be located exactly where shown. Component locations in the following graphics you will be using as you progress are identified by light green colors, on the PCB you will see only the component identifier such as C17.

You should now be at your bench or soldering station with the parts organized by component value with your tools at hand. Be sure to have good lighting and take your time. A magnifying glass to inspect soldering is also a good tool to have whether a bench or visor mode.

In some instances you will be requested to use the female breadboard wires to attach a component to the PCB. The female connector is just a convenience. Unless otherwise instructed, make them about 4” long. If you do not have the female bread board wires, simply solder a wire to the pin and the component location as described being sure to use heat shrink as described below using two pieces of heat shrink per wire for each end.

Before soldering a wire, slide a piece of heat shrink about 1/2” long over the wire back about a few inches. Do this for each soldered connection using a bread board wire. When all the wire for a single component has been soldered, slide the heat shrink so it fully covers the soldering lug on the component and use a heat gun to shrink the heat shrink.

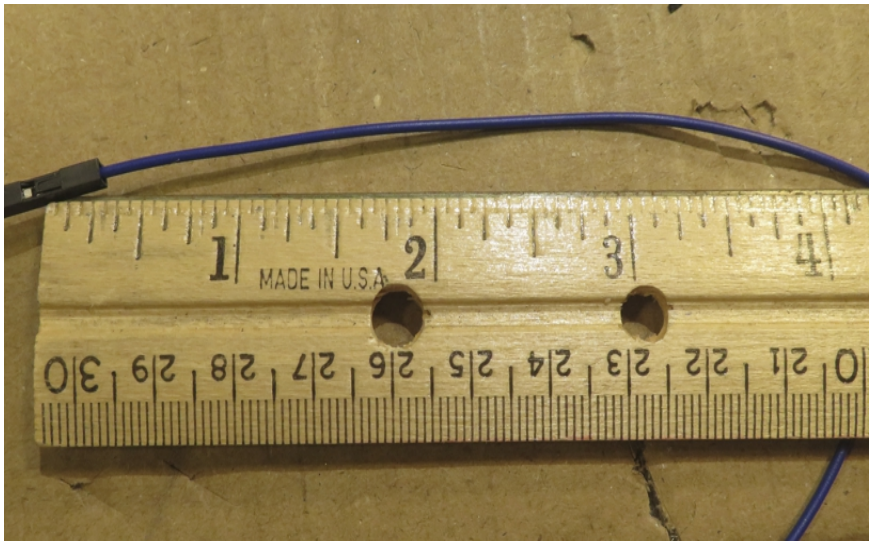


Figure 21: Cutting Jumper Wires To Length

Use heat shrink as shown on all the wires attached to the front and back face place components as shown being sure to cover the lug so the heat shrink acts as a stress relief. In some instances, you can slide a larger piece of heat shrink over a few individual wires with heat shrink creating a wire bundle if desired.

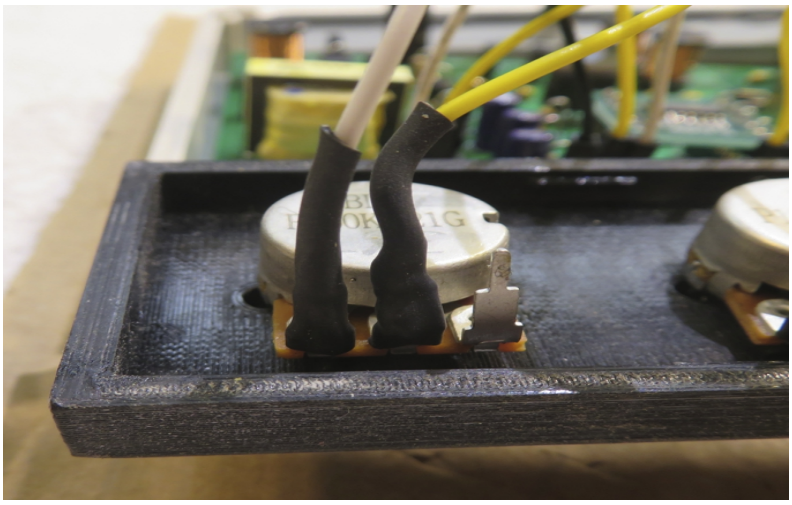


Figure 22: Heat Shrink As Stress Relief

Remember, be sure to wear a pair of glasses particularly when cutting component leads off the back of the PCB after soldering them.

Power Supply Assembly

A wall transformer steps down household current to 18 volts alternating current. Diodes acting as rectifier separate the positive component of the sine wave if you selected an AC source. The DC voltage out is regulated by 5 volt, 12 volt, and 15 volt regulators while a capacitor and inductor filter line noise. If the rectifiers (D1-D4) are installed backwards, negative 5 and 15 volts will be produced causing the transmitter not to transmit. Be sure to observe the correct diode orientation placing the diode band in the same direction as shown on the PCB. You can solder in the components as you progress or bend the leads so they are secure and solder them all at once.

Capacitors

Power capacitor locations are shown as follows highlighted in bright yellow squares. Orientation does not matter for the small yellow ceramic capacitors. For C4, place the long leg in the + hole being sure it is flush to the board due to minimal case clearance. There are a total of 7 capacitors, your Mouser bags will have them listed.

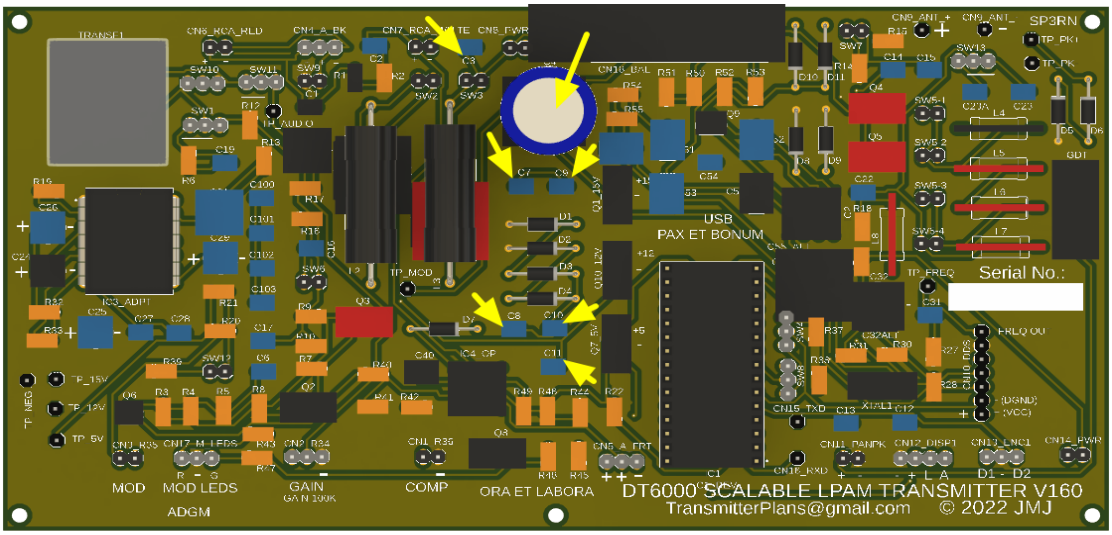


Figure 23: Power Supply Capacitor Locations

⁀ **C3 .1 uF** ⁀ **C7 .1 uF** ⁀ **C8 .1 uF** ⁀ **C9 .1 uF**

⁀ **C10 .1 uF** ⁀ **C11 .1 uF**

⁀ **C4 (7.5mm leads, verify flush to PCB) or C4ALT (5mm leads) 470 uF**

C4 may have 5mm (C4ALT) or 7.5mm (C4) leg spacing depending on availability and what you purchased, be sure to insert the long leg into the positively marked hole, particularly if using polarized capacitors.

Diodes / Power Regulators / Headers / Inductors

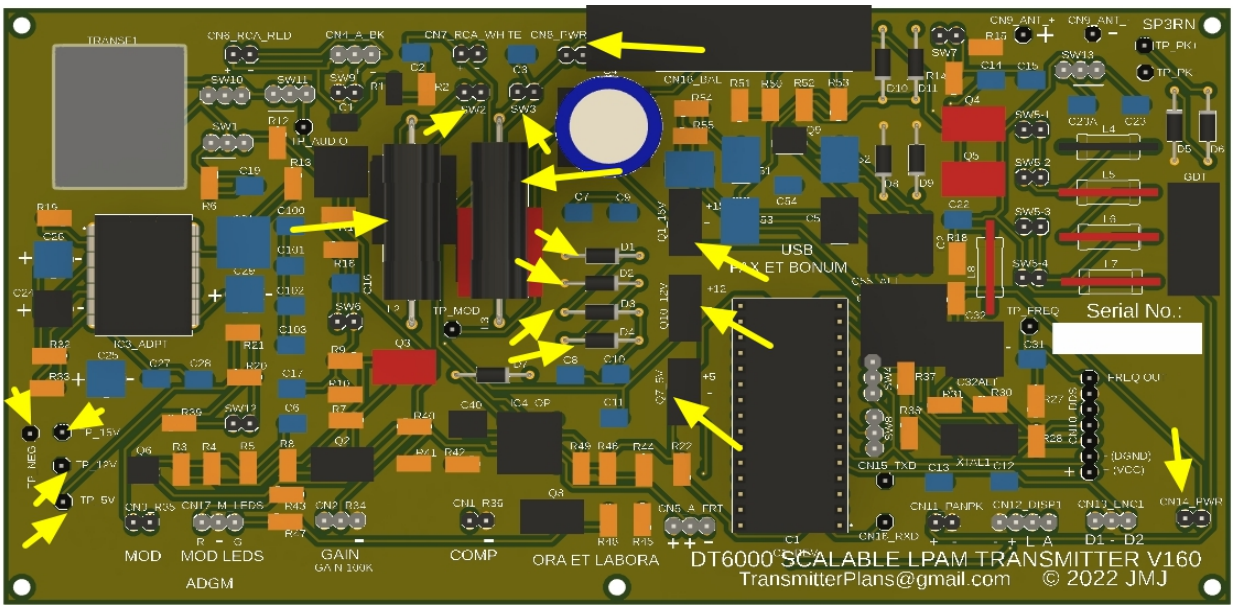


Figure 24: Power Supply Regulators / Headers / Diodes / Inductor Locations

Install Q1, Q7, and Q10 the power regulators so the flat side is towards the left and the black is towards the right front as shown. If not using the balanced audio Q10 and TP10 are not required.

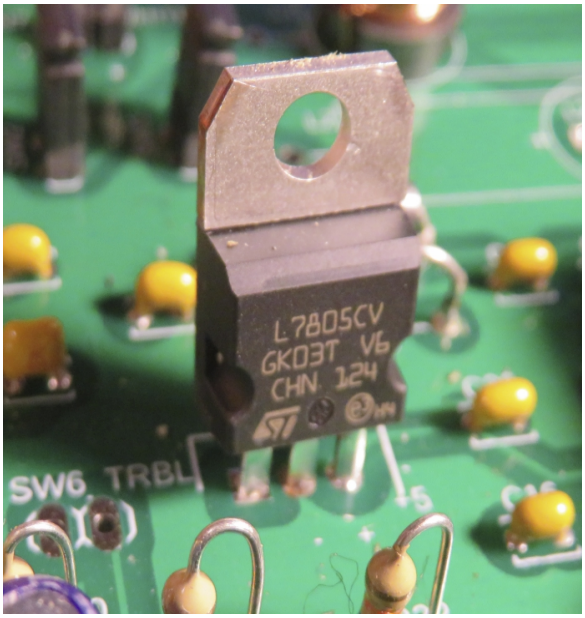


Figure 25: Power Regulator Orientation

‿ **Q1** ‿ **Q7** ‿ **Q10, REQUIRED ONLY WITH BALANCED AUDIO**

Be sure to observe the correct diode orientation placing the diode band in the same direction as shown on the PCB as shown below.

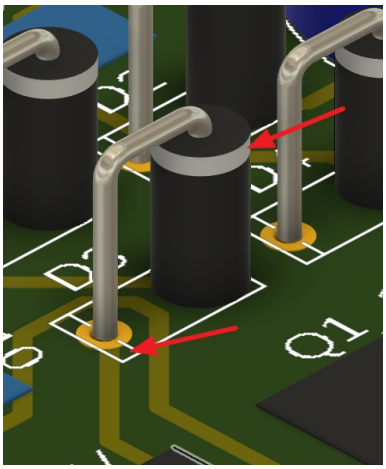


Figure 26: Diode Orientation

‿ **D1** ‿ **D2** ‿ **D3** ‿ **D4 (1N4002-TP)**

If supplied as one strip, use a utility knife to create a 2 pin header for each SW2, SW3, CN_18, and CN14 by cutting the strip on the notched segments. If it is doubtful you will ever use L2 and L3 for noise suppresion, simply solder a bridge across the two pads instead of placing a two pin header as described.

‿ **SW2** ‿ **SW3** ‿ **CN8** ‿ **CN14 (Or self resetting fuse, parts note 12)**

Place a female jumper over CN14. This connection may be used for a front mount power switch if ever desired. If ordered the self resetting fuse may be used as well cutting of the crimped segments and rebending the leads to fit into the holes.

‿ **CN14 (Or, Optional .25A Self-Reseting Fuse)**

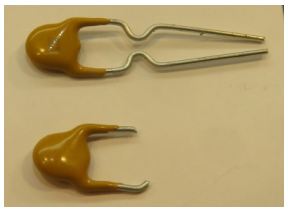


Figure 27: Self Resetting Fuse Leads

Cut and Bend Self Resetting Fuse Leads as Needed For CN14, or twist the leads so the kinks face out instead of in.

Two different types of inductors my be ordered, axial or radial. If you decided not to use these filters, be sure to but jumpers over SW2 and SW3 now.

⁀ L2 or L2 Alt ⁀ L3 or L3 Alt (Both are optional if not being used, place a jumper over SW2 and SW3)

If supplied as one strip, use a utility knife to create a 1 pin header for each TP_15V, TP_12V, TP_5V, and TP_NEG. If you prefer to use te probes and not the clips these may be omitted.

⁀ TP_15V ⁀ TP_12V ⁀ TP_5V ⁀ TP_NEG

Cut the male ends off two female header wires so the wire is about 4” long and remove about 1/4” of the insulation and slide about an inch of heat shrink over the wires to act as a stress relief on the soldered connections. Solder the wires to the power connector, and put the heat shrink in place and shrink with a heat gun. Polarity does not mater as the input is AC.

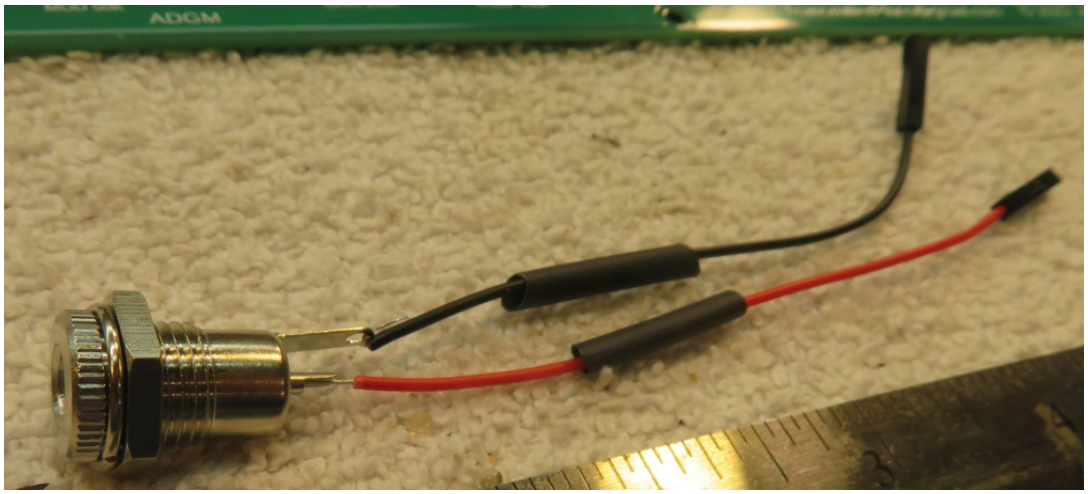


Figure 28: Power Connector Ready For Soldering

Power Connector

Power Validation

Connect the two female connectors from the case power connector to CN_8 and plug the wall transformer into an electrical 120v household receptacle. As this is alternating current, the connectors may be place on either header pin on CN_8.

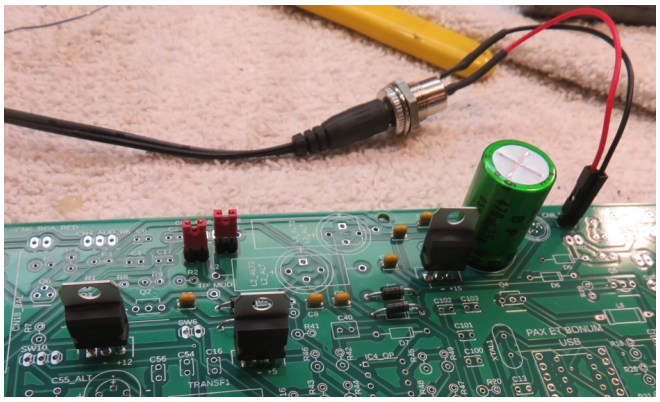


Figure 29: Power Supply Test Setup

Using a multimeter, connect the ground to TP_NEG and probe TP_15V, TP_12V, and TP_5V. The meter should read 15, 12, and 5 VDC respectively. If a negative voltage shows on the meter your leads may be reversed or the diodes are backwards, if no voltage, be sure your receptacle has power, check the components you have in place, and verify they are in place and soldered well by reinspecting each solder connection visually and trying to wiggle the component. Verify the path of the electricity through the circuit. Verify you have the female jumper over CN_14. If the voltages are different than

expected, verify your solder connections, particularly the regulator ground.

When testing is complete, disconnect the power source from the transmitter power connector. Leave the jumpers on SW2 and SW3.

Audio Assembly

The audio section provides adjustments for gain, modulation, and compression. Though a small surface mounted device, the surface mounted audio chip is relatively easy to solder on the 14 pin adapter. Search the internet on an instructional video if needed.

Audio Chip / Adapter and Capacitors

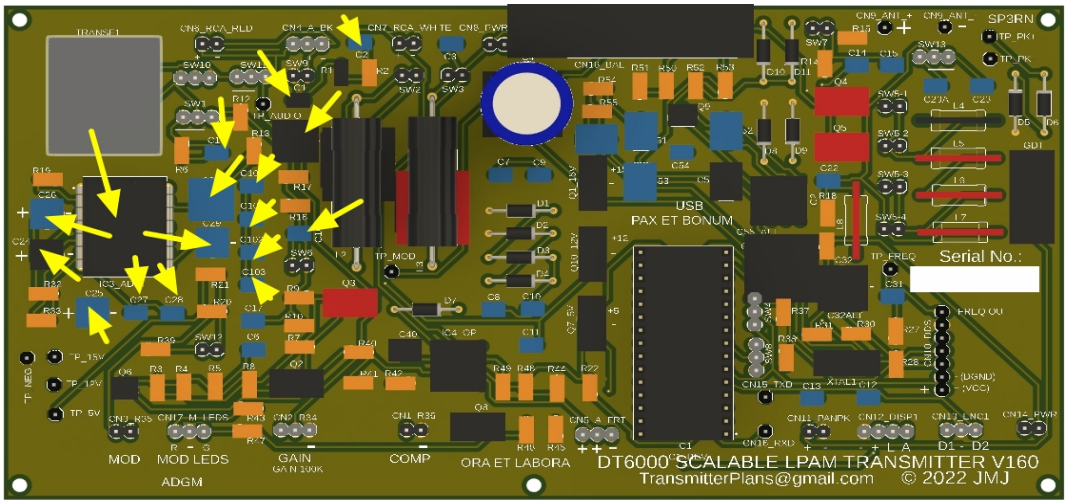


Figure 30: Audio Chip / Adapter / Capacitors Locations

Soldering the Audio Chip On The Adapter

If you know how to solder, you may wish to just solder the chip on the board. The audio chip is static sensitive. If working on carpet or similar material, wear a grounding wrist band if available. Alternatively, the chip may be soldered directly to the board if desire using the same procedure. Be sure to align the chip properly for pin 1 before soldering.

Figure 31: Soldering Supplies

Two other items will help you, CHIPQUICK flux and especially the copper wicking solder removal ribbon.

On both the adapter and chip you will notice there is a marker and dot respectively, these need to be oriented to each other to assure pin 1 is in the proper orientation. This is shown below. If you are unfamiliar with numbering chips, the dot is number 1 and the connection on the opposite side is pin 14. The pin numbers increase in a counter clockwise direction from the top.

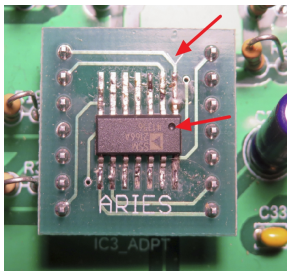


Figure 32: Audio Adapter Chip Orientation

Place the IC on the board aligning the IC leads over the pads on the adapter.

Place a small amount of solder on the iron tip and while holding the chip in place with your finger or a small flat screwdriver and tack one corner of the chip to the pad. No need to worry about bridging pins at this point. There is variability in the dot for pin one. The dot may be printed and more difficult to see as in the case of the chip below instead of a dimple as shown above.

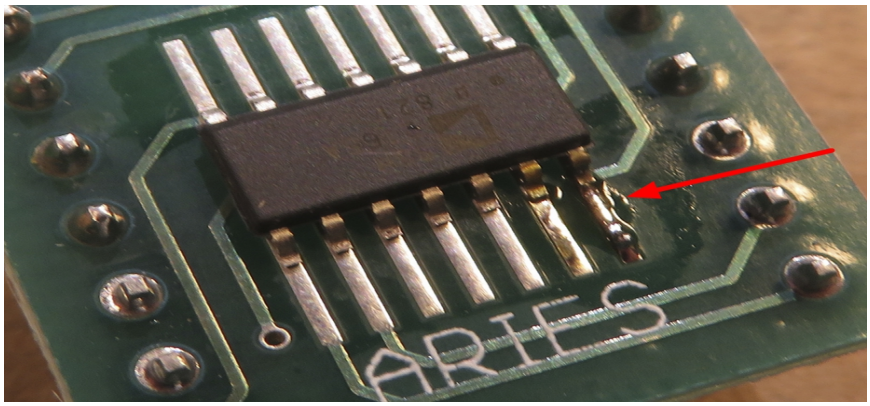


Figure 33: Tacking The Audio Chip

Check the alignment, and if satisfied, tack the diagonal corner of the chip to the pad, then the diagonal corner in the same manner. Here pins 14 and 7 were tacked, pins 1 and 8 would work equally as well.

Solder one compete side using a small amount of solder on the tip for each pad, don't worry about a bridge between the pads as shown, alignment is all that matters.

If the solder has bridged, remove any solder from the iron and touch the soldered pad. Some of the solder will adhere the iron taking the solder away from the bridge. If you have braided copper soldering wick, lay it over the pads on one side and touch the soldering iron to the wick and any excess solder will be absorbed by the wick removing the bridging.

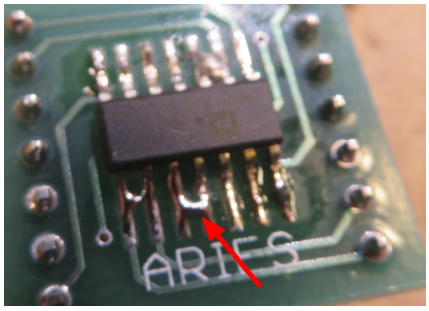


Figure 34: Audio Chip Solder Bridging

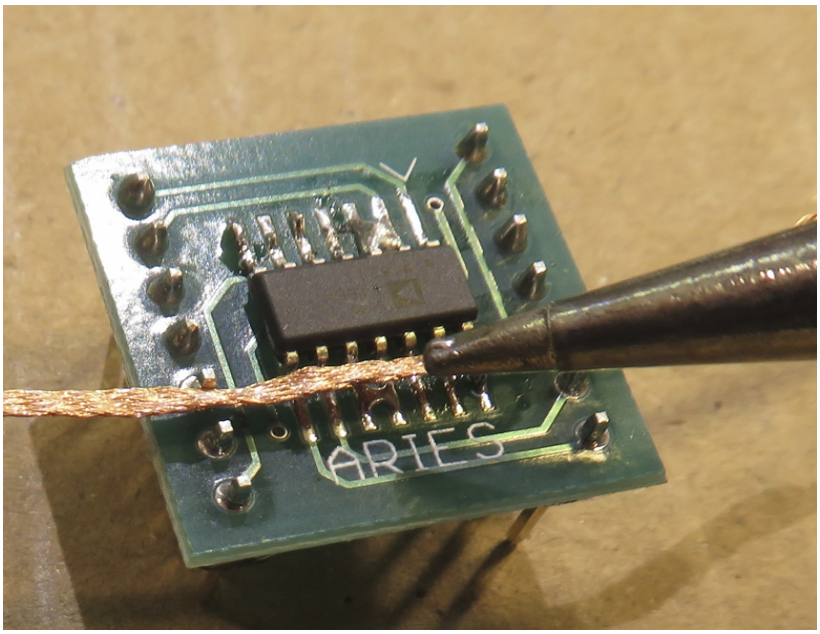


Figure 35: Using The Solder Wick To Remove Bridge(s)

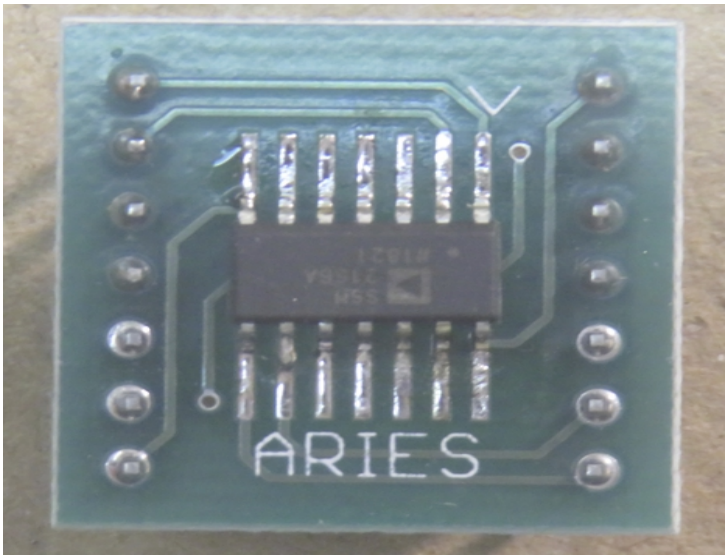


Figure 36: Finished Audio Chip Soldering

Solder Audio Chip to Adapter or Board

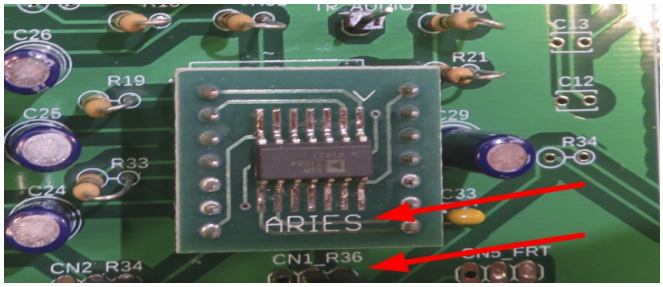


Figure 37: VERIFY Audio Chip Adapter

Orientation

Place the 7 pin female headers on the adapter audio adapter pins, align the adapter for pin one on the PCB and solder the pins on bottom of the PCB. The adapter pin orientation should be as shown above in the soldering section picture, with the ARIES text oriented right side up closest to you. Use the board marking IC3_ADPT in the picture to assure your orientation is the same.

Place Female Headers, Align, and Solder To Board

Electrolytic Capacitors

Place the long leg into the positive hole indicated on the PCB and mount flush to the board. These are all located near the audio chip, and mostly on the left side. If you are using polarized capacitors, the long leg orientation should be followed with the long leg to the + hole.

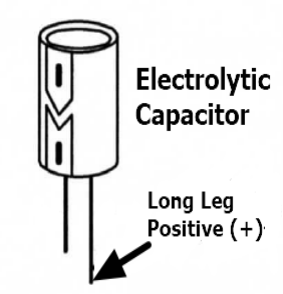


Figure 38: Electrolytic Capacitor Orientation

⁀ **C21 4.7 uF** ⁀ **C18 4.7 uF**

⁀ **C24 10 uF** ⁀ **C25 10 uF** ⁀ **C26 10 uF** ⁀ **C29 10 uF**

Ceramic Capacitors

⁀ **C27 220 pF**

⁀ **C16 .01 uF**

⁀ **C19 .047 uF**

⁀ **C1 .1 uF** ⁀ **C2 .1 uF** ⁀ **C28 .1 uF**

⁀ **C100 .1 uF** ⁀ **C101 .1 uF** ⁀ **C102 .1 uF** ⁀ **C103 .1 uF**

Transformer and Resistors

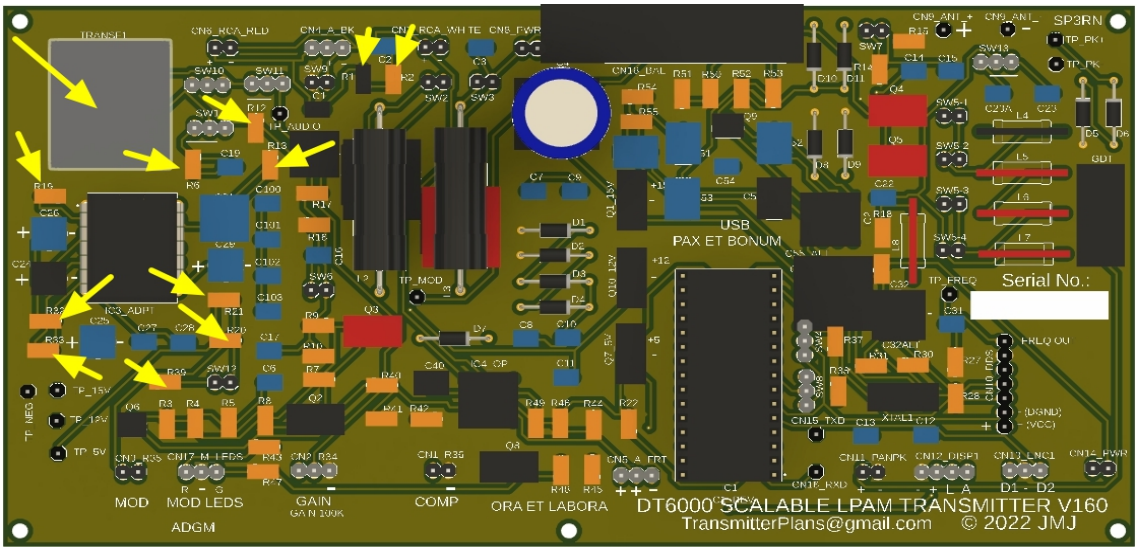


Figure 39: Audio Transformer and Resistors Locations

Remember to prebend the resistors with a small screwdriver shaft as a mandrel creating a radius.

- ⁀ **R21 1k ohms**
- ⁀ **R12 4.7k ohms**
- ⁀ **R19 10k ohms**
- ⁀ **R32 10k ohms**
- ⁀ **R6 15k ohms**
- ⁀ **R13 15k ohms**
- ⁀ **R33 30k ohms**
- ⁀ **R1 47k ohms**
- ⁀ **R2 47k ohms**
- ⁀ **R20 1 meg ohms**
- ⁀ **R39 1 meg ohms**

Mount the transformer so the dot on the board and the dot on the transformer align. On some boards the hole for pin 1 may have a circle around it instead of next to the pin hole as shown.

Figure 40: Audio Transformer Orientation

- **Transformer**

Audio Headers

The transmitter audio section requires 6 three pin headers, 7 two pin headers, and 1 one pin header in this section. Use a utility to score and cut the headers if needed.

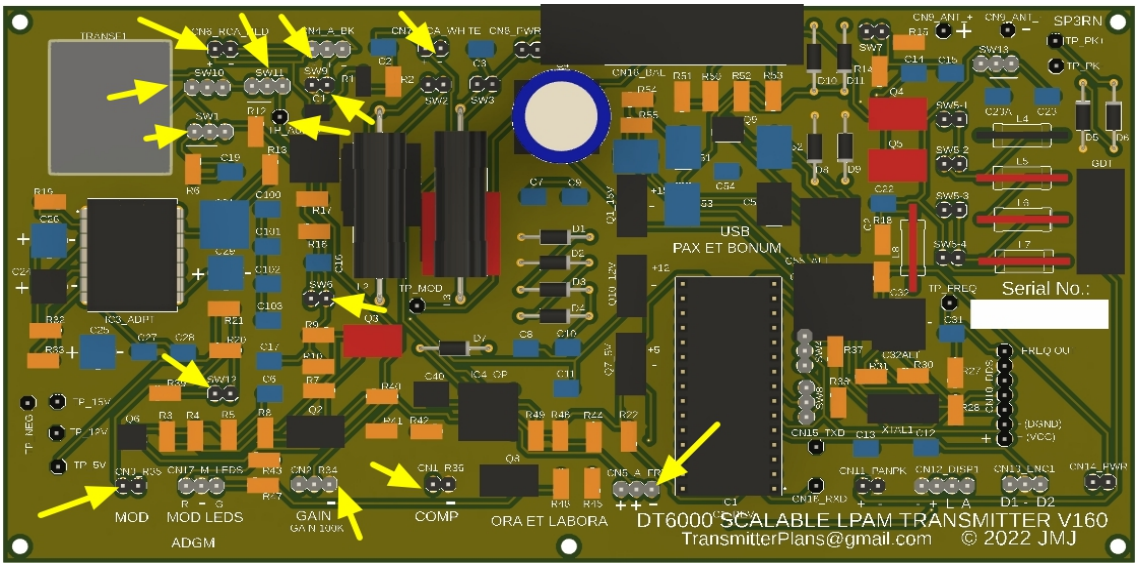


Figure 41: Audio Header and Switch Locations

Three Pin Headers

- **CN2 (Gain connection)**
- **CN4 (Audio In 3.5mm Plug Back)**
- **CN5 (Optional if not using front 3.5mm phono jack)**

⁀ **SW1 (Pre-Emphasis) (Place jumper over left and middle pins)**

⁀ **SW10 (Balanced Out) (No jumper)**

⁀ **SW11 (Audio Chip Bypass) (Place jumper over left and middle pins)**

Two Pin Headers

⁀ **CN1 (Compression connection)**

⁀ **CN3 (Modulation connection)**

⁀ **CN6 (RCA) (Optional input)**

⁀ **CN7 (RCA) (Optional input)**

⁀ **SW6 (Legacy Post Boost Original) (No jumper)**

⁀ **SW9 (Audio Ground) (No jumper)**

⁀ **SW12 (Noise Gate) (Nojumper)**

One Pin Header

⁀ **TP_Audio**

Audio Variable Resistors and 3.5mm Phono Plug

These components are mounted in the front and rear of the case on the end panels.

As you take the variable resistors out of the packages, label the back of the variable resistor with the component number and function to prevent confusion as all 3 look the same. Note the M, G, and C for modulation, gain, and compression as an additional check when installing.

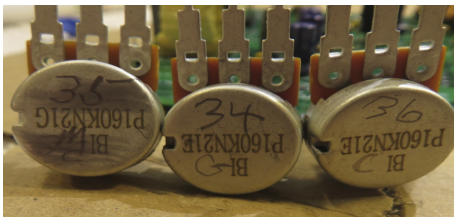


Figure 42: Control Markings

Cut 2 sets, 2 each of the header connection female wires removing the male end so the length and the attached female end remains on each wire so the wire is about 4” long, remove about 1/8” of insulation.

Cut a 1/2” piece of heat shrink to slide over each wire before soldering.

These are for R35 Modulation, and R36 Compression. If the lugs are vertical when looking at the flat end of the shaft where the knob will eventually slide on, that is, at 90 degrees to the shaft, use the needle nose pliers to bend the lugs 90 degrees or slightly more towards the back of the control so the lugs are parallel to the shaft as shown below.

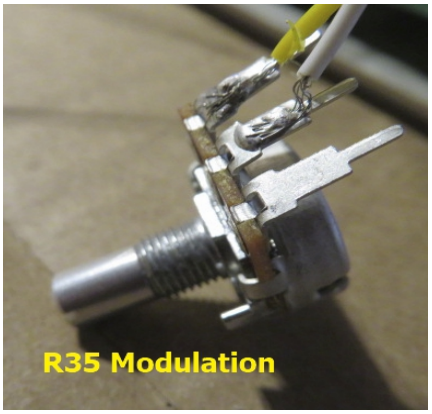


Figure 43: Bending Control Lugs, Make Sure heat Shrink Is On Before Soldering Wires

After verifying you have the heat shrink slid up on the wire, solder the wires onto the with the shaft facing you as noted in the pictures for R35 and R36.

⁀ **R35 Use the left and middle lugs as shown above on the left**

⁀ **R36 Use the right and middle lugs as shown above on the right**

For R34, Gain, cut 1 set, 3 each of the header connection female wires each with different colors removing the male end so the length and the attached female end remains on each wire so the wire is about 4” long. Cut a 1/2” piece of heat shrink to slide over the wire before soldering. Remove about 1/8” of insulation and solder the 3 different wires on the control lugs, same as just done for R35 and R36. See the soldering graphic below, notice the black ground wire is on the left.

When you have R34, R35, and R36 all soldered they should be similar to the following:

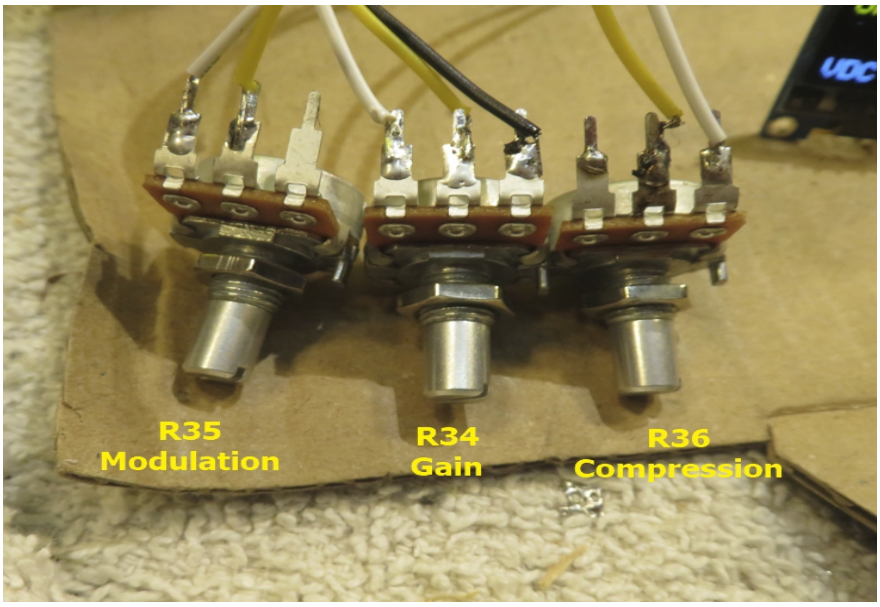


Figure 44: Controls With Completed Wire Soldering

After the heat shrink is slid over the lug and shrunk with a heat gun each potentiometer should be similar to the following picture, R34 is shown as an example.

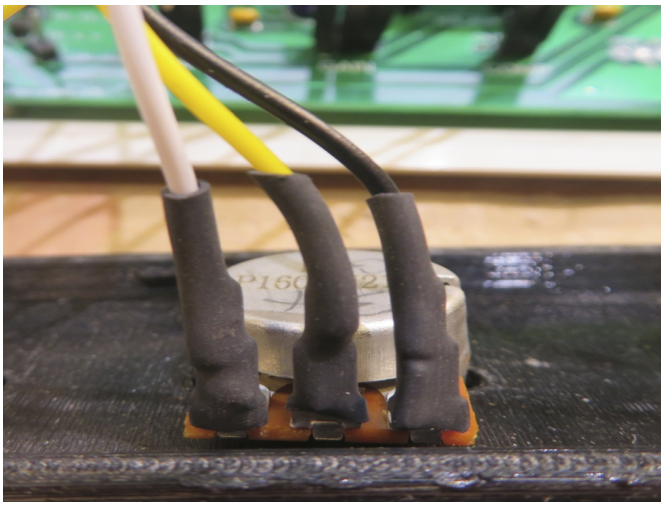


Figure 45: Controls With Stress Relief Heat Shrink

Later during the case assembly, the connections for the modulation, gain, and compression to the board are explained. Essentially however, the wires from the controls correspond to the pins from left to right.

If you decide to use the female phono plug in place of a soldered male patch cord, create 1 set of 3 wires, 2 may be the same and one different for the 3.5 mm phono jack and solder the female header wires to the connector placing the one different color wire to the ground pin on the connector, the long pin as shown with the red arrow. Make the wires about 4" long and slide the 1/2" of heat shrink over each wire and shrink after soldering.

Figure 46: Phono Plug

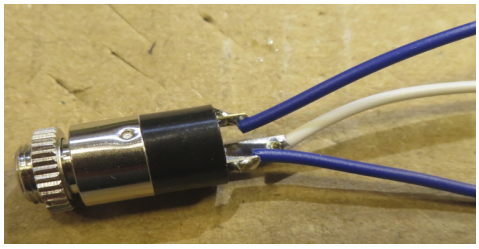


Figure 47: Phono Plug Soldering and Stress Relief Heat Shrink

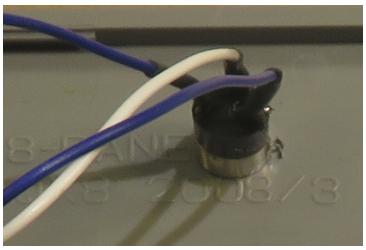


Figure 48: Phono Plug In Case

CN4

If using the optional front mounted 3.5 mm jack, cut a second set of female header wires a described and drill a hole in the front cover at the desired location to mount the female phono jack. From Mouser or Digikey order Schurter part number 4832.2300 or equivalent. Connect the female connectors to CN5 as described above.

(OPTIONAL RCA JACKS)

If you wish to use the optional RCA jacks, cut 2 sets, 2 wires in a similar fashion to above. Drill two holes in the back of the case end at the desired locations to mount the RCA jacks. On the PCB the polarity for the jacks is marked. The center of the jacks are the positive connection. From Mouser or Digikey order parts CUI RCJ-033 and RCJ-032 or equivalent. You will need to drill two holes in the rear panel in a convenient location to accommodate these jacks. Use the heat shrink in a similar way as with the back connector.

Initial Audio Settings Using On-Board Audio

This is the standard audio configuration, Place jumpers as follows:

SW1 - Place the jumper over the left and center pins enabling pre-emphasis, pins 1 and 2 (pins 2 and 3 ignore the pre-emphasis) **(Place jumper over left and middle pins)**

SW6 – No jumper (Ignores legacy audio filtering)

SW9 – No jumper in place (Audio source negative ungrounded to the transmitter)

SW10 – No jumper in place, balanced out not enabled (For balanced out pins 2 and 3 do not use the transformer, pins 1 and 2 use the transformer for the balanced out)

SW11 - Place the jumper over the left and center pins for using the audio chip (pins 1 and 2. (Pins 2 and 3 bypass the audio chip and balanced out) **(Place jumper over left and middle pins)**

SW12 – No jumper (disables noise gate)

Keep the SW1 jumpers in place, this is the standard configuration suitable for most users using the pre-emptive filtering which blocks frequencies less than about 1000 Hz.

The lines indicated with the red arrows below, also on the board indicate the two pins that should be connected with the jumper for SW1 and SW11 for the default settings.

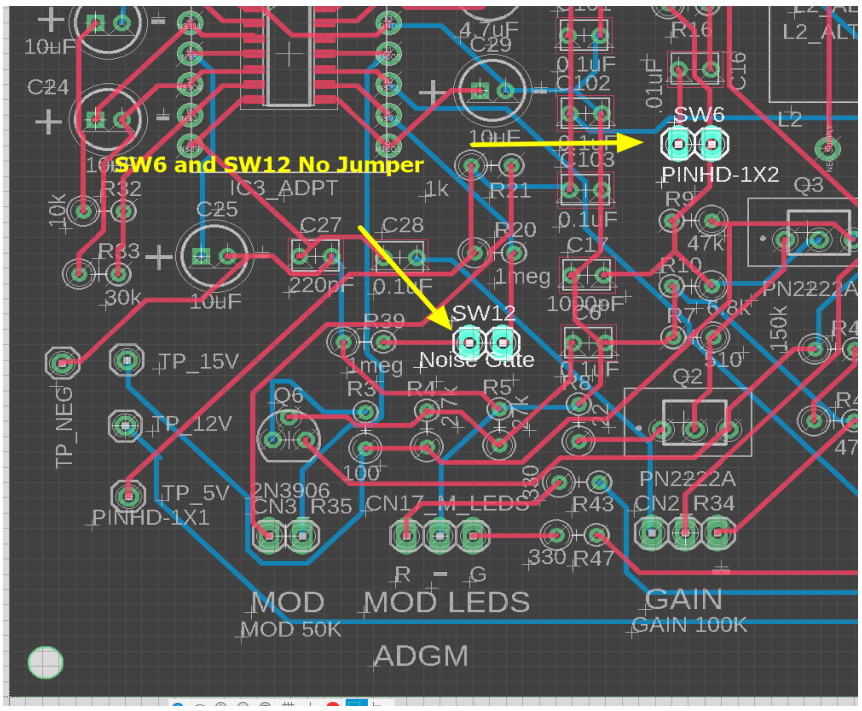


Figure 49: SW6 and SW12 Default Jumper Settings

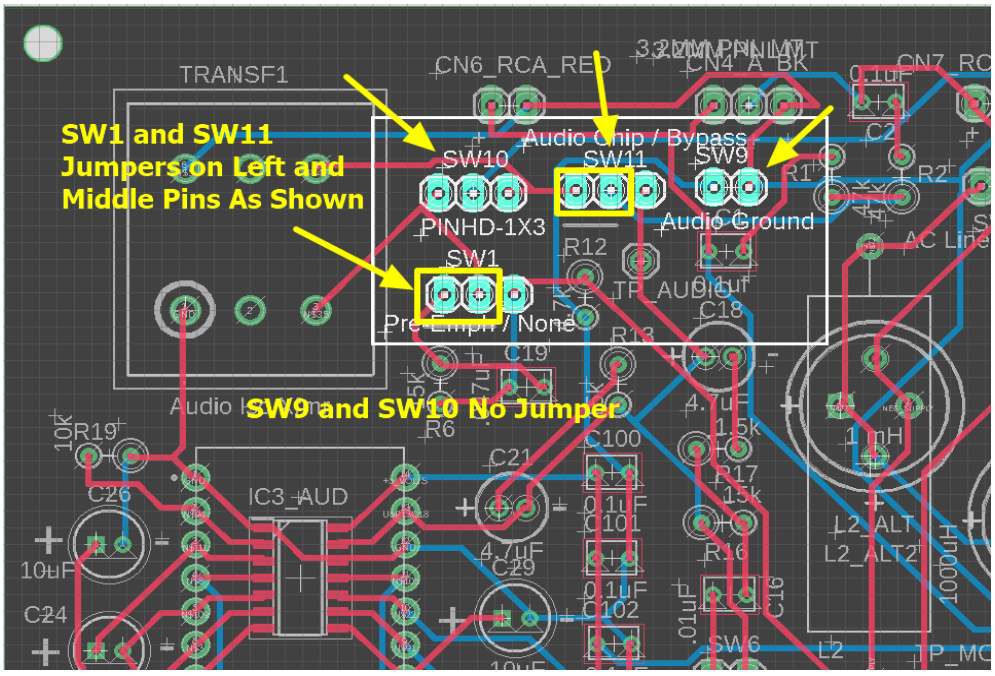


Figure 50: SW1, SW9, SW10, and SW 11 Default Jumper Settings

Frequency Assembly

The heart of the digital frequency generation is an AD9833 chip controlled by a microprocessor, an ATMEGA 328P or Arduino.

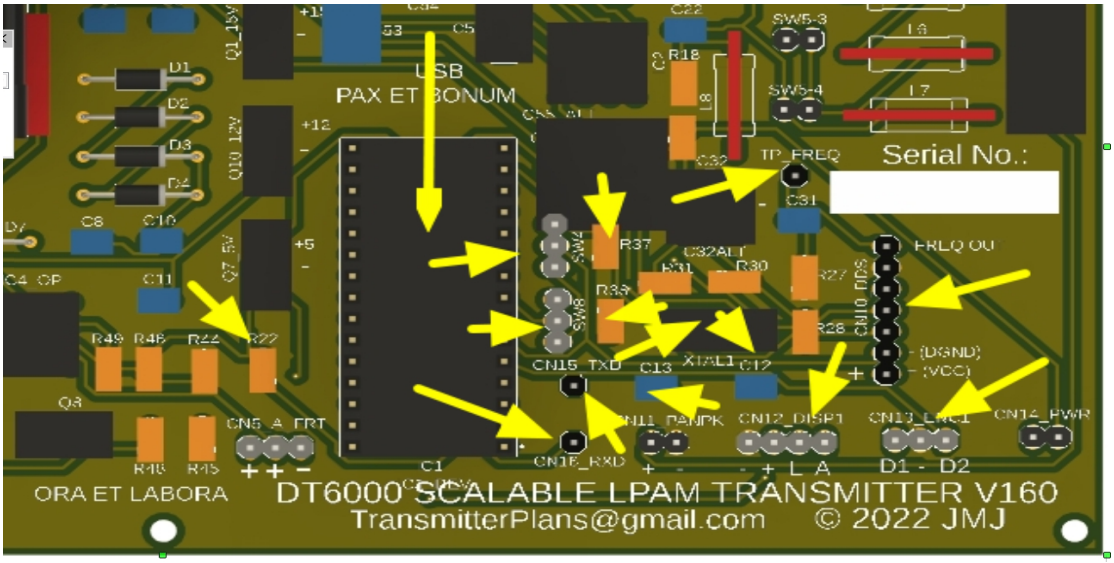


Figure 51: Frequency Component Locations

- **28 Pin Dip Socket IC1 OR two 15 pin headers placed on the NANO**

- **ATMEGA328P Chip, Pin 1 Matching PCB white dot as shown above on the lower right of the socket location OR place NANO on board with USB connections back**

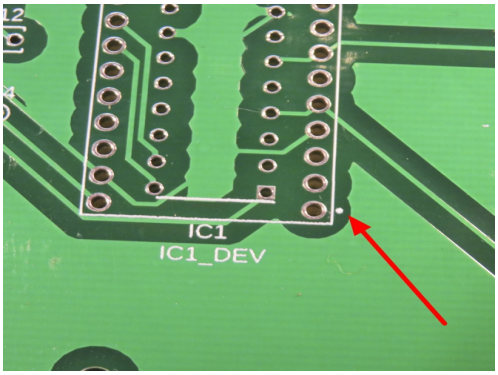


Figure 52: IC1 Pin 1 Location

If supplied as a strip cut a 7 segment section of the header with a utility knife for the AD9833 module. Place the female header on the AD9833 module. Match the 5V orientation on the module to the board and solder the header so the header is on the left side as shown. If not using a header, solder to the PCB as shown below.

Double check to show the text is as shown on the header and AD9833 module.

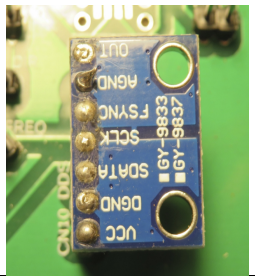


Figure 53: AD9833 Module Header Soldering and Orientation

⁀ **AD9833 Module Header and Module**

If supplied as a single header score a 1 piece section for TP_Freq

⁀ **TP_Freq**

⁀ **XTAL1**

⁀ **C12 22pf** ⁀ **C13 22pf**

⁀ **R22 10k ohms**

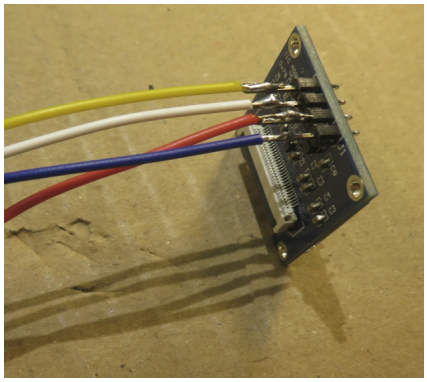
If supplied as a strip cut a 4 segment section of the header with a utility knife for CN12 and solder in place.

⁀ **CN12**

Using wires with all different colors, cut 4 of the header connection female wires removing the male end so the length and the attached female end remains on each wire. These are for connecting the OLED display.

Be sure to slide the heat shrink over each wire before soldering to the OLED display.

Solder the wires onto OLED display header first attaching the header if needed orienting the long part of the header opposite the display side. Note which color matches the OLED display header marking of -, +, L, and A and connect the female sections to the previously soldered 4 pin header.



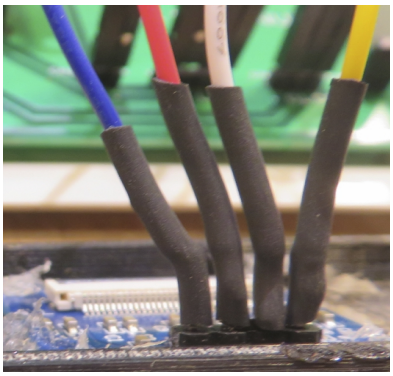


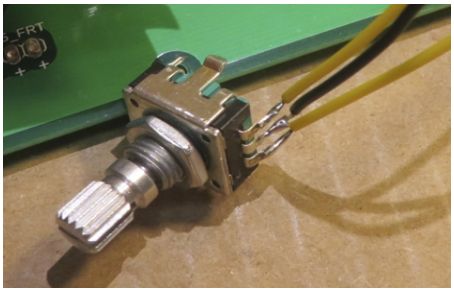
Figure 54: OLED Soldering

OLED Display

If supplied as a strip cut a 3 segment section of the header with a utility knife for CN13 and solder in place.

CN13

Using two wires with the same color and one different, cut 3 of the header connection female wires removing the male end so the length and the attached female end remains on each wire. Slide on the heat shrink. These are for connecting the encoder control. Solder the wires onto encoder so the two wires with the same are on the side connections and the single color is in the center. Attach the two wires with the same color of the PCB board to CN13 to the D1 and D2 pins. Connect the middle wire to the – pin.



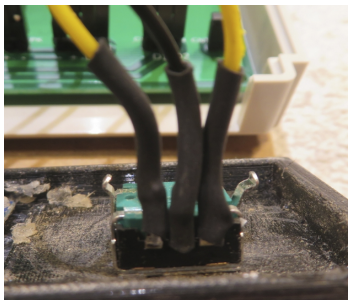


Figure 55: Encoder Soldering and Heat Shrink

Encoder

The following are required only if you plan on programming the ATMEGA chip or Nano.

Optionally not needed except for experimentation and not shown in these instructions, located to the right front of the socket for the ATMEGA328 are two pins, CN15_TXD and CN16_RXD.

If supplied as a single header score a 1 piece section for both connections.

⌒ **CN15_TXD (Optional)** ⌒ **CN16_RXD (Optional)**

⌒ **SW4 (Optional)** ⌒ **SW8 (Optional)**

⌒ **R37 (Optional)** ⌒ **R38 (Optional)**

These are optional but may be used as switches setting DP3 and or DP5 digital pins as high or low to control the program. These may be used to control display options, frequency ranges, or frequency increments for European or North America.

Do not overwrite the supplied ATMEGA328P-PU chip, take the chip out and use another ATMEGA328P-PU if you want to try programming the chip. You can program an Uno and take out the chip and put it in the transmitter. Better yet, take the chip out and simply use a Arduino Nano. The 15v power regulator and power supply pins on the pin may require minor bending if using a USB cable while the Nano is mounted on the board. Or, simply remove the Nano when programming.

Frequency Validation

Plug in the power source. The display should now light up and have a message “Tune To Frequency.”

Turn the encoder shaft slowly and verify frequencies appear as the shaft rotates, the VDC is meaningless as the circuit is not yet built. Connect an oscilloscope to the ground (TP_NEG) and the TP_FREQ pin and check the frequency, it should match the OLED display. If you do not have an oscilloscope, connect a jumper to the TP_FREQ pin and use a small transistor radio tuned to the display frequency and listen for increase volume or carrier hum when the transmitter is powered on and off.

When testing is complete, disconnect the power source from the transmitter power connector.

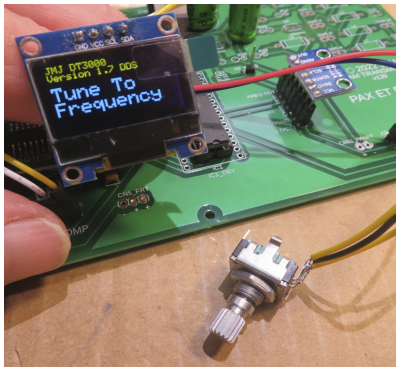


Figure 56: Initial Screen Display

Your initial power on screen display may not be an exact match to the one shown above. Turning the encoder knob will change the frequency.

The frequency may not change if left on the initialization screen for an extended time. Simply disconnect and reconnect the power and tune to the desired frequency.

Modulation / RF Assembly

This section also includes the optional modulation LED indicator circuit construction at the end.

Connections and Switches

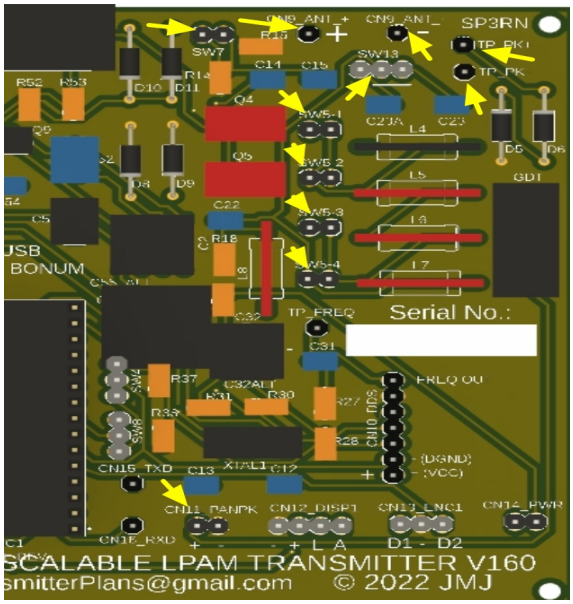


Figure 57: RF and Modulation Connection and Switch Locations

If supplied as one piece, use a utility knife to score and cut the header as follows:

1 three pin piece

6 two pin pieces

4 one pin pieces

Solder the 3 pin jumper in place.

⁀ **SW13 (Place jumper on pins 2 and 3, middle and right pins. Use the left and middle pins, 1 and 2 for the base loaded antenna)**

Solder the 2 pin jumpers in place.

⁀ **SW7 (No jumper, use jumper on baseloaded antenna)**

⁀ **SW5-1** ⁀ **SW5-2** ⁀ **SW5-3** ⁀ **SW5-4 (Jumpers depend on frequency used, see later section and table)**

⁀ **CN11**

Solder the single pins in place

⁀ **TP_PK+** ⁀ **TP_PK-**

⁀ **CN9_ANT(+)** ⁀ **CN9_ANT(-)**

Diodes / Inductors

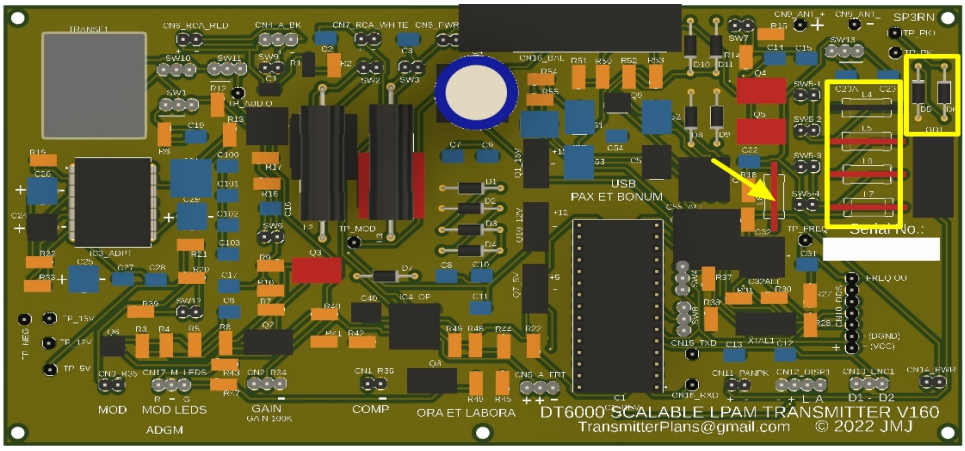


Figure 58: Modulation / RF Diodes / Inductors Locations

If D5 and D6 are installed backwards, the peak tuning voltage will always read zero. Be sure to follow the silk screen orientation on the PCB when mounting the diode verifying the band direction.

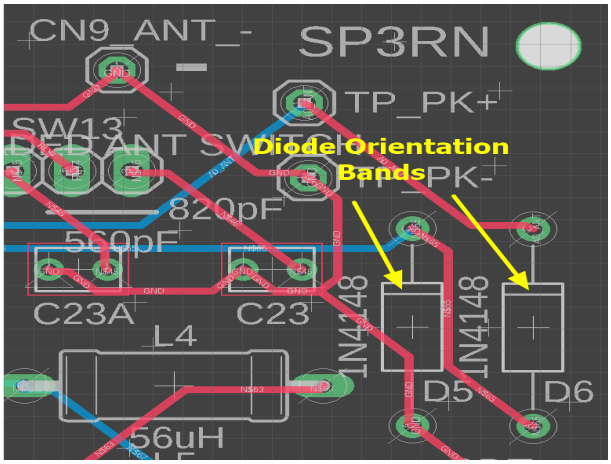


Figure 59: Orientating and Placing Modulation / RF Diodes

◯ **D5** ◯ **D6**

◯ **L4** ◯ **L5** ◯ **L6** ◯ **L7** ◯ **L8**

Modulation / Capacitors

For C32 place the long lead into the + position.

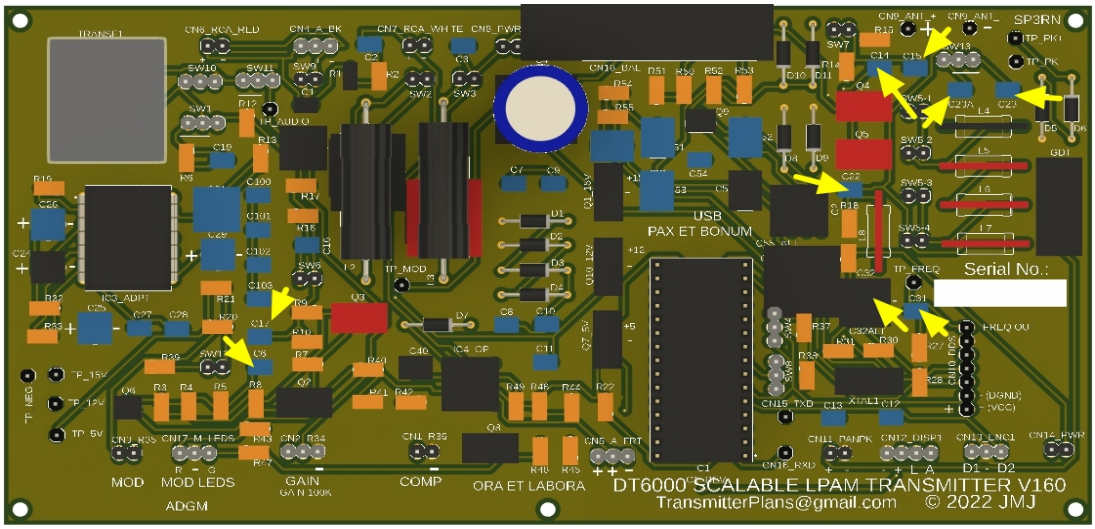


Figure 60: Modulation / RF Capacitors Locations

C15 200 pF

23 820 pF

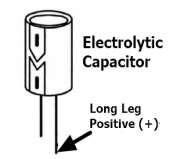
C23A 560 pF (Only required if using the base loaded antenna)

C17 1000 pF

C6 .1 uF **C22 .1 uF** **C31 .1 uF**

C14 .01 uF

C32 100 uF (observe polarization if required)



Modulation / RF Resistors

Use a small screwdriver shaft as mandrel to form the lead as previously discussed.

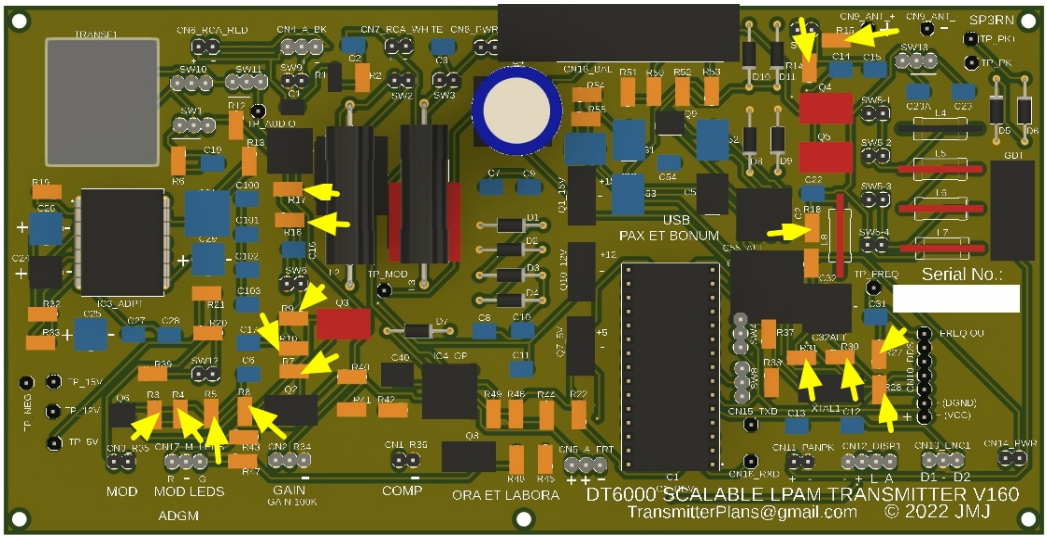


Figure 61: Modulation / RF Resistors Locations

- **R8 22 ohms**
- **R3 100 ohms**
- **R28 220 ohms**
- **R29 220 ohms**
- **R7 510 ohms**
- **R18 820 ohms**
- **R31 1k ohms**
- **R17 1.5k ohms**
- **R27 1.8k ohms**
- **R4 2.7k ohms**

- **R30 4.7k ohms**
- **R10 6.8k ohms**
- **R16 15k ohms**
- **R5 27k ohms**
- **R9 47k ohms**
- **R14 220k ohms**
- **R15 1meg ohms**

Transistors / RF Peaking Capacitor

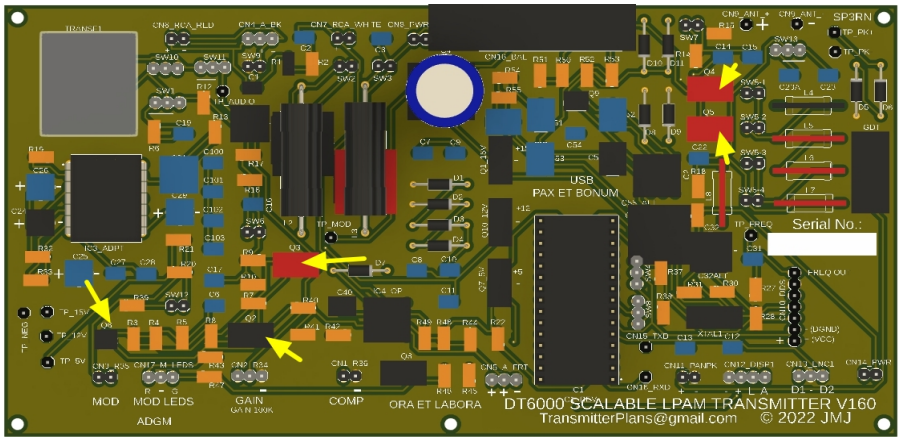


Figure 62: Peaking Capacitor Header Location

Orientate the transistors to the line in front of the legs on the PCB as shown below, the flat face to the line. Orientate Q6 to match the profile on the PCB.

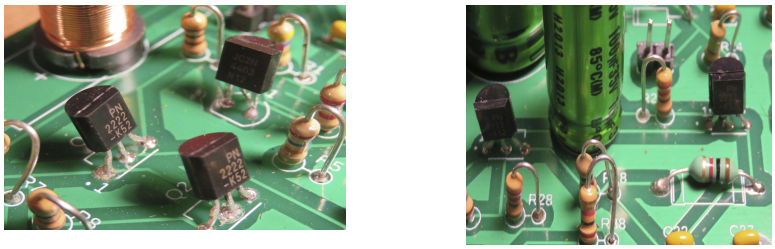


Figure 63: Transistor Orientation

⁀ **Q2** ⁀ **Q3** ⁀ **Q4** ⁀ **Q5 (PN2222TA - NPN)**

⁀ **Q6 (2N3906 or 2N4403BU PNP)**

The header, CN11 for the RF peaking capacitor should already be in place.

The completed peaking capacitor is shown below for reference, the instructions follow.

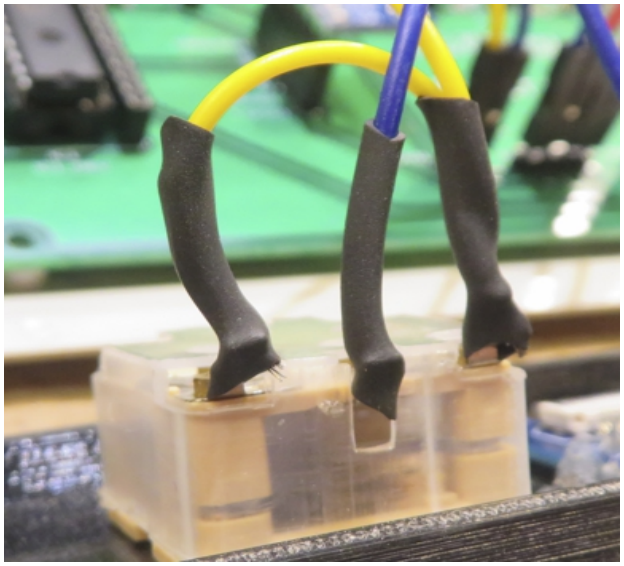


Figure 64: Peaking Capacitor Finished

Cut the 3 leads so each is just over about 1/8”.

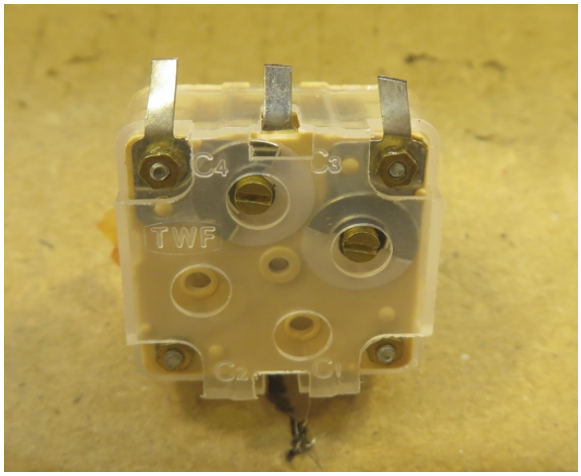


Figure 65: Capacitor With Trimmed leads

Cut three pieces of heat shrink and apply them to the wire before soldering. Using two wires with different colors, cut 2 of the header connection female wires removing the male end so the length and the attached female end remains on each wire. Solder one wire to the center lug noting the color of the wire. Solder the other wire to one of the side terminals.

Place the stand off in the threaded center nut used to make adjustments and using two pairs of long nose pliers hold the capacitor shaft and tighten the standoff. Be sure to use two pliers as tightening the standoff against the capacitor end stop will likely damage the capacitor.

Connect the wire which is soldered to the center lug of the capacitor to the CN9 pin marked -. Connect the other wire from the outside lug to the + pin on CN9.Modulator / RF Validation

Connect a short jumper to the + CN9 pin and apply power to the transmitter. Turn the encoder knob and the frequency should change and a VDC reading should now appear. Attach an MP3 player with a patch cord and tune a portable transistor radio in close proximity to the jumper antenna. You should hear the transmission on the radio. The VDC reading will not perform accurately or consistence without an audio signal and the 3 meter antenna attached.

Your final testing setup should look something like below. The black jumper on the right is to a ground, the red is to the antenna. The yellow and green alligator clips are hooked up to the female phono plug as previously described to verify the audio device is outputting a signal. The transmitter does not transmit until the encoder is turned and does not indicate “Tune To Frequency”

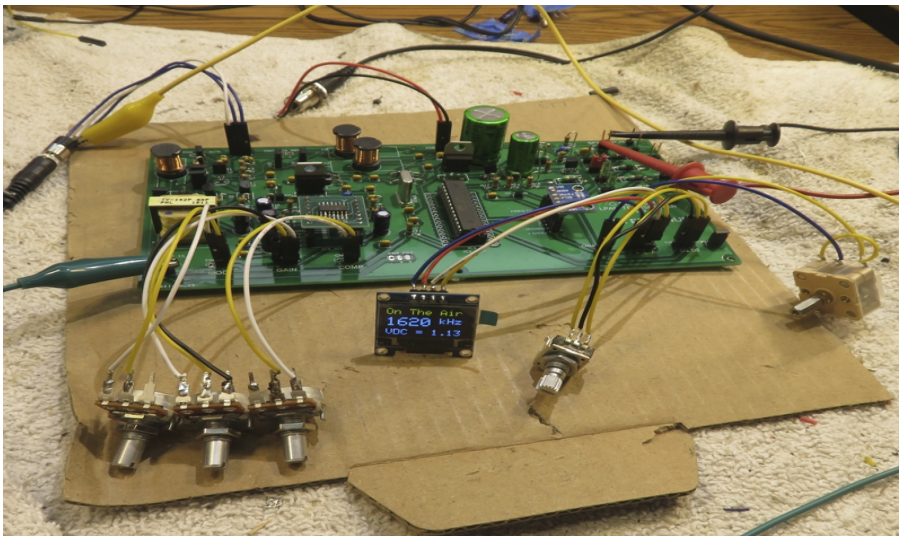


Figure 66: Assembled PCB With Components and Controls

Optional Modulation Indicator

The instructions for the optional indicator circuit are below.

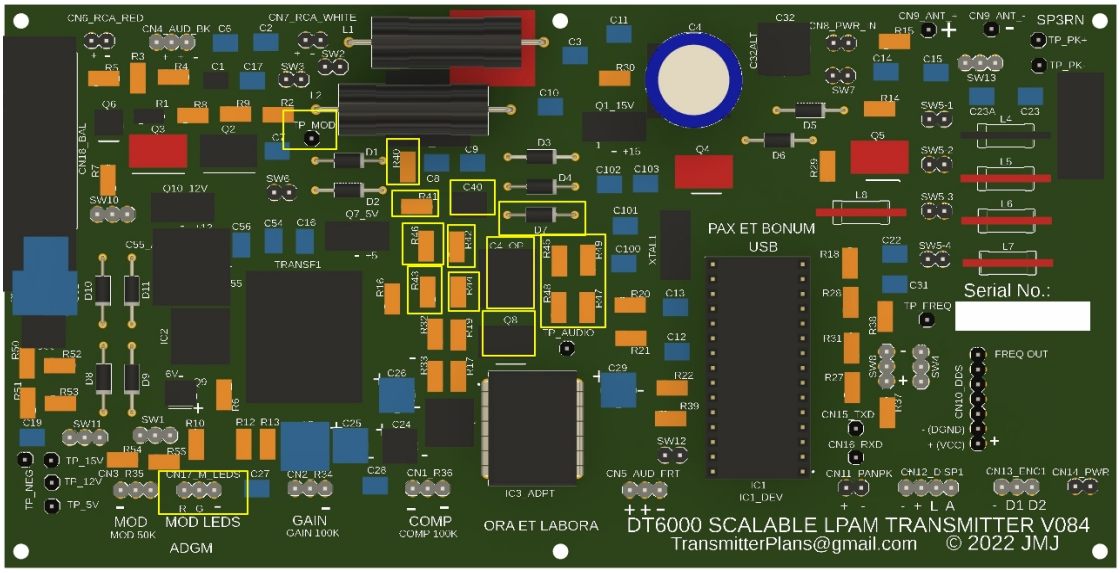


Figure 67: Optional Modulation Indicator Component Locations

If supplied as one piece, use a utility knife to score and cut the header as follows:

1 one pin piece for the modulation test point (TP_MOD)

1 three pin piece for CN17_M_LEDS

⁀ **TP_MOD** ⁀ **CN17_M_LEDS**

⁀ **Solder the 2x4 IC chip socket aligning the socket for pin 1 if marked to the pin 1 mark on the PCB, the dot.**

⁀ **Place IC4 into the socket aligning pin one to the dot or mark.**

⁀ **R43 330 ohms** ⁀ **R47 330 ohms**

⁀ **R45 510 ohms**

⁀ **R48 1k ohms**

- **R41 47k ohms**
- **R44 100k ohms**
- **R40 150k ohms** **R46 150k ohms** **R49 150k ohms**
- **R42 2 mega ohms**
- **C40 22uF**
- **D7 (1N4148)**
- **Q8 (PN2222TA - NPN)**

Use 3 female breadboard wires, preferably red, green and black. Keep the female socket on the wire and trim the length to about 4 inches removing about 1/8 of insulation at the end. Slide a piece of heat shrink longer than the insulated part of the LED plus about 1/2" over each wire. Using the diagram below solder the wires to the pins on the LED.

⁀ **LED Pin 1 (mid length), red wire**

⁀ **LED Pin 2 (center and longest), black wire**

⁀ **LED Pin 3 (shortest), green wire**

Slide the heat shrink over the connection covering the insulated LED and the soldered connection and use the heat gun to shrink the material.

Figure 68: Modulation LED Schematic

When instructed to assemble the case, on CN17_M_LEDS place the red female connector on the pin marked R, the green on G, and the black on -.

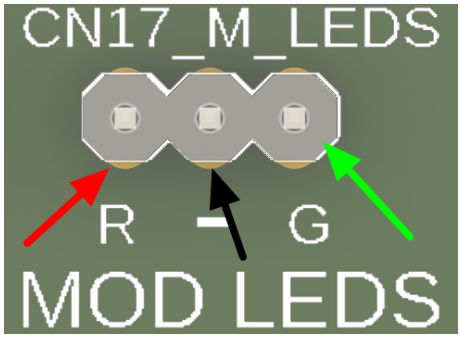


Figure 69: LED Pin Connection Layout

You will need to drill a hole in the front face plate to mount the LED. In between the Modulation knob and the Gain knob slightly above the middle is a good location as indicated below. Use a .200" bit or one that fits the LED lens for the hole. When assembling the LED on the face plate use a silicone adhesive or similar product. The LED should be flush with the face plate. Verify the LED location you select on the face plate will not interfere with the PCB when mounted in the case, it should be above the PCB, not below.

Figure 70: LED Location On Face Plate

- **Drill LED hole on face plate**

Optional Balanced Audio

The instructions for the optional balanced audio circuit are below.

Q10 and TP_12V should already be installed from the power section. If they are not installed, refer back to that section and install them.

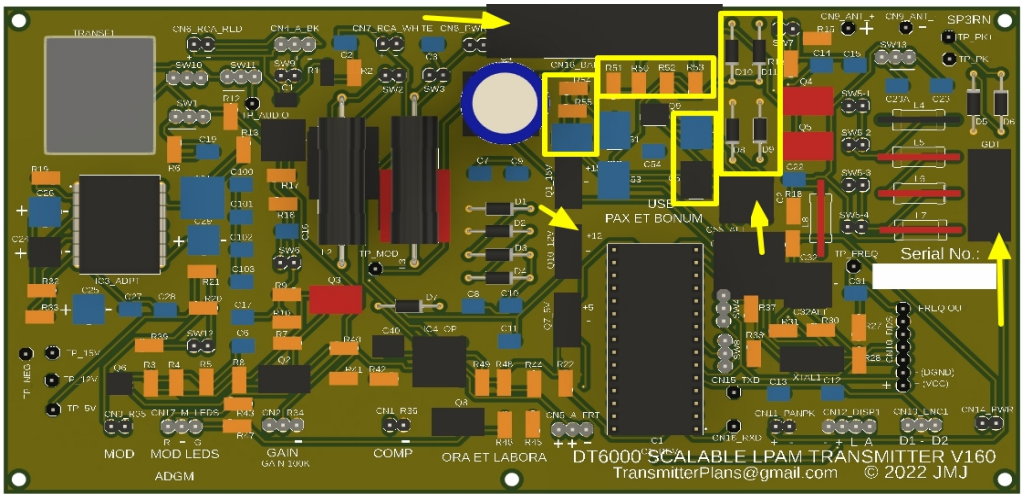


Figure 71: Balanced Audio Components Locations

⁀ **Solder the 2x4 IC chip socket aligning the socket for pin 1 if marked to the pin 1 mark on the PCB, the dot. Pin 1 is also indicated by the rectangular shaped solder pad.**

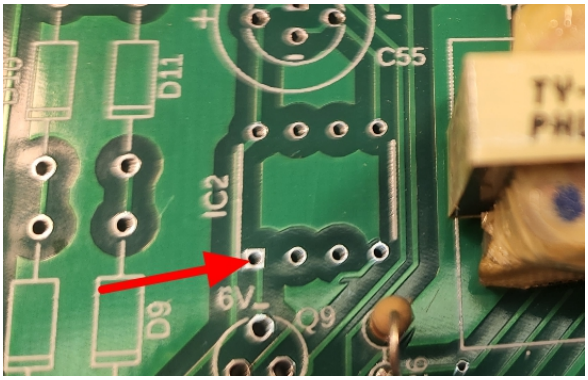


Figure 72: IC2 Pin 1, Square Solder Pad

⁀ **Place IC2 into the socket aligning pin one to the dot or mark.**

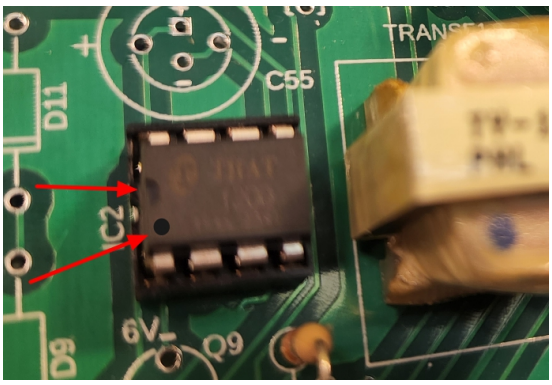


Figure 73: IC2 Pin 1 Dot

⁀ **R50 100 ohms** ⁀ **R53 100 ohms**

⁀ **R54 4.7k ohms**

⁀ **R51 110k ohms** ⁀ **R52 1 10k ohms**

⁀ **R55 220k ohms**

⁀ **C54 470pF**

⁀ **C51 .022uF** ⁀ **C52 .022uF**

⁀ **C50 .47uF** ⁀ **C53 .47uF** ⁀ **C56 .47uF**

⁀ **C55 220uF**

⁀ **Q9**

⁀ **D8** ⁀ **D9** ⁀ **D10** ⁀ **D11 (1N4148 or N914)**

⁀ **CN18 Aligns markings on connector and board for pin 1 if required. Connectors should face the back so holes may be drilled for wire entry to the case.**

For CN18 drill holes as required to feed wires through the case.

⁀ **GDT if being used**

If desired, pins 1 and 2 on CN18_BAL may be connected to a 18 VAC power source instead of using a wall mounted transformer. See the schematic for the connections from your balanced audio source and read the information on the jumper settings for more information.

Antenna Connection

The FCC has specific rules on the antenna, now would be a good point to review them as pointed out in the first part of the manual, particularly rule 15.219. To be fully compliant, the antenna must be permanently attached or attached by a unique connector. Soldering is the best way to permanently attached a piece of 20-22 gauge insulated wire no more than 3 meters at the most.

Should you desire otherwise and use the regular yellow coded phono jack, attach 3 meter or less length wire to the center connector and the ground to the outside ring. Again, though convenient, this is a non complaint modification and is not endorsed in this manual. Use the BNTECHGO wire for this purpose if desired. Place the female connector on the back face plate where it will not interfere with the components on the board and drill the location with a .25" bit.

⁀ **Male Antenna Jack and Solder Connection**

Likewise for the phono hole on the back plate, place the female connector on the back face plate where it will not interfere with the components on the board and drill the location with a .2500" bit.

⁀ **Back Plate Phono Jack Hole**

For the power hole on the back plate, place the female connector on the back face plate where it will not interfere with the components on the board and drill the location with a .4500" bit.

⁀ **Back Plate Power Jack Hole**

⁀ **Review these assembly instruction and verify completion**

Board Inspection

⁀ **Inspect all component soldering against the NASA specification pictures and verify no solder locations are bridged between leads, missed soldering connections. Preferably use a magnifying glass**

⁀ **Diodes, rectifiers, and IC chips have the correct orientation compared against the circuit board**

Front Panel Assembly

Assemble the front panel with the potentiometers (R34, R35, AND R36), encoder (ENC1), OLED, and peaking capacitor by removing the nuts and passing them through the case front. Be sure that the holding lug which protrudes from the front of the potentiometers is place in the indentation on the back of the front cover before the nut is tightened. The peaking capacitor requires two small screws to mount to the case. The order from left to right is: modulation, gain, compression, peaking capacitor, OLED, and tuning encoder. Be sure to have the heat shrink in place on the connections to act as a stress relief. See picture below.

If using the modulation indicator, place the LED in the hole you already have drilled per the instructions in the modulation indicator section.

Place the lug in the lug holes when mounting the potentiometers.

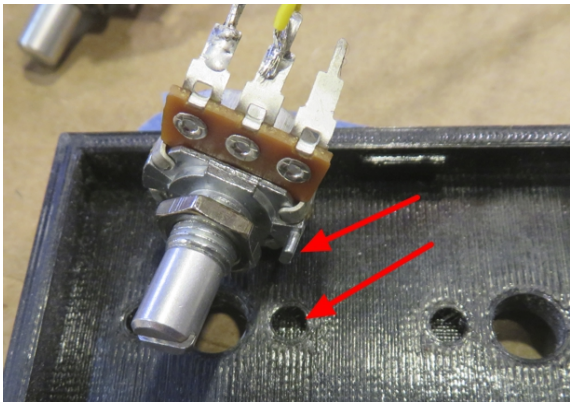


Figure 74: Control Pin Hole On Face Plate

Front Panel Assembly

Do not mount the OLED yet.

Place knobs controls, if necessary place a small amount of silicon glue on the control shaft to secure the knob to the shaft. Do not forget to place the controls through the front cover and the nuts on the shaft and tightening them before putting on the knobs. If needed open up the holes on the knobs with a . 2300” bit and test for fit, adjust as necessary. If the hole in the knob ended up over-sized, try a wrap of black electrical tape around the shaft.

Knobs

Board Placement & Face Plate Connections

Place the board in the enclosure soldered (components up) side down and secure with the 5 screws in the plastic posts Do not use a screw on the front center location.

⁀ **Board Screws**

⁀ **Connect the connectors in the front panel connections**

Use the following to connect the wires for the controls to the circuit board, the control pin is with the pins on top and the wires facing the back as if the knobs are set in the face plate.

Essentially the control lugs correspond to the board pins for the component lugs. If the lug does not have a wire, there is no matching board pin

On the Modulation board pins, pin 3 does not have a board pin. On compression, there is no pin for the left lug.

MODULATION (R35)

Board Left Pin - Control Lug LEFT

Board Right Pin - Control Lug CENTER

(Right Control Lug No Connection to Board)

MODULATION LED (CN17_M_LEDS)

Board Left Pin – Red (mid length lead)

Board Center Pin – Black (long lead center)

Board Right Pin – Green (short length lead)

GAIN (R34) (Be sure to verify the ground pin on the board Gain connectors using the TP_NEG pin and connect the Gain control right lug wire to the ground pin)

Board Left Pin - Control Lug LEFT

Board Center Pin (Neg) - Control Lug CENTER

Board Right Pin - Control Lug RIGHT

COMPRESSION (R36)

(Left Control Lug No Connection to Board)

Board Left Pin - Control Lug CENTER

Board Right Pin - Control Lug RIGHT

For the peaking capacitor, connect the center wire to the – pin on CN12 and the outside wire with the jumper on the capacitor to the + pin.

For the OLED connect the wires labeled on the OLED GND to -, VCC to +, SCL to L and SCA to A on the PCB on CN12. This is just the left OLED wire goes to the left most pin and so forth until the last OLED wire on the right goes to the right most pin.

For the encoder connect the center encoder wire to -, the other two wires to the outside pins D1 (left lug), D2 (right lug) on the PCB, on CN11.

Connect the connectors in the back panel connections (excluding the antenna)

For the 3.5 mm phono jack,

Connect the wire to the jack long lead to – pin , and the other two wires to the + pins as shown on the PCB for CN4.

For the power supply, CN8, simply connect the wires, orientation does not matter

Power supply

Connect antenna if you decided to modify the recommended soldered antenna, the center connection is + and the outside is -, just the same as a audio source. Make the connection to CN9, the center connection goes to the + pin on the left, the negative connection goes to the – pin. Place the heat shrink on the wires before soldering to the posts.

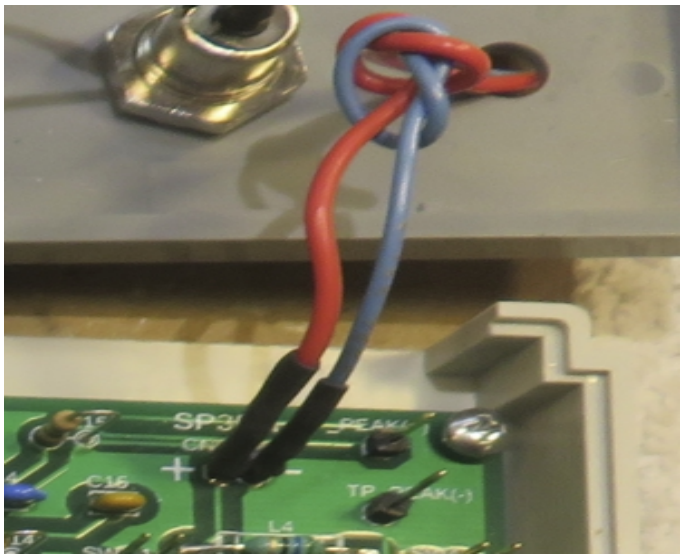


Figure 75: Soldered Antenna Connections

⁀ **Connect Antenna**

⁀ **Connect the power transformer to the connector**

Do not assemble the case.

Verify the jumpers as shown below and make any changes, this is the basic transmitting configuration using the preemptive filtering setting.

⁀ **SW1 – Place jumper between pins 1 and 2 (left and center pins)**

⁀ **SW2 – If not using L2 place a jumper**

⁀ **SW3 – If not using L3place a jumper**

⁀ **SW4 – No Jumper**

⁀ **SW5-1 – No Jumper, will be set later to your desired frequency**

⁀ **SW5-2 – No Jumper, will be set later to your desired frequency**

⁀ **SW5-3 – No Jumper, will be set later to your desired frequency**

⁀ **SW5-4 – No Jumper, will be set later to your desired frequency**

⁀ **SW6 – No Jumper**

⁀ **SW7 – No Jumper, always open unless using a base loaded antenna**

⁀ **SW8 – No Jumper**

⁀ **SW9 - No Jumper**

⁀ **SW10 – No Jumper**

⁀ **SW11 – Place the jumper between pins 1 and 2 (left and middle pins)**

⁀ **SW12 – No Jumper**

⁀ **SW13 – Place jumper between pins 2 and 3 (middle and right pins)**

⁀ **CN14 – Place jumper, must always be in place if not using an encoder with an on / off switch connected, not required if using a .25A self resetting fuse as mentioned in the parts description.**

⁀ **Attach the antenna ground to a good ground source such as a receptacle face plate screw**

⁀ **Set the Modulation knob turned midway**

⁀ **Set the Gain knob turned midway**

⁀ **Set the Compression knob turned midway**

⁀ **Set the Antenna Peaking knob turned midway**

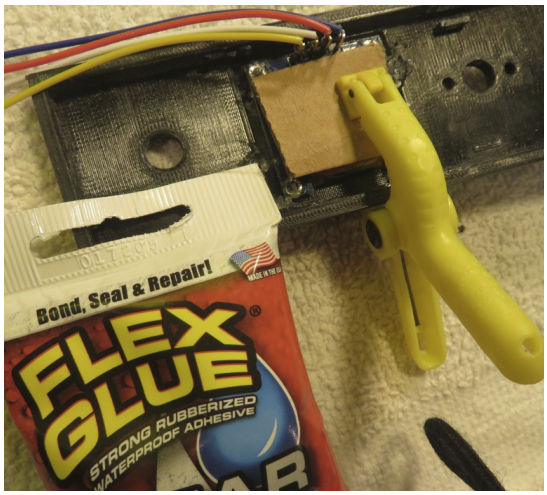
Secure The OLED On The Face Plate

Secure OLED as explained below.

There are variations for mounting the OLED display. Mount the display to the case front, and if using the bezel, mount the OLED to the bezel, then mount the bezel to the case front. Use silicon glue or similar adhesive (or hot glue gun) to fasten the OLED in place on the four corners so the screen area covered with the protective tape is centered on the opening. Allow to cure before installing the front cover on the transmitter.

Look at the display from the front of the case and be sure the OLED is centered and the full screen and text may be viewed from the window, adjust by sliding to either side or up in down. If needed, cut the small 4 tiny posts in the OLED hole and reposition the OLED as the OLED holes have significant variation between manufacturers in some cases.

Use blue painters tape to hold the OLED in the right place temporarily until the cure takes place if needed. Alternatively use a clamp as shown using two small pieces of cardboard to protect the circuit and display on each side. Once the adhesive has cured, slide the heat shrink over the connections and use a heat gun to shrink the heat shrink.



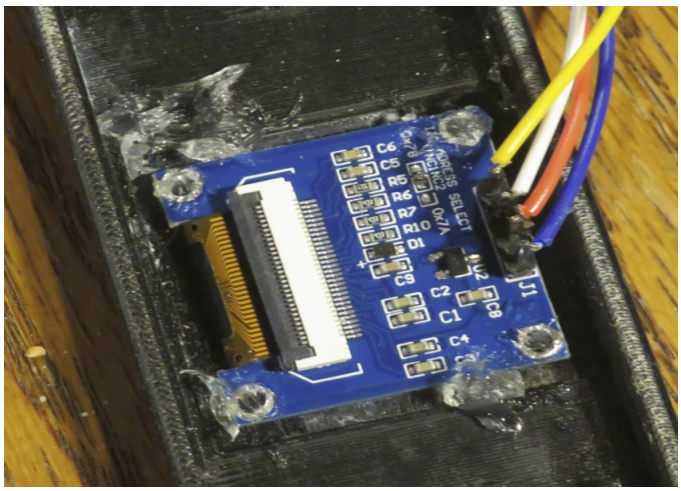


Figure 76: Securing The OLED On Face Plate

- **OLED Display Mount (Be sure to read above)**

Power On Checks

Plug the power connector into the transmitter and the transformer into a reciprocal.

Once the power is connected the transmitter display should be illuminated.

⁀ **On an AM radio, find a frequency which is not being used by a radio station.**

⁀ **Connect an audio device using the RCA connectors if installed or 3.5mm miniature stereo receptacle in the back first verifying a signal is being produced by the device such as musing playing through an earphone.**

⁀ **With the antenna attached, using the frequency knob, the tune the frequency to match the AM radio selected frequency, you should now hear the audio**

The the VDC antenna peak reading will not stabilize until an audio signal, ground, and antenna are provided.

Understanding The Knobs & Display

Your front panel should be similar to the panel shown below.

There are five knobs and one display. Each is explained below along with the adjustments for best audio transmission.

MODULATION – The modulation control increase or decrease the amplitude of the modulation on the carrier wave, more amplitude when the knob is turned to the right.

GAIN – The gain increases or decreases the audio level of the signal fed into the audio IC preamplifier allowing large levels of compensation for many audio devices. The maximum gain position is with the knob turned rotated all the way to the right.

COMPRESSION – Compression decreases the range of the audio to sometime a more soothing range. The compression is increased turning the knob to the right.

Using your test frequency from above, connect the music device and start transmitting the music with the sound initially set at the mid level. To obtain the best combination, of gain, modulation, and compression start with the gain control turned fully clockwise for the maximum and the modulation and compression minimized by turning the controls fully counter clockwise. Lower the volume if it is not clear or is distorted.

Turn the modulation knob slowly clockwise until distortion starts, then turn it back slightly so there is no distortion. If you have the modulation indicator option installed, any modulation less than over-modulation will cause the LED to be green while over modulation causes the LED to be red. Set the modulation just as not to cause the LED to turn red, or at least minimal red. Notice that as the audio source changes, such as changing a song the modulation may change as well causing over-modulation. The over modulation indicator only works when the audio chip is part of the audio circuit and does not work when bypassed or with the balanced audio.

The modulation, gain, and compression adjustments may affect the modulation, particularly using the balanced audio feature due to the THAT chip because the audio no longer passed through the initial resistors and capacitors upon entering the transmitter (R1, R2, C1, C2).

Depending on your balanced audio configuration, the over modulation detection may or may not be accurate.

Rotate the gain knob counter clock wise until the volume just starts to become lower. This setting combination limiting occurs only on music volume peaks. Turn the compression knob clockwise until to the point which maintains the loud and quiet sections at a level which suits the way you enjoy the music and does not have all flat volume.

FREQUENCY - The frequency knob adjust the frequency the transmitter operates by 10kHz increments from 520 AM to 1730 AM.

ANTENNA PEAK – This adjusts the transmitter to be resonant with the lowest capacitance. The lower the capacitance the more power to the antenna, a higher inductance is better than a lower inductance. Though display reads to 1/10 precision, the due to signal variation, just get the highest reading to a few 10ths. The voltage displayed is for peaking purposes only and likely does not represent the true signal voltage to to various components in the circuit allowing the digital display.

The the VDC antenna peak reading will not stabilize until a ground and antenna are provided.

If installed, adjust the modulation indicator so the color is usually green. Changing audio characteristics will change the modulation level which will likely require readjustment. This feature only works with the built in audio processing.

Understanding The Jumpers

There are a total of 14 jumpers indicated by the prefix SW providing maximum flexibility. You can skip this section if you want the default setup as explained in the DEFAULT JUMPER SETUP section below.

SW1 sets the pre-emphasis circuit for being used or not. Use positions 1 and 2 (left and middle) for pre-emphasis excluding low frequencies and positions 2 and 3 to bypass the pre-emphasis. Unless you are doing something special with your audio, may want to set the jumper to positions 1 and 2, left and middle. See which setting sounds best for what you are broadcasting.

SW2, SW3 provide ground isolation options to reduce possible hum by removing the jumpers provided you installed the inductors L2 and L3. However, the best distance is with the jumpers in place and not isolated. Ground the transmitter via the antenna wire to a face plate screw.

SW4, SW8 used for setting the digital pins 3 and 5 respectively high or low to offer more programming options.

SW5-1, SW5-2, SW5-3, SW5-4 inductors may be adjusted to produce between 56 and 788 uH. The inductance is additive when combined by having the jumpers in place. Most people do not need to use this feature for optimal transmission. The jumper values are as follows:

SW5-1 = 56uH (if ordering from Digikey revise the table with the 47 uH inductor value if desired but the small difference in inductors does not significantly change the ranges shown making the changes unnecessary)

SW5-2 = 82 uH

SW5-3 = 180uH

SW5-4 = 470 uH

One way to find out which combination is theoretically best is to pick your desire frequency and look at the following table. Pick the highest inductance in your frequency range. Then systematically lower the inductance repeaking the VDC each time. The VDC will increase and then decrease once the optimum inductance is passed. When that happens go back to the highest combination. The X indicates having the jumper in place. You will find for a given frequency having the highest inductance will achieve resonance with the lowest peaking capacitance. So be sure to start at the higher end of the inductance and work down until you pass the VDC peak, then go back. This table is for a 3 meter antenna, a shorter antenna will resonate and peak differently. It is interesting to watch how the frequency changes the voltage over the entire frequency range.

In practice try various combinations to see what gives the highest VDC with your antenna of the length you use, but remember the legal maximum length is 3 meters. Interestingly enough, the VDC reading is highly subject to wall circuit wires in houses or in relatively close proximity.

Frequency kHz	SW5-1	SW5-2	SW5-3	SW5-4	uH
1485-1720		X			82
1145-1607	X	X			138
1003-1407			X		180
876-1229	X		X		236
831-1166		X	X		262
754-1059	X	X	X		318
620-871				X	470
586-823	X			X	526
572-803		X		X	522
545-766	X	X			608
528-740			X	X	650
520-710	X		X	X	706

Figure 77: Inductor Frequency Schedule

In practice voltage peaking is subject to many factors and is mostly an academic exercise as the transmitter easily covers the area allowed by the FCC.

SW6 Boosts treble about 8dB with the midpoint of the boost curve at 2kHz. Without this jumper in place, there will be a relatively flat audio response. This is the original AMT3000 treble boost circuit and can be improved upon using the pre-emptive filtering jumper SW1 set to pins 1 and 2. Chances are you will never use SW6. Simply remains in the circuit for those that believe it was useful.

SW7 must be open unless using a base loaded antenna. Instructions may be found be an internet search on SSTRAN Base Loaded Antenna if desired, or used the information at the end of this manual.

SW8 and SW4 used for setting the digital pins 3 and 5 respectively high or low to offer more programming options.

SW9 – Grounds the audio to the transmitter ground, probably never used.

SW10 sets the balanced output to use the transformer or not, pins 1 and 2 bypass the transformer, pins 2 and 3 send the balanced audio signal through the transformer. Should be removed unless using the balance audio input. Remove the SW11 jumper if using the balanced audio.

SW11 is the audio bypass jumper. To exclude the transmitters audio chip set to pins 2 and 3. To use the chip, set to pins 1 and 2. Most people will always have this set to pins 1 and 2.

For most users processing your own audio is not suggested or needed, but the capability is provided for those who would like to try it or experiment. Studio audio equipment varies, as such, if using other than the default jumper settings, study the schematics to conclude what jumper settings would work best for your particular equipment.

SW12 is the optional noise gate filter, to exclude lower frequencies put this jumper in place.

SW13 is set to pins 2 and 3 for the 3 meter wire antenna, and pins 1 and 2 for the base loaded antenna if used.

Default Jumper Setup

This combination with the 3 meter antenna has generally been found to produce the best results. The SW5 jumpers should be set to the frequency you will use per the above table. A jumper must be on CN14 to provide power unless replacing the jumper with a self reseting fuse.. Most people will find this to be the best combination for general usage.

However, a stronger signal may be produced by trying different SW5 combinations at the next higher or lower frequency than suggested in the table, or possibly all together combinations as every installation is different and affected by local AC power lines as well. Use the VDC meter in the front of the transmitter or a radio to listen to signal strength while you make adjustments to the SW5 jumpers. Peaking is mostly an academic exercise and not needed as the transmitter easily covers the area allowed by the FCC with peaking. Just be sure to use a ground to the transmitter.

Maximize the VDC voltage or the highest volume on the radio for a given SW5 inductor combination.

SW1 – Place jumper between pins 1 and 2 (left and middle pins)

SW2 – If not using L3 place a jumper

SW3 – If not using L2 place a jumper

SW4 – No Jumper (Digital programming pin 3)

SW5-1 – No Jumper

SW5-2 – No Jumper

SW5-3 – No Jumper

SW5-4 – No Jumper

SW6 – No Jumper

SW7 – No Jumper, always open unless using a base loaded antenna

SW8 – No Jumper (Digital programming pin 5)

SW9 – No Jumper

SW10 – No Jumper

SW11 – Place jumper between pins 1 and 2 (left and middle pins)

SW12 – No Jumper

SW13 – Place jumper between pins 1 and 2 (left and middle pins)

CN14 – Place jumper, must always be in place if not using an encoder with an on / off switch connected, or not used if using a self resetting fuse.

Figure 78: Default Jumper Settings Listing

Assemble The Case

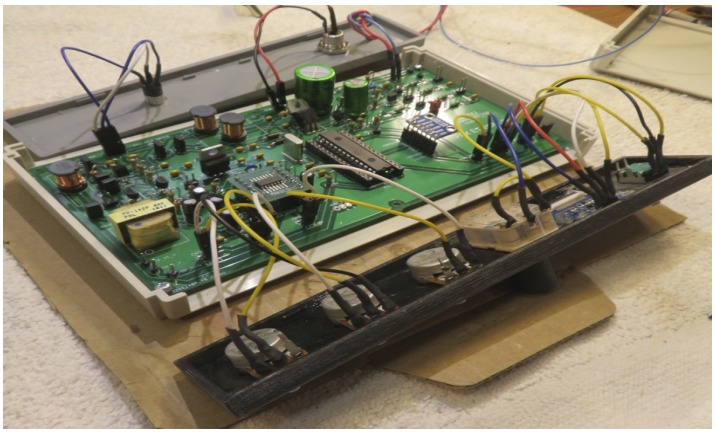


Figure 79: Case Assembly

Mount the completed PCB in the case if already no done using the 5 sheet metal screws leaving the front center screw out as it would interfere with the peaking capacitor. Your board should be similar to the one shown above. Be sure you have the heat shrink on as it acts as a stress relief for the wires to the components mounted to the face plate and back plate.

Now that you have verified the transmitter is working correctly, take the back of the case setting it in place. You will need to drill three holes, one for the miniature phono plug (.25”), the power jack (.430”) and the antenna and ground wires (.25”) to come through unless using the optional RCA jack for the antenna. Verify the locations you select will not interfere with any mounted components and drill the required holes. Place the components in the holes and secure them adding wire for the antenna and ground being sure to solder them well and tie a knot for pull protection. Recheck the connections are on the proper connection pin from the case components as needed.

Be sure the lugs for the components of the face plate have no vertical bend or even better, bent slightly beyond horizontal downward to assure case clearance as the face plate snaps in place.

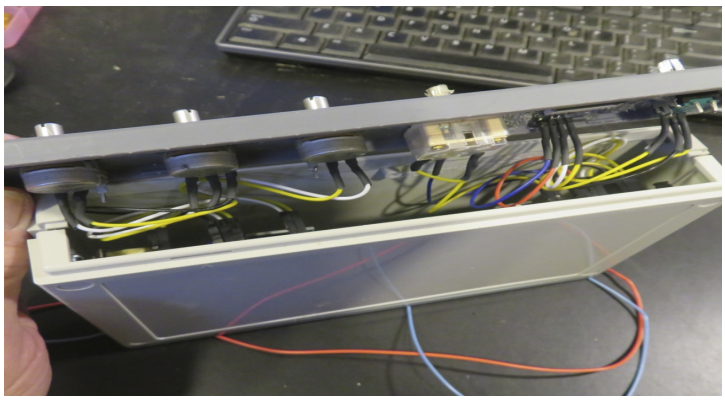


Figure 80: Wires Before Closing Case, Bottom View

Assemble the case, hopefully you practiced in advance as suggested to be familiar with the assembly process. Make sure the lower and up half are fitted together tightly

Be careful with the wires that they are not between the face plate and the case, it is a tight fit but it all will go together.

Indoor Antenna Location

Select a location as free as possible of other electrical sources and electrical wiring. The best range will be found with a vertical antenna with the ground connected to a good earth ground such as a receptacle face plate screw. Even with a poor installation not following these guidelines, the transmitter will cover an entire house with the signal.

Final Installation Considerations

Noise in form of hums and static are common occurrence due to the many source of electrical interference.

The noise created by virtually all electronic and some non electronic machines due to static electricity.

Grounding, filtering and shielding are the most effective ways of reducing electrical interference. The transmitter uses inductors which may be used to aide in this process.

Use of this transmitter is for learning purposes and the antenna should never exceed 3 meters, the legal limit and the connection should be soldered to assure compliance to the FCC regulations.

Programming Your Own ATMEL Chip

It is quite simple to program the chip only alternative for the transmitter instead on using an Arduino Nano. All you need to to is have an Arduino Uno which uses the same chip and download the program to the Uno. The Uno chip is then removed and then be placed into the transmitter assuming it has the required components in place. Nothing else is needed, no need to purchase anything to burn the chip. Just be sure the chip you purchase to replace the chip in the Uno has the bootloader installed.

Alternatively, you can program the chip while in the transmitter using the RXD and TXD pins on the PCB.

Pre-Emphasis Boost

The pre-emphasis boost is a high pass filter which begins attenuating lower audio frequencies starting at about 80Hz with the 0.047uF capacitor and with the 0.01uF capacitor attenuation starts at about 400Hz. It is unlikely you will be able to notice much of a difference between the two capacitor values by ear. However if you wish to eliminate more lower audio frequencies, the 0.01uF capacitor would likely be the better choice. This is shown in the two Bode plots below.

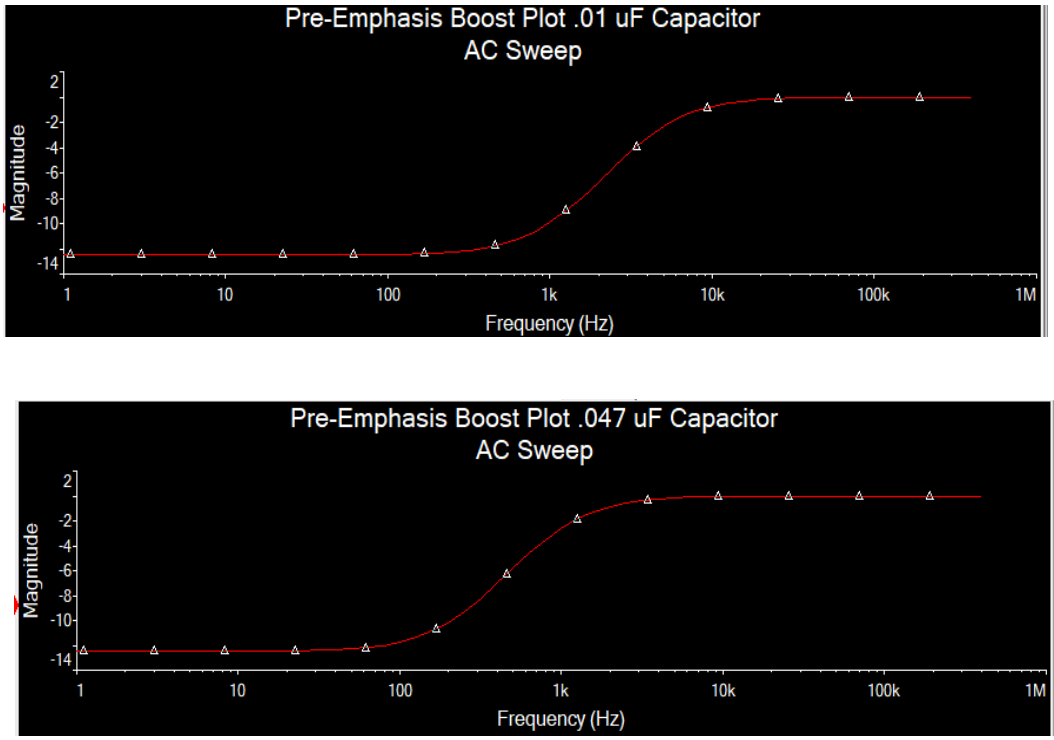


Figure 81: Pre-Emphasis Bode Plots Showing Frequency Shift Versus Capacitance

Modulation Indicator

The modulation indicator circuit detects when the IC3 audio chip over modulates producing a higher than usual voltage. This features only works accurately with the built in audio processing. This in turn causes over modulation in the RF carrier, more precisely carrier pinchoff. Over modulation (lower plot high values) can be seen in the following picture from an oscilloscope. Notice how the increased voltages correspond to over modulation in the RF carrier, the top plot without any amplitude.

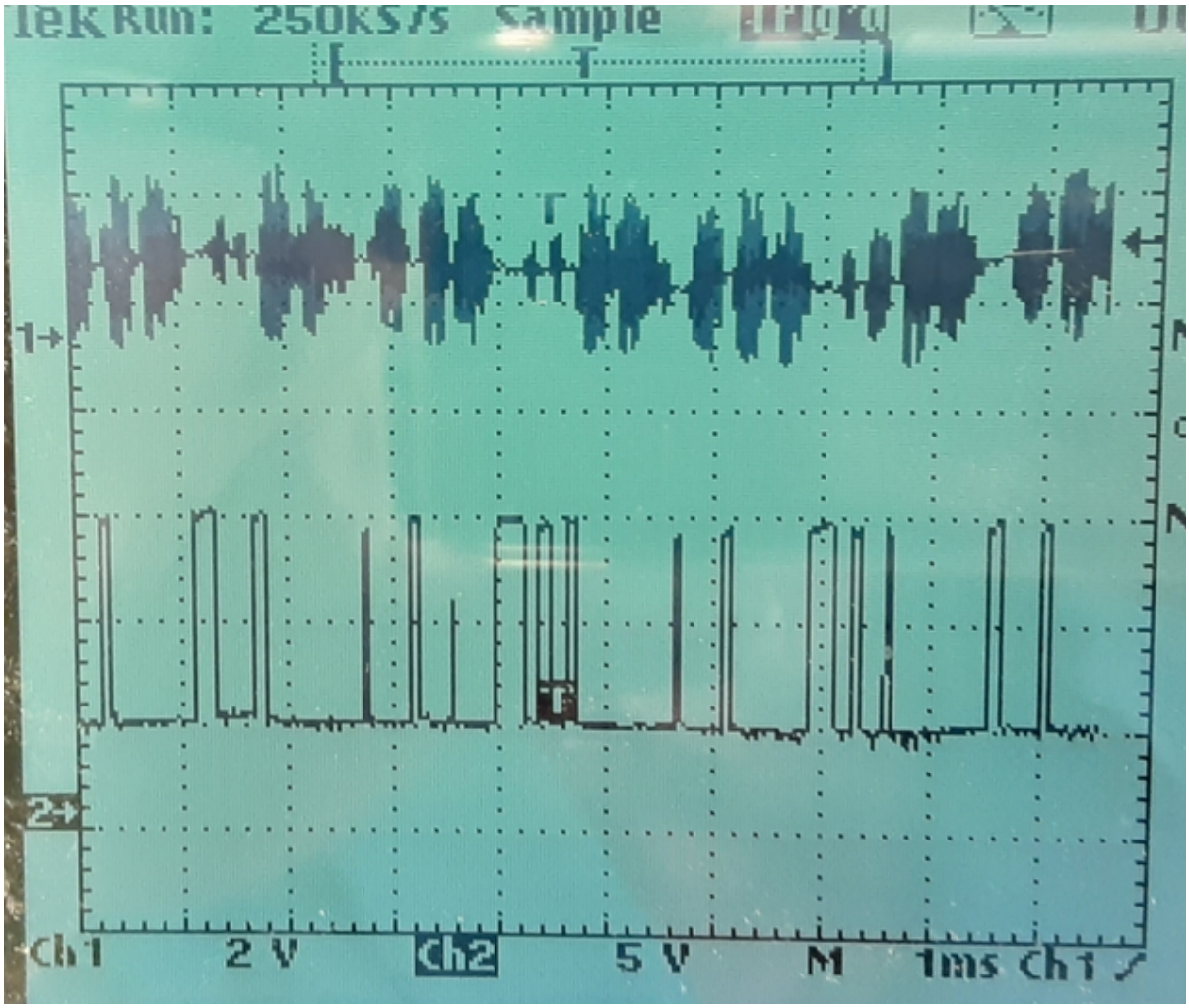


Figure 82: Over-modulation Oscilloscope Display

The peaks shown above would cause the red LED to light while when the peaks do not occur, the LED will be green. For this condition, the LED would be alternating between red and green, a borderline condition. As the gain knob is turned clockwise increasing the audio signal, the modulation knob must be turned counterclockwise, lowering the modulation to prevent over modulation condition keeping the LED green instead of red.

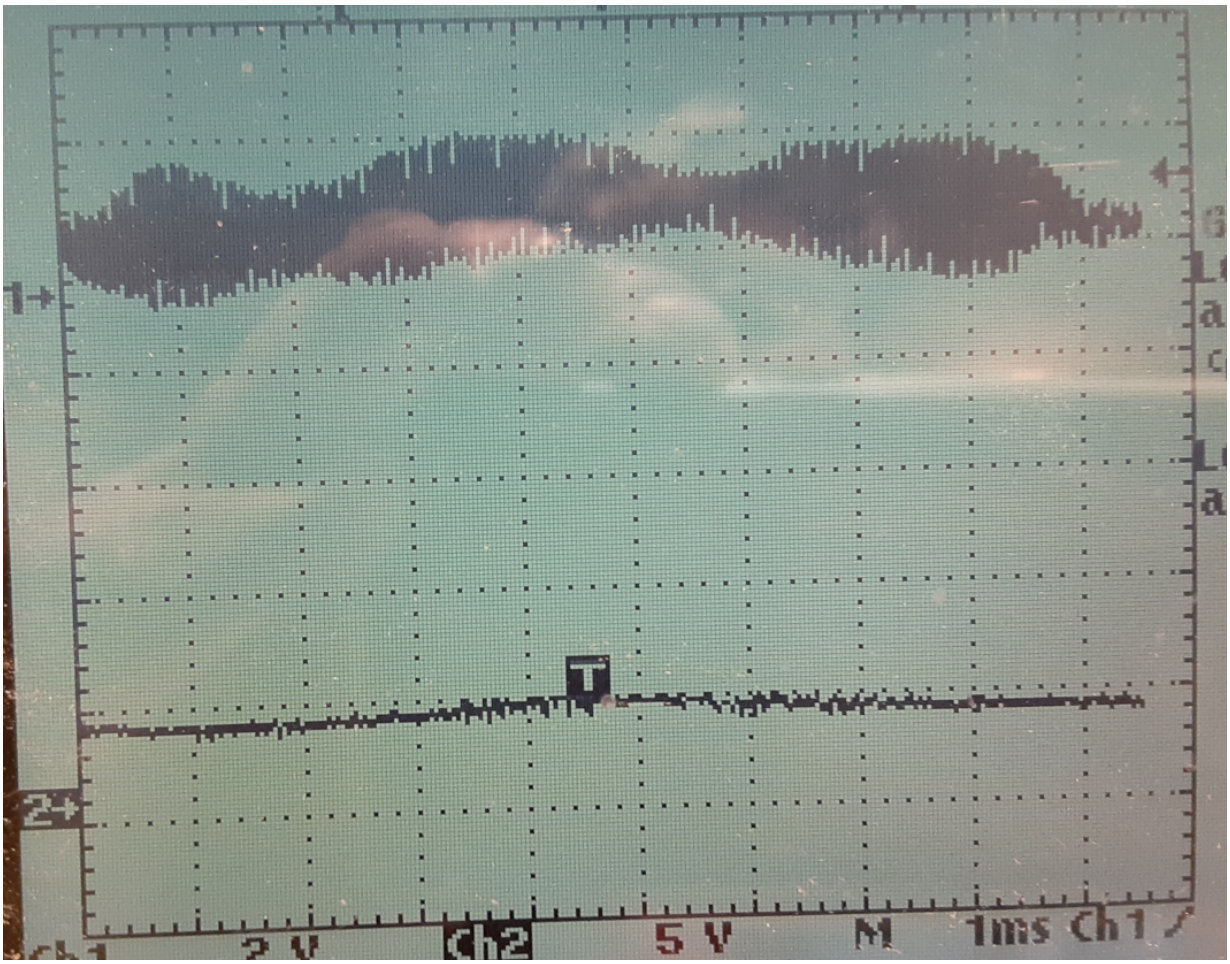


Figure 83: Non Over-modulated Audio Signal (Upper) and RF Carrier (Lower)

In this condition the LED would be green indicating no over-modulation.

The modulation, gain, and compression adjustments will not affect the modulation, particularly using the balanced audio feature due to the THAT chip is excluded from the circuit. IC3 must be part of the circuit to have the over-modulation indicator function properly.

Specifications

Frequency Coverage	520-1720 kHz in 10 kHz steps
Frequency Selection Method	Rotary encoder with digital display
Frequency Resolution	.1 Hz with 25 MHz reference clock
Frequency Generator	Analog devices AD9833 chip
Microprocessor	ATMEGA328P or equivalent
Modulation Type	Amplitude Modulation
Maximum Modulation Level	100.00%
Power Input to Final RF Stage	100 mW
Antenna	118” wire
Antenna Matching	Tunable pi-network matching a high impedance antenna to low impedance RF output
Output Tuning	4 jumpers allowing an inductance range from 82 – 788 uH
RF Output Metering	Measured via a digital display in VDC at maximum resonance
RF Grounding Options	Jumper plug options including / excluding isolation inductors for power supply and audio source ground paths up to isolation transformer
Audio Response	20 Hz to20 kHz +/- 1 dB
Audio Treble Boost	+8 dB, boost midpoint a 2 kHz via jumper
Audio Distortion	Less than 0.5% THD through audio stages
Minimum Audio Input level	200 mV RMS for 100% modulation (input gain a maximum)
Audio Compression	Adjustable from 1:1 to 5:1. Attack time less than 1 ms. Suitable for voice and music
Audio Processor	Analog Devices SSM2166P
Audio Limiting	Adjustable Threshold. 15:1 compression above threshold
Audio Isolation	Common device ground, positive signals isolated
Front Panel Controls	Audio input Gain, Modulation level, and Compression level, antenna peaking, and frequency Selection
Rear Panel Jacks	3.5 mm (1/8”) female phono plug, RCA antenna / ground jack, and 2.1mm power input jack
Display	.96” OLED 128x64
Operating Input Voltage	18V RMS AC in, or 20V DC in
Wall transformer Voltage	120V 60 Hz
Case Dimensions	7.8” x 4.75” x1.5”
Weight	Approximately 16 oz

Figure 84: Specifications

Learning Resources

Original AMT 3000 Transmitter History

https://rec.antiques.radio-phono.narkive.com/nVE1woVa/new-amt3000-transmitter-kit

https://rec.antiques.radio-phono.narkive.com/bz96jjpM/transmitter-to-my-old-am-radios

Books and Links

Most of these may be found at minimal cost or free through thrift stores and internet searches for the pdfs. Of course there are many others as well.

Nice Antenna Information
https://www.navy-radio.com/manuals/10228d/rm32_manual_64-08.pdf
https://www.navy-radio.com/manuals/et2-vol7-12417-1995.pdf

Electronics For Dummies, Doug Lowe

Practical Electronic For Inventors, Scherz / Monk

Basic Radio: Understanding the Key Building Blocks

Publisher ： American Radio Relay League (ARRL); 1 edition (Jan. 2005)

Author: Hallas

ASIN ： B012HU0HU8

The Electronics of Radio

Cambridge University Press; 1st edition (August 13, 1999)

ISBN-10 ： 0521646456

Schematics

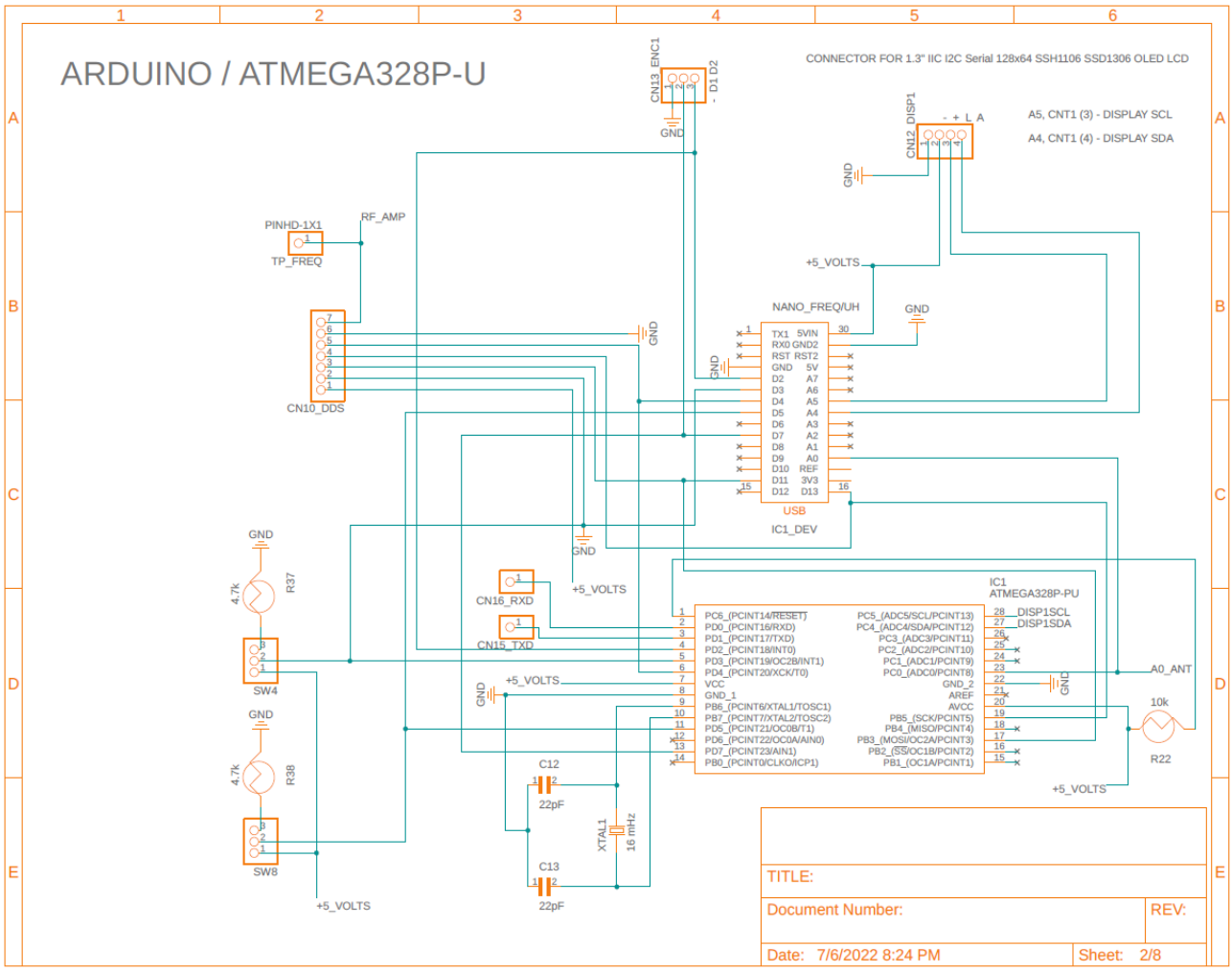


Figure 85: ATMEGA / Arduino Section Schematic

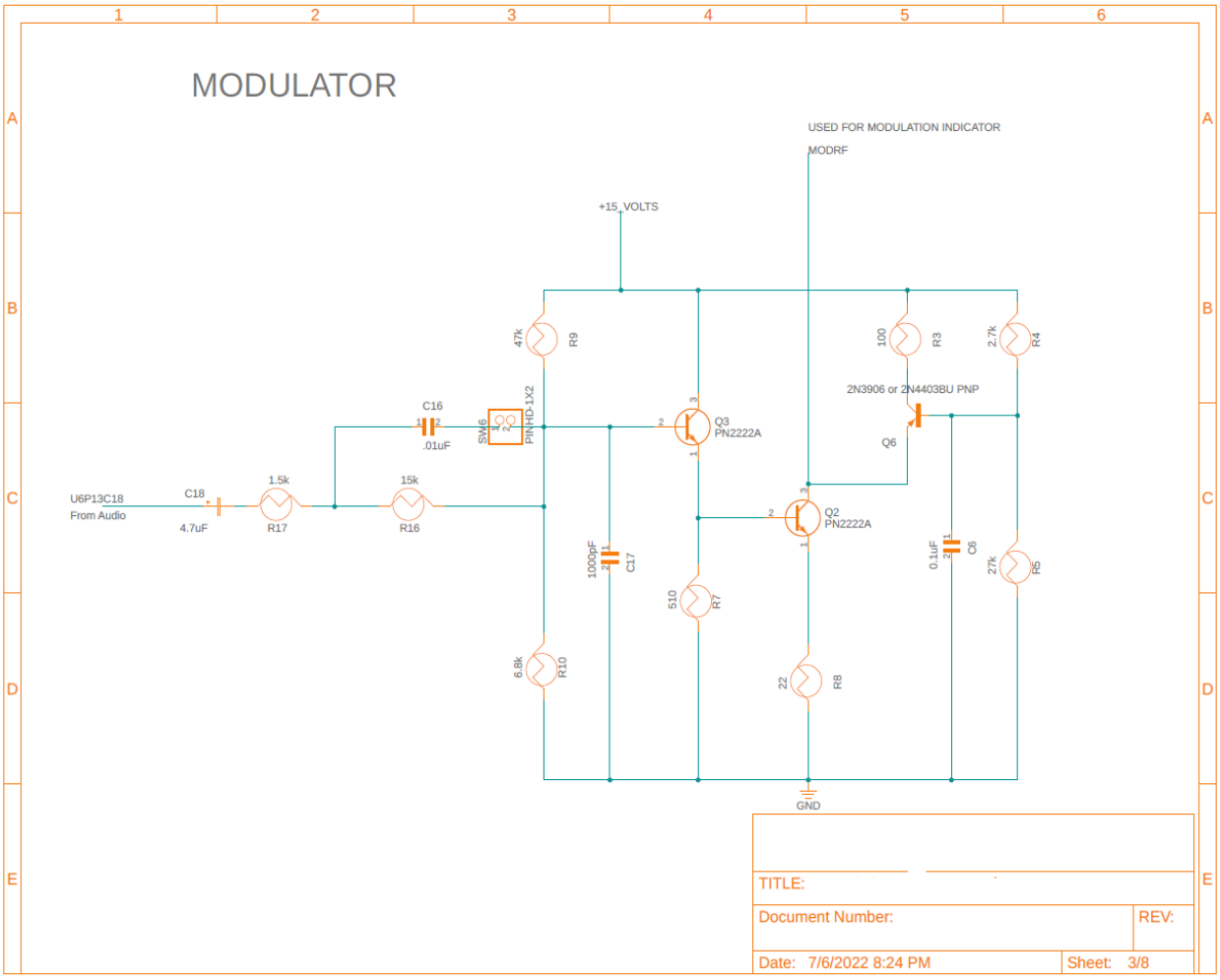


Figure 86: Modulation Section Schematic

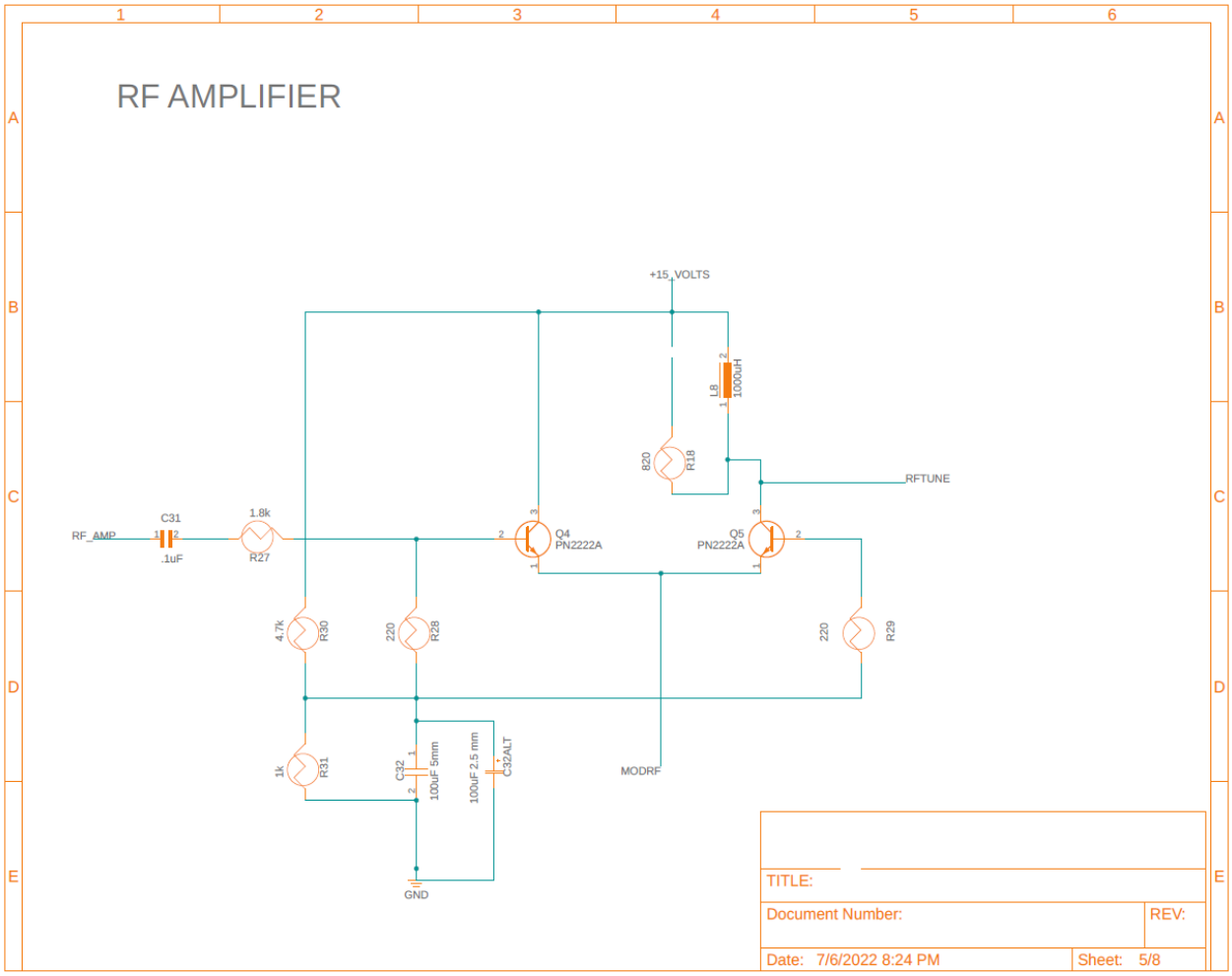


Figure 87: RF Section Section Schematic

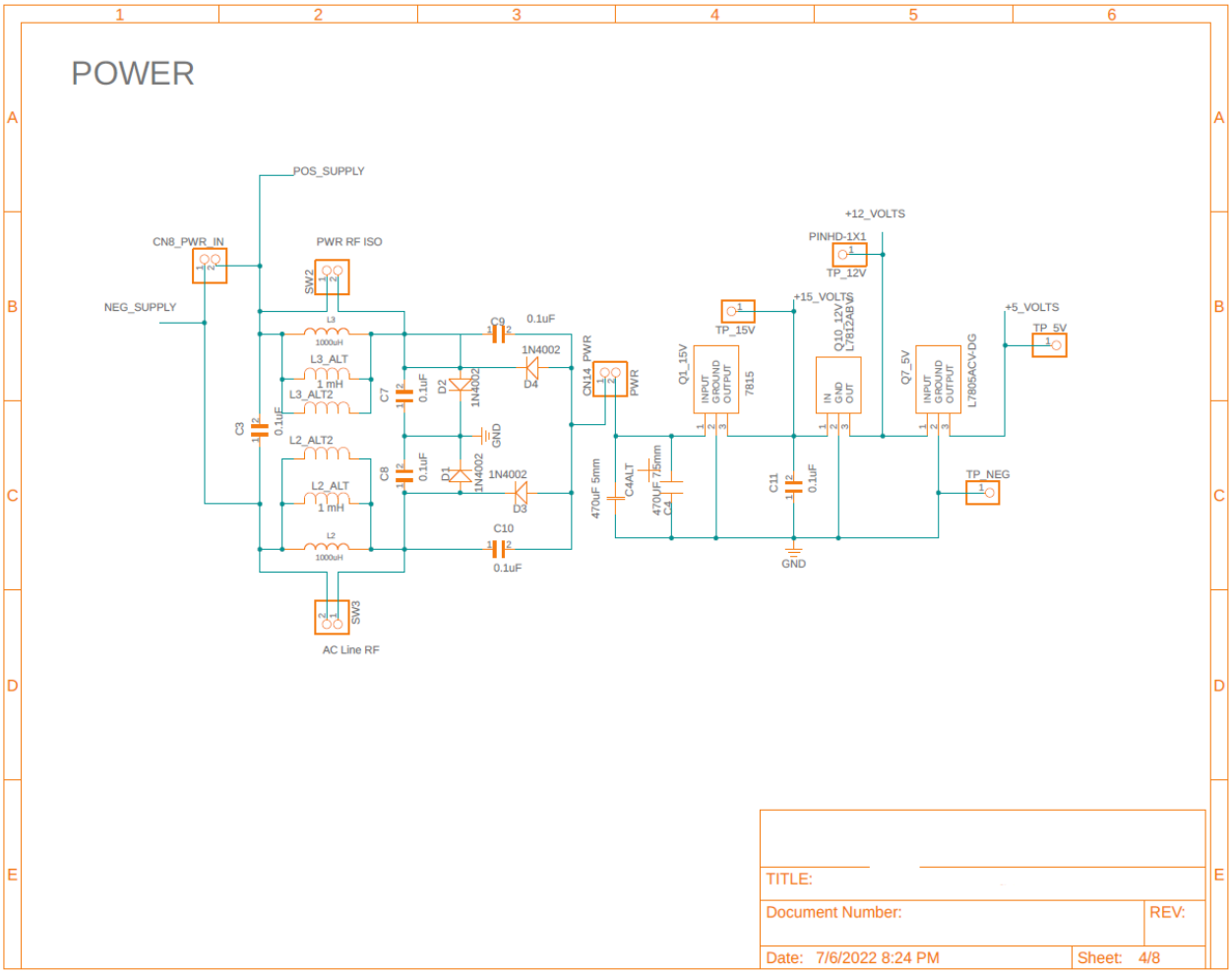


Figure 88: Power Section Schematic

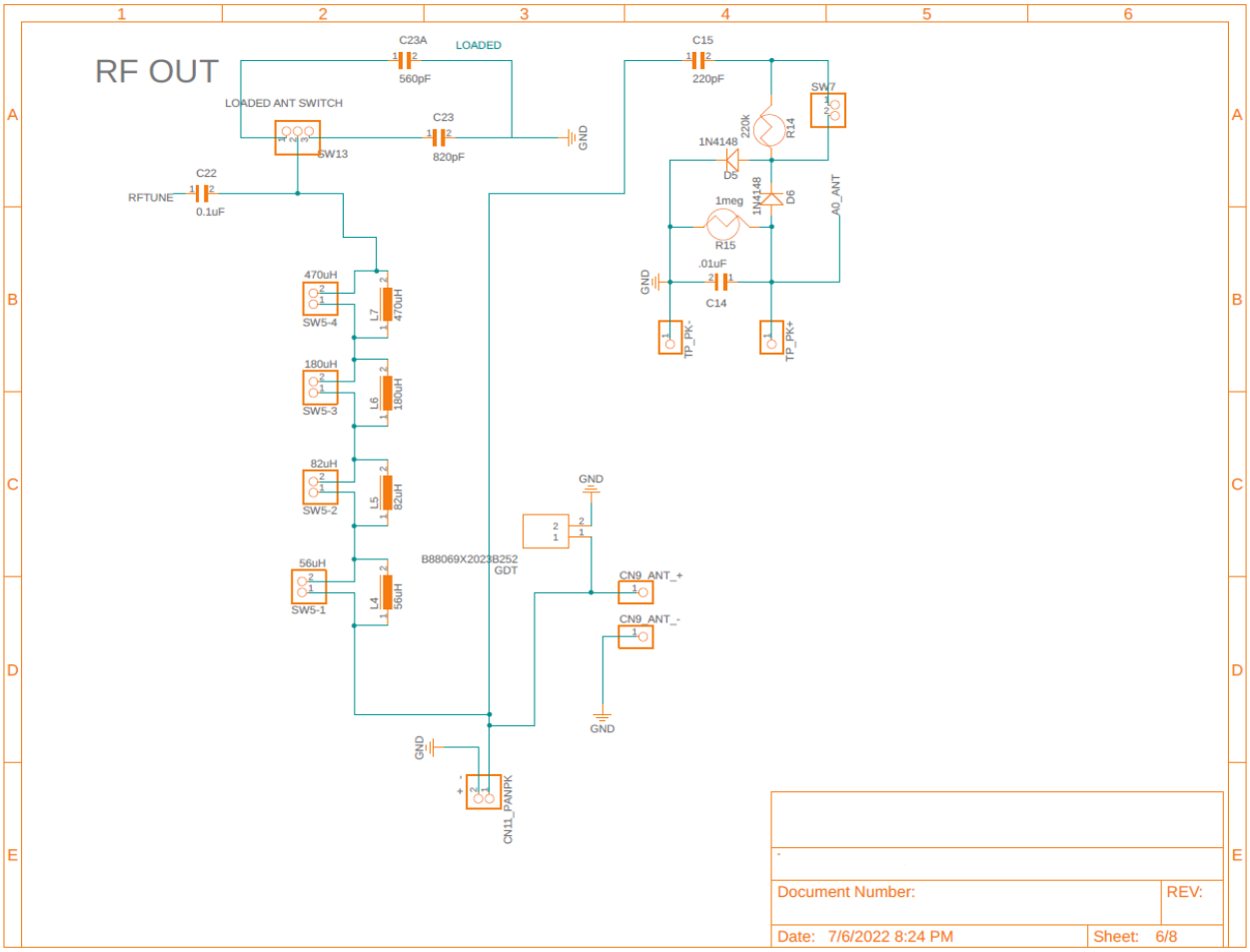


Figure 89: RF Out Section Schematic

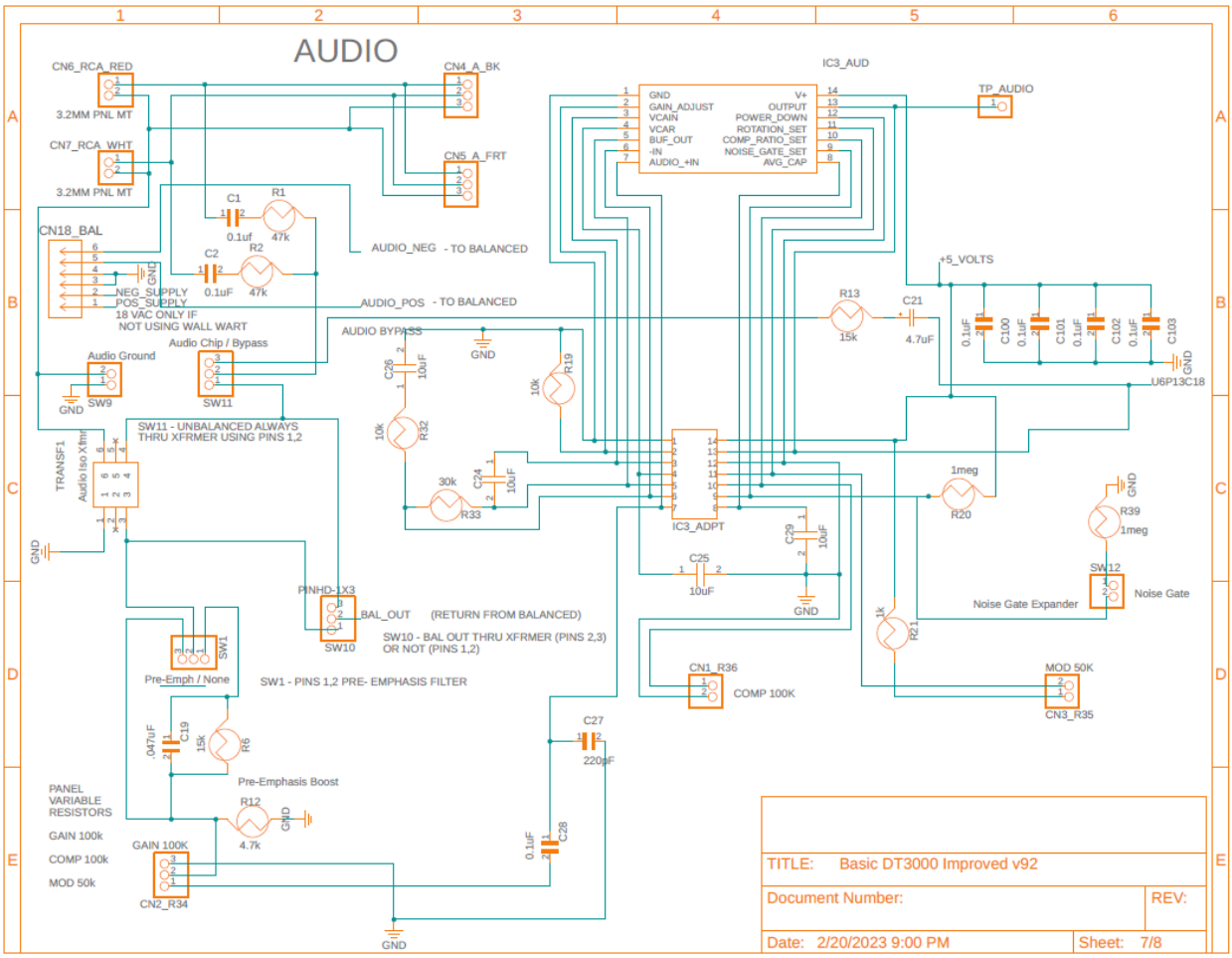


Figure 90: Audio Section Schematic

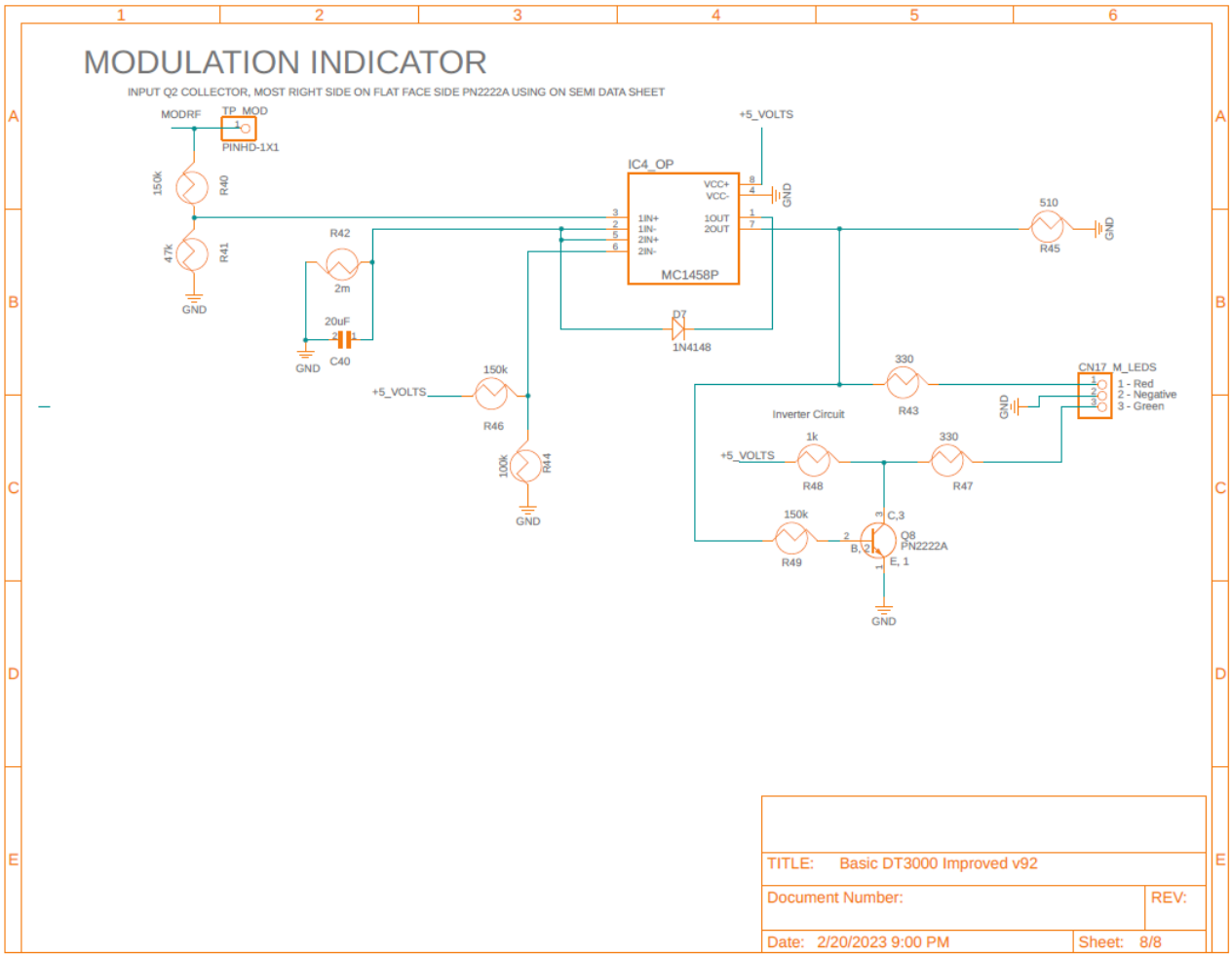


Figure 91: Modulation Indicator Section Schematic

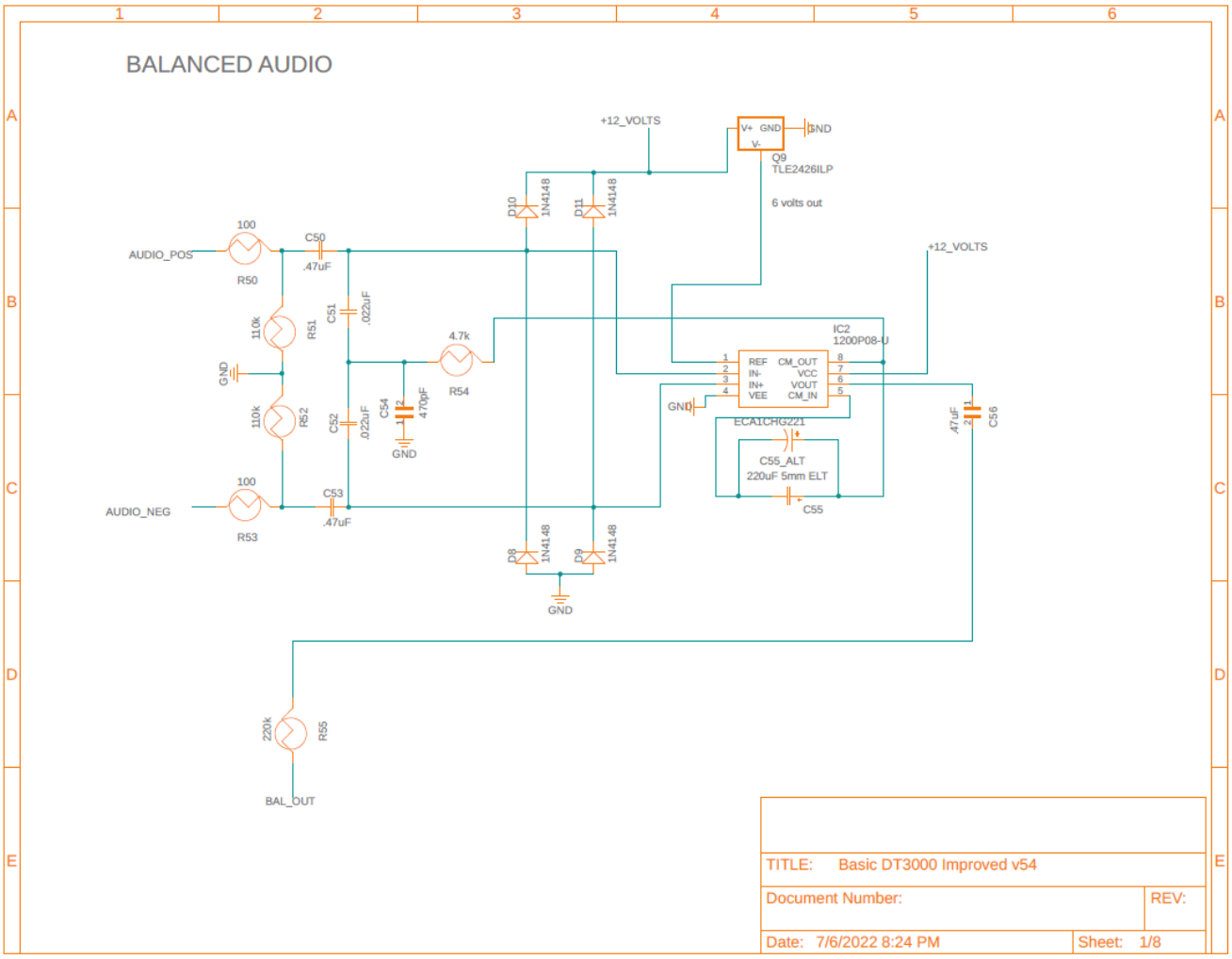


Figure 92: Balanced Audio Schematic

Base-Loaded Vertical Antenna Instructions

http://www.sstran.com/pages/sstran_buildant.html

Constructing a Base-Loaded Vertical Antenna

Safety and Legal Warnings

SSTRAN provides these antenna plans as a courtesy to our customers who want to experiment with a high performance antenna. Construction, installation, and use of this antenna is solely at your own risk. SSTRAN can not be held liable for any personal injury, property damage, or any other legal liabilities that you may incur at any time during the construction, installation, or use of this antenna.

PERSONAL SAFETY

1. As with any DIY project using hand tools, power tools and chemical products, there is always a risk of *personal injury*. Read and understand the safety notices that are included with all tools and chemical products that you use.
2. Installation of this antenna may present a risk of *electric shock injury* or *electrocution*. You must take all precautions to ensure that the antenna and any connecting wires will not come in contact with a live electric wire while maneuvering the antenna into position during installation. You must also ensure that no part of the antenna will contact a live electric wire in the event that the antenna becomes dislodged from its mounting position for any reason at any time.
3. As with any outdoor antenna, there is always the risk of lightning damage. For your safety, and to reduce the risk of damage to your home or property, ensure the transmitter is properly grounded.

LEGAL ISSUES

1. Check your local ordinances and covenants to ensure that your antenna installation complies with any rules that may be in effect that restrict the size, height, and location of outdoor antennas.
2. When constructed according to the plans, this antenna will comply with the generally accepted interpretation of FCC Part 15 section 15.219 governing antenna dimension restrictions . Be aware that the FCC can order you to cease operations if you cause interference to any commercially licensed station. You will reduce your likelihood of receiving an FCC order if you build the antenna as described, choose an unused frequency in your area, and operate your station in a civil manner.

Important Transmitter Information

The AMT3000 transmitter must be modified according to the instructions given in Required AMT3000 Circuit Modifications. These modifications are simple, but very important. This antenna will not perform properly without the transmitter modifications.

02/16/2005 Update

Thanks to more customer comments, steps 1, 8 and 9 under "Winding The Coil" were corrected.

03/07/2004 Update

Thanks to customer comments, the antenna plans have been refined to somewhat simplify construction. The new version will perform exactly the same as the original version. If you are currently constructing the original version or want to reference the original version you can access the plans here: original antenna plans

A well constructed tuned vertical antenna is a must for getting maximum range from your Part 15 AM transmitter. The FCC restricts the total length of the antenna, feed line, and ground lead to 3 meters (118 inches). This is very short at AM broadcast band frequencies. Because of this restriction, even the best Part 15

compliant antenna will not be very efficient compared to those big commercial broadcast station towers. Because the feed line length is included in the total length, the transmitter must be mounted at the base of the antenna in a weatherproof enclosure.

The antenna described here is designed to be rugged and stable in an outdoor environment. All materials are readily available from your local home improvement store (Home Depot, Lowes, Sears Hardware) and from electronics mail order suppliers (Mouser Electronics). You should be reasonably handy with hand tools and an electric drill. You also will need to do a couple of copper pipe "sweat" solder joints using a small propane torch and a few PVC solvent weld joints.

The antenna tuning range is restricted to 1500 kHz - 1700 kHz to make it simpler to construct.

For best results your antenna should be elevated by 20-25 feet, but you can still get good performance by mounting it on a pipe near ground level. Be sure to consider that you will need to access to the bottom portion of the antenna and the transmitter for tuning after installation.

Familiarize yourself with the antenna drawing and parts list: Drawing and Parts List and procure any parts that you need. If you have ever done any plumbing around the house, you may already have some of these parts.

If you don't have experience with solvent-welding PVC pipe fittings or soldering copper pipe fittings, click on the links to the left for some simple guidance.

Power and Audio Cables

The power and audio cables will need to be long enough to reach the transmitter at its final installation location.

You can extend the 18 VAC wall transformer output wire by fabricating an extension from readily available parts. Obtain one 2.1 mm power plug (female) and one 2.1 mm power socket (male) from RadioShack. Most any two conductor wire will work because the current draw is small. A length of lightly insulated lamp cord will work as long as the insulated wire will fit into the plastic handle of the 2.1 mm plug. Solder the plug and jack to the ends of the two conductor wire. Polarity is not important.

Obtain audio cables that will be just long enough to reach the transmitter in its final installation location. You can join shorter cables with female-to-female adapters. If the adapters will be outside, be sure to tape them well to seal out moisture. Long audio cables will attenuate higher audio frequencies. You can compensate by driving the audio from a low impedance source such as the 8 ohm speaker output terminals of a stereo amplifier. Make sure the Treble Boost jumper plug (S6) on the transmitter board is installed in the shorted position. You may also want to add treble boost to your audio source signal.

Fabricating The Loading Coil

This is the most time consuming step. The coil is made by wrapping #16 Nysol insulated wire in a tight spiral around a section of 3" white schedule 40 PVC pipe. However, tapping points must be formed at every other turn near one end of the

coil, making the winding process a little more complicated. Note that the outside diameter of the 3" PVC pipe is actually 3 1/2". The 3" nominal size refers to the inside diameter.

Do not use gray or black PVC pipe for the coil. Use only white schedule 40 PVC. Gray and black PVC may be formulated with carbon pigment, which can cause coil losses to be higher.

Preparing The PVC Pipe Before Winding The Coil

PVC pipe cutters are available, but are expensive. PVC can be easily cut with a hacksaw. A 24-tooth blade will make a nice cut. Use a miter box or other suitable method for guiding the blade to get a square cut. Or, you can mark the cut line with a pencil around the circumference, and make partial cuts incrementally around the circumference to avoid drifting off the line. Use sandpaper to remove outside burrs.

1. Begin by cutting an 11" section of 3" white PVC pipe (ref. 16).

2. Use medium-grit sandpaper to sand the entire outside surface until all lettering is removed and the surface is no longer shiny.

3. Mark the pipe 2 inches in from each end and wrap masking tape around the pipe at the marks so that the pipe is exposed between the marks. Coat the entire 7 inch long exposed area with exterior grade varnish to seal the pipe and keep it from absorbing moisture (PVC tends to absorb moisture over time which can lead to higher coil losses).

4. After the varnish dries, use a fine-tipped felt marker and a straight-edge to draw a single straight reference line from one end of the pipe to the other, parallel to the sides of the pipe.

5. On the reference line, mark and drill a 3/32" diameter hole 3" from one end. Now mark and drill a second 3/32" diameter hole 1/2" to either side of the first and at the same 3" distance from the end of the pipe. These two holes will secure the wire while you wind the coil.

Winding The Coil

You will now begin winding the coil, but first some important points. The coil must be wound tightly. There must be no space between turns. Be careful to avoid kinking the wire. Carefully straighten any kinks as you go along.

This is fairly stiff wire and will spring outward if you don't maintain constant tension on the wire while winding. Cut a bunch of 2" long strips of plastic electrical tape before you start. Keep them handy to put on the coil at various places as you wind to hold the wire in place. There will be a total of 87 turns in the coil. You should apply a strip of tape to the coil about every 5 turns or so to prevent the coil from springing out if you relieve the tension at any time. After winding is complete, you will be drilling two more holes to secure the wire at the far end. Once the wire is secured tightly through these holes, you can safely remove all the tape strips.

To avoid kinking the wire, it must be unrolled from the spool as you roll it onto the pipe. Place the spool of wire on a dowel or metal rod that is secured in a vise, or C clamp, in a vertical position. Devise a method for putting some drag on the spool

to keep the wire in tension as you wind. One way to do this is to clamp the dowel somewhat off-vertical so the spool tends to bind slightly against the top of the vise as you unwind the wire.

1. Unwind some wire from the end of the spool and insert the end about 12" into the hole that is on the reference line. Using pliers, form the wire protruding inside the pipe into a U shape and feed it back out through the second hole. Keep forming and pulling the wire out until the wire is snug against the inside of the pipe between the holes. Bend the length of the wire that now protrudes outside the pipe toward the closest end of the pipe to keep it out of the way while you wind the coil.

2. Electrically, it doesn't matter which direction you wind the coil. Choose a direction that is comfortable for you.

3. Wind 63 full turns of wire, tight and closely spaced around the PVC pipe. Secure this part of the coil well with tape before continuing to wind the rest of the coil.

Beginning at turn 63, you will be forming a tap point every other turn for the remainder of the winding process. A tap is formed by bending the wire with pliers to form a small "U" or hump in the wire. The hump should be about a quarter inch wide and about a quarter inch high. These measurements aren't critical. The objective is to form the wire out away from the pipe sufficiently to allow clearance for soldering a wire to the tap.

Before forming each tap, the wire needs to be tinned with solder for a total length of about 1" (1/2" on either side of the center of the tap). The wire has an insulating coating. If you purchased the recommended Nysol insulated wire, you may be able to solder directly to the wire with a high wattage iron without first stripping the insulated coating. Test this by attempting to apply solder to the end of the short piece of wire protruding from the pipe at the start of the winding. It helps to scrape away a small area of the coating down to bare copper to aid heat flow to the wire. Start heating at the bare copper and flow a blob of solder onto the wire. Move the iron and solder blob slowly along the wire until the Nysol coating begins to bubble and the solder adheres evenly to the wire. If you are not satisfied with the results, you will need to thoroughly scrape away the coating all around the wire with a sharp knife before applying solder.

Taps should be staggered about a half inch each side of the reference line to make it easier to make a connection without shorting to adjacent taps. Begin with the peak of the first tap hump positioned 1/2" before the reference line, then position the next tap hump peak 1/2" after the reference line, and so on.

4. Form the first tap at turn 63 (reference line minus 1/2").

5. Wind two full turns and form a tap that is staggered from the previous tap (reference line plus 1/2").

6. Repeat step 5 until you have a total of 12 taps staggered alternately before and after the reference line. The last tap should be at the 85 turn point.

7. After the last tap, continue to wind 2 more turns to the reference line.

8. Cut the wire with about 2" excess after the reference line. Secure the wire

well with tape while you drill two more holes. This wire will be connected to the antenna pipe clamp in a later step.

9. As you did at the beginning of the coil, drill two 3/32" holes at the end of the coil, one on the reference line and one 1/2" beyond the reference line. Insert the wire end into the hole on the reference line and back out the other hole. Cut the wire that now protrudes out to about 1/2". Then scrape and tin the end. This end wire is at turn 87 and will serve as the final "tap" point.

10. Now that the wire is secured at both ends of the coil, you can remove all the tape strips.

11. Coat the outside of the coil with a second coat of exterior grade varnish taking care not to get varnish on the wire ends or on the taps Coat just the coil, not the unvarnished ends of the plastic pipe.

12. After the second coat of varnish dries, remove the masking tape and cement the 3" PVC pipe caps (ref. 15) onto the ends of the coil pipe. See Solvent Welding PVC Joints for PVC pipe cementing instructions.

Antenna Construction Steps

First, some notes on cutting copper pipe. The best way to cut copper pipe is with a wheel-type tubing cutter. A cutter that can handle up to 3/4 in. pipe is inexpensive and worth purchasing at a home improvement store Copper pipe can also be cut with a fine-tooth hack saw. Be careful while cutting copper pipe with a hacksaw so as not to deform the circular shape of the pipe. Don't bear down too heavily while cutting, and lighten up while cutting the last little bit. Use a file to dress down any burrs.

1. Cut a 98" length of 1/2" copper pipe (ref. 2).

2. Solder the cap to one end (ref. 1). See: Soldering Copper Pipe Joints for instructions if you haven't soldered copper pipe before.

3. Cut a 10" length of 3/4" copper pipe (ref. 4).

4. Solder the 3/4" sweat to 3/4" male threaded copper adapter (ref. 6) to one end of the 3/4" pipe (ref. 4). Soldering the adapter in this step before cutting slots in the pipe in the next step will alleviate possible problems caused by pipe deformation while clamping for the cuts.

5. Lengthwise slots must be cut in the top end of the 3/4" copper pipe (ref. 4). Clamp the pipe in a vise or clamp it to a work surface with C clamps. Use some small scrap boards to distribute the clamping force to prevent deforming the pipe. Using a 24-tooth hacksaw, make two 3 in. long cuts in the form of a cross as illustrated.

6. Bend two of the opposing tabs created in step 5 inward a little more than the thickness of the pipe wall to allow the tabs to overlap each other when the hose clamps are tightened.

7. With a fine tipped felt pen, mark the non-capped end of the 1/2" antenna pipe at three points 3", 7", and 11" from the end. Extend the marks at each point all the way around the circumference of the pipe. Label each line: "top" (at

3"), "mid" at (7"), and "bottom" at (11"). This will help during the tuning procedure to indicate the limits of adjustment.

8. Loosely position the two hose clamps (ref. 3) over the 3/4" copper pipe (ref. 4). Temporarily insert the non-capped end of the 1/2" copper pipe (ref. 2) into the 3/4" copper pipe for a distance of at least 4" or more. Tighten the top hose clamp while watching for the tabs in the 3/4" pipe to begin overlapping each other. If the tabs jam together and don't overlap, try loosening the clamp and re-bending two opposing tabs a little farther inward (repeat of step 6). Once the overlap allows you to clamp the 1/2" pipe firmly, tighten the bottom clamp firmly. Now that the clamps have formed the tabs in the proper position, you may loosen the clamps and remove the 1/2" pipe to make it easier to finish assembling the antenna.

9. Cut a 10". length of 1 1/2 " PVC pipe (ref. 9).

10. Cement a 1 1/2" slip to 1 1/2" female threaded PVC adapter (ref. 14) on each end of the 10" PVC pipe (ref. 9).

11. Screw the 1 1/2" male threaded to 3/4" female threaded galvanized iron reducing bushing (ref. 7) into the PVC adapter at either end of the 10" PVC pipe. The threads are tapered so the fittings will get tight when they are threaded together about half way. Tighten firmly with a wrench or large channel-lock pliers.

12. Screw the threaded end of the adapter (ref. 6) previously installed on the 3/4" copper pipe (ref. 4) into the 3/4" threaded center hole in the reducing bushing (ref. 7). The threads are tapered so the fittings will get tight when they are threaded together about half way. Tighten firmly with a wrench or large channel-lock pliers.

13. Install the pipe grounding clamp (ref. 5) onto the upper portion of the 3/4" sweat to 3/4" male threaded copper adapter (ref. 6). This is called a "grounding clamp" in the electrical trade, but is actually being used here to make the RF connection to the copper antenna pipe.

14. Fasten the completed loading coil assembly to the 1 1/2" PVC pipe section (ref. 9) oriented with the tapped end of the coil down. Use two plastic wire ties (ref. 8) around the loading coil pipe and the 1 1/2" PVC pipe as illustrated. Position the tie wraps just inside the caps as illustrated. If your wire ties aren't long enough, you can daisy chain two or more to get the required length. Tighten the wire ties as much as you can with pliers. Apply a dab of PVC cement to both wire ties where they contact the 1 1/2" PVC pipe to prevent them from slipping.

15. Cut the 12" top coil end wire just long enough to comfortably reach the "ground clamp" (ref. 5) without straining. Scrape (if necessary) and tin the end of the wire. Insert the end of the wire into the ground clamp and tighten the wire clamping screw firmly.

Mounting The Weatherproof Box

Since the exact mounting position and dimensions are determined by the size and shape of your chosen weatherproof, the following steps are written in general terms.

Here are some important points to keep in mind.

- The transmitter should be mounted no higher than the bottom of the loading coil winding. This will minimize capacitive coupling between the coil and the transmitter board.
- The antenna and ground leads that run from the transmitter to the coil and the metal pipe mast, respectively, should be kept as short as possible for Part 15 compliance. Generally, this limits the choice of transmitter orientation inside the box to the vertical position with the transmitter rear panel facing up, as illustrated.
- The component side of the transmitter circuit board must be accessible for setting the frequency switches and adjusting the trimmer capacitor. Again, the transmitter orientation shown in the illustration is good for accessing the board.
- The weatherproof box should be no larger than necessary to reduce wind resistance and stress on the box mounting points. For a heavier box, you might consider using two U-shaped pipe mounts to attach the box more securely.

Now on with mounting the box:

1. Drill holes in the box for the two mounting screws (ref. 13). Exact position is not important, but they should be spaced far apart and should be on the vertical center line of the box.
2. Drill holes in the box large enough to pass the power and audio cable plugs into the box. These holes should be offset horizontally from the box center line enough to clear the mast pipe and must be positioned upward from the transmitter enclosure rear panel in its final position. See illustration. Note: if your audio source is already monophonic, you need only one audio cable plugged into either audio jack on the transmitter. If your source is stereo, you will need both left and right audio cables.
3. Drill a separate hole large enough to pass the antenna and ground wires out of the box.
4. Temporarily thread the top end of the antenna mast pipe (ref. 12) into the threaded PVC adapter (ref. 14) and tighten firmly.
5. Hold the box in its final position against the mast pipe and mark the locations on the pipe for the two mounting screws (ref. 13). Drill holes in the mast pipe at the marked locations. Use a drill sized to just clear the diameter of the screws at the valleys of their threads. Run the screws in and out of the holes a couple times to form the threads in the pipe sections.
6. With the same drill bit used in the previous step, drill a hole in the mast pipe for the self-threading ground screw (ref. 13) approximately as shown in the illustration. Run the screw in and out of the hole a couple times to form the threads in the pipe.
7. Attach the box to the mast pipe with two self-threading screws (ref. 13) through the mounting holes just prepared.

8. Attach the mating halves of the adhesive velcro strips (ref. 10) to the bottom of the transmitter enclosure and to the inside of the weatherproof box, respectively as illustrated. Remove the top cover from the transmitter for later access to the switches and trimmer capacitor for final tuning. You may elect to just leave the cover off in the final installation.

9. Route the antenna and ground wires from the transmitter rear panel out through the hole in the box that you previously drilled for them. Cut the black ground wire to the minimum length that will comfortably reach the ground screw on the mast pipe, allowing an extra 3/4" for the connection. Strip 3/4" of insulation from the wire. Lightly twist the conductor strands together, and tin the exposed wire with solder. Don't connect the ground wire to the mast pipe yet.

10. Cut the white antenna wire to the minimum length that will comfortably reach the uppermost tap on the coil (not the upper coil end wire), allowing an extra 1/4" for the connection. Strip 1/4" of insulation from the wire. Lightly twist the conductor strands together, and tin the exposed wire with solder. Don't connect the antenna wire to the coil yet. You will do that later after selecting the proper tap in the tuning procedure.

11. Remove the antenna assembly from the mast pipe by unscrewing at the antenna assembly/mast pipe fitting. Lay the antenna assembly aside while you install the mast pipe in its final location.

Installation

Installing The Mast Pipe

Install the mast pipe (ref. 12) securely in its final position making sure that the threaded end with the ground screw hole is at the top. How you mount the mast pipe is up to you. Some suggestions:

- If the mast pipe is fairly short, dig a hole about 3 ft deep and 1ft in diameter. Place the mast pipe in the hole. Mix a bag or two of concrete and pour around the pipe in the hole. Support the pipe vertically (check with a level) until the concrete sets.

- A longer mast pipe may be installed on the side of a building. You can use TV antenna mast wall mounts (RadioShack), or you can fabricate wood or metal wall standoff supports and use U shaped pipe mounts or U bolts. Wood supports can be fabricated from 2 x 4 wood stud stock. Metal supports can be fabricated from universal angle iron stock and bolts. The pipe should extend all the way to ground level to provide the necessary signal ground path and added support.

Grounding The Mast Pipe

Grounding is very important to the performance of your antenna. The mast pipe needs to be well grounded to minimize antenna ground loss. High resistance to ground will cause most of your signal to be dissipated in the ground resistance. Ground resistance drops when you are able to connect to a conductor that has a large area buried in moist ground.

A metal cold water pipe that has a good conductive path underground can

sometimes provide a very good ground, but presence of corrosion, gaskets, poorly conducting fittings or plastic pipe sections can severely affect the conduction path.

If your soil around the mast is relatively rock free, you will get good results with several 8-foot long electrical grounding rods driven vertically into the soil around the base of the mast. You will need to connect the tops of the rods to the mast with heavy copper wires (#14 or #12 are practical sizes). Use one or more grounding clamps above ground level at the base of the mast pipe to connect the ground wires. The ground rods are made of steel clad with an outer jacket of copper. They are available from home improvement stores and electrical supply dealers.

Burying a number of bare copper wires at least 6 ft. long (longer is better) in a radial pattern around the base of the mast is a popular solution, especially when your soil is too rocky for ground rods. Use as many wires as you can manage and make them as long as possible. Use un-insulated wire that is #14 gauge or heavier. Solid un-insulated wire is available in various size rolls from home improvement store and electrical supply dealers. You can rent a powered wire trencher from your local tool rental store. They cut a slot in the ground with a bladed wheel. You can lay a lot of wire in one day with a trencher. The wires need to be bonded together at the mast and connected to the mast. You can use one or more grounding clamps at the base of the mast pipe above ground level.

Mounting The Antenna And Transmitter To The Top of the Mast Pipe

1. Screw the antenna assembly onto the top of the mast pipe and tighten firmly.
2. Attach the black ground wire to the mast pipe by forming the wire around the ground screw and then tightening the screw firmly down on the wire to make good contact.
3. Slide the 1/2" antenna pipe (ref. 2) back into the slotted 3/4" pipe (ref. 4) for a distance of 7" so the line labeled "mid" is even with the top of the 3/4" pipe, and tighten the two hose clamps (ref. 3) sufficiently to keep the antenna pipe from slipping downward.

Tuning

Proper tuning of your antenna is critical to achieving maximum performance. The antenna has a very sharp resonance point. You must follow the tuning instructions carefully. Tuning must be done with the antenna installed in its permanent location.

1. Route the audio and power cables up to the transmitter, pass them through the holes in the transmitter box, and plug them into the transmitter jacks.
2. Apply power to the transmitter and connect the audio cables to an audio source.
3. Loosen the two hose clamps enough to be able to work the 1/2" pipe up and down for adjustments, but not so loose that it slides downward on its own. Start at the midpoint of adjustment range, which is the point where the 1/2" pipe is inserted into the top end of the 3/4" pipe for a length of 7". The range of adjustment is plus or minus 4" from the midpoint. Never raise the antenna to a point where less than 3' is inserted into the top of the 3/4" pipe, or it will

not be supported properly by the hose clamps.

4. Insert the probes from an analog or digital voltmeter into the two holes on the right side of the transmitter circuit board labeled T1 (positive) and T2 (negative). Set the meter to read DC volts, and set it to the lowest range that will allow reading up to about 15 volts DC. Your voltmeter should have an input impedance rating of at least 10 megohms. This is common for virtually all battery operated meters currently on the market.

5. Choose your desired operating frequency in the range between 1500 kHz and 1700 kHz. Pick a frequency that is unused in your area. Set the 8-position DIP switch, S4, to your chosen frequency according to the chart in the manual. Also, double check that all four switches on the 4-position DIP switch, S5, are set to the ON position. Set the trimmer capacitor, C5, to its minimum setting (rotate until the half moon shaped metal plate on the top faces the front side (control side) of the transmitter circuit board.

6. Set the front panel GAIN control to its minimum setting (fully counterclockwise) to ensure the transmitter is not being modulated during the tuning process.

7. Holding the short antenna wire lead coming from the transmitter antenna plug, touch it to the topmost loading coil tap (topmost tap, not the top end of the coil). Note the meter reading. Now touch the wire to each successive tap, moving downward along the taps (including the bottom coil end wire) until you find the tap that gives the highest meter reading. If you see the voltage peak and then start to drop lower as you move to successive taps, go back to the one that gives the highest reading. Temporarily clamp the wire in contact with this tap using an alligator clip or small paper clamp and move your hands and body away at least 2 feet. Note the meter reading and then move and clamp the wire to successive taps on either side of this tap until you find the one that gives the maximum meter reading with your hands and body away from the antenna at least 2 feet.

8. Fine tune the antenna by working the 1/2" pipe antenna up or down about a half inch at a time until you find the position that gives the highest meter reading with your hands and body at least a 2 feet away from the antenna.

9. If the voltage reading at the tuning peak is greater than 13 volts DC, increase the trimmer, C5, capacitance by rotating the trimmer clockwise until the voltage drops to 13 volts DC. Re-adjust the antenna length downward until the voltage peaks again. If the voltage peak is still higher than 13 volts DC. Repeat the process of increasing the trimmer capacitance and re-tuning the antenna until you get 13 volts DC at the tuning peak. You should only have to repeat this process a couple of times. This is an important step. Don't treat it lightly. If the voltage is not reduced to 13 volts DC, your RF output signal may be distorted resulting in audio distortion of the received signal. When the meter reads 13 volts DC, the antenna is perfectly matched to the transmitter: the power output will be maximum and the audio will be undistorted.

10. Solder the transmitter antenna lead to the selected tap. All other taps above and below your selected tap will remain unconnected. The portion of the coil between the selected tap and the top end wire now has the required inductance to tune to your selected frequency. The portion of the coil below

your selected tap is electrically open-circuited and does not contribute to the coil inductance.

11. Re-check that the voltage reading is still 13 volts. If it has changed higher or lower, repeat steps 8 and 9 to ensure the antenna is tuned properly after soldering the transmitter antenna wire, and then tighten the two hose clamps firmly.

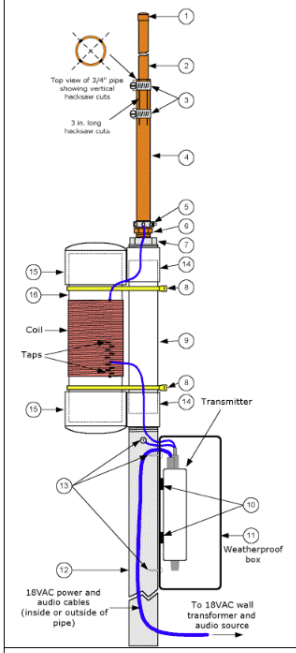
12. Adjust the GAIN, MODULATION, and COMPRESSION controls to your preference according to the instructions in the manual. If you choose to use an external audio processor for level, compression and limiting control, set the GAIN and MODULATION controls to maximum (fully clockwise) and set the COMPRESSION control to minimum (fully counterclockwise). Your external audio processor must then be set for the proper audio level and limit level to achieve 100% modulation without over modulation.

Sealing The Box Against Moisture

Apply RTV silicone adhesive or 100% silicone caulk liberally around all wires where they enter the box to block any moisture from entering the box. .This is an important step. Any water that gets onto the circuit board will quickly damage the board. Attach the box cover.

Antenna Diagram And Parts List
(Revised 05/05/2009, MarVac Electronics link updated)

Back to "Building a Base-Loaded Vertical Antenna"



Dwg. Ref.	Qty	Description	Source
1	1.	1/2" copper pipe cap	Home improvement store (plumbing dept.)
2	98 in.	1/2" copper pipe (Type L)	Home improvement store (plumbing dept.)
3	2	3/4" hose clamps	Home improvement store (plumbing dept.)
4	10 in.	3/4" copper pipe (Type M)	Home improvement store (plumbing dept.)
5	1	Pipe grounding clamp to fit 3/4" pipe	Home improvement store (electrical dept.)
6	1	3/4" sweat to 3/4" male threaded copper adapter	Home improvement store (plumbing dept.)
7	1	1 1/2" male threaded to 3/4" female threaded galvanized iron reducing bushing	Home improvement store (plumbing dept.)
8	2	large plastic wire tie, also known as "tie wrap"	Home improvement store (electrical dept.)
9	10 in.	1 1/2" white schedule 40 PVC pipe	Home improvement store (plumbing dept.)
10	2	3" long adhesive-backed Velcro strips	Home improvement store (hardware dept.)
11	1	Waterproof box: plastic or metal outdoor electrical box. Minimum inside dimensions: 7" x 6.5" x 2"	home improvement store (electrical dept.) or electrical supply store
12	(see note 1)	1 1/2" rigid metal conduit	Home improvement store (electrical dept.)
13	3	#10 x 1" self-tapping stainless steel screw	Home improvement store (hardware dept.)
14	2	1 1/2" slip to 1 1/2" female threaded white schedule 40 PVC adapter	Home improvement store (plumbing dept.)
15	2	3" white schedule 40 PVC cap	Home improvement store (plumbing dept.)
16	11 in.	3" white schedule 40 PVC pipe	Home improvement store (plumbing dept.)
-	1	Small can PVC solvent cement, medium consistency	Home improvement store (plumbing dept.)
-	1	Small can PVC solvent cleaner	Home improvement store (plumbing dept.)
-	1	1 lb spool #16 AWG gauge magnet wire	MarVac Electronics http://marvac.com/detail.aspx?ID=32610 or powerwerx.com http://www.powerwerx.com/product.asp?ProdID=2101

Note 1. Be sure to use "rigid metal conduit", not the lighter grade conduit made for interior wiring. You can join several lengths with threaded couplers to get your desired height. If you need to cut an odd length, be sure the cut end is on the bottom of the mast and that a threaded end is on the top.

Modifying the AMT3000 for Driving the Base-Loaded Vertical Antenna

(Updated July 1, 2009)

Why Do You Need to Modify Your AMT3000?

The AMT3000 is designed for ease of tuning with a non-critical antenna setup for the casual user who wants to broadcast to radios within a house. The standard AMT3000 antenna output circuit is designed to match a high-impedance, short wire antenna. The base-loaded vertical antenna presents a low-impedance to the transmitter. The simple transmitter changes described here enable the AMT3000 to drive the low impedance antenna efficiently. The AMT3000 internal inductors are bypassed, and instead, the external base-loading coil provides the required inductance. The antenna has a very high Q, which means that harmonic radiation will be highly attenuated (just as is true for the standard AMT3000). The transmitter modifications do not change the FCC-mandated 100 milliwatt RF input power specification.

If You Have Not Yet Assembled Your AMT3000

If you have not yet assembled your AMT3000 kit and want to use it with the base-loaded vertical antenna, follow these instructions.

1. Skip the assembly step that calls for installing resistor R18 (820 ohms). This component location will remain vacant.
2. At the assembly step that calls for installing capacitor C23 (820 pF), install instead, a 560 pF, 50VDC ceramic capacitor. Both the 820 pF capacitor and the 560 pF capacitor are included in the kit. If you have misplaced the 560 pF capacitor, you may order one by sending an e-mail request to mailto:orders@sstran.com.
3. Install a jumper plug across the two jumper pins at location S7.
4. Set all four switches to the ON position on the S5 DIP switch pack. These switches must always remain ON. They are not used as part of the tuning procedure for the base-loaded vertical antenna.
5. Follow the tuning instructions in Building a Base-Loaded Vertical Antenna in place of the tuning instructions in the manual.

If You Have an Assembled AMT3000

If you already have an assembled AMT3000 and want to modify it for driving the base-loaded vertical antenna, follow these instructions.

1. Remove resistor R18 (820 ohms). You can clip the resistor out with wire cutters or unsolder it. This component location will remain vacant.
2. Unsolder capacitor C23 (820 pF) and insert in its place a 560 pF, 50VDC ceramic capacitor. If you have misplaced the 560 pF capacitor that was included in your kit, you may order one by sending an e-mail request to mailto:orders@sstran.com.
3. Install a jumper plug across the two jumper pins at location S7.
4. Set all four switches to the ON position on the S5 DIP switch pack. These switches must always remain ON. They are not used as part of the tuning procedure for the base-loaded vertical antenna.
5. Follow the tuning instructions in Building a Base-Loaded Vertical Antenna in place of the tuning instructions in the manual.