DP-FAM-250-2.5
DP-FAM-500-2.5

Fast Amplitude Modulation HV Driver

Technical Description
Rev. 2206

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Lithuania

CONTENTS

List of Figures

List of Tables

This chapter contains the warranty statement and service contact information.

1.1. Warranty Statement

This Pockels cell driver is protected by one-year warranty covering labor and parts. The warranty enters into validity since the shipment date. Any evidence of improper use or unauthorized attempts at repair leads to warranty cancellation.

1.2. Service Contact Information

For service/warranty requests, please contact:

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2.1. General Information

2.1.1. Model

DP-FAM-250-2.5 – 250 kHz maximal repetition rate driver

DP-FAM-500-2.5 – 500 kHz maximal repetition rate driver

2.1.2. Main Components

Table 1. Main components

Component	***Quantity***
High voltage (HV) driver DP-FAM-xxx-2.5	1
DC power cable (l=1.5m)	1
BNC-SMB cable (l=1.5m)	1 for Mode 1 preset driver 2 for Mode 2 preset driver
HV cable (l=1.5m)	1
Pair of cables for HV output to the Pockels cell (<10 cm)	1
BNC-MCX cable (l=1.5m)	1
Technical description	1

2.2. Technical Specifications

Table 2. Technical specifications

Parameter	*Specifications*
Maximum HV repetition rate, *kHz*	250 / 500 (depends on model)
HV input, *kV*	2.65…2.7
HV output control range, *kV*	0.1…2.5
Maximum HV consumption (HV load = 6 pF), *W*	60 @ 250 kHz 120 @ 500 kHz
Maximum load capacitance, pF	8
Polarity	Positive
HV pulse rise time, *ns*	< 26
HV pulse fall time, *ns*	< 13
HV pulse duration, *ns*	70…3000 @ 250 kHz 70…1000 @ 500 kHz
HV pulse delay, *ns*	45
External triggering pulse amplitude @50Ω load, *V*	3.5…5
External triggering pulse rise time, *ns*	< 10
External triggering modes, factory preset [1]	Mode 1 – single pulse trigger control Mode 2 – 2-pulses trigger control
External triggering pulse duration (for mode 2), *ns*	>30
Time range between SYNC1 and SYNC2 (Mode 2) or pulse duration SYNC1 (Mode 1), ns	100…3000 @ 250 kHz 100…1000 @ 500 kHz
Minimal time gap from SYNC2 to SYNC1 (Mode 2) or from falling to rising edge (Mode 1), ns	1000
HV control (modulation) input amplitude range, *V*	0.1…4.9
Low voltage DC requirements	24±1 V;500 mA
Connector	Molex Micro-Fit 3.0
Dimensions, *mm*	110(139) x 69 x 57
Water connector (if installed)	“Festo” or analogous for OD=6mm tube
Maximal operating temperature of base plate, °*C*	35
Weight, *g*	1100

[1] Check a sticker on top of the driver whether it is factory preset for Mode 1 or Mode 2 operation

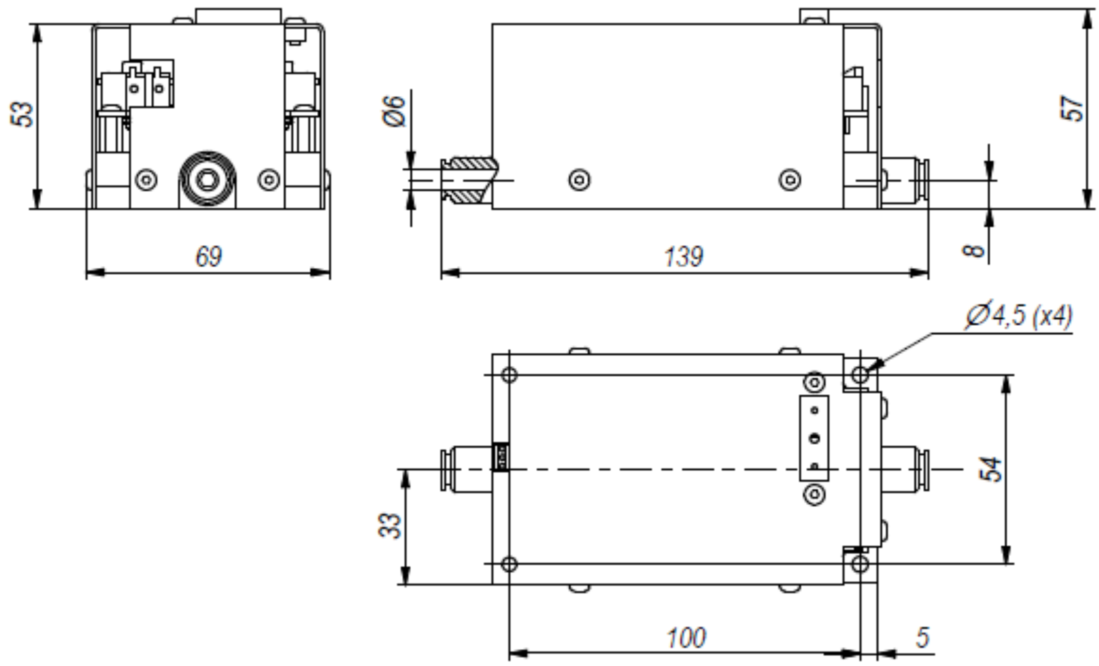


Figure 1. Outline drawing and dimensions of the driver

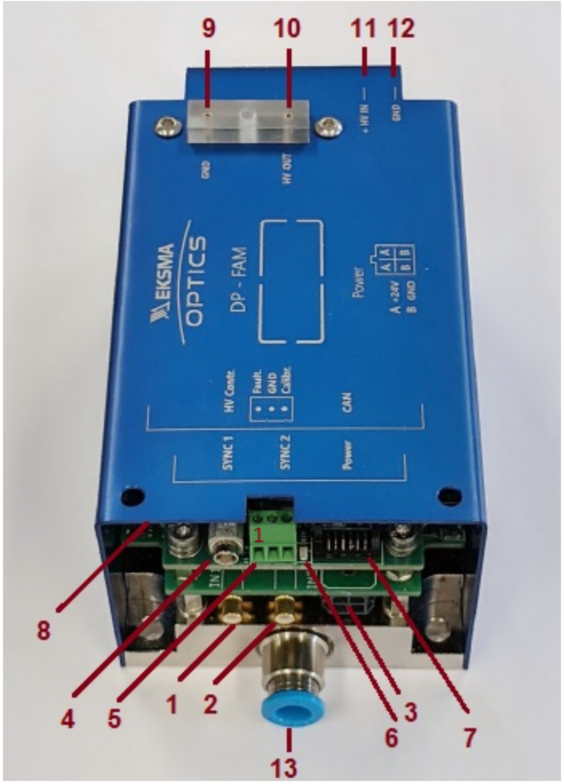


Figure 2. Driver ports

Table 3. Driver ports

#	*Port*
1	SYNC1 input
2	SYNC2 input
3	Connector for HV supply Molex 4 (Microfit 3 series) interface for +DC supply (“A” is +DC; “B” is GND)
4	HV Control (Modulation) input
5	Connector for fault output and calibrate input (see **Figure 8**)
6	LED indication for fault and calibrate
7	CAN interface connector
8	50 Ohm jumper for HV control input
9	GND output to Pockels cell
10	HV output to Pockels cell
11	HV input
12	HV GND input
13	Connections for water cooling hoses (2 pcs.)

Equipment is designed to be safe under normal environmental conditions according to 1.4.1. 61010-1@IEC:2010 (Safety requirements for electrical equipment, control and laboratory use):

1. indoor use;
2. altitude up to 2000 m;
3. temperature 5˚C to 35˚C;
4. maximum relative humidity 80% for temperatures up to 31˚C decreasing linearly to 50% relative humidity at 35˚C;
5. POLLUTION degree 1: no POLLUTION or only dry, non-conductive POLLUTTION occurs.

Warning:
The safety of the system incorporating driver and HV power supply is the responsibility of the assembler of the system.

Operating the driver is allowed to persons acquainted with the operation manual and having permission to deal with voltages over 1000 V.

Do not remove unit covers while power cable is connected to the mains (if applicable).

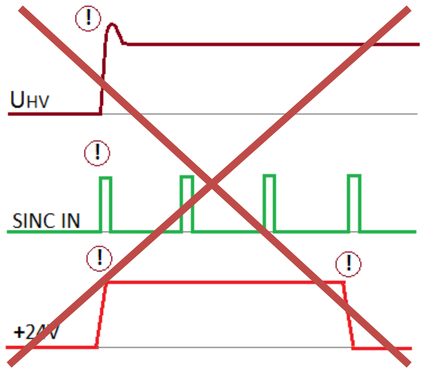
Do not touch any parts of the system when high voltage is applied, as it may cause injury or death.

Do not operate the unit until is **grounded** and the load is connected.

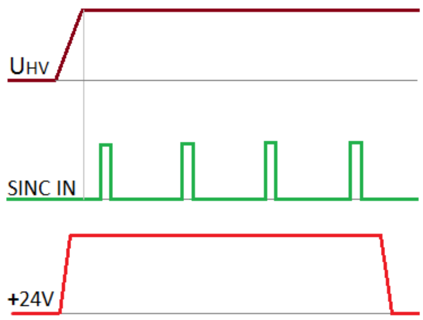
Do not use the unit if any defects have been detected.

Attention!
Please read these important notes before using the product!

1. External triggering pulses to SYNC IN inputs may be applied only if high voltage and DC power are provided and turned on. When turning off the driver, first turn off synchronization pulses, then turn off the power. Otherwise, the driver may be damaged.



Incorrect driver operation*. SYNC IN pulses appears before HV and 24V; SYNC IN pulses continues after 24V is switched off; HV supply gives an overshot.*



Correct driver operation

Figure 3. Driver operation chart

2. The pulse shape (including fronts) can be measured indirectly. On your oscilloscope, select 1 V sensitivity and the 1 M input. Then an isolated 1:10 divider should be slowly and carefully moved towards the hot output wire. When the probe is ~10 mm away from the hot output wire, the pulse shape should appear in the oscilloscope (amplitude should be several volts). Do not place the probe too close to the hot output wire – a discharge may start and damage the driver. This measurement method is not suitable for measuring >500 ns pulses.

3. If attempt to measure the parameters using an oscilloscope, probe needs to be very firmly connected to driver output before turn on HV. Bad probe contact can damage driver.

1. Set-up cooling

This driver is cooled either by heatsink or external water. Water connectors used are for 6mm OD hoses. The cooling should ensure the base plate temperature does not exceed 35°C during operation. The power to be removed by cooling is equal to HV power supply power consumption.

2. Connect wires to the Pockels cell

There are several requirements for the wires leading from outputs GND and HV OUT to the Pockels cell.

The wires must be about 0.24 mm^2 CSA. Both wires must be as short as possible and of equal length. Their length must not exceed 100 mm. The hot wire must be at least 5 mm away from any conductive materials (including the operator's fingers and instruments) – this is done to avoid any additional capacitive load. Otherwise, the driver's characteristics may degrade and/or the driver may be damaged.

3. Ground the Pockels cell driver together with the generator and HV supply

The driver output of several kilovolts (kV) with very fast edges is a powerful source of electromagnetic interference (EMI). Please ensure proper wiring and grounding to avoid problems caused by interference.

The best solution to minimize EMI is to mount the driver and the HV power supply on the metal body of the laser. The driver base plate must have very good contact with the ground wire of the HV power supply, such as the four mounting holes on the edges of the board.

If the EMI level is still very high, attempt mounting ferrites on all power and control wires leading to the driver and power supply (except wires to the Pockels cell).

Please note that the aluminum case of the driver is not designed to provide effective EMI shielding. Essentially, correct wiring provides best results.

4. Supply voltage to the driver from the DC power supply

For a safe start of the driver, the DC power supply must provide at least 0.6 A peak current when turning on. Although most DC power supplies are capable of providing this, it is recommended to double-check your supply as an insufficient peak current may damage the driver.

5. Supply voltage from the HV supply

If the HV power supply is manufactured by another manufacturer, ensure there is no overvoltage while turning it on before supplying voltage.

6. Provide synchronization pulses from the generator

It is necessary to measure the generator output voltage with a 50 Ω load before applying synchronization signals to the DP-FAM driver. Amplitude needs to be in the range of 4…5 V. Voltage lower than 4 V is not recommended due to growth of output pulse jitter. Make sure that the delay between **SYNC1** and **SYNC2** (Mode 2) pulses or **SYNC1** duration (Mode 1) is longer than 100 ns. Shorter delay or of the synchronization pulses may damage the driver. Note that output pulses is about 30 ns shorter than input.

After voltage is measured and correct timing is set, remove the 50 Ω load and connect synchronization pulses to the driver.

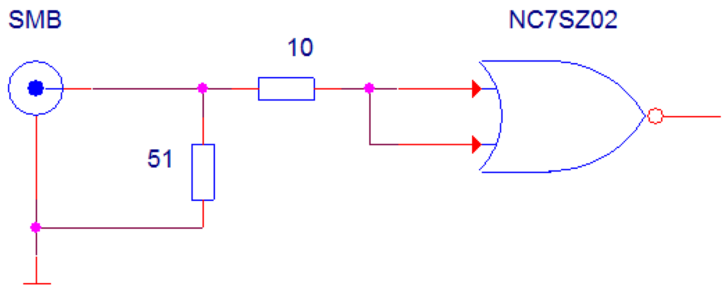


Figure 4. SYNC input circuit

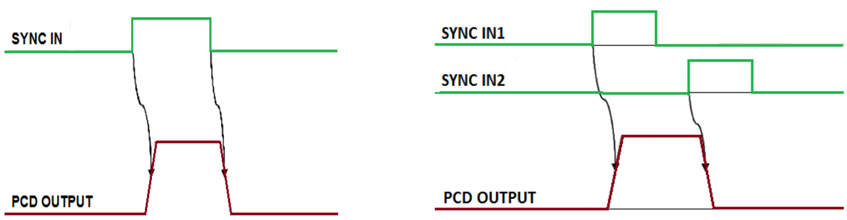


Figure 5. Control timing principle charts with 1 sync pulse (Mode 1, left) and with 2 sync pulses control (Mode 2, right)

7. Prepare analog control signal

Amplitude of HV output to Pockels cell is controlled by **HV Control** input. Input signal amplitude can be in range 0.1V...4.9V. Signal lower than 0.1V will result in an unstable HV output. Input resistance is 1kΩ without a jumper (**#8**) or 50 Ω with a jumper.

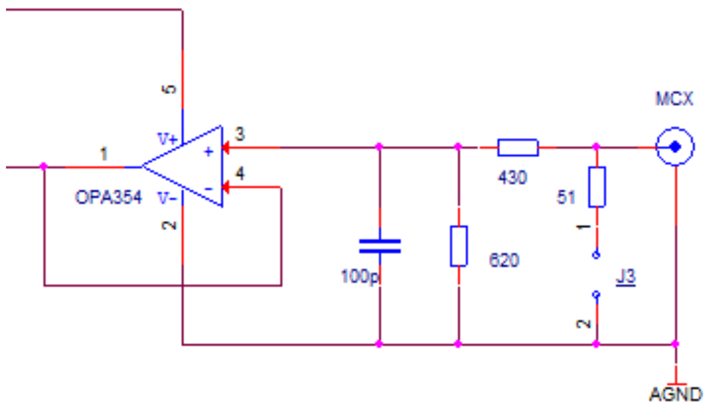


Figure 6. HV Control input circuit

8. Apply amplitude control timing

The HV Control input is used to set HV voltage to Pockels cell. Amplitude can be controlled individually for each output pulse in range from 0.1 to 2.5 kV. HV control input is read-out during **SYNC1** fall in Mode 1 or **SYNC2** rise in Mode 2 and used to set next HV pulse amplitude as it is shown in Figure 6 diagram.

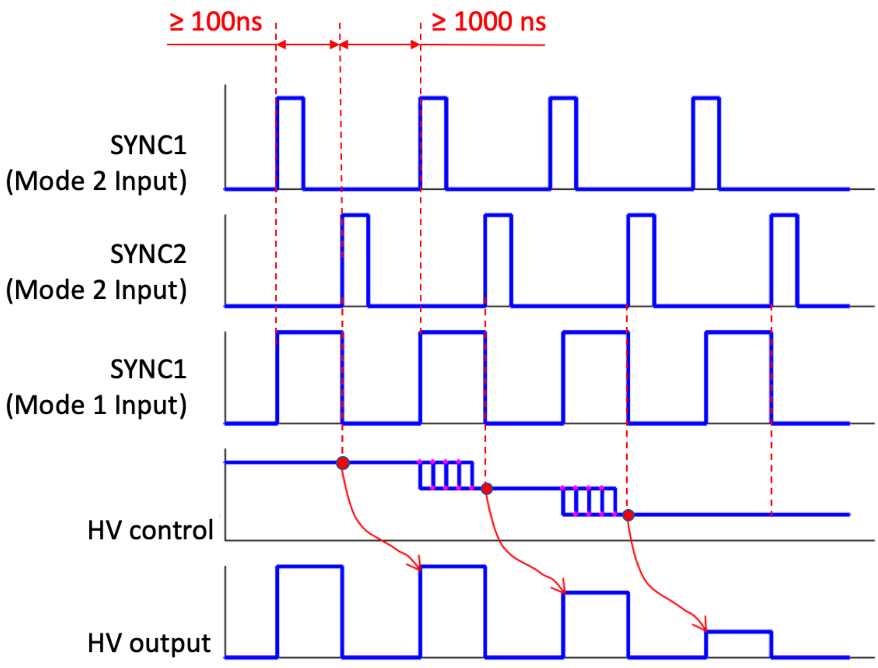


Figure 7. HV Control principle timing chart. Either Mode 1 or Mode 2 is used for control

9. Run the driver to operate

Turn on +24V and HV power supplies. Apply 0.1…4.9V level **to HV Control** input. Apply SYNC pulses according to your timing requirements. HV pulses should appear at the output (pay special attention to clause **#2** in Chapter **5** on how to test the output).

10. Calibration

Calibration process establishes conformity between HV control signal and HV output voltage. During operation, driver constantly self-calibrates. However, it is recommended to run calibration every time you turn on the driver in prior to operation to avoid temporal HV control inconformity just after start.

Next control sequence should be applied to run the driver with in-prior calibration.

- Run the driver to operate as per clause 6.9.
- Provide single pulse to pin 1 of calibration connector (**#5**). Pulse amplitude 2.5…5V, duration 50ns…0.1s.
- The **Calibrate** LED (**#6**) lights while driver is calibrated. The same time pin 3 of **connector (#5)** is clamped to GND (see Figure 8).
- Duration of calibration process can take time up to several minutes if you use current Pockels cell for the first time. It will take less than one second if no hardware changes were applied from last run. You can start normal driver operation immediately when calibration ends.

See the CAN interface description Chapter **8** for more details about calibration.

11. LED (#6) functions

This LED illuminates if:

- Calibration is running;
- Driver pad temperature is too high (more than 60°C, default value).

Short LED pulses are possible during normal operation. This indicates that the HV pulse amplitude temporary deviates by 2% or more from the expected value.

12. Connector (#5) Fault pin

The (**#5**) fault pin3 connector is an open collector output (see figure below). It works simultaneously with LED **(#6)** and permits monitoring the driver status. Maximal output current is 30 mA.

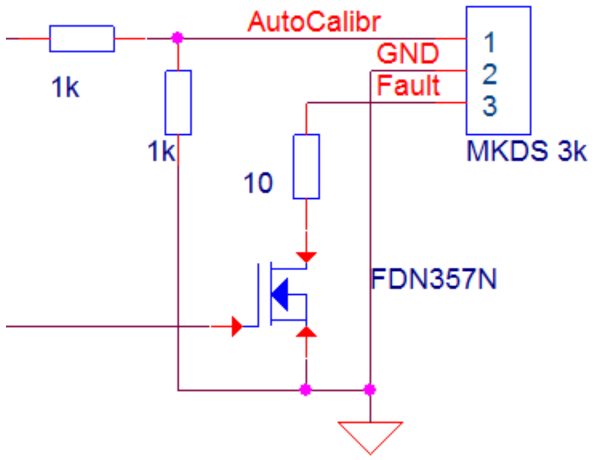


Figure 8. Fault output circuit

1. Connect **CAN BOX** to **PC** and **DP-FAM** driver by cables.
2. Turn on +24V power supply.
3. Install and open **CAN Browser** Apps.
4. Set required settings.

8.1. Basic Settings

8.1.1. Vprog

Read last sampled Vprog voltage.

8.1.2. Vfb

Read last sampled output (feedback) voltage.

8.1.3. Output control mode

Choose output control mode:

- Manual – output voltage is set using Vset or DAC* registers;
- Proportional – output voltage is proportional to Vprog;
- Sine^2 – output voltage is proportional to square sine of Vprog,

Output control table (OCT) is used to convert Vprog to output voltage.

For proportional mode:

$$Vout = Voutmin + (Voutmax - Voutmin) * \frac{Vprog - Vprogmin}{Vprogmax - Vprogmin}.$$

For Sine^2 mode:

$$Vout = Voutmin + (Voutmax - Voutmin) * sin^2\left(\frac{\pi}{2}\frac{Vprog - Vprogmin}{Vprogmax - Vprogmin}\right).$$

Sampled Vprog value is limited to fit Vprogmin - Vprogmax interval prior to calculating Vout.

8.1.4. Feedback control

Feedback control = ON – output voltage is compensated to minimize Vfb – Vset error. Since correction is made after each sync in pulse, FAM high voltage supply should be stable any time synchronization pulse arrives. To prevent improper corrections to DAC table while HV power is off, DAC table corrections are not made while Vfb is less than Vout min.

8.1.5. Tdrv

Driver temperature reading.

8.1.6. DAC table

Voltage feedback control is performed for each Vset value. Initial Vset to DAC conversion values are stored in DAC table.

8.1.7. Vset continuous scan

To calibrate initial Vset to DAC conversion values in DAC table we need to test each set point several times. Calibration is performed as follows:

- Turn on HV power supply
- Feed SYNC IN with 50 kHz or higher rate signal. Slower clock rates are OK, but it will take longer to calibrate each set point. At 50 kHz one minute should be enough.
- Set ‘Output control mode’ register to Manual.
- Set ‘Feedback control’ register to ON.
- Set ‘Vset continuous scan’ register to ON.
- To compensate all voltages, set Vout min to 0.
- It is recommended to to monitor Vfb graphically using *CanBrowser→Tools→Show Chart*. After long enough scan sweeps Vfb(t) curve should appear linear, a nice triangle from Vsetmin to the top. Flat top corresponds to max available Vout, depends on used HV power supply. Flat bottom corresponds to min available Vout, depends on used HV power supply and ‘DAC min’ register setting.

8.1.8. Save DAC table

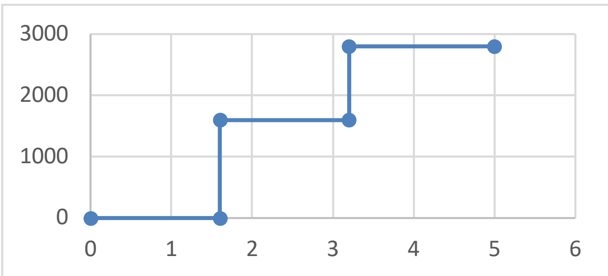
Once Vset continuous scan test is done, you may save new initial Vset-DAC table. You may also save the current DAC table, which may include corrections for temperature drift etc. Continuous scan test is optional. Save DAC table=SAVE always save current DAC table.

8.1.9. Output control table

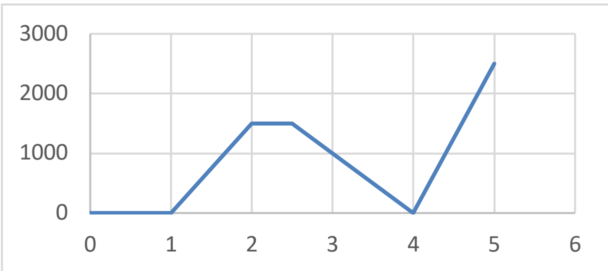
‘Output control mode’=Table uses output control table (OCT) to convert Vprog to Vset. You define points $Vout_N(Vprog_N)$, each pair of adjacent $Vprog_N$ points is connected with a line. Points are sorted in memory by increasing Vprog, no need to swap or move OCT points to order by index as well.

Examples:

OCT index	***OCT Vprog***	***OCT Vout***
0	0	0
1	1.6	0
3	1.601	1600
5	3.2	1600
4	3.201	2800
2	5	2800



OCT index	***OCT Vprog***	***OCT Vout***
0	0	0
1	1	0
3	2	1500
5	2.5	1500
4	4	0
2	5	2500



Vout min and max limits always apply to calculated Vout value in all modes Proportional/Sine^2/Table.

8.1.10. OCT number of points

You may define from 2 to 100 points.

N = 'OCT number of points' tells with point indexes are valid, OCT index 0 to N-1 are valid, all other points are ignored.

8.1.11. Save OCT

'Save OCT'=SAVE saves valid OCT points.

8.2. Advanced control registers

8.2.1. Tjcpu

CPU junction temperature.

8.2.2. Calibrate Vfb divider

Feedback voltage calibration coefficient.

8.2.3. DAC Min and DAC Max

Minimum and maximum DAC limits.

8.2.4. DAC table, DAC table index and DAC table data

These registers allow reading and modifying of DAC table entries.

8.2.5. ADC

Read ADC output registers.