Converting an AD9850 DDS Signal Generator into an Amplitude Modulated Exciter

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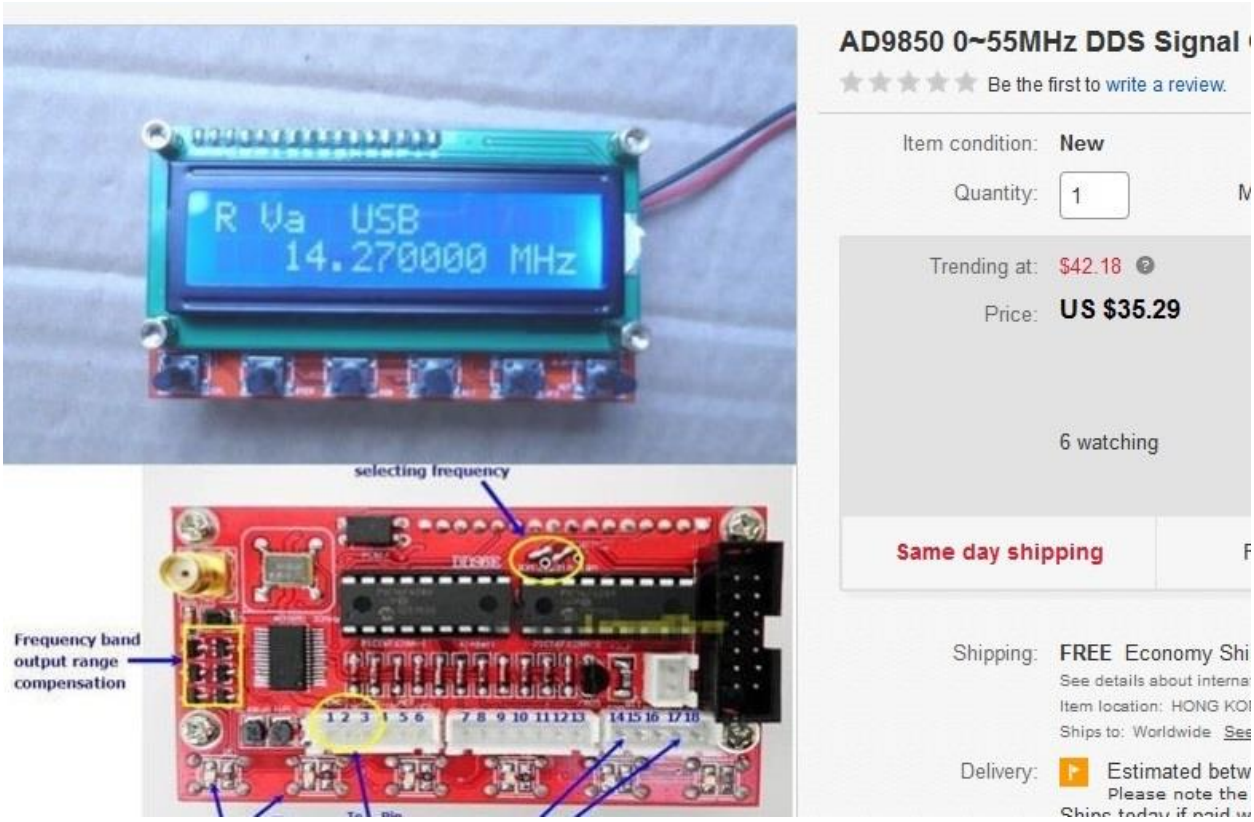
The Analog Devices AD9850 DDS Synthesizer is a popular chip for VFO projects. Ready-made boards from overseas are cheap and available on EBay. Although the modulator circuit I've come up with should work with any AD9850 based board, the focus of this article will be on the device shown below. It's available on EBAY. Search for 0-55MHz DDS VFO. This article is meant to be a guide and not step by step instruction. It was written with the assumption that the experimenter knows what they are doing!!!

Amplitude modulation is created by injecting audio into the power control stage of the AD9850 (Pin12). The Analog Devices recommends a 3.9K resistor from Pin 12 to ground which fixes the output level for the chip. This modification requires replacing that 3.9k resistor with the circuit shown on the next page. The AD9850 is capable of transmitting a fully modulated AM signal with audio bandwidth exceeding 20-10,000Hz. Audio harmonic distortion measured at 1 KHz is 5% @95% modulation… which isn't too bad. The audio input requires a line level signal.

There is scattered info about this VFO on the internet but nothing very clear about its operation. I've attempted to document this device with more accuracy and detail. Even if you're not interested in making this gizmo into a transmitter, it will still make an excellent DDS VFO!



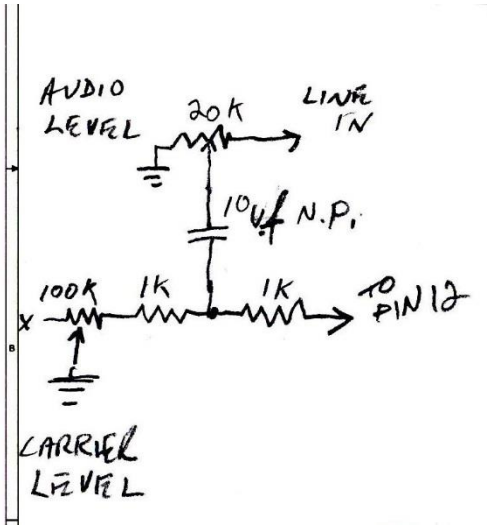
This VFO has a few nice features that make it very functional for the ham radio operator.

-Band switching outputs for nine HF band sections.

-Built in amplifier stage which brings the RF output to around 0dBm. This is a good level for directly driving the final PA stage in many 100 watt class HF transceivers.

-Frequency compensated design keeps the output level from dropping off above 24 MHz

-19 memory channels



Above is the modulator circuit. This circuit is a bit of a balancing act between the carrier and audio settings. Changes to the carrier control will affect the audio level. Changes to the audio control will not affect the carrier level. Set the carrier level first, then adjust the audio.

Notes

1. After removing the 3.9K resistor use a shielded piece of wire to connect the power control pot (10 turn 100k). Make sure the shield goes to ground and the center wire goes to the pad connected to pin 12 on the AD9850. A 330pf or 470pf goes across this connection to bypass any stray RF to ground. Immobilize the wire with a zip tie to avoid stressing the tiny solder pads.
2. The onboard 78L05 gets fairly warm with a 13.8 volt supply. Power the VFO with 8 volts or replace the 78L05 with an external 7805.
3. With the back of the VFO facing you, you will see two solder bridges (blobs) near the top right between the PIC controllers and the solder pads for the LCD. Remove the bridge marked 21M (the one on the right). Leave the other bridge in place. These two bridges enable the frequency compensation circuit. The bridge on the left enables the compensation circuit for 10 meters and is necessary for sufficient output power. The one on the right however, boosts 15 meters too much and that's why it needs to be disconnected.

4. The mode switch steps through AM, CW, USB and LSB. These "modes" only change the offset frequency that is programmed in the CAL menu. There is a separate +5v output signal for each mode selected.
5. **Getting the VFO into transmit mode** Transmit mode switches the R on the LCD to T. It also disables the CW offset and RIT. The attached schematic shows a PTT switch attached between U3 pin 2 and ground. It doesn't work. R2 (4.7k) needs to be changed to 10k for that circuit to function.
6. **If you use this VFO/exciter to drive a transceiver output stage you will be bypassing the transceiver's ALC and SWR fold back protection!!! Understanding an amplifier's operating parameters is key. Know before you blow!** …sorry
7. Power output from the VFO is lower on 160m than the other bands.
8. **Final PA (RF) amplifiers** There is a classic 100 watt design that seems to be used in many '80's and '90's Japanese transceivers. A single 2SC1971 driving a pair of higher rated transistors (2SC2509 in the Kenwood 450S) driving a pair of 2SC2879 as finals. The output level range of the VFO is suitable for the input level of this type of amplifier. But it still is possible to overdrive the amplifier input (and therefore the output) if the carrier control is set too high! I've also used this VFO with an Icom 706. The Icom 706 PA has a lower input drive requirement so 15dB of attenuation was needed on the VFO output. Be Careful!
9. I found the attached schematic on the web. It is not completely accurate!!
10. **Band Switch outputs** from PIC2 (U2). Many HF amplifiers have 6 band filters. Using diodes I combined the outputs of pins 16 and 15 for 20 meters, 13 and 12 for 15 meters and 11 and 10 for 10 meters. See the attached photos.

PIN

1 .918 - 2.883 MHz

18 2.884 – 5.898 MHz

17 5.899 – 8.912 MHz

16 8.913 – 12.976 MHz

15 12.977 – 16.908 MHz

13 16.909 – 19.922 MHz

12 19.923 – 23.986 MHz

11 23.987 – 27.918 MHz

10 27.919 – 30.015 MHz

4 30.016 – 56.250 MHz

11. Parts:

    EC11 rotary encoder

    10 turn 100k potentiometer for the carrier control *

10 turn 20k potentiometer for audio level control *
1k, 4.7k and 10k ¼ watt resistors
10uf non-polarized capacitor
330pf or470pf capacitor
1N4148 or similar diodes
ULN2803A Darlington transistor array. This chip's 8 outputs can be directly connected to the band switching relays on a PA filter board. There are other ways of controlling those relays but this chip simplifies things. A +5v signal on the input will sink the output to ground (up to 500ma).

*The 100k 10 turn pot is necessary for accurate carrier control but you might be ok with a 1 turn 20k pot for the audio

Buttons

CAL- Push and hold while powering on the VFO to enter the calibration mode. While in the calibration mode the CAL button will step through the following menu. Use the rotary encoder to change the settings.

DDS REF MULT - X1 or X6 Default is x1 for the AD9850 chip

SYSTEM CLK - Calibrates the output frequency for dead on balls accuracy.

OFFSET FREQ – Changes the displayed frequency by the selected value. The actual output frequency remains the same.

MAX DDS FREQ – Sets upper tuning limit.

MIN RX DDS FREQ – Sets lower tuning limit.

SSB OFFSET – When in USB or LSB mode, the actual VFO output frequency is shifted by the selected amount in both TX and RX mode.

CW OFFSET – When in CW mode, the actual VFO output is shifted by the selected amount in the RX mode only.

SAVING – exactly that

Remember to step through all menus until "SAVING" appears!

Without activity, the calibration mode will timeout in 8 seconds and normal VFO operation will resume. No settings will be saved.

STEP – Press and hold. An underscore will appear on the LCD display. Use the rotary encoder to select the step size then release. Pressing the rotary encoder switch also selects step size.

RIT/VFO SWAP – Short press enables RIT. Use rotary encoder to adjust RIT frequency. Long press swaps Va and Vb frequencies. B=>A or A=>B

SSB/LOCK – Short press cycles through AM, CW, LSB and USB modes. Long press locks VFO

VFO AB/MEM SAVE – Short press selects Va or Vb. Long press displays ->

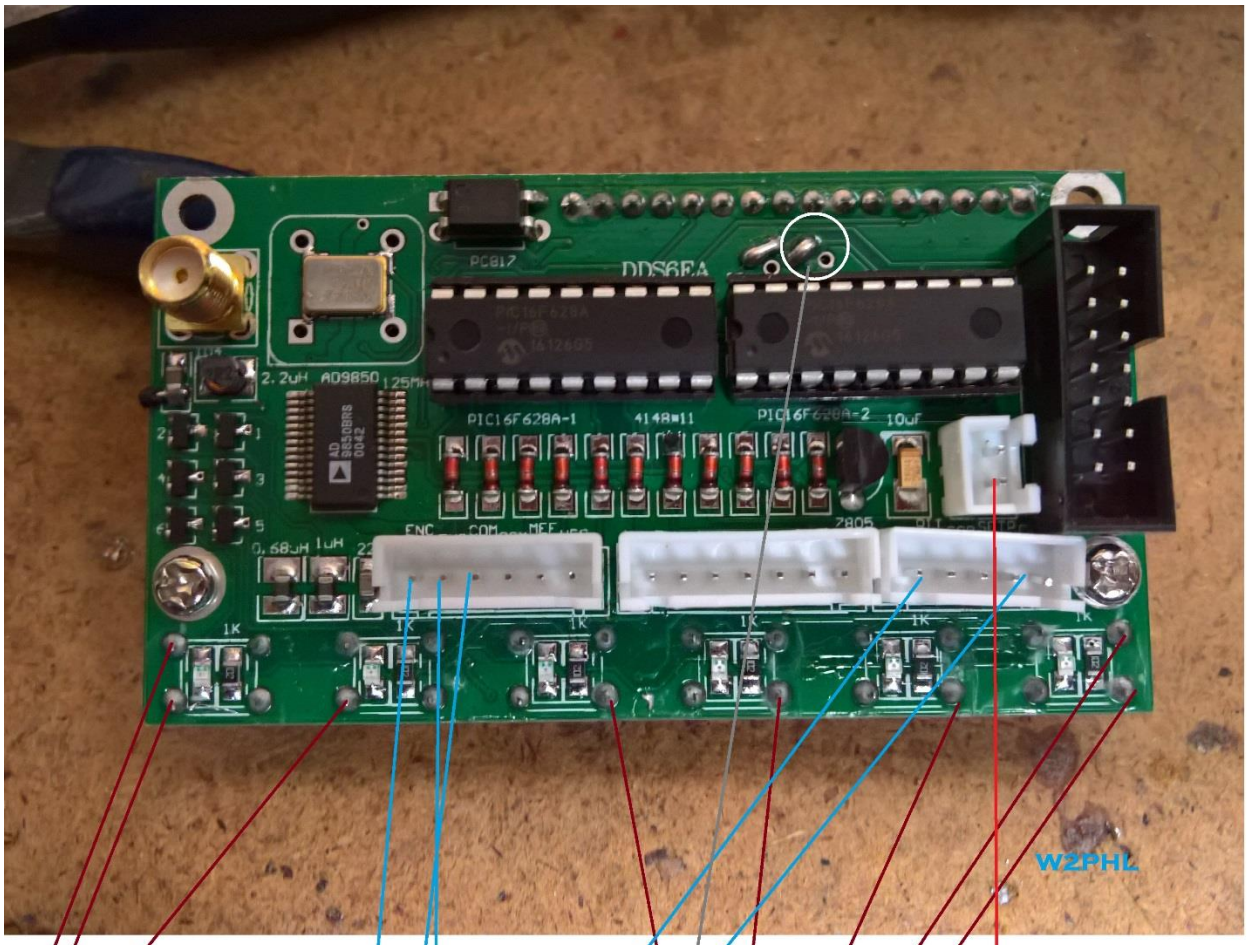
MEM/VFO – Short press selects memory or VFO mode. Use rotary encoder to select M1-M19. Long press selects memory save.

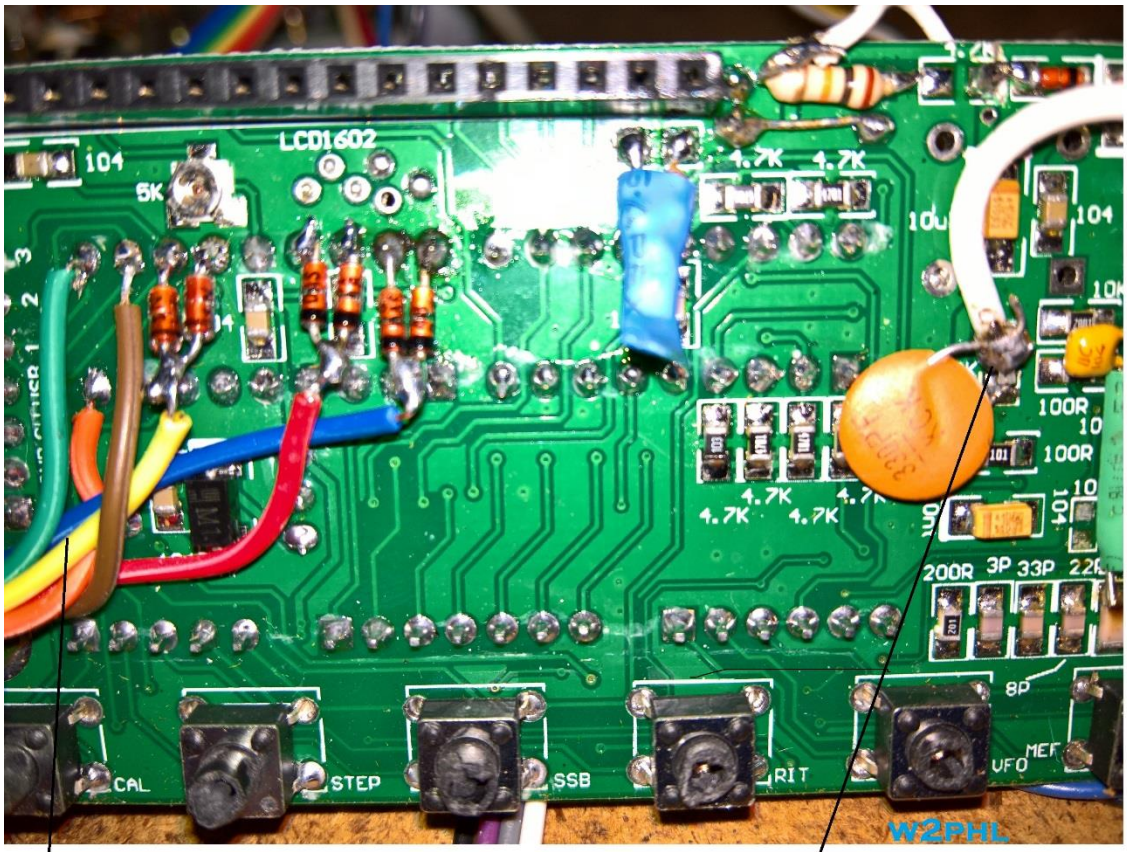
Save VFO to memory

1. Select the desired memory location (M1-M19) using MEM/VFO button and the rotary encoder.
2. Return to VFO mode (MEM/VFO button). Tune either Va or Vb to the desired frequency.
3. Long press VFO AB button until "->" is displayed. If it doesn't appear after a few seconds, release VFO AB and try again. It always works on the second try.
4. Long press MEM/VFO until "SAVE TO Mxx" appears, then release. Long press MEM/VFO again until "SAVING" appears.

Write memory to VFO

1. Select the VFO you wish to write to with VFO AB button.
2. Select desired memory location M1-M19 using MEM/VFO button and rotary encoder.
3. Long press MEM/VFO to transfer memory to the selected VFO.

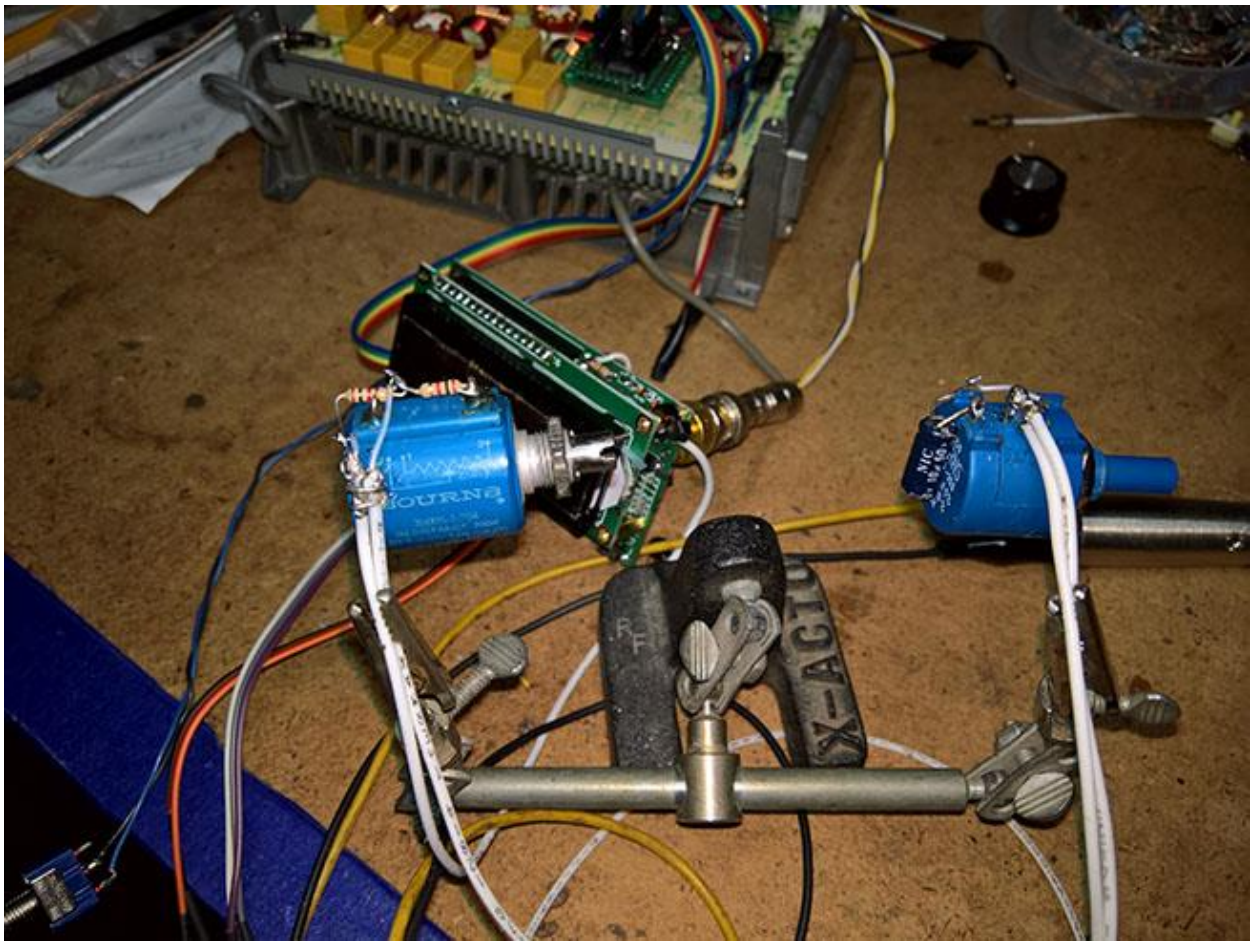

DDS6EA
PIC16F628A-1
AD9850
W2PHL
COMMON FOR MEM/VFO & VFOAB
MEM/VFO
VFO AB
CAL
COMMON FOR CAL, STEP, MODE, RIT
STEP
MODE/LOCK
RIT
+ 8 VDC
ROTARY ENCODER
FRONT VIEW
1 2 3
4 5
FREQUENCY COMPENSATION JUMPERS:
REMOVE THIS BRIDGE TO REDUCE OUTPUT ON 15M



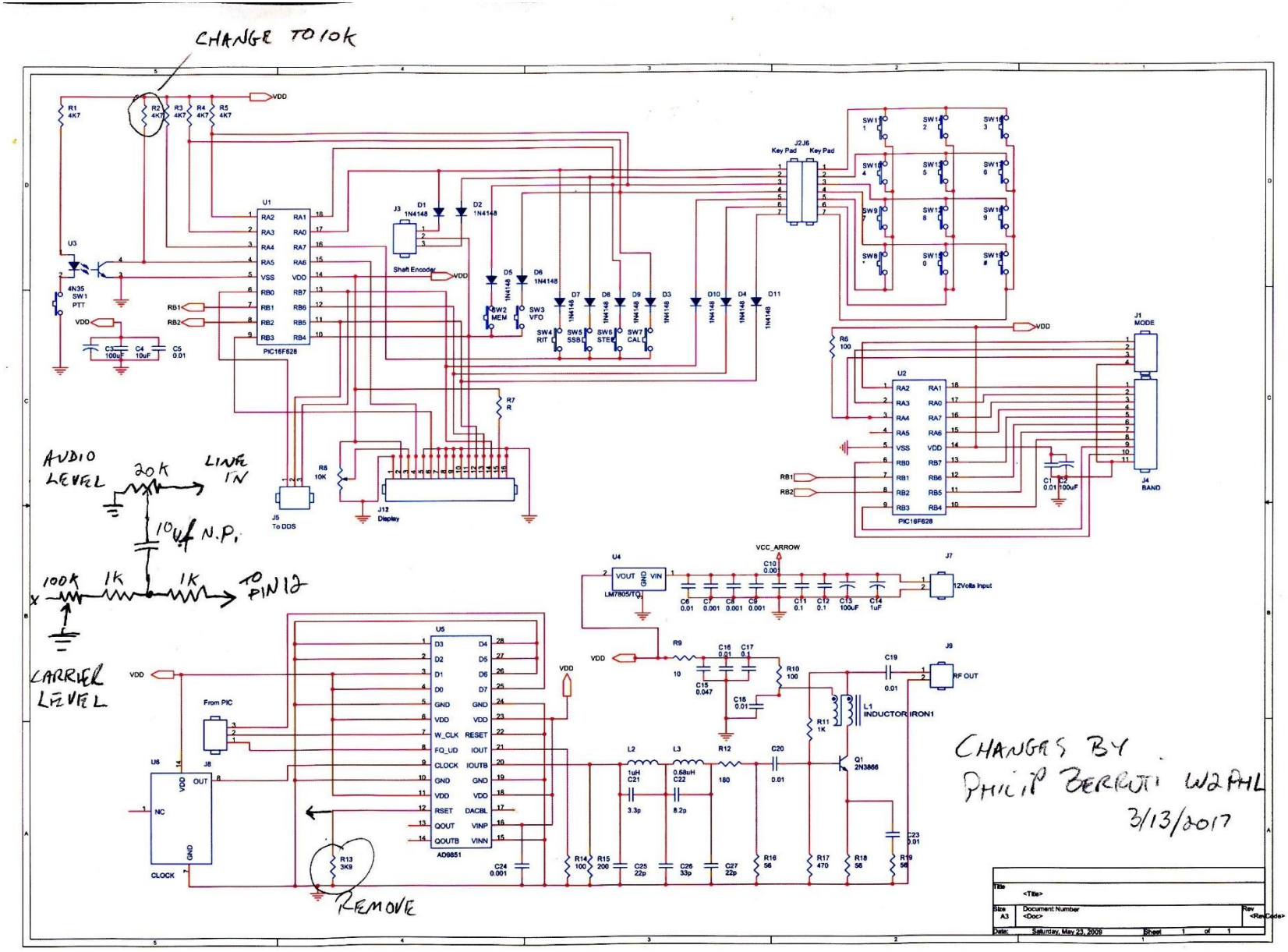
BAND SWITCH SIGNALS +5 VDC

(THE CATHODES ARE ONLY CONNECTED TO THE WIRES. THEY ARE NOT BRIDGED TO THE OTHER SIDE OF THE CHIP!!!)

SHOWING SHIELED WIRE IN PLACE OF 3.9K RESISTOR WITH 330PF CAP ACROSS THE SHIELD AND CENTER



Carrier level pot is on the left.


CHANGE TO 10K
AUDIO LEVEL
20K
LINE IN
10uf N.P.
100K
1K
1K
TO PIN 12
CARRIER LEVEL
REMOVE
CHANGES BY PHILIP BERRUTI W2PHL 3/13/2017
PIC16F628
AD9851
LM7805/TO
12Volts Input
RF OUT
Key Pad
Shaft Encoder
To DDS
Display
From PIC
CLOCK
INDUCTOR/IRON1
2N3866
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