

JUMA PA-100D OPERATING MANUAL **5B4AIY Firmware Version: 1.05b**

The PA-100D is a companion 100W all-band linear amplifier primarily intended for the Juma TRX-2 all-band 10W transceiver, but can also be used with almost any low-power transceiver.

This document describes the operation and setup of this equipment using firmware version 1.05b, software modifications and changes made by Adrian Ryan, 5B4AIY.

The revised firmware incorporates a number of changes to enhance the utility of this amplifier. These instructions assume that you have already performed the necessary setup and calibration steps.

The enhancements are:

1. User selectable temperature units of either Centigrade or Fahrenheit.
2. User selectable frequency/band units of either MHz or metres.
3. User selectable fan control option
4. Enhanced serial test facility.
5. Improved resolution and accuracy of voltage, current and power displays
6. Minor user interface modifications.

Front Panel Controls



Juma PA100D Front Panel

Control Description

PWR

This button is used to power-up and power-down the amplifier, as well as several secondary functions. To power up the amplifier, briefly press the button. The display will illuminate and a sign-on message will be displayed:

```
JUMA-PA100 1.05b  
OH2NLT OH7SV
```

After a short delay, the main screen will be displayed, as shown above.

UP/DOWN

These buttons are used to increment/decrement the various user settings, depending upon the current operating mode. In the normal mode, these buttons alter the gain settings of the amplifier, as shown by the G1 – G4 indicators on the display. G1 is the lowest gain, and the gain can be increased in 1dB steps. In fact, the “gain” changes are simply an attenuator being switched in and out of circuit, but it is convenient to think of this in terms of overall gain.

DISPLAY/CONFIG

This button has two functions. In the normal mode it allows the user to display a number of internal parameters. From the normal display, a single push will show the current output power. The next push will display the SWR, followed by the supply voltage, the amplifier current, and finally the temperature in either °C or °F.

If the button is pressed and held, this will invoke the User Configuration mode, which is fully covered in a later section. To exist from the User Configuration mode, press and hold the button until a beep is heard, whereupon the normal display will return.

OPER

This button is used to place the amplifier in either the standby mode or the operate mode.

With this firmware revision the amplifier will always power up in the standby mode as a precaution, except when the System Setup is selected, when it will power up in the operate state.

In the standby mode the signal path is straight through, with neither filters nor attenuation present. A connected transceiver will be able to transmit and receive directly to the connected antenna. The metering functions of the amplifier will operate to show the output power and SWR, although at low power levels the accuracy is somewhat reduced.

Press this button to select the operate mode. In this mode the amplifier will be fully functional.

If this button is pressed and the power switch operated to turn the amplifier on, the flash writer will be invoked. This is used with the Ingenia loader program to update the firmware. For further details, please see the article on the Juma website which covers this procedure.

AUTO

This button is used to select either the manual or automatic band selection, in conjunction with the BAND+ and BAND- buttons.

The current selection is displayed on the lower line of the display. To use the manual mode, press the button to select M on the lower line, and use the BAND+ or BAND- button to select an amateur band from 160m – 10m. This will select the appropriate low-pass output filter, but exercise care, as inadvertent selection of the wrong filter could damage the amplifier. For example, selecting the 80m band filter when transmitting on the 40m or higher band at high power levels could seriously damage the filters.

It is preferable to use the AUTO band select mode, if possible. In this mode there are three detection possibilities, selected via a setting in the User Configuration mode. Please refer to this section for details concerning the use.

BAND+

There is a secondary function to this button. By pressing and holding this button and then powering up the amplifier, the factory defaults can be reloaded. Previously this was assigned to the OPER button, but also assigned to this button at power up is the flash writer. As it can be a little disconcerting to see this prompt, the default reload function has been moved.

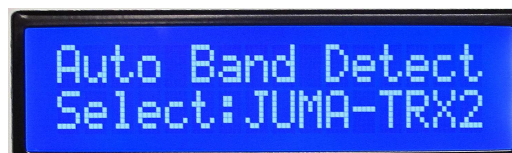
Release the BAND+ button and the display will prompt you for a selection, either press the BAND+ to reload the default settings, or the BAND- button to abort and continue.

User Configuration Mode

This mode is used to setup the various options and settings for proper operation of this amplifier. To select this mode, press and hold the DISPLAY/CONFIG button until you hear a long beep, and the screen will change to reflect this mode. The various settings are changed with the UP/DOWN buttons

To move from one menu item to the next, briefly press the DISPLAY/CONFIG button. To exit, press and hold the button until a long beep is heard.

Auto Band Detect



Default: JUMA-TRX2

This governs the operation of the AUTO feature. There are three selections:

- a. **JUMA-TRX2.** This mode should be selected when the amplifier is connected to the Juma TRX2 transceiver. It relies on the presence of a serial data link between the amplifier and the transceiver. The transceiver's RS-232 port mode should be set to JUMA TRX2, and port speeds must be the same. The default of 9600 Baud is

satisfactory. If this mode is selected, the following RS-232 selection will also be forced to the JUMA-TRX2 setting.

- b. **FT-817** This setting will allow automatic band detection when connected to a Yaesu FT-817 or similar transceiver with the appropriate accessory cable. This transceiver outputs a stepped DC voltage which can be detected by the amplifier and used to automatically select the correct band. The rear accessory BAND socket should be used.
- c. **F-Sense** With this mode selected, the incoming RF signal from the transceiver is measured in frequency, and the result used to select the correct low-pass filters. No connections other than the RF cable and the PTT line are required. To use this mode, select the TUNE mode on the connected transceiver and inject between 2 – 10 watts. The amplifier will detect the signal and select the appropriate filter automatically.

Serial Protocol



Default: JUMA-TRX2

This allows the selection of either the JUMA-TRX2 protocol for automatic band selection, or the Test Mode. Note that the JUMA-TRX2 mode is automatically selected and cannot be changed if the similar mode is selected in the Auto Band Detect menu. The test mode allows the user to perform various low-level tests, as well as obtain a dump of the current internal configuration and calibration values.

Serial Speed



Default: 9600 Baud

This sets the communications speed for the RS-232 port and can be set from 1200 Baud – 115200 Baud. The other parameters are fixed at 8 data bits, 1 stop bit, no parity.

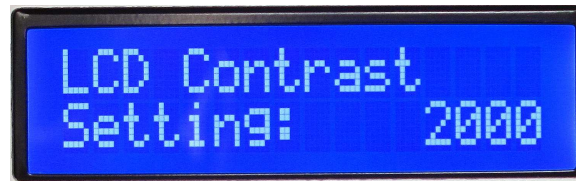
LCD Backlighting



Default: 300

Set the level you wish for the display illumination using the UP/DOWN buttons. Note the a setting of 0 will turn the backlighting off. The range is from 0 – 1100.

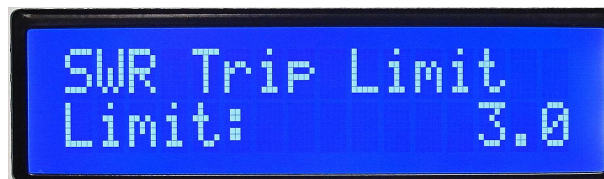
LCD Contrast



Default: 2000

Adjust with the UP/DOWN buttons for a suitable display. The range is from 0 – 3500.

SWR Trip Limit



Default: 3.0

Adjust with the UP/DOWN buttons over a range from 1.0 – 10.0, a default setting of 3.0 is recommended.

Temperature Unit Selection



Default: Celsius

Using the UP/DOWN buttons select either °C or °F. Note that if the units are changed, then the following menu settings for the alarm and fan cut-in temperatures will be automatically preset at their respective default values in the new scale.

Fan Control

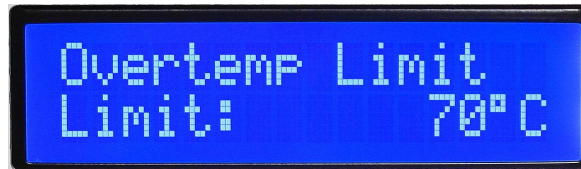


Default: Normal

This is a new feature. Some users prefer the cooling fan to operate all the time irrespective of the heat sink temperature. Use the UP/DOWN buttons to select one of the following modes.

- Normal:** In this mode the fan operation is entirely determined by the heat-sink temperature.
- Low:** In this mode, the fan will run continuously at the low speed, but will switch to the medium or high speed in response to the heat-sink temperature.
- Medium:** The fan will run at medium speed, but will switch to high speed in response to heat-sink temperature.
- High:** The cooling fan will operate at high speed all the time.

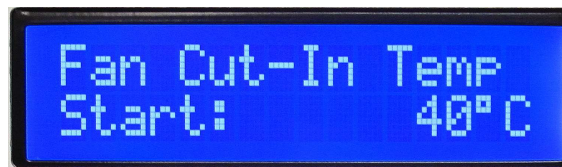
Over-Temperature Limit



Default : 70°C/160°F

Using the UP/DOWN buttons, select a suitable limit. The range is from 50°C – 100°C or 120°F – 212°F.

Fan Cut-In Temperature



Default: 40°C/104°F

Using the UP/DOWN buttons, select a suitable temperature for the cooling fan to start. The range is from 0°C – 80°C, or 32°F – 170°F.

When the heat-sink temperature reaches the cut-in point, the fan will start at low speed, assuming the normal mode of operation has been selected in the previous menu.

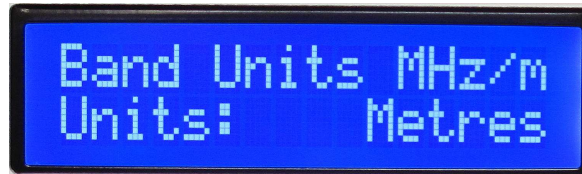
When the heat-sink temperature has risen to 5°C/10°F higher than the preset cut-in temperature, the fan speed will increase to the medium setting. If the temperature rises by 10°C/20°F above the cut-in temperature, the fan will run at its maximum speed.

Although the range of cut-in temperatures are from 0°C – 80°C, or 32°F – 160°F, the actual maximum cut-in temperature will be determined by the Over-Temperature Limit setting. The actual maximum permissible cut-in temperature will always be 20°C/40°F lower than the Over-Temperature Limit setting, or 80°C/160°F.

Although a zero temperature setting may seem somewhat odd, its purpose is to allow you to quickly verify that the fan operates in response to temperature. As an example, assume room

temperature is 25°C, if you reduce the cut-in temperature to 25°C you should hear the fan start at low speed. Reduce the setting to 20°C, and the fan should run at medium speed. Reduce it to 15°C, and the fan should run at its maximum speed. Reset the temperature to the desired setting when done.

Band Units



Default: MHz

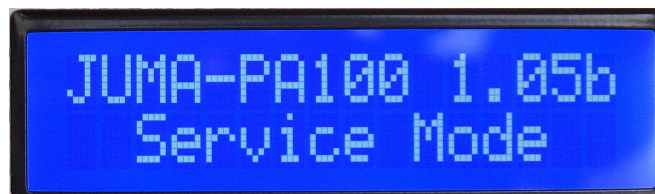
This is a new feature. Using the UP/DOWN buttons select either MHz, or metres.

To exit and save the current settings, press and hold the DISPLAY/CONFIG button until a long beep is heard.

System Configuration

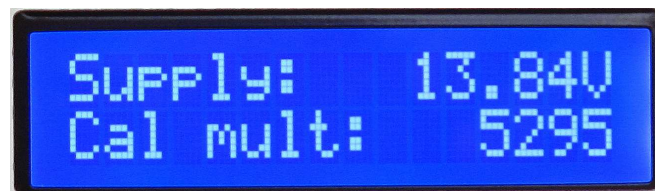
To calibrate the amplifier, connect a suitable transceiver to provide a drive signal, and ensure that the PA100D has the correct band selected. In the Service Mode, the amplifier will power-up in the operate mode.

This section covers the system calibration settings which are only infrequently changed. To enter this mode, press and hold the PWR button until the following screen is displayed:



Release the button and the calibration menu screens can be selected by briefly pressing the DISPLAY/CONFIG button.

Voltage Calibration



Default: 5250

Limits : 5000 – 5500

The measurement system of the amplifier has been modified to obtain increased resolution and precision.

The voltage measurement section is the most precise, as its sample voltage is obtained directly from a precision potential divider formed by R27/R28 on the control board, and this voltage is directly sampled by the A-D convertor.

Measure the input voltage at the amplifier's power connector with a precision 4-digit digital multimeter, and using the UP/DOWN buttons alter the calibration factor so that the displayed voltage matches as closely as possible the measured value.

It should be possible to arrive at a display that matches within ± 1 digit in the least significant figure – in the display above, if the measured value was 13.84V, then you should be able to adjust the display to read between 13.83 – 13.85.

Note that as with all digital sampling systems there is an inherent quantisation uncertainty of ± 1 in the last digit.

The display is a direct sample of the A-D convertor's output, no averaging takes place, and thus you will see significant jitter at some calibration settings. When the display is used with the amplifier in its normal mode, the voltage displayed is the result of a 16-sample average, and is thus much less prone to jitter. The non-averaged value shown here allows you to adjust the calibration for both the most accurate and the most stable display.

Current Calibration



Default: 1260

Limits : 750 – 2000

The current sense is obtained from a precision 0.005 Ω current shunt resistor, R7, in series with the main power bus. The voltage developed across this shunt is processed by IC1, a MAX4373 high-side current sense amplifier/convertor and the scaled voltage is measured by the A-D convertor. The nominal scale factor is 100mV/A.

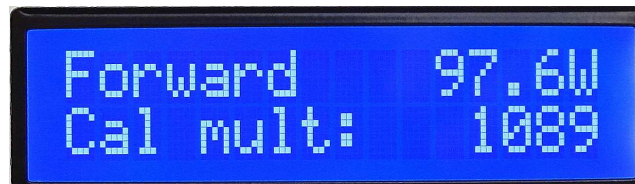
The most accurate method of calibrating the ammeter is to use a clip-on DC ammeter and a precision digital multimeter. Alternatively, if you have access to a precision high-current shunt you can connected this in series with your supply and measure the shunt voltage. If neither of these means is available but your power supply has an accurate digital ammeter, then this can be used as the reference.

Inject a suitable drive signal, wait for the current reading to stabilise, then using the UP/DOWN buttons adjust the calibration factor to obtain a match as close as possible to the reference measured value.

This measurement is less accurate than the voltmeter for a number of reasons. First, although the current shunt is principally the current shunt resistor, in addition there is the contact resistance of the four solder pads.

The varying construction techniques as well as differing types of solder will all add a varying contact resistance which will affect the calibration. In addition, at high currents the resistor will dissipate a certain amount of power which will cause heating, adding a further uncertainty to the measurement. Thus, although the resolution of the ammeter is 0.1A, the accuracy will probably not be better than $\pm 0.5A$ at the nominal output power of the amplifier.

Output Power Calibration



Default: 1200

Limits: 750 – 1500

The RF output power is measured from the DC output voltage obtained from a dual directional coupler on the main board. This measurement is probably the least accurate.

Because power is proportional to the square of the voltage, any errors or differences in construction will be magnified when the A-D output is squared to perform the power calculation. Equally, the output voltage of the diodes is only reasonably linear at fairly high powers, as the output power is reduced the accuracy will degrade.

In order to calibrate this measurement, either you will need access to a fairly accurate RF power meter, or you can use an accurate directional coupler and an oscilloscope. In my case I had access to both methods, and was thus able to confirm the relative accuracy of both methods.

The power meter method is by far the easiest. Inject a suitable RF drive signal, wait for the output power reading to stabilise, and using the UP/DOWN buttons adjust the calibration factor to obtain the closest possible agreement between the display and the measurement reference.

To use the direction coupler/oscilloscope method, connect the output of the amplifier to the directional coupler with as short a piece of co-ax as possible, and connect the output of the directional coupler to a high-power 50 Ω dummy load. Connect the oscilloscope to the directional coupler's coupled port and terminate the input to the oscilloscope with a 50 Ω feed-through termination.

If it is a digitising oscilloscope, set it up to measure the RMS voltage at the input. With a -30dB coupler, at 100W the coupled port will provide a 100mW signal into the feed-through termination. This will give a 6.3V p-p signal into the oscilloscope. Measure the amplitude of

the signal, and calculate the coupled power level. Taking into account the coupler loss, adjust the calibration for the best match.

If you do not have access to either of these pieces of test equipment, then the default calibration value will be accurate enough for most purposes – this is the least accurate of the measurements, and is really intended as an indication of output power rather than a precision measurement.

Beep Length



Default: 50mS

Limits : 0 – 100

Using the UP/DOWN buttons, adjust for the desired time. Note that a time of 0 will disable the beeper, no audio annunciator tones will then be generated.

Polling Time



Default: 8.0 Seconds

Limits : 0 – 30

Using the UP/DOWN buttons adjust for the desired polling rate. This is the time interval that will elapse between the PA-100D query attempts to the Juma TRX2. If you are using the TRX2, then any band changes or transmit status changes are conveyed via the serial port, but in addition the PA100D will also query the TRX2. Setting the rate to 0 will disable polling.

Reset Defaults



The final page allows you to reset to the factory defaults. To do so, press and hold the OPER button until you hear a beep, the factory defaults will then have been restored. (See also the use of the BAND+ button.)

Note that you can only reset the factory defaults from this menu page! To save the current calibration values, briefly press the DISPLAY/CONFIG button to return to the first page, and

briefly press the OPER button, the current values will be saved, and the system will return to normal operation.

Serial Test Mode

The amplifier has an enhanced serial test feature that can be useful for a number of test purposes. To use this feature, in the User Configuration mode, ensure that the Auto Band detect is set to something other than JUMA-TRX2. If this latter mode is selected, then the serial port mode is automatically configured as JUMA TRX2, and cannot be altered.

In the Serial Port mode, select Test Mode, and set the speed to a suitable value, 9600 Baud is usually satisfactory.

Connect your PC running a terminal program to the amplifier via a serial port or a USB to RS-232 convertor if your computer is not equipped with a normal RS-232 port.

Enter the letter I (Capital I) on the terminal, and the amplifier should respond as shown below:

```
Software version: 1.05b, Copyright Juha Niinikoski OH2NLT
~~~~~[COMMAND TABLE]~~~~~
I      Help - (This Screen)
A      ADC Channel Dump
b      LCD Bar Graph Test, ESC to exit
C      Clear Factory Default reset counter
D      Dump System & User Settings
E      Dump EEPROM contents
f      Toggle Frequency Sense On/Off
t      Buzzer Sound Test
W      Write ASCII to LCD, ESC to exit
w      Write HEX to LCD, 1B to exit
c      Continuous SPI write
Z      Divide-By-Zero Trap
```

This “Help” display can also be obtained by entering ?, H, or h. Enter D, and the following display will be obtained:

```
System Calibration Settings
Battery Voltage Factor : 5295
PA Current Factor      : 1295
Power Meter Factor     : 1089
Beep Length Time      : 50 mS
Serial Link Polling    : 8.00 Seconds

User Configuration Settings
LCD Contrast           : 2000
LCD Backlighting       : 300
RS-232 Port Mode       : Test Mode
RS-232 Port Speed      : 19200 Baud
Frequency Sense Mode   : Frequency Sense
SWR Trip Limit         : 3.00
Temperature Units      : Celsius
Fan Speed Control      : Normal
Temperature Alarm Limit: 70C
Fan Start Temperature  : 40C
Current Amplifier State: Standby
Band Select            : Manual
Band Display Units     : Metres
```

Your settings will, naturally, be somewhat different.

Enter A, and the following display will be obtained:

```
ADC 9 = 1015 Scaled: 1.239V 13.1 Amps
ADC 10 = 2578 Scaled: 3.148V 13.651 Volts
ADC 11 = 0 Scaled: 0.000V 0 Out-Of-Band
ADC 12 = 75 Scaled: 0.092V 0.1 Watts (Reverse)
ADC 13 = 2963 Scaled: 3.618V 95.6 Watts (Forward)
ADC 14 = 433 Scaled: 0.529V 26 Celsius
```

This displays the output and scaled values from the Analogue to Digital convertor in the microprocessor.

The display shows the ADC channel number, the raw value, the scaled equivalent input voltage, and the actual display that would be obtained, also scaled by the calibration factor to the measurement unit.

For example, the first line shows the output from ADC channel 9. The raw value is 1015, which corresponds to an input voltage of 1.239V. This corresponds to a current of 13.1 amps when scaled with the calibration factor of 1295 obtained from the previous dump. The actual calculation is:

$$\begin{aligned} I &= \text{ADC} * \text{Calibration Factor} / 100,000\text{Amps} \\ &= 1015 * 1295 / 100,000 \\ &= 1,314425 / 100,000 \\ &= 13.1 \text{ Amps} \end{aligned}$$

The second line shows that the output of ADC channel 10. The raw value is 2578, corresponding to an input voltage of 3.148V, and the scaled display reading would be 13.65V. The actual calculation is:

$$\begin{aligned} V &= \text{ADC} * \text{Calibration Factor} / 1,000,000 \\ &= 2578 * 5295 / 1,000,000 \\ &= 13,650,510 / 1,000,000 \\ &= 13.65\text{V} \end{aligned}$$

The third line shows the output of ADC channel 11. This channel is used with a Yaesu FT-817 transceiver or similar, and represents the band select voltage. I have simulated the actual voltages and confirmed that when the Auto Band Select is set to Yaesu 817, the appropriate amateur band filters are selected. The voltage thresholds are:

BAND	VOLTAGE
1.8MHz – 160m	0.33V
3.5MHz – 75/80m	0.67V
7.0MHz – 40m	1.00V
10.0MHz – 30m	1.33V
14.0MHz – 20m	1.67V
18.0MHz – 17m	2.00V
21.0MHz – 15m	2.33V
24.0MHz – 12m	2.67V
28.0MHz – 10m	3.00V

The tolerance is $\pm 100\text{mV}$. Note that voltages below 0.23V and above 3.1V are invalid. If the input voltage is below 0.23V, then the Out-Of-Band selection is made. Above 3.1V and the unknown selection will be made corresponding to the 28MHz filter.

The next line shows the output from ADC channel 12, the reverse power channel used for SWR calculations.

The next line shows the output from ADC channel 13, the forward power channel. The calculation for both the forward and reverse power is the same, and uses the same calibration factor. In this case the forward power raw value is 2963 corresponding to an input voltage of 3.618V. The calculation is:

$$\begin{aligned}
 P &= (((\text{ADC} * \text{ADC}) / 10) * \text{Calibration Factor}) / 10,000,000 \\
 &= (((2963 * 2963) / 10) * 1089) / 10,000,000 \\
 &= ((8,779,369) / 10) * 1089) / 10,000,000 \\
 &= 956,073,284 / 10,000,000 \\
 &= 95.6\text{W}
 \end{aligned}$$

The last line of the display shows the output from ADC channel 14, the temperature measurement channel.

It shows that the raw output was 433, corresponding to an input voltage of 0.529V. In this case there is no software calibration factor. The design of the temperature measurement system takes advantage of the accurately known change of base-emitter voltage of a silicon transistor with temperature. The transistor is Q3, a BD139, mounted on the backplate of the power

amplifier. It is fed with a constant current, and is used both as a temperature sensor and a temperature compensated voltage source to provide the bias current to the output transistors.

As the temperature of the heat-sink increases the base-emitter voltage will fall. The base-emitter voltage of the output transistors will also fall, and if no temperature compensation were applied, a constant bias voltage would cause their collector currents to increase. This would result in increased dissipation, and even higher heat-sink temperatures, with a resultant further reduction in base-emitter voltage, and eventually thermal runaway. With the temperature compensated bias voltage from Q3, the collector currents of the output transistors are stabilised, and thermal runaway prevented.

From the theory of silicon diodes, it is known that the temperature characteristic of a silicon diode junction is such that the forward voltage of the diode will change by about $-2\text{mV}/^\circ\text{C}$.

Thus, in the temperature sense amplifier A1-B, the potentiometer is used to adjust the offset voltage and calibrate the sensor, and the negative change in DC output voltage is amplified by the x10 DC gain of the inverting amplifier giving approximately $+20\text{mV}/^\circ\text{C}$ over a range from $0^\circ\text{C} - 100^\circ\text{C}$, with an input voltage range to the ADC of $0 - 2\text{V}$.

The reference voltage for the A-D convertor is the $+5\text{V}$ logic supply, and thus at a 2V input the convertor output will be $2/5 * 4096 = 1638$. The scaling factor used is 4000, and thus the calculation is:

$$\begin{aligned} T &= ((2/5) * 4096) * 4000 / 65536 \\ &= 0.4 * 4096 * 4000 / 65536 \\ &= 100^\circ\text{C} \end{aligned}$$

The potentiometer is used to calibrate the system, and all that is required is to measure the heat-sink temperature, and adjust the potentiometer to suit. In practice, leave the amplifier to acquire the ambient temperature by letting it sit for an hour or so, use an accurate digital thermometer, and adjust the potentiometer as required.

For the Fahrenheit scale, the conversion is:

$$\begin{aligned} T &= (((2/5) * 4096) * 7200) / 65536 + 32 \\ T &= (0.4 * 4096 * 7200 / 65536) + 32 \\ T &= (1638.4 * 7200 / 65536) + 32 \\ T &= (11,796,480 / 65536) + 32 \\ T &= 180 + 32 \\ T &= 212^\circ\text{F} \end{aligned}$$

Entering the letter t will invoke the buzzer sound test:

```
Sound Test
Enter Frequency (100 - 5000Hz): 500
Data Value: 7372
Enter duration (mS): 1500
```

Enter the letter E and a dump of the EEPROM contents will be obtained:

```
Dump EEPROM contents

0000 0000 0000 0000 0000 0000 0000 0000 0000
0010 0000 0000 0000 0002 0000 07D0 012C 0001
0020 0004 012C 0001 0000 0046 0028 0001 0000
0030 0000 F561 FFFF FFFF FFFF FFFF FFFF FFFF
0040 050F 0000 14AF 0000 0441 0000 0441 0000
0050 0032 1F40 BE4E 1388 C3E7 FFFF FFFF FFFF
0060 FFFF FFFF FFFF FFFF FFFF FFFF FFFF FFFF
0070 FFFF FFFF FFFF FFFF FFFF FFFF FFFF FFFF
0080 FFFF FFFF FFFF FFFF FFFF FFFF FFFF FFFF
0090 FFFF FFFF FFFF FFFF FFFF FFFF FFFF FFFF
00A0 FFFF FFFF FFFF FFFF FFFF FFFF FFFF FFFF
00B0 FFFF FFFF FFFF FFFF FFFF FFFF FFFF FFFF
00C0 FFFF FFFF FFFF FFFF FFFF FFFF FFFF FFFF
00D0 FFFF FFFF FFFF FFFF FFFF FFFF FFFF FFFF
00E0 FFFF FFFF FFFF FFFF FFFF FFFF FFFF FFFF
00F0 0011 FFFF FFFF FFFF FFFF FFFF FFFF FFFF
Last success code = 7F
```

It is beyond the scope of this manual to explain the mapping of the EEPROM. If you are curious, you will need to read the source code, with particular reference to the file: `pa100_eeprom.h` which shows how the data values are mapped. The first 25 words are used by the user setup contents, and the 26th word is the checksum. As an example, note the checksum F561 at word 26.

This information is mainly of use to those wishing to modify the software, to verify that their EEPROM changes have been accomplished correctly.