USB Function Generator / 2-Channel Oscilloscope / Frequency Counter

DDSG2A User Manual
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Introduction

The DDSG-2A is a multi-function electronics test and measurement device comprising a Direct Digital Synthesizing (DDS) Function Generator, a 2 channel Real-Time Storage oscilloscope (DSO) Demodulating Logarithmic Amplifier (log amp), and a Frequency Counter. In addition, the DDS, Log Amplifier and DSO functionality is combined to allow integrated frequency/amplitude sweep generation and response monitoring for easy characterization of frequency response of circuit under test.

The small, portable hardware package connects to your PC via an optically isolated full speed USB interface for PC protection and eliminates effects of noise from USB bus and PC ground.

All device control and monitoring is managed via an intuitive graphical PC software interface. The use of small package fine pitch components allows high number of functions to be integrated in a small and economical instrument.

This low-cost, easy to use device is a perfect solution for engineers and hobbyists alike who need to generate and analyze signals from DC to 100 MHz. Unit is capable to generate signals to 200 MHz but with increased distortion caused by DDS maximum clock is limited to 400 MS/s.

Light weight plastic enclosure contains one layer of aluminum folium from inside to improve device immunity to EMC and minimizes interference with other electronics device. PCB assembly is done using automated pick and place machine with vision system. Re-flow profile is computer controlled and after testing board is coated with urethane.

Arbitrary Function Generator with Direct Digital Synthesizer (DDS)

The Direct Digital Synthesis Function Generator provides an array of standard signal waveforms, including; Sine, Square, Ramp, Triangle & Pulse. Additionally, more complex waveform are provided, such as, Swept Frequency Sine, Modulated Sine Wave (AM/FM) and Arbitrary Waveform Generation (Voltage, Frequency, Phase). Finally Swept Sine Frequency or amplitude modes are provided, integrated with the DSO monitor, for analysis of frequency and amplitude response characteristics of system under test. TXCO Frequency stability is 2.5ppm.

Generator Operating Modes:
- Single Tone- Sine, Square, Ramp @ Triangle
- Pulse (user specified mark/space)
- Swept sine (Freq start/stop and step period control)
- AM/FM modulated Sine (external Modulation)
- Arbitrary (Voltage, Frequency, Phase)
- Frequency and amplitude sweep with monitor (mVrms, dBmV or dBm)

The Function generator is controlled through the easy to use PC based Graphical interface shown right.

Mode Selection activates all the appropriate control panels for clarity and also conveniently displays signals limits of selected mode in same window.

As well as the generator modes controlled by this application, the monitored frequency and amplitude sweep functions are controlled in the “DDSG Monitor” window shown below.

Maximum available power into 50 ohm load from 1 to 100 MHz.
# Generator Specification

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Min</th>
<th>Max</th>
<th>Typical</th>
<th>Description Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time Base Accuracy</td>
<td></td>
<td></td>
<td>±2.5ppm</td>
<td>Derived From TCXO Data Sheet</td>
</tr>
<tr>
<td>Frequency range</td>
<td></td>
<td></td>
<td></td>
<td>Increase distortion and No amplitude calibration for</td>
</tr>
<tr>
<td>Sine Wave</td>
<td>0.01 Hz</td>
<td>100 MHz</td>
<td></td>
<td>frequencies 100 -200Mhz due to max DDS DAC sample clock of</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>400MS/S</td>
</tr>
<tr>
<td>Frequency resolution</td>
<td></td>
<td></td>
<td>0.00465Hz</td>
<td></td>
</tr>
<tr>
<td>Sine wave and square wave mode</td>
<td></td>
<td></td>
<td>0.093 with</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>400Mhz clock</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Amplitude range</td>
<td>10mVpp High-Z 5Mv-50Ohm</td>
<td>5Vpp @DC-40Mhz@High-Z 2.5Vpp -50Ohm</td>
<td>See page# 2 for available power into 50 Ohm over frequency range</td>
<td></td>
</tr>
<tr>
<td>DC Offset</td>
<td>-1V</td>
<td>4V</td>
<td></td>
<td>No load or hi Impedance load(divide by 2 for 50ohm load)</td>
</tr>
<tr>
<td>Output impedance</td>
<td></td>
<td></td>
<td>50 Ohm</td>
<td></td>
</tr>
<tr>
<td>Pulse width</td>
<td>10ns</td>
<td>2s</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rump and Triangle Frequency range</td>
<td>0.1 Hz</td>
<td>100KHz</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arbitrary points</td>
<td>2</td>
<td>1024</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arbitrary points sampling frequency</td>
<td>250 Hz</td>
<td>100Mhz</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DDS Clock Range</td>
<td>1 MHz</td>
<td>400 MHz</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Using Generator

Power and USB cables have to be connected before DDSG2A application is open. Two separate windows should appear after DDSG2A is open.

One window is called “Function GeneratorDDSG2A” and second one is “DDSG Monitor”. Generator window contains controls for signal generated only and monitor contains controls for Oscilloscope, Frequency Counter and also controls generator in Frequency Sweep mode.

If DDSG2A device is used only as generator then monitor window can be closed or downsized, but monitor window can not work alone with generator window closed.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Min</th>
<th>Max</th>
<th>Typical</th>
<th>Description Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>DDS DAC Voltage Resolution</td>
<td></td>
<td></td>
<td>14 bit</td>
<td>Derived From DDS IC(AD9954) Data Sheet</td>
</tr>
<tr>
<td>DDS Phase Control Resolution</td>
<td></td>
<td></td>
<td>14 bit</td>
<td>Derived From DDS IC Data Sheet</td>
</tr>
<tr>
<td>DDS Frequency resolution</td>
<td></td>
<td></td>
<td>32 bit</td>
<td>Derived From DDS IC Data Sheet</td>
</tr>
<tr>
<td>DDS Amplitude (scale)Control</td>
<td></td>
<td></td>
<td>14 bit</td>
<td>Derived From DDS IC Data Sheet</td>
</tr>
<tr>
<td>Resolution</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DDS Phase Noise</td>
<td></td>
<td></td>
<td>105 dBC/Hz</td>
<td>Derived From DDS IC Data Sheet</td>
</tr>
<tr>
<td>Rise/Fall time(square wave and pulse)</td>
<td></td>
<td></td>
<td>5ns</td>
<td></td>
</tr>
</tbody>
</table>

Parameter Min Max Typical Description Comments

Using Generator

Power and USB cables have to be connected before DDSG2A application is open. Two separate windows should appear after DDSG2A is open.

One window is called “Function GeneratorDDSG2A” and second one is “DDSG Monitor”. Generator window contains controls for signal generated only and monitor contains controls for Oscilloscope, Frequency Counter and also controls generator in Frequency Sweep mode.

If DDSG2A device is used only as generator then monitor window can be closed or downsized, but monitor window can not work alone with generator window closed.
Generating Single tone sine and Modulated sine

1. Connect Generators “OUT” to circuit under test
2. Open “Function Generator DDSG2A” window
3. Select “Single Tone Sine” or ”Sine Modulated” (if modulation needed) in “Mode Selection” combo box
4. Select frequency unit (Hz, kHz or MHz) in combo box right from frequency entry text box
5. Enter frequency value in frequency text box
6. Select amplitude unit in combo box
7. Enter Amplitude value
8. Select DC Offset mode (Manual, Vpp/2 or 0.00); if manual mode is selected then offset unit have to selected and offset value have to be entered. If Vpp/2 is selected then device will generate offset equal Vpp/2 so that output voltage is always positive only swinging from 0 to Vpp. Use “Vpp/2 +” to drive TTL or CMOS digital circuit.
9. Check 50 Ohm box if circuit under test have input impedance of 50 ohm
10. Check 20dB attenuator for low amplitude low noise signals.(0-500mV or 0-250 mV@50ohm)
11. If “Sine Modulated” mode is selected then perform following four steps:
   • Connect modulation signal to CH1 input of Function Generator and use volt/div channel one to adjust amplitude since modulation signal use scope channel 1 amplifier
   • Select modulation type (External AM or External FM)
   • If “FM” is selected then maximum frequency deviation will be about 100 KHz for 4Vpp Input signal (use arbitrary frequency mode for greater deviation)
   • Select additional AM modulation gain (0.5,1,2 or 4 Volt of input voltage to make 100% AM
12. Click “RUN” or “REFRESH”

Output signal should be present at” OUT” If all entries are within device operating range. If entered amplitude is higher then available power at given frequency then message box saying that amplitude is too high for frequency entered and device will generate maximum available power after clicking ok on message box.

Read “calibration” section, if output amplitude, offset or frequencies errors are in not acceptable range.
Generating Pulse

1. Connect Generators “OUT” to circuit under test
2. Open Function Generator window
3. Select “Pulse Generator” in “Mode Selection” combo box
4. Select “Pulse” and “Pause” duration unit (ns, us or ms)
5. Enter “Pulse” and “Pause” duration value
6. Select “Single” or “Continues” in “Mode” selection box
7. Select amplitude unit in combo box
8. Enter Amplitude value
9. Select DC Offset mode (Manual, VPP/2 or 0.00); if manual mode is selected then offset unit have to be selected and offset value have to be entered. If Vpp/2 is selected then device will generate offset equal Vpp/2 so that output voltage is always positive only swinging from 0 to Vpp.
10. Check 50 Ohm box if circuit under test have input impedance of 50 ohm
11. Check 20dB attenuator for low amplitude low noise signals.(0-500mV or 0-250 mV @50ohm)
12. Click “RUN” or “REFRESH”

If “Single” mode is selected then single pulse will be triggered with click on” RUN”

Software will use best hardware ability to generated pulse as close as possible to value entered. Pause duration will have greater error since pause time is made using smaller time segments which duration will depend from pulse length.

Use invert check box for negative pulse polarity.

Generating Arbitrary Voltage

See “Voltage1” text file found in DDSG2A installation folder for reference.

1. Make tab separated arbitrary points text file like one with first five points in example file supplied (Voltage1.txt) with DDSG2A software. First two lines will be ignore by application and can contain anything. Third line contains first arbitrary point. Voltage value must be in second column and range is from 0 to 5000mV.
2. Connect Generators “OUT” to circuit under test
3. Open Function Generator window  
4. Select “Arbitrary” in “Mode Selection” combo box  
5. Select “Voltage” in “Arbitrary” combo box  
6. Enter minimum time step “Min.t(ns)” (range is 10-66ns)  
7. Enter multiplier value for profile1 and profile 2 if profile2 is used. (one arbitrary point  
   period = “Min.t(ns)” * multiplier  
8. Enter profiles start and stop point number  
9. Load arbitrary file using browser button and “Load profile from file” button  
10. Click “REFRESH” or “RUN” Button.

**Example of arbitrary file with 2 profiles**

One profile have multiplier of 50 and second of 10, which with minimum time step of 10ns and start point=1,  
Final point = 5, generates form shown on picture below.

Arbitrary voltage file contains:
Arb.Pt. Voltage (mV)
--------------------------------
1 0  
2 1000  
3 1500  
4 2000  
5 2500

**Generating Arbitrary Frequency**

Follow same steps as described in “generating arbitrary voltage” section, except that arbitrary file will contain frequency values in hertz and arbitrary selection will be frequency. See “Frequency1” text file found in DDSG2A installation folder for reference.

**Generating Arbitrary Phase**

Follow same steps as described in “generating arbitrary voltage” section, except that arbitrary file will contain Phase values in degrees (0.00-360.00) and arbitrary selection will be Phase.
See “Phase1” text file found in DDSG2A installation folder for reference.

**Generating Sweep Sine**

1. Select Sweep Sine generator in “Mode Selection”
2. Enter start frequency, stop frequency, number of steps and step time in sweep generator frame.
3. Select amplitude and dc offset following steps described in “generating single sine”
4. Click “RUN” or “REFRESH”

**Generating Square Wave**

Wave can operate in two different modes.

In “Square Wave” mode DDS uses RAM and arbitrary voltage feature to generate square wave. Amplitude resolution in this mode is 14 bit and frequency resolution error is maximum 50 kHz.

Bias and amplitude range is same as in single tone sine.

In “Square Wave2” mode DDS generate sine eave first then use comparator then a programmable attenuator before final amplifier. Amplitude resolution is 8 bit and output range is:1-5 Vpp

Frequency resolution is 0.1 Hz

There is no bias control.

Amplitude in this mode is sensitive on temperature change since it uses active attenuator for amplitude control.

This mode is mainly provided to be used for logical gates driving and to be used with undersampling DDSG2A scope function to measure propagation delay since frequency and phase can be controlled allowing DDSG2A scope to display signal with bandwidth of 100MHz.

See calibration section for amplitude calibration in “Square Wave2” mode.

**Frequency Sweep with RF Monitor**

The DDS AND DSO functionality of DDSG2A have been combined to allow integrated frequency/amplitude sweep generation and response monitoring for easy characterization of the
frequency & amplitude response of system under test.
The measurement and display functions of the monitor are closely coordinated with selected sweep signals and sweep signal control and monitoring is also combined in “DDSG2A” Monitor for user convenience.
The display can be configured for a variety of vertical measurements units (mVrms, dBmV, dBm).
The example below illustrates the frequency sweep function used for characterization of a 10.7 MHz band –pass filter.

Monitor sweep specifications:

- Voltage detector amplitude range: -77-0Dbv
- Detector frequency range: 200kHz-200Mhz
- Input impedance: 50 ohm
- Monitor amplitude measurements: 100mVrms/div, 250mVrms/div, 5dBmV/div, 10dBV,10dBm, 15dBm

1. Select “frequency sweep” mode in DDSG Monitor Window (Shown on picture right)
2. Enter start and stop frequency
3. select amplitude unit and enter amplitude
4. Select RF detector display unit (left lower corner of window (100mVrms/div, 250mVrms/div,10dBm..etc)
5. Connect DDSG2A device “OUT” to the input of circuit under test.
6. connect ddsg2a CH1 IN to circuit under test output
7. Click START

This test shows band pass filter frequency response.
Start frequency is set to 9.7 MHz and stop frequency to 11.7MHz
Generator output amplitude is 0dBm
Amplitude Sweep with RF Monitor

Amplitude sweep will generate single tone sine wave with constant frequency and phase and linear amplitude increase starting from start amplitude and ending at stop amplitude.
RF monitor with input at CH1 will measure RF level and display magnitude.
One example application would be amplifier linearity, gain, input and output amplitude range.

1. Select “Amplitude Sweep” in “Mode” combo box
2. Enter frequency
3. Enter start and stop amplitude
4. Click “RUN” or “REFRESH”

Digital Sampling Oscilloscope (DSO)

The Digital Sampling Oscilloscope provides two high speed channels with an analog bandwidth of 10 MHz for any signal source and 100 MHz for signals synchronized from same device generator. Two different kinds of ADC converters are provided.
One 2 channel ADC with maximum 40Ms/s and with 8 bit resolution and second one with one channel, 480Ks/s 12 bit resolution allowing higher dynamic range for low frequency signal such as audio.
Two sampling modes are available, real time and interleaved under sampling.
Real time sampling is provided for signals up to 10MHz and (time base 1s - 100ns)

For signal sourced from the DDSG2A Function Generator (and with allowable frequency shift of 1 kHz), interleaved under sampling mode extends the signal measurement capability to up to 100 MHz (time base: 1us - -1ns)

The DSO is configured and its result displayed via the “DDSG2A Monitor Window” which is part of DDSG2A Application.

DDSG Monitor Provides an easy to use graphical interface for oscilloscope, frequency and amplitude sweep functions and the frequency counter.
Graphical results for DSO and sweep functions are displayed at resolution of 640x512 pixels.
In oscilloscope mode, the display provides a view of the most recently acquired samples (mapped onto 640 pixels).

In addition, the monitor applications records 2048 mapped samples so that scope display window can be moved back in time to view previously captured signals (just over 3 windows). Cursor measurements functions are provided for both horizontal and vertical quantities. Trigger amplitude and CH1/CH2 zero levels are displayed visibly in monitor window and can be controlled by user.

**DSO Specifications:**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Min</th>
<th>Max</th>
<th>Typical</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Real Time Scope sampling speed</td>
<td>64 S/s</td>
<td>2x40MS/s 8bit</td>
<td>1x500kS/s 2 bit</td>
<td></td>
</tr>
<tr>
<td>Real Time Scope Bandwidth</td>
<td>DC</td>
<td>10Mhz</td>
<td></td>
<td>Vertical amplifier bandwidth is 100 MHz but sampling speed limits usable bandwidth to 10Mhz</td>
</tr>
<tr>
<td>Scope Record length</td>
<td>640</td>
<td>2048</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scope Input Impedance</td>
<td></td>
<td>1Mohm/20pF</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scope Display Size</td>
<td></td>
<td>640 X 512</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scope Vertical display divisions</td>
<td>10mV, 20mV, 50mV, 100mV, 200mV, 0.5V, 1V</td>
<td>10mV works only in 12 bit mode</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Real time Horizontal/div:</td>
<td>100n, 200n, 500n, 1u, 2u, 5u, 10u, 20u, 50us, 100u, 200u, 500, 100m, 500m, 1s</td>
<td>1m, 2m, 5m, 10m, 20m, 50m, 1s</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interleaved under sampling mode Horizontal/div</td>
<td>1n, 2n, 5n, 10n, 20, 50n, 100n, 200n, 500n</td>
<td>Works only if signal originated from same generator or is synchronized from same generator and frequency is allowed to shift up to 1kHz</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oscilloscope Interleaved under sampling mode bandwidth</td>
<td>1Mhz</td>
<td>100Mhz</td>
<td></td>
<td>Prescaler used is rated 2GHz, but device is tested with 1Ghz</td>
</tr>
<tr>
<td>Frequency counter frequency range</td>
<td>1Hz</td>
<td>1GHz</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Using Real Time Oscilloscope

Real item oscilloscope can work as one channel 500Ks/s 12 bit or two channels with maximum speed of 40 Ms/s simultaneously ob both channels

Fastest time division in 12 bit mode is 200us and 100ns in 40Ms/s mode

- It is recommended to stop display before changing any settings or moving channels, trigger, and cursor position.
- If stop button is not used then process will be too slow.

For best results use standard oscilloscope passive probes with division ratio of 10 and bandwidth of 100 MHz or higher and calibrate probes input capacitance.

Generator in “Square Wave” mode with 1 kHz output can be used for passive probes input adjustment.
Select Scope CH1, Scope CH2 or Scope CH1+CH2

Select Real Time Sampling mode

2048 points box will transfer 2048 adc values during each frame refresh. This will slow refresh rate but it will allow viewing 2048 points by using slider and Hor.Position tab.

Reset DSG2A will reset generator cpu and synchronize adc cloks. Use this button if if unexpected noise exit in hi speed adc mode.

Selected cursor will become solid line and unselected one will be doted line

Use slider to adjust channel position trigger position, horizontal position

Select 12 bit 300Ks if one channel is set and time division is greater then 200us

User tab strip to enable vertical cursors for delta voltage measurements or horizontal cursor for delta time measurements, or disable both.

Use tab strip for channels position, trigger position, horizontal display position and cursors (horizontal or vertical)
Using FFT Spectrum Analyzer

FFT spectrum analyzer can be used in CH1 only or CH2 only mode. 2048 samples box have to be checked before scope start. Select time base so that frequency of interest is covered with at least 10 or more periods. Select volt dive so that amplitude covers between half and ¾ of vertical display. Use 12 bit ADC if frequency is low like in audio range for greater dynamic range. Click “RUN” to display waveform as scope and fill buffer. Click “STOP” and then “FFT” button.

Picture on right shows 1 kHz 5Vpp sine wave generated with same device generator using 12 bit ADC. Moving mouse over display will update frequency and magnitude information found at the bottom of screen.

Using Interleaved Under-Sampling Oscilloscope

Interleaved sampling mode allows hi resolution timing measurements by using synchronizing signal source (generator) with scope and by controlling sampling phase.

This mode can not work properly if signal did not originate from same generator or is synchronized with it as shown on diagram below.
Picture shows propagation delay test of logic NOR gate 74AC00 with generator with “Square Wave2” mode 30Mhz 3.3V output amplitude connected with short not terminated coax 50 cable to input gate and passive probes 200Mhz bandwidth x10 converted at gate input@ CH1 and output@CH2)

**Using Frequency Counter**

Frequency counter have 3 frequency ranges.
Range 1 Hz-20 MHz uses scope channel one (CH1 IN) input amplifier to allow dc coupling for low frequency counting and amplitude adjustment.
Range 10-300 MHz and range 200-2000 MHz uses presales and are ac coupled with input impedance of 50 ohm. And it requires 50 ohm coax cable connection.

**Calibration**

Device is calibrated by adjusting calibration data in calibration file which is unique for each device. Calibration is done after device is produced and user can calibrate it using previously calibrated instruments like oscilloscopes, millimeters, frequency counters...etc.

"CaldataXXXXXXX" text files contains calibration data loaded at software start up and if manually loaded thru Calibration File load Button.
“XXXXXXX” Portion of calibration data file name represent device serial number found on device label and stored in device USB chip.
This allows multiple DDSG2A devices to be used with same PC with multiple applications open.
Changing Cal Data values will affect generator frequency, DC offset, Amplitude, oscilloscopes voltage accuracy ...etc

**Generator Frequency** is calibrated by fine tuning calibration data in line 2 of cal data file. This line is initially 1 since TCXO have 2.5ppm accuracy which is best we have available. Increasing values will increase frequency.

**Generator Sine Wave Amplitude** in frequency range:
Increasing values of cal data will increase amplitude.
- DC-1Mhz is done with adjusting line 4
- 10 MHz - adjust cal data line 5
- 20 MHz - adjust cal data line 41
- 30 MHz - adjust cal data line 42
- 40 MHz - adjust cal data line 43
- 50 MHz - adjust cal data line 6
- 60 MHz - adjust cal data line 44
- 70 MHz - adjust cal data line 45
- 80 MHz - adjust cal data line 46
- 90 MHz - adjust cal data line 47
- 100 MHz - adjust cal data line 7

**Generator Square Wave2 amplitude** is calibrated by fine tuning calibration data in line 28 for 1Vpp
Increasing values in cal data will decrease amplitude.
- 1Vpp – line 28
- 2Vpp – line 29
- 3Vpp – line 30
- 4Vpp – line 31
- 5Vpp – line 32

**Generator DC Offset** for sine waves and square wave is calibrated by fine tuning calibration data in line 3 of cal data file. Increasing values of cal data will increase offset voltage.

**Generator Arbitrary Voltage DC offset** is calibrated by fine tuning calibration data in line 11
Increasing values of cal data will increase offset voltage.

**Generator Ramp DC offset** is calibrated by fine tuning calibration data in line 13
Increasing values of cal data will increase offset voltage.

**RF Voltage detector(log amp) Offset (intercept)** is calibrated by fine tuning calibration data in line 15
Increasing values of cal data will increase RF detector offset.

**Oscilloscope CH1 Gain for 1V/div and 0.5V/div** is calibrated by fine tuning cal data line 19
Increasing values of cal data will decrease scope voltage gain

**Oscilloscope CH1 Gain for 0.2V/div and 0.1V/div** is calibrated by fine tuning cal data line 18

**Oscilloscope CH1 Gain for 50mV/div and 20mV/div** is calibrated by fine tuning cal data line 35

**Oscilloscope CH2 Gain for 1V/div and 0.5V/div** is calibrated by fine tuning cal data line 24

**Oscilloscope CH2 Gain for 0.2V/div and 0.1V/div** is calibrated by fine tuning cal data line 25

**Oscilloscope CH2 Gain for 50mV/div and 20mV/div** is calibrated by fine tuning cal data line 38

Scope offset cal data is used only at device application start up before “Cal Offset” Button is activated.
“Call Offset” button is used to set dc offset to zero when scope probes are open or connected short to ground.

**Oscilloscope CH1 Offset for 1V/div,0.5V/div,0.2V/div,0.1V/div** is calibrated by tuning cal data line 21
Increasing values of cal data will decrease scope voltage gain

**Oscilloscope CH1 Offset for 50mV/div and 20mV/div** is calibrated by tuning cal data line 34

**Oscilloscope CH2 Offset for 1V/div,0.5V/div,0.2V/div,0.1V/div** is calibrated by tuning cal data line 26

**Oscilloscope CH2 Offset for 50mV/div and 20mV/div** is calibrated by fine tuning cal data line 37