JUMA 100W PA – Digital Board

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Contents

Purpose

This is the third document in this series that describes the build and testing of the JUMA PA100-D in a step by step process with thoughts and ideas based on my build of the 100W PA. Most of the graphics are from the JUMA website[1] and are placed in the order of the build as it progressed. Other photographs are those taken by myself during the build of the PA100-D.

This document aggregates the information provided on the JUMA website into a single document with additional commentary by myself. Thanks also to Ed (WA4MZS) for review comments which have been included.

Each section of the document provides the schematic diagram, the PCB layout, parts list and then the installation instructions. Testing of the PA100-D is in the latter part of the document.

Digital Control Module

General

JUMA PA100 Digital Control module provides the necessary control signals for the JUMA PA100 main board and for the power amplifier module. The schematic diagram for this board is provided in Figure 1 and Figure 2.
The Digital Control module measures and displays various analog signals like power, SWR and amplifier temperature. Users can select the measured parameters for the display. The display is 2x16 characters in size. The output power is shown with a graphical "bar graph" display. User controls are eight push buttons. Please refer to the User Manual for push button functions. The Digital Control Module monitors SWR, amplifier temperature and drain current measurements. The firmware generates alarms and shuts down the power amplifier if limits are exceeded.

Operating modes

The Digital Control Module can be used to select the amplifier operating frequency manually. Three automatic frequency tracking modes are also supported. The Digital Control Module can communicate with the JUMA-TRX2 through RS232 interface. Yaesu 817 voltage coded band data input is also supported. The Digital Control Board circuitry and firmware also supports an input frequency sensing technique. F-sense band selection allows the JUMA-PA100 to automatically track the band with any SSB / CW transceiver.

Power supply

A linear regulator is used to generate the +5V main operating voltage for the Digital Control board. +5V is also used for the microcontroller A/D converter reference voltage. The accuracy of the measurements depends upon the +5V supply. There is a calibration procedure for most A/D measurements in the microcontroller firmware. Push button SW7, Diode D1 and FET transistors Q1 & Q2 form the firmware controlled power switch. Transistor Q4 switches power for the main board.

Microcontroller

The dsPIC30F6014A microcontroller is a performance overkill for this application. The PIC 30F6014A is however a good choice for this application for several reasons. Controlling the JUMA-PA100 amplifier requires plenty of microcontroller I/O resources. An 80-pin 30F6014A microcontroller provides all that we need. The microcontroller is the same that is used in the JUMA-TRX2. This makes logistics and firmware support easier.

[1] http://www.jumaradio.com/juma-pa100/

Fan control

Power amplifier cooling fan speed is firmware controlled. The firmware can set three different fan speeds. The fan motor current is set with R1, R2, Q5 and Q6.

SPI bus

SPI bus is reserved for possible extensions.

F-Sense circuit

The F-sense board conditions and limits input RF signal for the frequency measurements. Future signal clipping is done with Schmitt trigger inverter IC1. After IC1 the RF signal is counted with microcontroller Timer1 system. A firmware algorithm is used to find out SSB signal frequency.

Digital I/O

Two digital outputs 2DB and 4DB are used to control RF input attenuator.
Six digital outputs 1M8 to 21-28M are used to control the filter select relays.
The control signals are:
OC digital input is the over current indication from the main board.
OC-CLR is digital output for clearing the over current protection circuit.
KEY is digital input requesting amplifier on.
TX+ is digital output controlling the power amplifier on/off state.
PWR-SW is digital input indicating power switch button state.
PWR-ON is digital output controlling the power supply on/off switch transistors.
FAN1 and FAN2 are digital output signals for the fan control.

RS232 interface

Microcontroller UART1 is connected to RS232 transceiver circuit IC10. RS232 signals are connected via main board to the F-sense board and back plate jack. RS232 interface can be used to connect the JUMA-TRX2 and JUMA-PA100 together for band tracking. RS232 interface can also be used for various JUMA-PA100 tests. Microcontroller UART2 is reserved for future use. UART2 signals are available at connector J1.

Analog measurements

Microcontroller A/D converter is used to measure six different analog signals. The signals are:

ID	Power amplifier transistor collector current
BATT	JUMA-PA100 operating voltage
BAND	Yaesu 817 band select voltage
REW-PWR	SWR bridge reflected voltage
FWD-PWR	SWR bridge forward voltage
TEMP	Amplifier temperature

LCD

A 2x16 character LCD display is used to display the amplifier state and measurements. Firmware loads some custom characters to the display. A bar graph meter is formed and displayed with these custom characters. The LCD back light and contrast are user adjustable.
The Microcontroller PWM unit is used to form two DAC outputs:

- First DAC R41, C71, IC11-A, Q3 and associated components generate adjustable LCD back light current.
- Second DAC R39, C70 and IC3A provide contrast voltage for the LCD display.

Push buttons

Front panel buttons are momentary switches which firmware reads via microcontroller I/O pins. When the button is pressed I/O logic state is “0”. In normal state push button I/O signals are “1” logic state. Switch debounce is done in the firmware.

Feedback tones

User interface feed back tones are played with a miniature speaker BZ1. A microcontroller timer and PWM system is used for the sound generation.

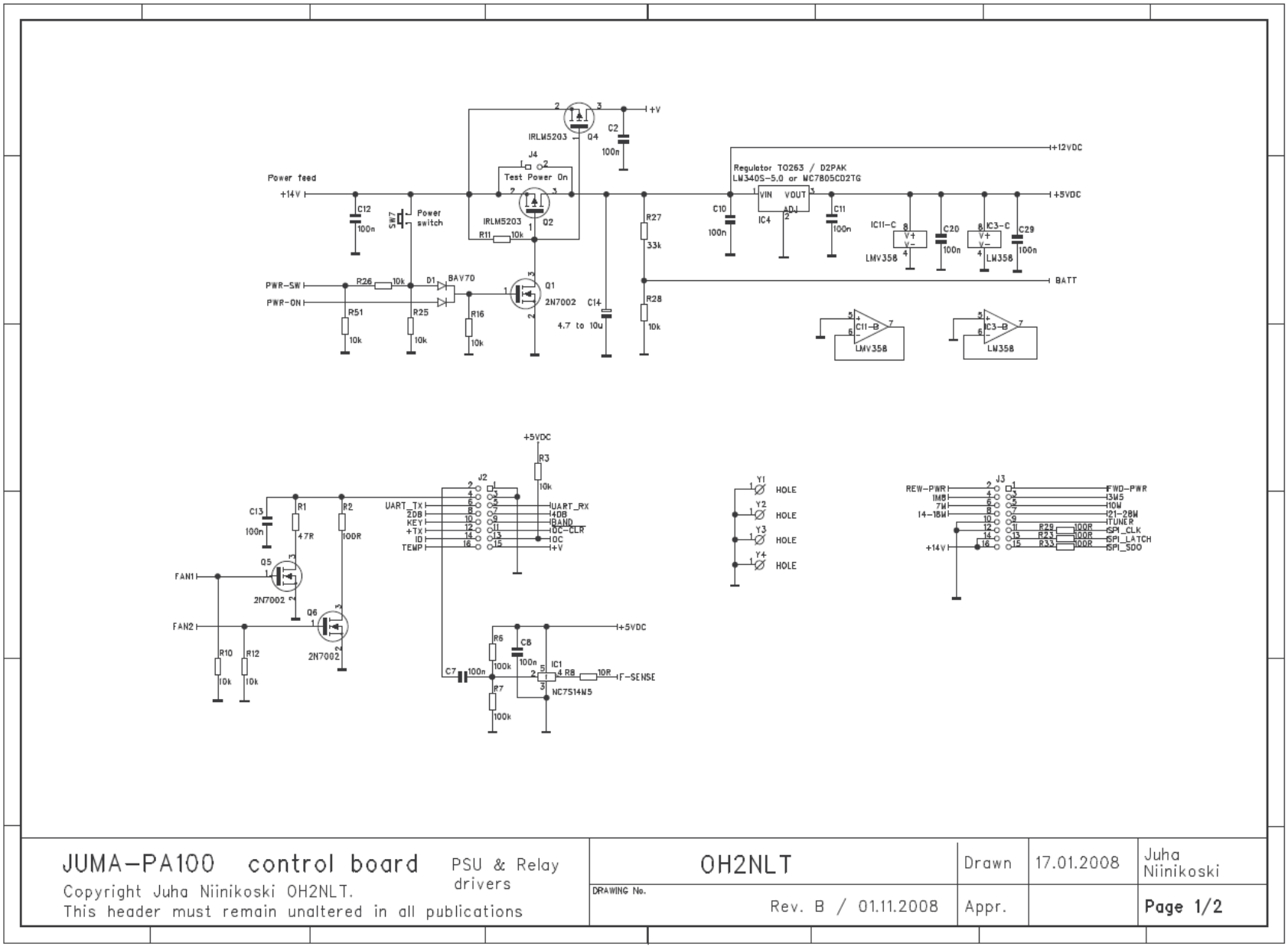

Figure 1 JUMA-PA100 Digital Board Schematic Diagram Page 1

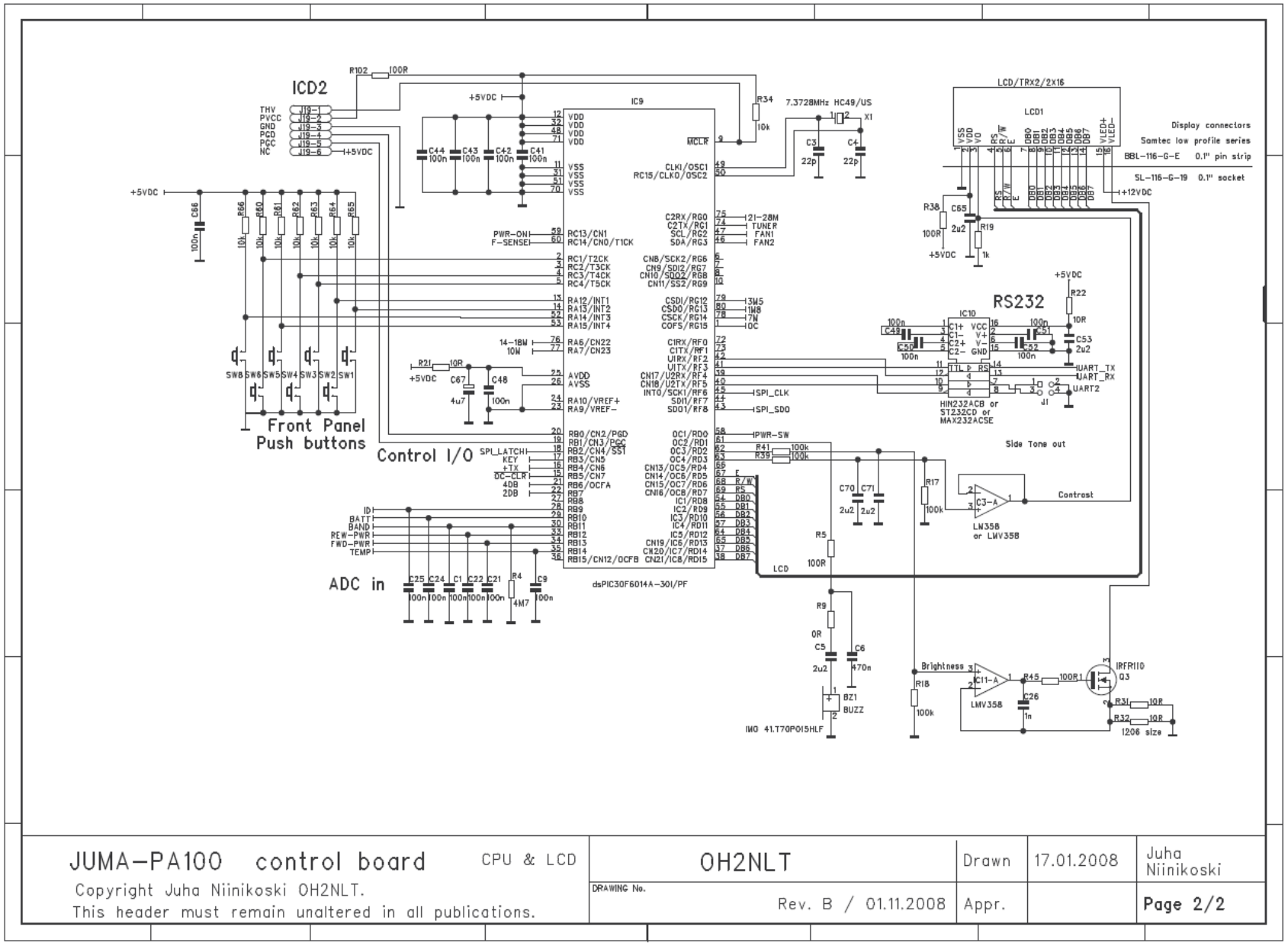

Figure 2 JUMA-PA100 Digital Board Schematic Diagram Page 2

PCB Layout

Figure 3 and Figure 4 show the top views of the Digital Control PCB, both diagrammatic and actual.

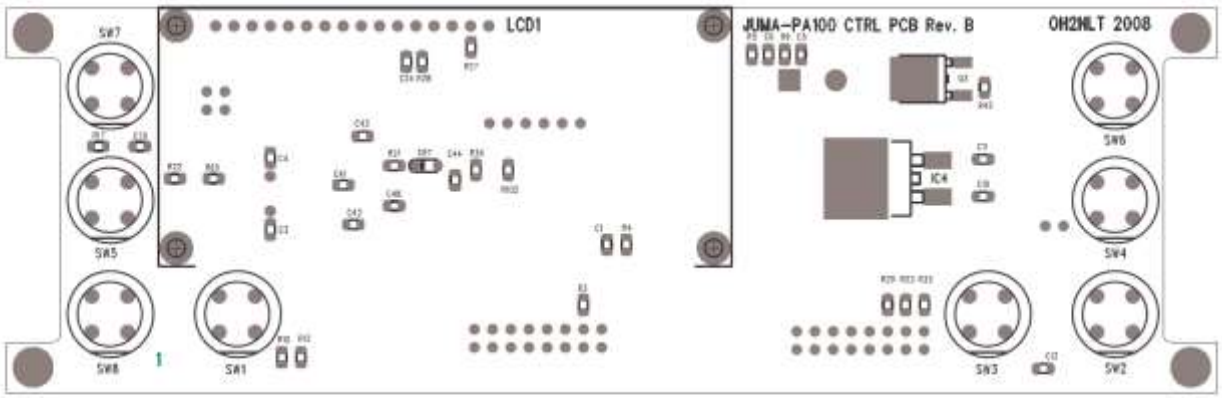

Figure 3 Digital Control Board – Diagrammatic Top View

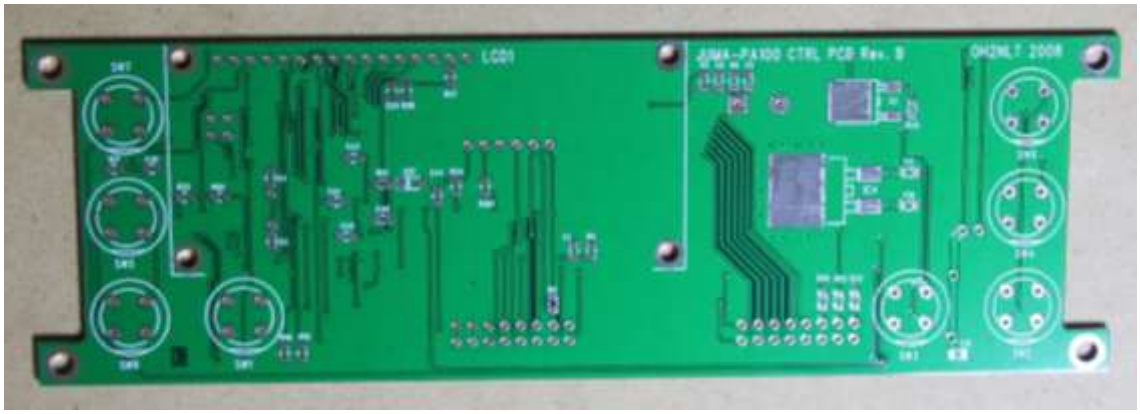

Figure 4 Digital Control Board – Top View

Figure 5 and Figure 6 show the bottom views of the Digital Control PCB, both diagrammatic and actual.

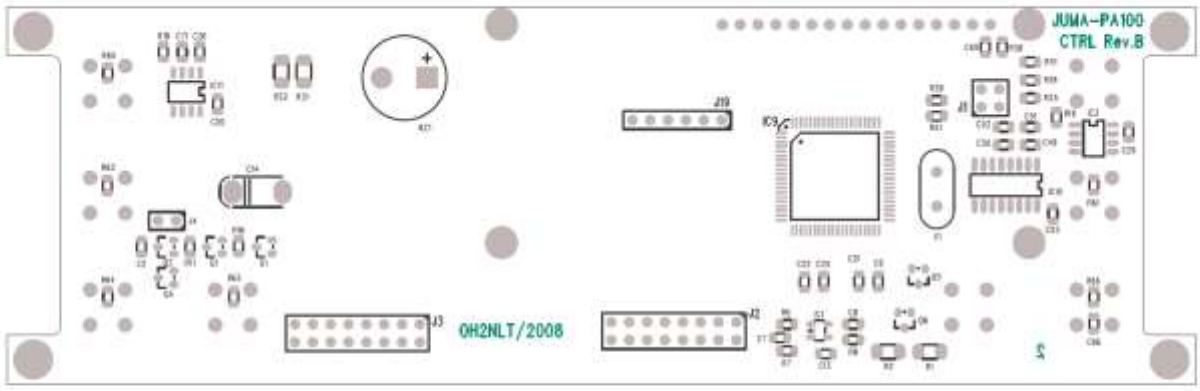

Figure 5 Digital Control Board – Diagrammatic Bottom View

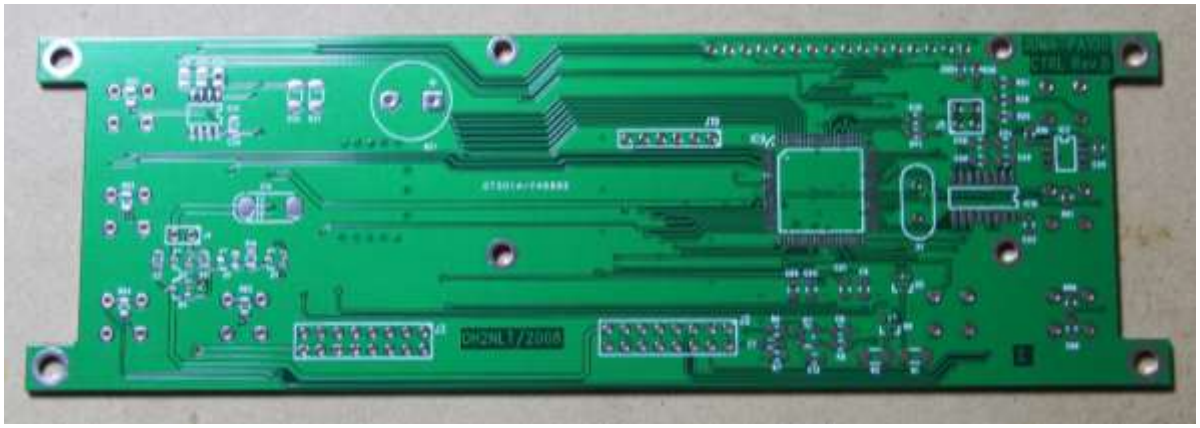

Figure 6 Digital Control Board – Bottom View

Resistors

JUMA-PA100 Digital Control Board Part list Rev. B 2017-05-04

Part number	Value / type	Qty	Description	Note
R31, R32	10R	2	Resistor SMD size 1206	
R1	47R	1	Resistor SMD size 1206	
R2	100R	1	Resistor SMD size 1206	
R9	0R	1	Resistor SMD 1%, 0805	
R8, R21, R22	10R	3	Resistor SMD 1%, 0805	
R5,R23,R29,R33,R38, R45,R102	100R	7	Resistor SMD 1%, 0805	
R19	1k	1	Resistor SMD 1%, 0805	
R3, R10, R11, R12, R16, R25, R26, R28, R34, R51, R60, R61, R62, R63, R64, R65, R66	10k	17	Resistor SMD 1%, 0805	
R27	33k	1	Resistor SMD 1%, 0805	
R6, R7, R17, R18, R39, R41	100k	6	Resistor SMD 1%, 0805	
R4	4M7	1	Resistor SMD 1%, 0805	

There are a large number of resistors to be mounted on the Digital Control Board and it is recommended that you mark each one off as you solder it in place. Refer to Figure 7 where you can see how I have marked each one off. As many of these are quite small I found that more time was spent finding the correct location on the PCB than was actually taken to solder them into place. Take your time and you will get through them all.

Figure 8 and Figure 9 show the Digital Control Board with both the resistors and capacitors fitted.

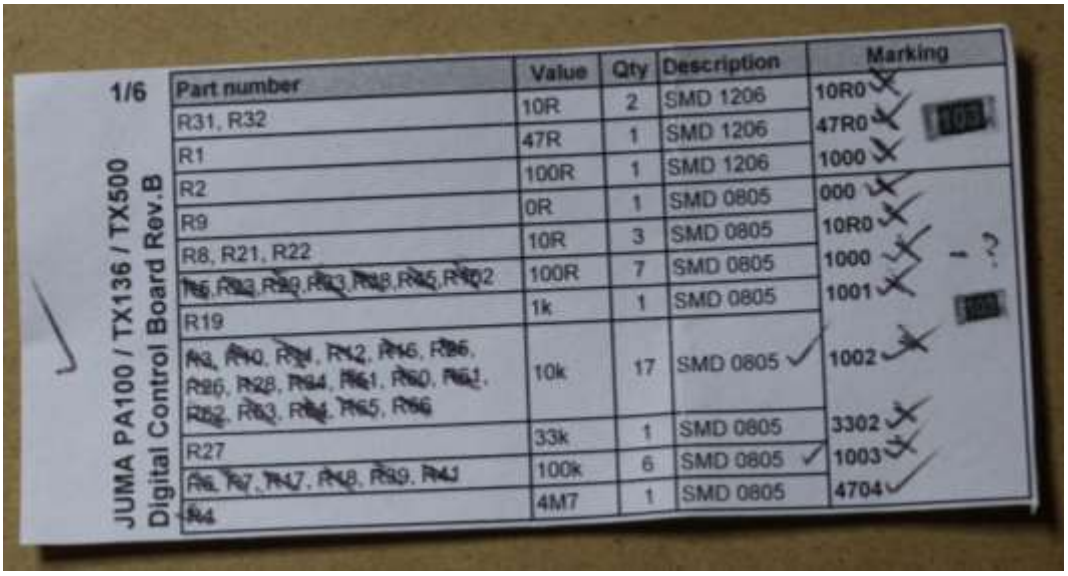

Figure 7 Digital Control Board – Resistor Pack Documentation

Capacitors

Part number	Value / type	Qty	Description	Note
C3, C4	22p	2	Ceramic NP0, 0805	
C26	1n	1	Ceramic X7R, 0805	
C1, C2, C7, C8, C9, C10, C11, C12, C13, C20, C21, C22, C24, C25, C29, C41, C42, C43, C44, C48, C49, C50, C51, C52, C66	100n	25	Ceramic 0805 X7R	
C6	470n	1	Ceramic X7R 0805	
C5, C53, C65, C70, C71	2u2/16V	5	Ceramic X7R 0805	
C67	4u7/6V Case style A	1	Tantalum Capacitor SMD	
C14	4u7/35V Case style D	1	Tantalum Capacitor SMD	

As with the resistors, there are also a large number of capacitors so take your time and work your way through them. There is colour coding on one of the capacitor packs and all the rest can be determined from the quantity supplied.

Figure 8 and Figure 9 show the Digital Control Board with both the resistors and capacitors fitted.

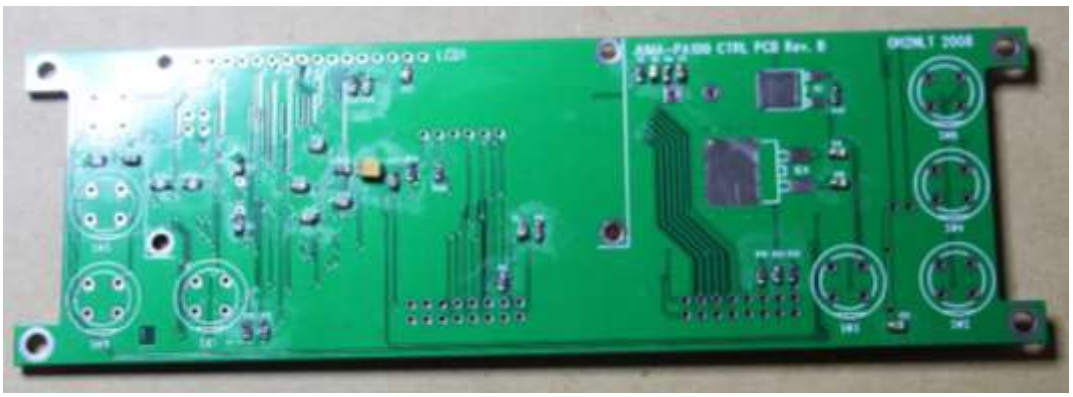

Figure 8 Digital Control Board – Top View with Resistors and Capacitors fitted

Figure 9 Digital Control Board – Bottom View with Resistors and Capacitors fitted

Semiconductor Devices

Part number	Value / type	Qty	Description	Note
D1	BAV70 SOT-23	1	Diode dual or similar SOT-23 common cathode Si-diode	
Q2, Q4	IRLML5203TRPBF SOT-23	2	or Si2307DS or Si2309DS or similar MOSFET P-type low Rds (< 0.5 ohm)	
Q1,Q5,Q6	2N7002 SOT-23	3	MOSFET N-type or similar, Rds < 10 ohm	
Q3	IRFR110 DPAK	1	MOSFET N-type	
IC4	7805 TO263 / D2PAK MC7805CD2TG or LM340S-5.0	1	Voltage regulator	
IC3, IC11	LMV358 SO-8	2	Dual OPAMP or similar rail to rail type	
IC1	NC7S14M5	1	SOT23 Schmitt trigger inverter	
IC10	HIN232ACB, Intersil, SO16	1	RS232 driver or ST232ACD ST Microelectronics, or MAX232ACSE Maxim	
IC9	Microchip dsPIC30F6014A-30 I/PF	1	Microcontroller	
X1	7.3728MHz XTAL	1	HC49/U4	

One of the problems I encountered with the semiconductors on the Digital Control Board was the correct orientation of the PIC on the board. This is an 80 pin IC and if you install it the wrong way round, removal without the correct equipment would be very difficult. My PIC had what appeared

to be two locating marks and initially I could not determine, which was the correct mark to use for orientation and which was simply a manufacturing mark. The Juma forum fortunately provided the answer. Ed WA4MZS provided the picture in Figure 10 and gave credit to N3ZV who had installed his PIC for the correct orientation. The larger mark is the manufacturing mark.

Before installing the PIC, I would recommend that you review some YouTube videos on the WWW to show the correct technique to soldering these components in place. The use of a liquid flux is essential. I took great care to get the IC aligned correctly in positon and then soldered just one pin to hold it in place and then one on the opposite side to lock it in. Soldering can then be done by the washing solder across all pins and then cleaning up using solder wick or by individually soldering each pin. Review what is on the WWW and then select the method you are most comfortable with or get someone more experienced to install that IC. Please ensure when you use this technique that you don't leave any solder bridges like I did. Refer to the Chapter on Testing to see what should be done before powering up. It is worth spending some time with a very good magnifying glass or loupe to ensure that you have not left a solder bridge between any of the pins on the PIC. Murphy's Law will state that it is between the +5V and the OV lines which is the problem that I had.

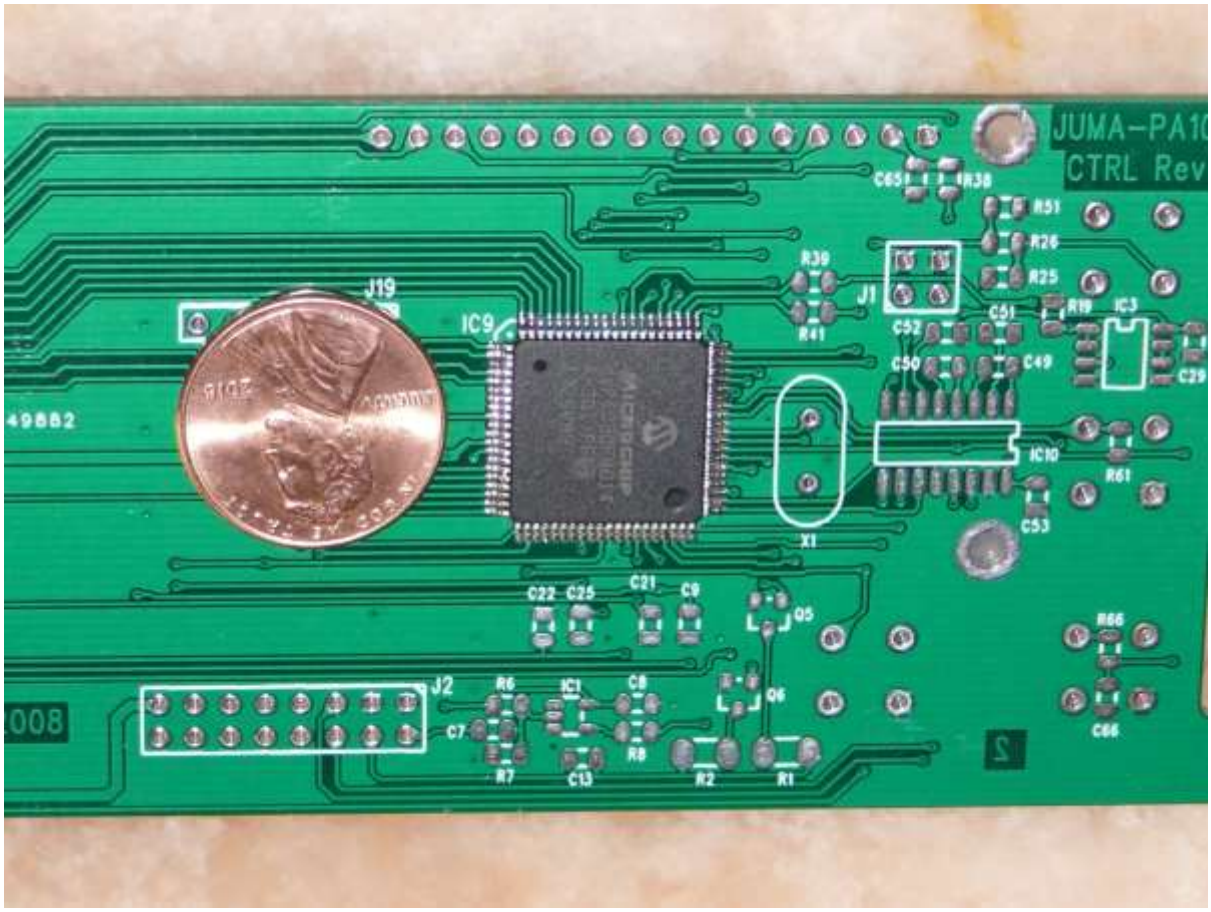

Figure 10 Digital Control Board – Bottom View with correct orientation of PIC

Figure 11 Digital Control Board – Bottom View with PIC and Crystal Installed.

Note that the crystal is actually included in the next pack (JUMA PA 100D / TX136 / TX500 Digital Control Board Rev.B 4/6).

Figure 12 Digital Control Board – Front View.

Other Hardware

Part number	Value / type	Qty	Description	Note
J2, J3	2x8 e.g. snippet of Tyco Electronics 5-826632-0 or MOLEX 90131-0775	2	Pin header 2.54 mm pitch pin length max 6.7 mm	
J1	2x2 e.g. snippet of Tyco Electronics 5-826632-0 or MOLEX 90131-0775	1	Pin header 2.54 mm pitch pin length 6.7 mm	
J4	1x2	1	Pin header 2.54 mm pitch pin length max 6.7 mm For test/programming power on jumper.	
J19	1x6	1	Pin header 2.54 mm pitch pin length max 6.7 mm e.g. snippet of Harwin M20-9992046 or MOLEX 90120-0784	

Part number	Value / type	Qty	Description	Note
Jumper	J4 / test power on. **Do not install** for normal operation.	1	Pitch 2.54 mm	
LCD1	Everbouquet MC1602C8-SBLWU, Blue	1	LCD module 2 x 16 with LED back light 12'o clock type!	
Machine screw	For LCD mounting	4	M2.5 x 12 mm, Phillips pan head	
Spacer tube	For LCD mounting	4	L 4 mm, D 5 mm, d 3.5 e.g Ettinger 05.53.043	
Washer	For LCD mounting	4	Shakeproof M2.5	
Nut	For LCD mounting	4	M2.5	
Tinned copper wire	0.5 mm, L approx 300 mm	1	For LCD module to DDS board interconnection	
BZ1	IMO 41.T70P015H-LF	1	Miniature speaker, PCB	
SW1, SW2, SW3, SW4, SW5, SW6, SW8	ITT Cannon D6R10LFS	7	Push Button Switch Grey	
SW7	ITT Cannon D6R50LFS	1	Push Button Switch Green	
Spacer screw	For DDS board installation into the front panel	4	M3, L=12 mm e.g. Ettinger 05.13.123 or 05.13.121 or Harwin R30-3001202	
Washer		4	Shake proof M3	
Nut	For spacer screw	4	M3	
Machine screw	M3 x 6	4	Phillips pan head PCB to front panel fixing	
PCB	JUMA PA100 Control PCB	1		
PCB	JUMA-PA100-D Front panel PCB	1		

The remaining hardware are the pin headers, the LCD display, the loudspeaker and the pushbuttons.

The LCD display is mounted using for M2.5x12 bolts with nuts and shakeproof washers. Fit these first before attempting to solder the connections between the two boards.

Ensure that the orientation is correct in that the solder holes on the top of the LCD display line up with the solder holes on the Digital Control PCB. This is shown in Figure 13 which also shows the 0.5mm tinned wire which has been provided to make the connections between the LCD display and the Digital Control PCB. This wire is provided in Pack 4/6.

Take care to ensure that the connections are straight through between each board as shown in Figure 14. Also make sure that none of the mounting hardware for the LCD display touches the components on the front of the Digital Board.

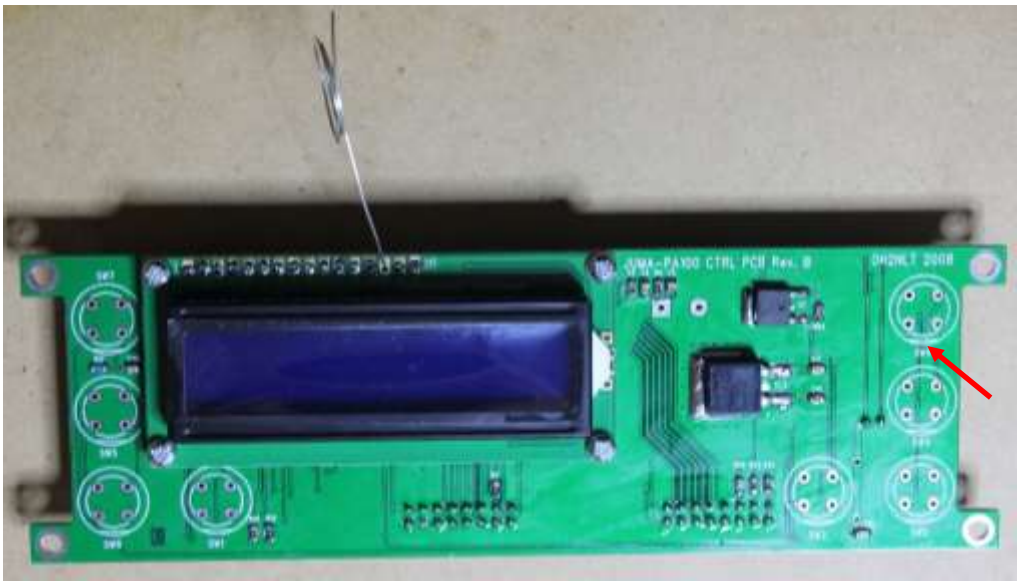

Figure 13 Digital Control Board – Front View with LCD display in place – last pin being soldered.

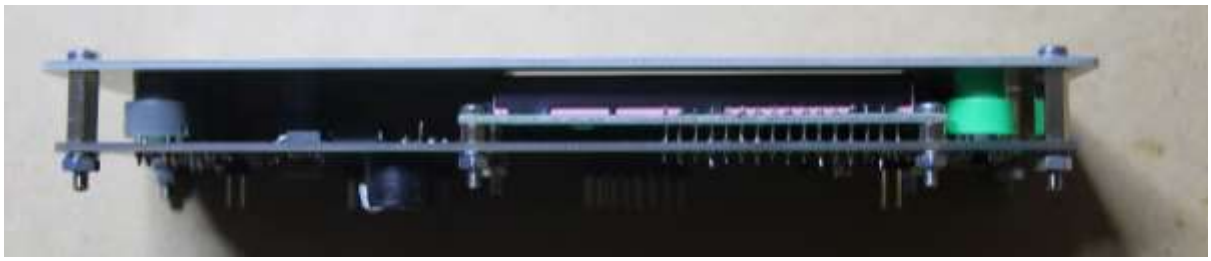

Figure 14 Digital Control Board – Top View with LCD display in place with soldered links.

Don't forget to mount the small loudspeaker as shown in Figure 15. Note that this component is polarised and the removable tab on the top shows the position of the positive pin.

Figure 15 Digital Control Board – Rear View with all components in place.

The next step is to fit the eight pushbuttons, 7 grey and one green. Make sure that the green one is in the correct position. To get the correct positioning of the pushbuttons put them into position without soldering making sure that the flats on the pushbuttons are correctly orientated to the indicator on the PCB. This is shown by the red arrow in Figure 13 and this orientation is applicable to each pushbutton. The pushbutton in their correct positons are shown in Figure 16.

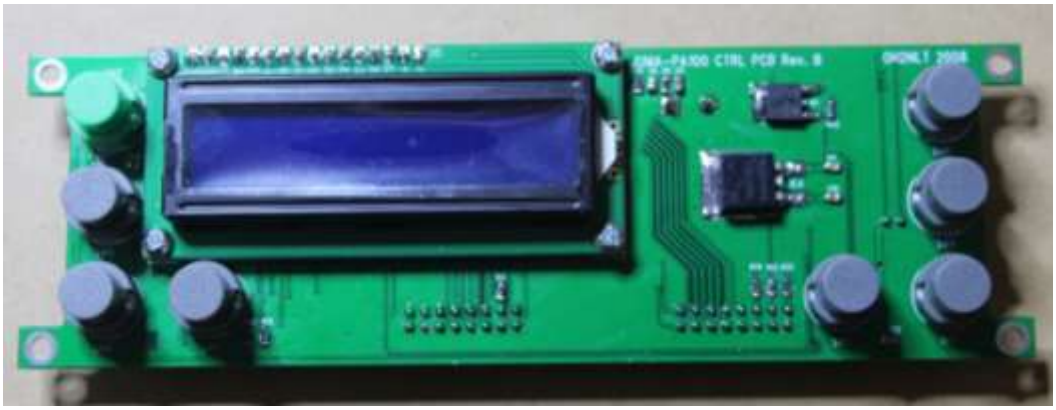

Figure 16 Digital Control Board – Front View with pushbuttons in place but not soldered.

Position the front cover over the pushbuttons and mount the front cover in place using the M3x12 spacers and associated M3 x 6 bolts, nuts and shake proof washers. This is shown in Figure 17.

Note that there is enough room for the pushbuttons to come out of the PCB but they can be easily repositioned into the correct holes.

Stand the board on edge and solder just one pin of each pushbutton to hold them in place. Then go around again gently pushing against each one while resoldering that hole. Once this is done the board can be placed on the front panel and all of the pins soldered to complete this board.

Figure 17 Digital Control Board – Front View with pushbuttons in place and front panel fitted.

Testing

At this stage I would recommend that you do a few tests before powering up the Digital Control Board to verify that it is working correctly.

I had rushed ahead at this stage and fully assembled the PA and then powered up the complete unit which resulted in smoke coming from the PA, which I later tracked down to be a burnt 12V line on the Main Board. Very frustrating!

Before powering up the digital board the following is suggested:

1. Measure the resistance between Pin 16 of J3 on the Digital Control Board and Pin 12 of J3 on the Digital Control Board. It should be a few hundred thousand ohms. Certainly not zero ohms. This will check the 14VDC line into the Digital Board.
2. Measure the resistance to ground on the output of the 5 VDC regulator, Pin 3 of IC4. It should be a high impedance to ground. Certainly not zero ohms which would indicated a short somewhere that needs to be found before you apply power. This checks the +5VDC line for shorts.

Using a current limited power supply:

1. Connect +12V to Pin 16 of J3 on the Digital Control Board,
2. Connect 0V to Pin 12 of J3 on the Digital Control Board
3. Press the Green button. This operates a latching circuit to hold the power on. The LCD display should show the sign-on message:

JUMA-PA100 V1.04
OH2NLT OH7SV

4. After a short delay, the main screen will be displayed.
5. Use the Band UP and Down buttons to step through the bands and generally have a play with the pushbuttons. Without the rest of the PA being connected there is limited functionality available.