Fox Delta
Amateur Radio
Projects & Kits

PM4-GLCD
Precision
RF Low-Power Meter

For power levels less than 0 dBm (1mW)

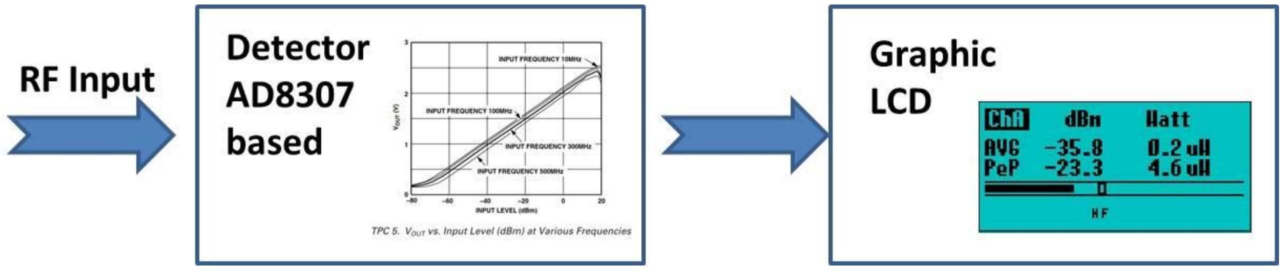
June 2013

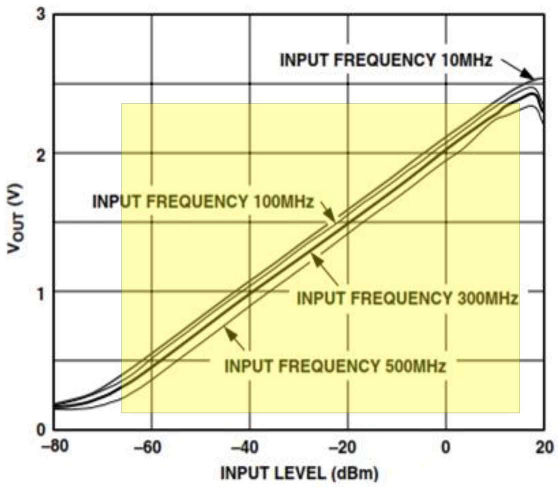
Index

1. Project description

This PM4-GLCD Precision RF Meter consists of two units, the PM4 ***RF Sensor Board (RFSB)*** with a 50 ohms resistive coupler and the ***Graphic LCD (GLCD)*** **Control Unit** that displays the computed results. The firmware in the GLCD uses special algorithms to read the RF level detected by the RFSB's **Analog Devices**™ AD8307 chip – Precision DC-500MHz logarithmic amplifier. The PIC processor computes the dBm, Watt, Vrms values and displays these as numeric values and also drives the analog bar-graph.

Graphical Summary of the Measuring Process





TPC 5. V_{OUT} vs. Input Level (dBm) at Various Frequencies

The **Analog Devices**™ AD8307 chip's linear portion of its transfer function is used for this project. This defines the region between +15 and -70dBm which is highlighted in the diagram above

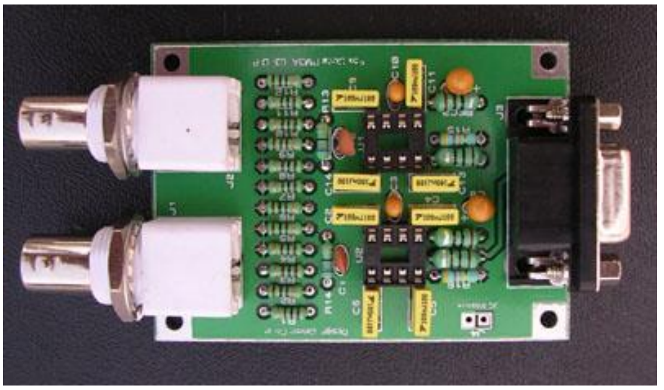
Overall Linearity

The **Analog Devices**™ AD8307 circuitry has a linear response over the range 0.3V at -70dBm to 2.4V at +15dBm with a slope of 25 mV/dBm. The response outside of this region becomes progressively non-linear and it's not advisable to operate the chip outside this range. However, due to stray PCB capacitances, slight non-linearity may occur.

Two input Channels are managed by the PIC processor software

The PM4 has two BNC Connectors these are used to measure for each channel:

- **AVG** - Average
- **PeP** - Peak Envelope Power



WARNING

The AD8307 PM4 Sensor board can only measure power levels less than 0 dBm (0.001 Watts or 1mWatts)

To measure 10 Watts a 40dB attenuator must be used.

2. Definitions

*“**Peak envelope power** (PEP) is the highest envelope power supplied to the antenna transmission line by a transmitter during any full undistorted RF cycle or series of complete radio frequency cycles. PEP is normally considered the occasional or continuously repeating crest of the modulation envelope under normal operating conditions…*

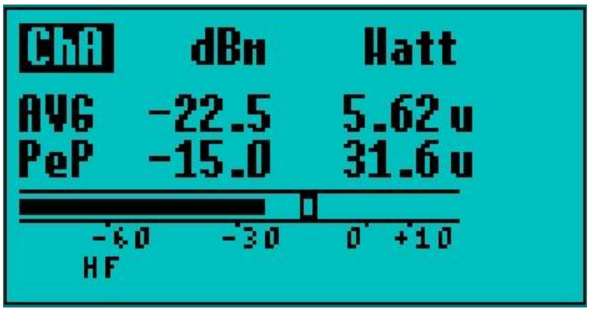
***AM PEP** Assuming linear, perfectly symmetrical, 100% modulation of a carrier, PEP output of an AM transmitter is four times its carrier PEP; in other words, a typical modern 100-watt amateur transceiver is usually rated for no more than, and often less than, 25 watts carrier output when operating in AM.*

***PEP vs. Average Power** PEP is equal to steady carrier power, or CW dot or dash average power, in a properly-formed CW transmission. PEP is also equal to average power in a steady FM, FSK, or RTTY transmission.*

***PEP** bears no particular ratio or mathematical relationship to longer-term average power in distorted envelopes, such as a CW waveform with power overshoot, or with complex amplitude modulated waveforms, such as SSB or AM voice transmissions. Typical average power of a SSB voice transmission, for example, is 10-20% of PEP. The percentage of longer term average power to PEP increases with processing, and commonly reaches ~50% with extreme speech processing.”*

Reference (ARRL Handbook for Radio Amateurs)

The meter samples the signal input every 10 milliseconds and refreshes the GLCD values every 1 second. The **AVG** value displayed is the average of 100 measurements, the **PEP** value is the highest recorded value of the 100 readings.



Power readings are displayed as **dBm** and **Watts**.

NOTE 1.

How to convert dBm to watts

1 dBm = 0.001258925 Watt

$P_{(W)} = 10^{(P(dBm)/10)} / 1000 = 10^{((P(dBm) - 30)/10)}$

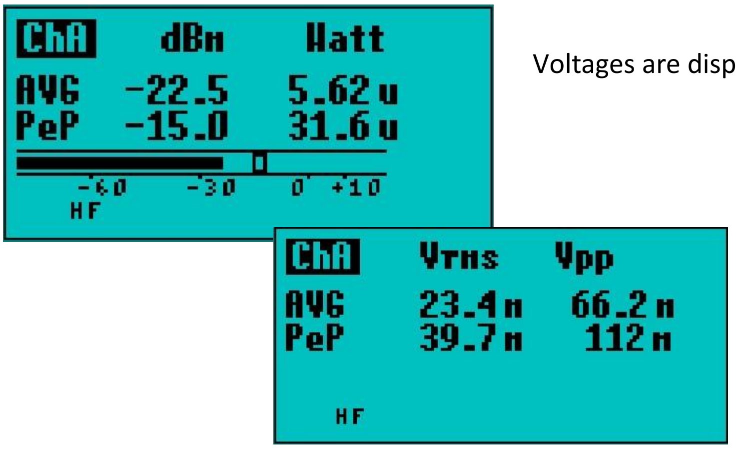
power conversion of dBm to Watts is given by the formula (ref. 50 ohm)

Example1.

-22.5 dBm = 5.62 uW

$P_{(W)} = 10^{(-22.5_{(dBm)}/10)} / 1000 = 10^{((-22.5_{(dBm)} - 30)/10)}$ = 5,6234e-6 = 5.62 uW

3. Available display



Voltages are displayed as Vrms and Vpp

NOTE 2.

How to convert dBm to Voltage

$V_{(pk)} = 10^{((P_{(dBm)} - 10) / 20}$

$V_{(rms)} = V_{(pk)}/\sqrt{2}$

$V_{(pp)} = V_{(rms)} * 2.8285$

power conversion of dBm to Voltage is given by the formula (ref. 50 ohm)

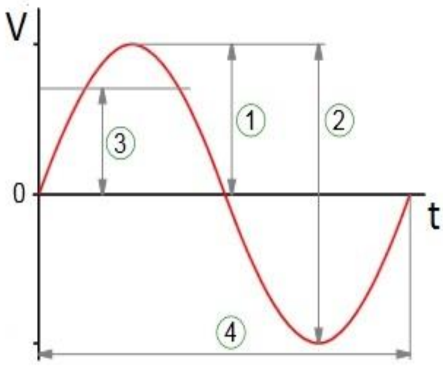
Example

-15.0 dBm = 0.0397 Vrms

$V_{(rms)} = 10^{(-15.0 -10) / 20} / 1.4142 = 0.03976$ Volt

The V_{pp} value is useful since this can be directly compared to any oscilloscope measurement taken of the same source.

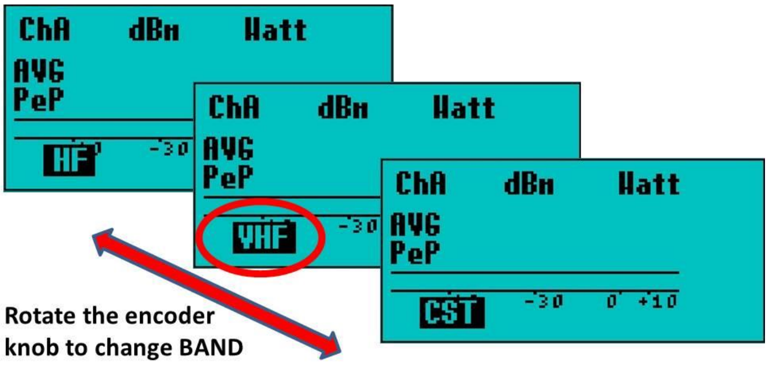
1. $_{pk}$
2. V_{pp}
3. V_{rms}



The software auto-ranges for each measurement and will display W, mW uW, V, mV alongside the numeric value.

4. Calibrating the AD8307

The AD8307 sensor's transfer function can be affected by the PCB design and component layout, resulting in a slight deviation for the ideal transfer function shown on the **Analog Devices™** data sheet. To correct for the slight deviation, the software uses offsets for each channel and frequency band. The offsets are incorporated into the calculations for each band's measurement.



The "adjustments" for each band to compensate for any deviations are stored in (calibration memories)

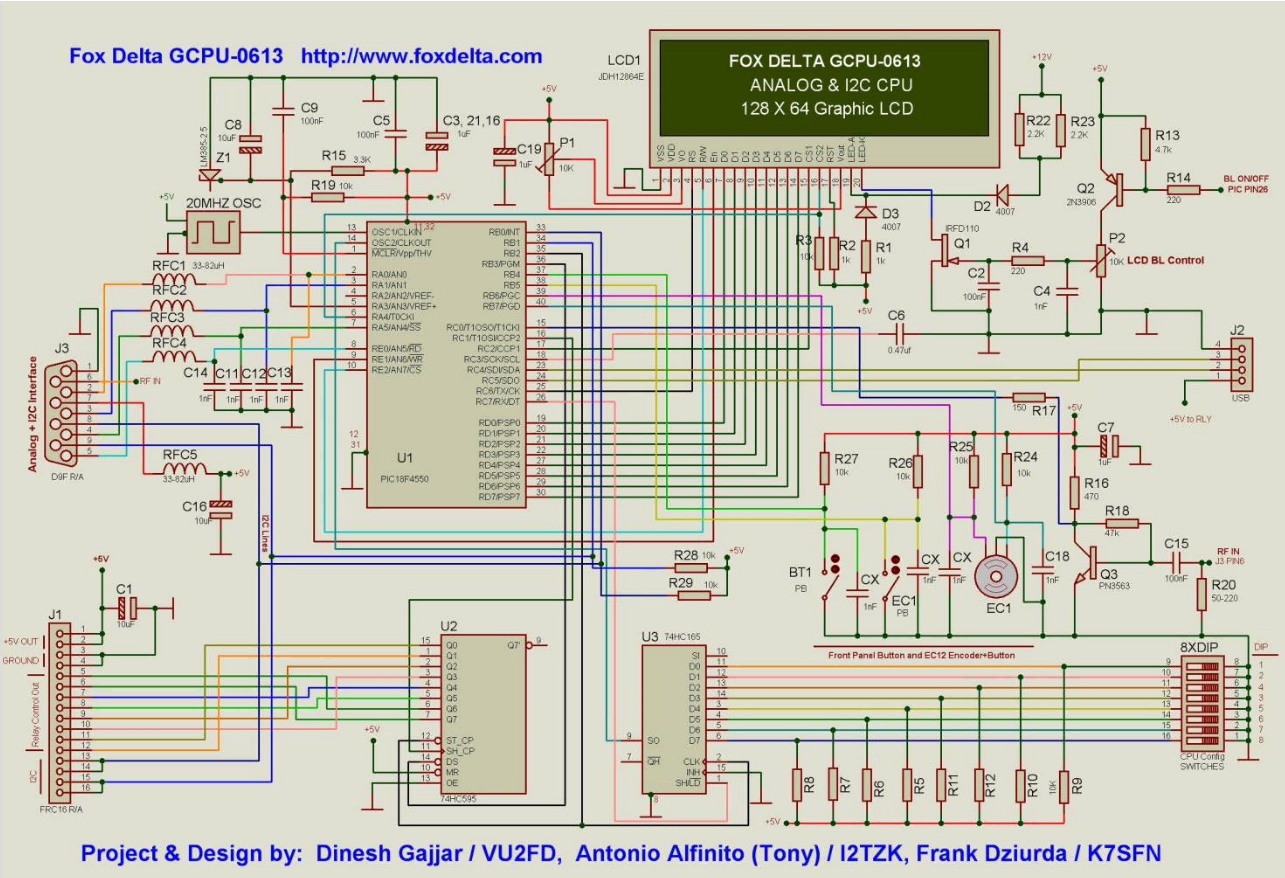
The available bands are (MF, HF, VHF and 1 Custom). The latter is user defined to suit an individual's requirements.

5. Hardware implementation

5.1 GLCD unit

The ***PM4.hex firmware*** runs on a ***Microchip^{TM} 18F4550 microprocessor*** board using ***Samsung^{TM} KS0108 based graphic LCD.***

(For further information concerning the design details please refer to GCPU-0613 kit on the FoxDelta web site.)



Signals from the AD8307 sensor are applied to

- **Channel A** : 18F4550 pin2 or J3 DB9 pin2
- **Channel B** : 18F4550 pin3 or J3 DB9 pin3

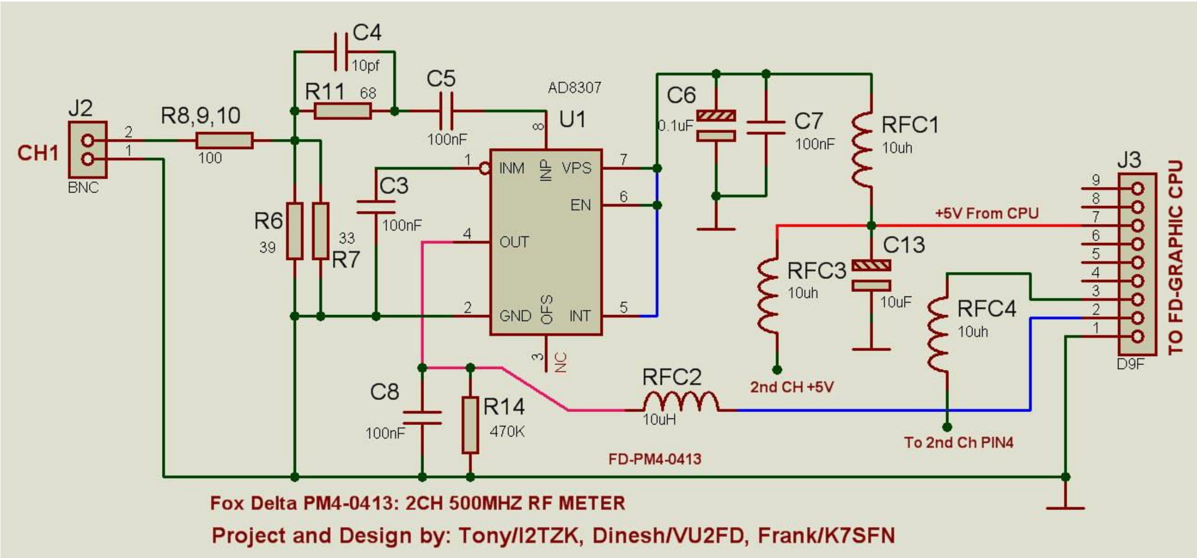
Ground and +5V are also available at J3 connector.

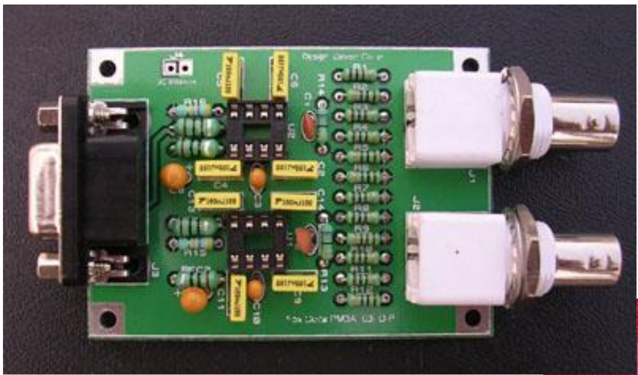
5.2 AD8307 Sensor Unit

Several projects on the **FOX-DELTA Web site** use this popular **Analog Devices** ™ logarithmic amplifier e.g. “FC3 Frequency Counter”, “SWR Analyzer”.

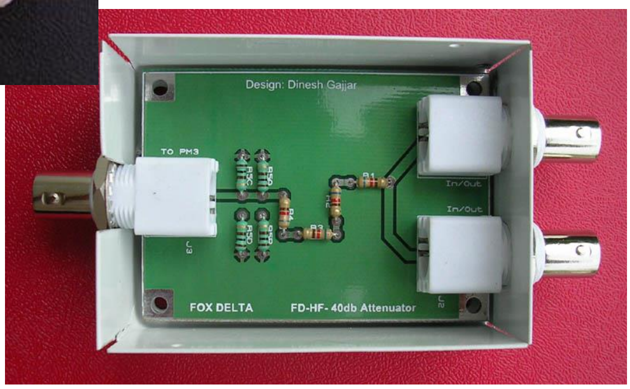
The FOX DELTA PCB is laid out symmetrically with two 50 Ohm BNC connectors for the two channels and single DB9 Connector that links to the GLCD unit.

The schematic diagram below only shows one of the sensor’s channels .





PM4 2 channels sensor

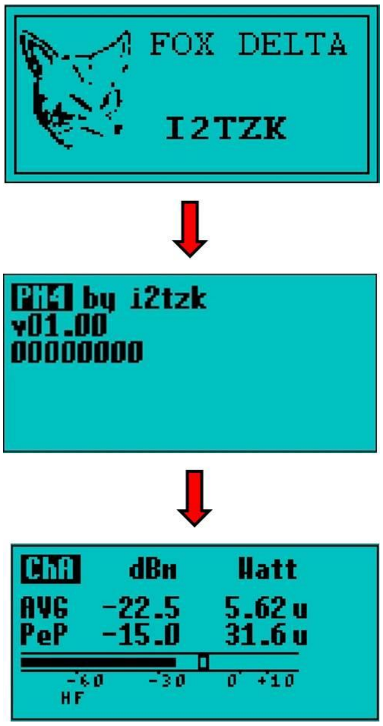


IMPORTANT

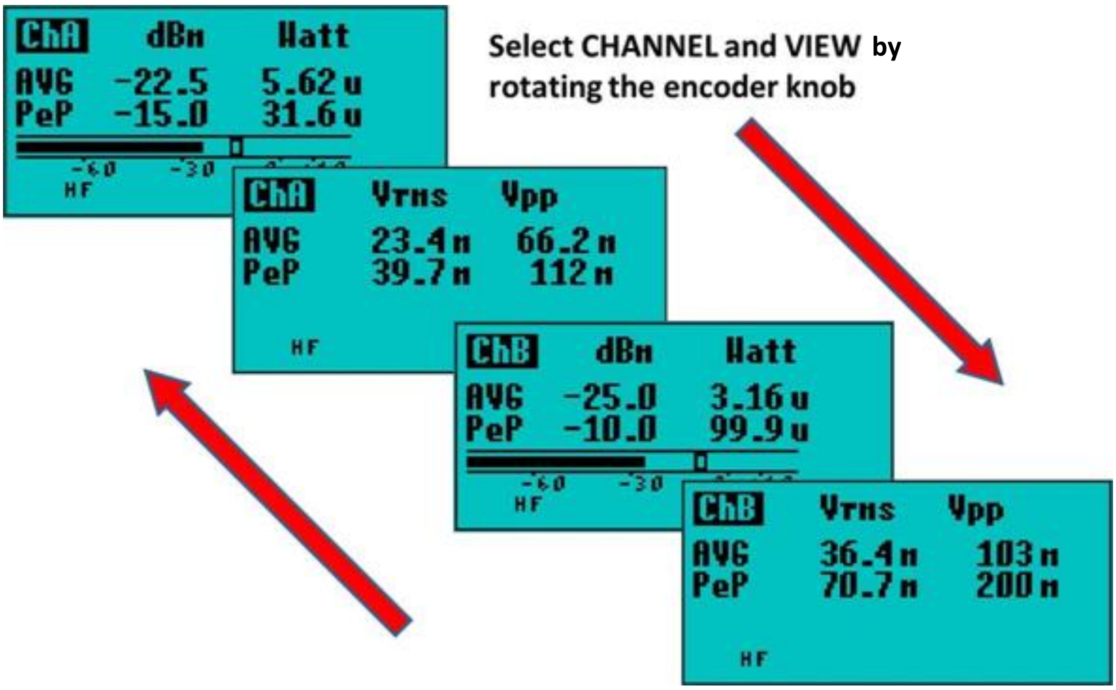
Fox Delta FD-HF 40dB attenuator
Required to measure higher power levels
(See notes)

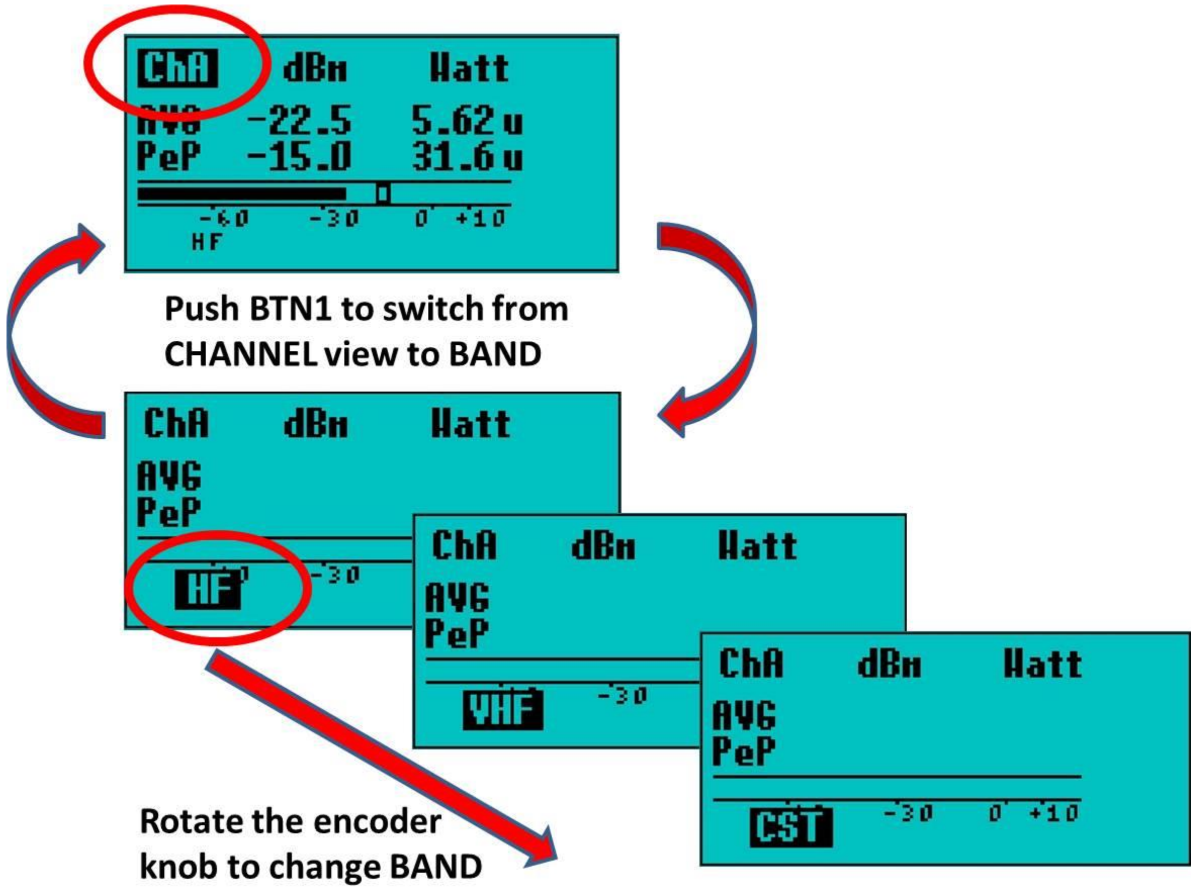
6. GLCD Controller functions

Power ON sequence



PM4 is now ready to measure the signal input to Channel A.




ChA dBm Watt
AVG -22.5 5.62 u
PeP -15.0 31.6 u
-60 -30 0 +10
HF
Push BTN1 to switch from
CHANNEL view to BAND
ChA dBm Watt
AVG
PeP
HF
ChA dBm Watt
AVG
PeP
VHF
ChA dBm Watt
AVG
PeP
CST
-30 0 +10
Rotate the encoder
knob to change BAND

7. Calibration

7.1 Calibration Memories

There are 4 calibration memories MF, HF, VHF and a Custom position.

The “factory default” calibration memories for the Fox-Delta “PM4 remote Sensor Board” are show below. However, these can be changed to suit user requirements i.e. to improve accuracy at a specific frequency and power level e.g. 1.9 MHz, 7 MHz, 14 MHz, & 430 MHz

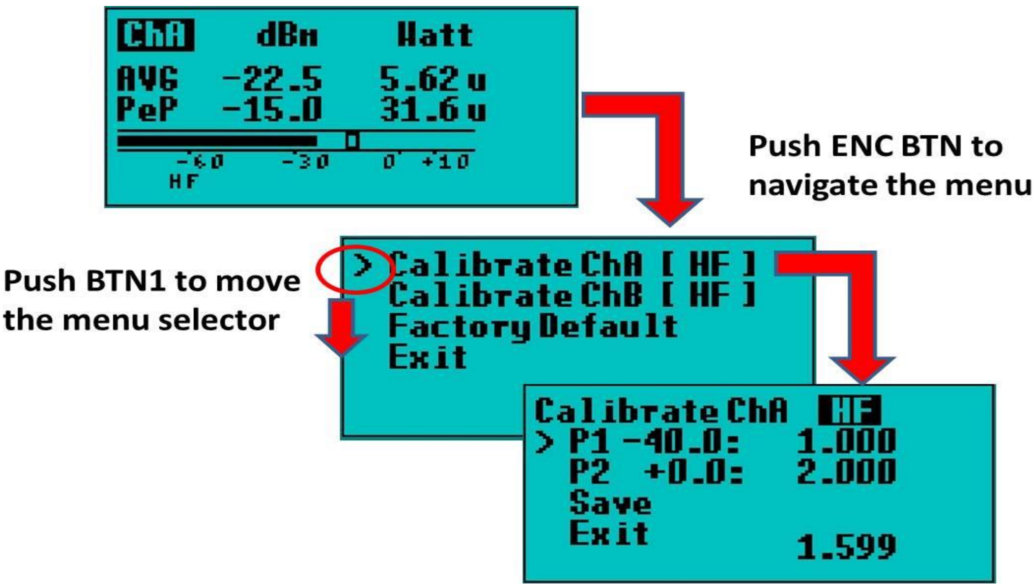
Default calibration values are the same for both Channel A & B:

Band	Frequency	Point1 -40dBm	Point2 0dBm
MF	3.6 MHz		
HF	14 MHz		
VHF	144 MHz		
Custom 1	10 MHz		

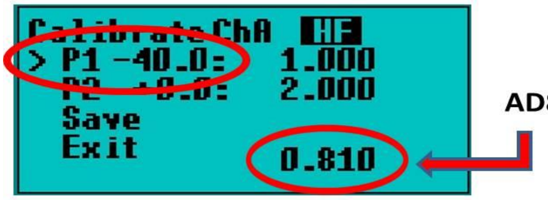
7.2 Calibration Process

An accurate 50 ohm RF source is required that can be set to 0dBm and -40dBm levels for each band. The calibration algorithm will calculate the slope and amount of offset required for each band.

To calibrate, select the Configuration Menu by pushing the ***ENC BTN***, then move the Menu Selector to Channel A or B, you want to calibrate.

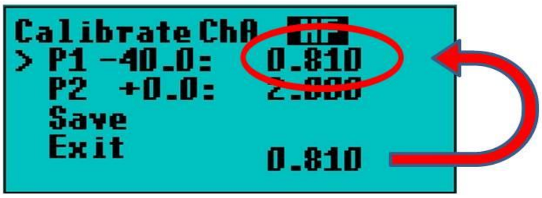


Inject a precise -40dBm signal

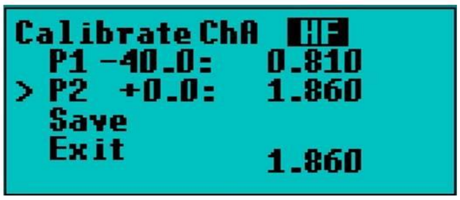


AD8307 Vout (volt)

Push ENC BTN to read the AD8307 Vout



Repeat for P2

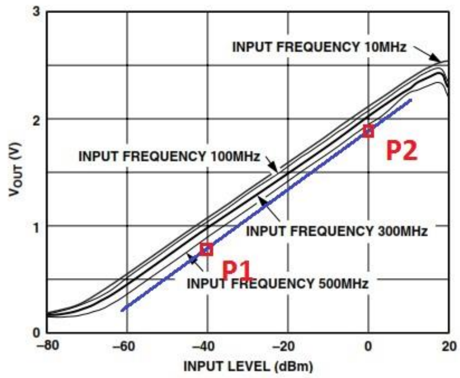


The Calibration process is best explained in the TPC 5 diagram below using the example values

Example values measured during calibration at frequency Fxxx Hz.

- P1: -40dB =>Vout = 0.810 V
- P2: 0dBm => Vout = 1.860V

After calibration, the memories will be contain values for P1 & P2 so that transfer function corresponds to the straight blue line.



TPC 5. V_{OUT} vs. Input Level (dBm) at Various Frequencies

Do not forget to SAVE the values by pushing ENC BTN. The menu label will blink stating that calibration points are stored in the memory.