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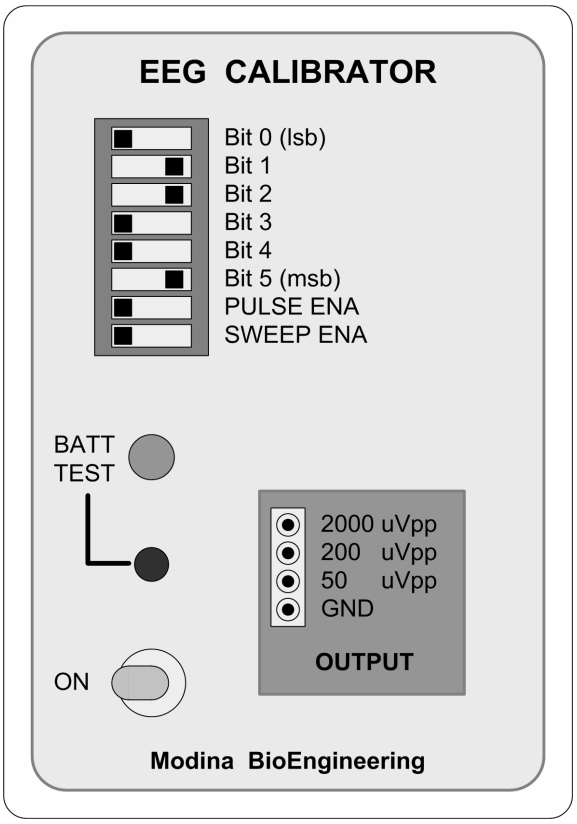

NOTE: This User Manual is intended for the EEG Calibrator programmed with version 1.3 Firmware. Different Firmware versions can have differently behaving functionality.

Introduction

The ***EEG Calibrator*** is intended for the performance measurement, confirmation and the evaluation of various EEG Neurofeedback devices and solutions. The unit can be used to measure the performance of EEG hardware, software or a combination thereof. It could also be used to evaluate neurofeedback treatment protocol design behaviour as designed in software packages such as BioExplorer, BioEra or similar.

The ***EEG Calibrator*** is a sinewave generator that can produce 1 to 64Hz sinewaves of known, fixed amplitude. Besides being able to select the frequency in 1Hz steps via DIP-switches, the unit also allows for frequency sweeps and pulse generation. The latter is a square wave pulse that can be used to measure things such as settling time, digital filter response, phase delay, etc.

Technical Specifications

Frequency range	1 to 64 Hz sine wave in 1Hz steps programmable via DIP switches
Frequency accuracy	± 2%
Frequency generation	8-bit PWM 200-point lookup table 2^{nd} order low pass filtered at 160Hz (-3dB)
Pulse width	10, 20, 30 & 40 µS programmable
Pulse width repetition	10, 20, 40, 80, 160 & 320 mS programmable
Output voltage	50µVpp (SPOT & SWEEP mode) 200µVpp (SPOT & SWEEP mode) 2000µVpp (SPOT & SWEEP mode) 125, 500, 5000 µV (PULSE mode)
Output voltage accuracy	± 3% (SPOT & SWEEP mode)
Output Impedance	≤ 200 ohms (output setting depending)
Output Protection	The output is short circuit protected
Power Supply	Single 1.5V battery, AA-size
Power Consumption	Typically 14mA @ 1.5V
Battery life	Approximately 40 hours

Replacing the Battery

IMPORTANT NOTICE

PLEASE ENSURE CORRECT BATTERY POLARITY.

PLACING THE BATTERY THE WRONG WAY ROUND CAN POTENTIALLY DAMAGE THE UNIT!

The ***EEG Calibrator*** runs from a single 1.5V alkaline battery [size AA] that should give approximately 40 hours of operation. To replace the battery follow these steps:

1. Ensure that the unit is switched off;
2. Unscrew the 4x screws and remove the enclosure's lid;
3. Unclip the old battery by tugging on the battery strap or alternatively, lever the battery out with a very small jeweller's type screwdriver.
4. Fit a new battery, ensuring that the polarity is correct as indicated in the bottom of the battery compartment. The PCB is also market with a "+" to indicate the side to which the positive battery terminal should point.
5. Replace lid, ensure correct orientation (the foam pad glued to the inside of the lid should press onto the battery and not the PCB).

Battery Test

Whenever the ***EEG Calibrator*** is switched on, a battery check is performed. If the battery is OK, the LED is flashed three times in quick succession. Should the battery be low (under 1.2V), the LED will remain extinguished.

The battery test can be repeated at any time by simply pressing the push button switch.

Making DIP-Switch Selections

The ***EEG Calibrator*** uses an 8-way DIP-switch to select the mode and configure the frequency, sweep rate, pulse duration, etc. Because these switches are rather tiny, the best way to change the settings is by using a ball-point pen. A pencil should not be used as this could cause pencil dust to penetrate the switch after prolonged use (pencil dust contains carbon which is conductive). A clutch pencil where the led has been retracted, however, would also be fine.

NOTE: ***It should be ensured that the individual DIP-switches have been moved right to their end-stops, otherwise a switch might be read with the wrong logic state.***

Modes of Operation

The ***EEG Calibrator*** has three modes of operation:

- **SPOT** sinewave generation
- **SWEEP** sinewave generation
- **PULSE** generation

The required mode is selected via DIP-switch 7 & 8 as shown in the following diagram:

SPOT SINEWAVE:

SW	1 (Bit 0 (lsb))	2 (Bit 1)	3 (Bit 2)	4 (Bit 3)	5 (Bit 4)	6 (Bit 5 (msb))	7 (PULSE ENA)	8 (SWEEP ENA)
ON	X	X	X	X	X	X		
OFF							■	■

SWEEP SINEWAVE:

SW	1 (Bit 0 (lsb))	2 (Bit 1)	3 (Bit 2)	4 (Bit 3)	5 (Bit 4)	6 (Bit 5 (msb))	7 (PULSE ENA)	8 (SWEEP ENA)
ON	X	X	X	X	X	X		■
OFF							■	

PULSE GENERATION:

SW	1 (Bit 0 (lsb))	2 (Bit 1)	3 (Bit 2)	4 (Bit 3)	5 (Bit 4)	6 (Bit 5 (msb))	7 (PULSE ENA)	8 (SWEEP ENA)
ON	X	X	X	X	X	X	■	
OFF								■

X = don't care

To select or change a specific mode, adjust DIP-switch 7 & 8 as indicated in the above figures.

Connecting the Output Leads

The ***EEG Calibrator*** is shipped with two crocodile terminated leads, one to be connected to the ground (GND) socket and the other to be connected to one of the output taps of either 50/200/2000 uVpp.

The output circuit consists of a voltage divider network as shown in the figure below.

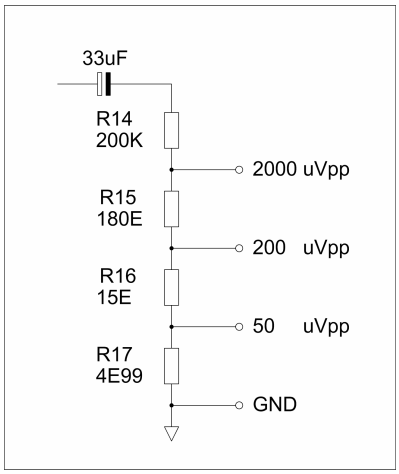

Figure 1: ***EEG Calibrator*** Output Circuit

With extra test leads, it would be possible to say, connect channel 1 of an EEG amplifier to the 50uVpp output and channel 2 to the 200uVpp output tap.

It is also possible to connect the leads across say, resistor R16 (i.e. the return wire is no longer plugged into GND but into the 50uVpp socket. The output voltage will then be the difference as indicated in the above diagram (200 – 50), i.e. 150uVpp.

Finally a word of caution: The crocodile clamps can damage the surface coating of EEG electrodes. We recommend either using old, unused electrodes or alternatively, clamp only onto the pin shroud (electrode depending).

SPOT Sinewave Usage

In this mode the ***EEG Calibrator*** generates a sinewave of specific frequency. This function can be used for the following:

1. Amplitude/gain checks for hardware/software;
2. Amplitude calibration of EEG hardware should this be fitted with trimmers;
3. Frequency measuring accuracy of the software (given a specific sampling rate);
4. Performance of software filters.

Note on point (4): Filter performance checks can be manually executed by measuring the amplitude at every frequency step and plotting this on graph paper (amplitude versus frequency).

		Bit 0 (lsb)	Bit 1	Bit 2	Bit 3	Bit 4	Bit 5 (msb)	PULSE ENA	SWEEP ENA
	SW	1	2	3	4	5	6	7	8
SPOT SINEWAVE:	**ON** **OFF**	**-**	**F**	**R**	**E**	**Q**	**-**	▮	▮
1 Hz	-	**0**	**0**	**0**	**0**	**0**	**0**	0	0
2 Hz	-	**1**	**0**	**0**	**0**	**0**	**0**	0	0
3 Hz	-	**0**	**1**	**0**	**0**	**0**	**0**	0	0
4 Hz	-	**1**	**1**	**0**	**0**	**0**	**0**	0	0
▼	-	▼	▼	▼	▼	▼	▼	▼	▼
64 Hz	-	**1**	**1**	**1**	**1**	**1**	**1**	0	0

0 = DIP switch OFF
1 = DIP switch ON

TABLE 1. SPOT SINEWAVE CONFIGURATION

The actual frequency is adjusted by setting the DIP-switches 1 to 6 in binary format with the least significant bit (LSB) being SW1 and the most significant bit (MSB) being SW6.

See Appendix A for the complete, 64-step, lookup table covering the 1 to 64Hz spectrum.

SWEEP Sinewave Usage

In this mode the ***EEG Calibrator*** generates a sinewave that is swept automatically in a number of various methods. This function can be used to visually check the performance of the following:

1. Overall frequency response of the hardware/software system;
2. The impact frequency shaping filters have on the system;
3. Check the trigger points of neurofeedback treatment protocols.

In this mode DIP-switches 1 & 2 set the way the sweep is performed, i.e. up-ramp, down-ramp or triangular (zigzag). Switches 3-6 are used to select the sweep rate. The sweep is generated by stepping through the 64 steps in equally spaced time intervals, the sweep thus follows a linear staircase over the sweep frequency.

In the slowest sweep, each discrete frequency is held for approximately 248mS. At this rate the saw-tooth sweep takes 16 seconds and the sea-saw sweep 32 seconds to complete.

In the fastest sweep, each discrete frequency is held for approximately 8mS resulting in 0.5 or 1 second to complete the sweep for the saw-tooth and sea-saw sweeps respectively.

		Bit 0 (lsb)	Bit 1	Bit 2	Bit 3	Bit 4	Bit 5 (msb)	PULSE ENA	SWEEP ENA
	SW	1	2	3	4	5	6	7	8
SWEEP SINEWAVE:	**ON** **OFF**	**S1**	**S2**	**R1**	**R2**	**R3**	**R4**	▮	▮
reserved	-	**0**	**0**	X	X	X	X	0	1
Decreasing freq. saw-tooth	-	**0**	**1**	X	X	X	X	0	1
Increasing freq. saw-tooth	-	**1**	**0**	X	X	X	X	0	1
Rise & fall, triangular	-	**1**	**1**	X	X	X	X	0	1
Sweep rate 1 (slow)	-	X	X	**0**	**0**	**0**	**0**	0	1
Sweep rate 2	-	X	X	**1**	**0**	**0**	**0**	0	1
Sweep rate 3	-	X	X	**0**	**1**	**0**	**0**	0	1
Sweep rate 4	-	X	X	**1**	**1**	**0**	**0**	0	1
Sweep rate 5	-	X	X	**0**	**0**	**1**	**0**	0	1
Sweep rate 6	-	X	X	**1**	**0**	**1**	**0**	0	1
Sweep rate 7	-	X	X	**0**	**1**	**1**	**0**	0	1
Sweep rate 8	-	X	X	**1**	**1**	**1**	**0**	0	1
Sweep rate 9	-	X	X	**0**	**0**	**0**	**1**	0	1
Sweep rate 10	-	X	X	**1**	**0**	**0**	**1**	0	1
Sweep rate 11	-	X	X	**0**	**1**	**0**	**1**	0	1
Sweep rate 12	-	X	X	**1**	**1**	**0**	**1**	0	1
Sweep rate 13	-	X	X	**0**	**0**	**1**	**1**	0	1
Sweep rate 14	-	X	X	**1**	**0**	**1**	**1**	0	1
Sweep rate 15	-	X	X	**0**	**1**	**1**	**1**	0	1
Sweep rate 16 (fast)	-	X	X	**1**	**1**	**1**	**1**	0	1

X = Don't care
0 = DIP switch OFF
1 = DIP switch ON

TABLE 2. SWEEP SINEWAVE CONFIGURATION

PULSE Generator Usage

In this mode the ***EEG Calibrator*** generates a pulse (square wave) for which the pulse-width as well as the pulse repetition rate can be programmed. This function can be use to measure or verify the following:

1. Settling time of hardware/software system;
2. Settling time of frequency shaping filters;
3. Asynchronous sampling delays;
4. System Propagation delays.

In this mode DIP-switches 1-3 are used to program the pulse-width while switches 4-6 program the required pulse off period.

Note: In this mode the output voltage is approximately x2.5 greater than when generating spot or sweep sine waves. The ***EEG Calibrator*** should not be used for amplitude measurement/calibration when in pulse generator mode.

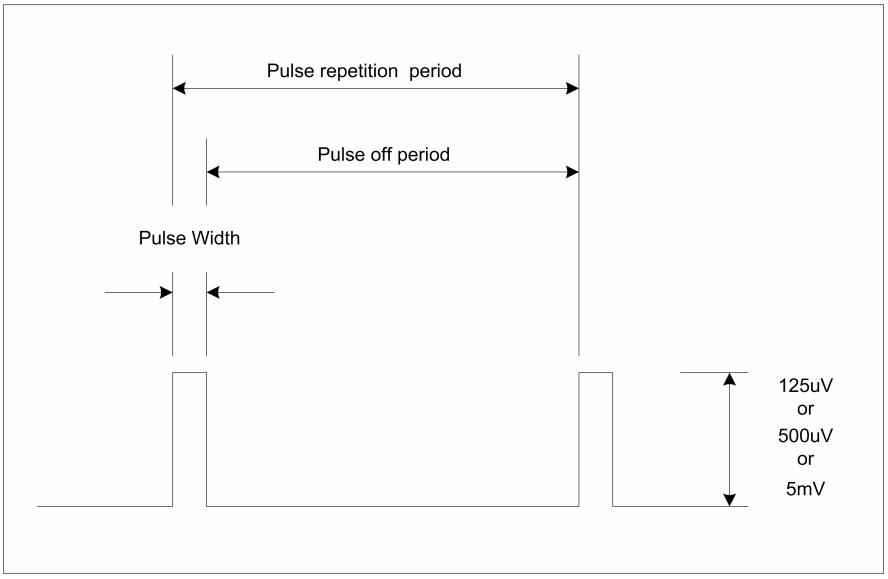

FIGURE 2. PULSE TIMING DIAGRAM

From the above diagram it can be seen that:

Pulse Repetition Period = Pulse Width + Pulse Off Period

For small Pulse Width Periods, the Pulse Repetition Period and the Pulse Off Period can be considered the same.

		Bit 0 (lsb)	Bit 1	Bit 2	Bit 3	Bit 4	Bit 5 (msb)	PULSE ENA	SWEEP ENA
	SW	1	2	3	4	5	6	7	8
PULSE GENERATION:	**ON** **OFF**	**W1**	**W2**	**W3**	**R1**	**R2**	**R3**	▮	▮
Pulse width: 16 mS	-	**0**	**0**	**0**	X	X	X	1	0
Pulse width: 32 mS	-	**1**	**0**	**0**	X	X	X	1	0
Pulse width: 48 mS	-	**0**	**1**	**0**	X	X	X	1	0
Pulse width: 64 mS	-	**1**	**1**	**0**	X	X	X	1	0
Pulse width: 80 mS	-	**0**	**0**	**1**	X	X	X	1	0
Pulse width: 96 mS	-	**1**	**0**	**1**	X	X	X	1	0
Pulse width: 112 mS	-	**0**	**1**	**1**	X	X	X	1	0
Pulse width: 128 mS	-	**1**	**1**	**1**	X	X	X	1	0
Pulse repetition: 0.5 sec	-	X	X	X	**0**	**0**	**0**	1	0
Pulse repetition: 1.0 sec	-	X	X	X	**1**	**0**	**0**	1	0
Pulse repetition: 1.5 sec	-	X	X	X	**0**	**1**	**0**	1	0
Pulse repetition: 2.0 sec	-	X	X	X	**1**	**1**	**0**	1	0
Pulse repetition: 2.5 sec	-	X	X	X	**0**	**0**	**1**	1	0
Pulse repetition: 3.0 sec	-	X	X	X	**1**	**0**	**1**	1	0
Pulse repetition: 3.5 sec	-	X	X	X	**0**	**1**	**1**	1	0
Pulse repetition: 4.0 sec	-	X	X	X	**1**	**1**	**1**	1	0

X = Don't care
0 = DIP switch OFF
1 = DIP switch ON

TABLE 3. PULSE GENERATION CONFIGURATION

Appendix – A

FREQUENCY SELECTION VIA DIP SWITCHES

FREQ [Hz]	DIP SWITCH SETTING						FREQ [Hz]	DIP SWITCH SETTING					
	1	2	3	4	5	6		1	2	3	4	5	6
1	0	0	0	0	0	0	**33**	0	0	0	0	0	1
2	1	0	0	0	0	0	**34**	1	0	0	0	0	1
3	0	1	0	0	0	0	**35**	0	1	0	0	0	1
4	1	1	0	0	0	0	**36**	1	1	0	0	0	1
5	0	0	1	0	0	0	**37**	0	0	1	0	0	1
6	1	0	1	0	0	0	**38**	1	0	1	0	0	1
7	0	1	1	0	0	0	**39**	0	1	1	0	0	1
8	1	1	1	0	0	0	**40**	1	1	1	0	0	1
9	0	0	0	1	0	0	**41**	0	0	0	1	0	1
10	1	0	0	1	0	0	**42**	1	0	0	1	0	1
11	0	1	0	1	0	0	**43**	0	1	0	1	0	1
12	1	1	0	1	0	0	**44**	1	1	0	1	0	1
13	0	0	1	1	0	0	**45**	0	0	1	1	0	1
14	1	0	1	1	0	0	**46**	1	0	1	1	0	1
15	0	1	1	1	0	0	**47**	0	1	1	1	0	1
16	1	1	1	1	0	0	**48**	1	1	1	1	0	1
17	0	0	0	0	1	0	**49**	0	0	0	0	1	1
18	1	0	0	0	1	0	**50**	1	0	0	0	1	1
19	0	1	0	0	1	0	**51**	0	1	0	0	1	1
20	1	1	0	0	1	0	**52**	1	1	0	0	1	1
21	0	0	1	0	1	0	**53**	0	0	1	0	1	1
22	1	0	1	0	1	0	**54**	1	0	1	0	1	1
23	0	1	1	0	1	0	**55**	0	1	1	0	1	1
24	1	1	1	0	1	0	**56**	1	1	1	0	1	1
25	0	0	0	1	1	0	**57**	0	0	0	1	1	1
26	1	0	0	1	1	0	**58**	1	0	0	1	1	1
27	0	1	0	1	1	0	**59**	0	1	0	1	1	1
28	1	1	0	1	1	0	**60**	1	1	0	1	1	1
29	0	0	1	1	1	0	**61**	0	0	1	1	1	1
30	1	0	1	1	1	0	**62**	1	0	1	1	1	1
31	0	1	1	1	1	0	**63**	0	1	1	1	1	1
32	1	1	1	1	1	0	**64**	1	1	1	1	1	1

0 = DIP switch OFF
1 = DIP switch ON