

PowerHap™ – Piezo Actuators for Active Haptic Feedback

Application note

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PowerHap – Piezo Actuators for Active Haptic Feedback

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2 Introduction

This evaluation kit was developed to support engineers during their first steps designing applications with the PowerHap piezo actuators for haptic feedback.

This evaluation kit is available in two versions.

The design is not qualified regarding manufacturing and operation over the whole operation temperature range or lifetime.

The evaluation kits provided by TDK are intended to be used for functional testing only.

Due to their purpose, evaluation driver kits are not intended to be used by the same procedures regarding returned material analysis (RMA) and process change notification (PCN) as regular products.



The board described is an evaluation driver board dedicated for laboratory environment only. It operates at voltages up to 124V. This board must be operated by qualified and skilled personnel familiar with all applicable safety standards.

2.1 Ordering Code

Version 1 was designed to drive up to five PowerHap It can be ordered by using the ordering code Z63000Z2910Z 1Z 7.

Version 2 can drive a single PowerHap actuator at a time. It can be ordered by using the ordering code Z63000Z2910Z 1Z 1.

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2.2 Content of evaluation driver kit

One channel evaluation kit

- Power supply (12 V DC / 1 A) shipped with two pin connector (Euro connector)
- Micro USB cable
- One part of each PowerHap type (15G; 7G; 2.5G)
- USB memory stick
 - PC configuration software*
 - Documentation
- 4 pcs female connectors
- One channel driver board

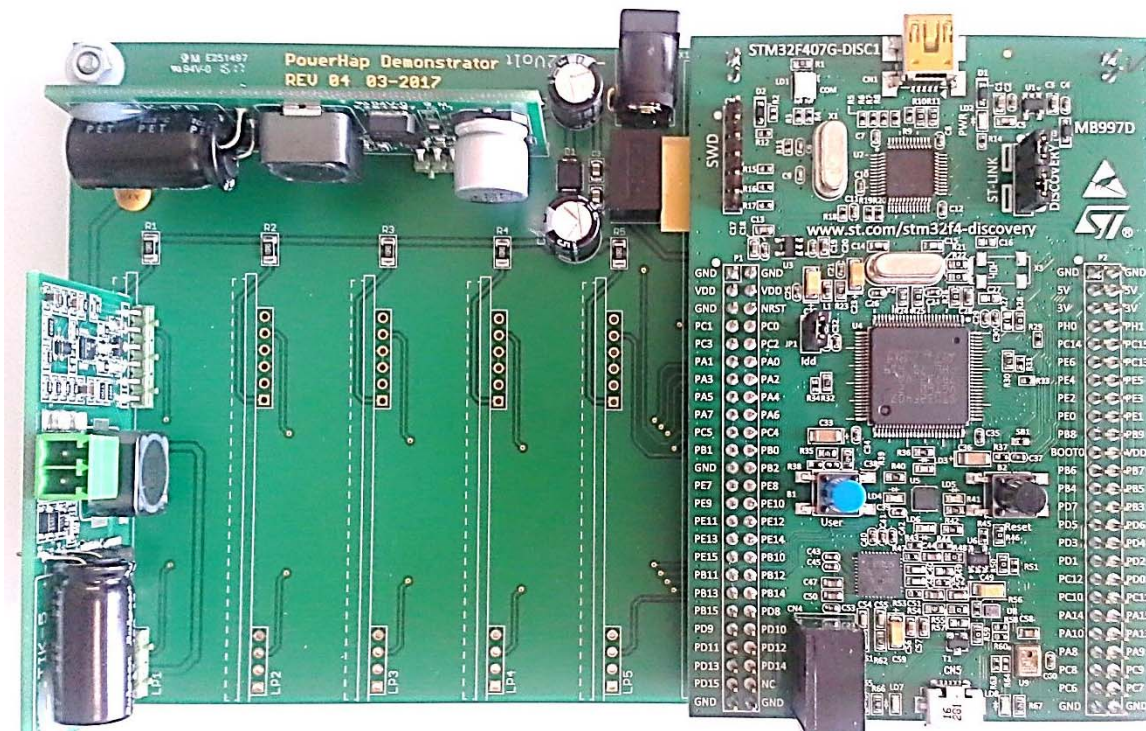


Figure 1: PowerHap 1-channel driver board

*In case your company policy does not allow the use of USB sticks pls. contact your TDK sales contact person.

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The Five channel evaluation kit shipped with two pin connector (Euro connector)

- Power supply (12 V DC / 1 A)
- Micro USB cable
- One part of each PowerHap type (15G; 7G; 2.5G)
- USB memory stick
 - PC configuration software*
 - Documentation
- 8 pcs female connectors
- 5 channel driver board

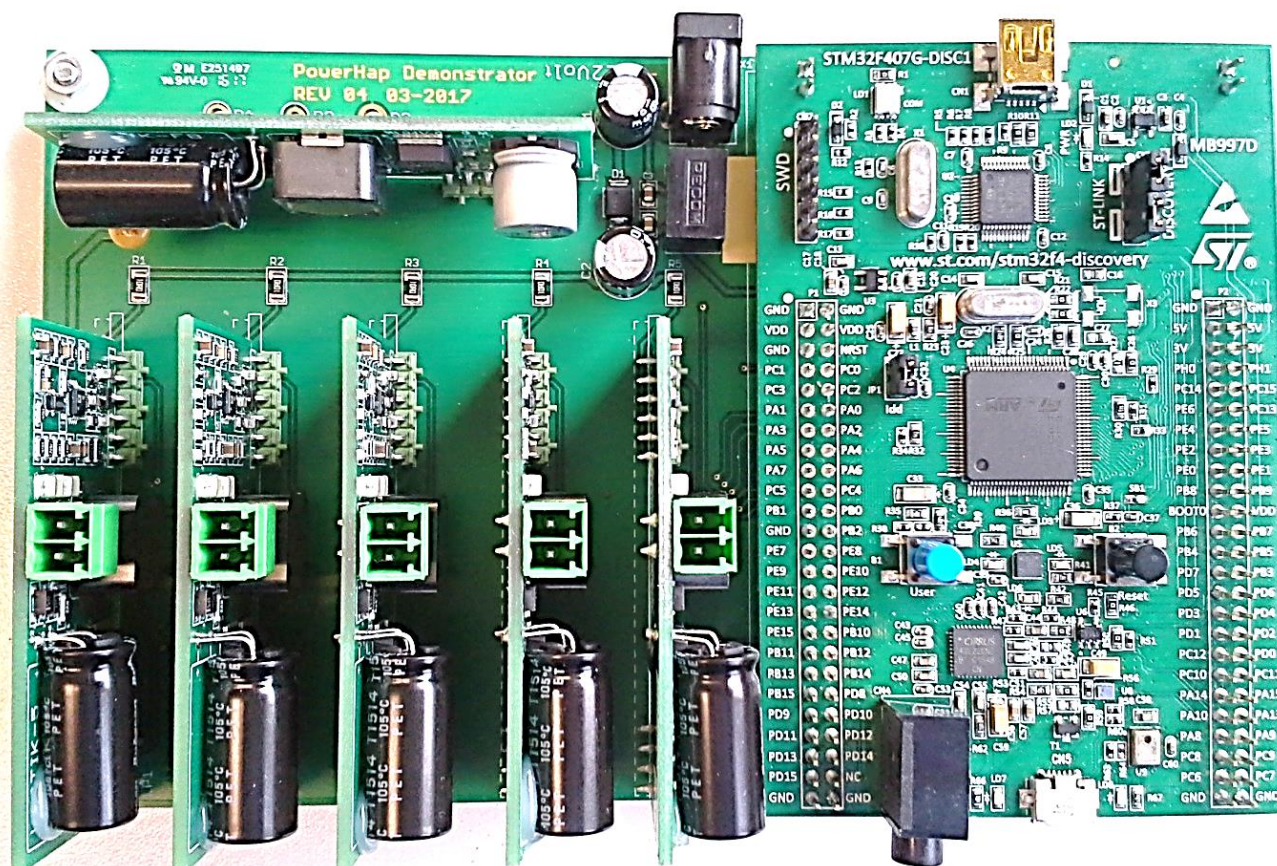


Figure 2: PowerHap 5-channel driver board

* In case your company policy does not allow the use of USB sticks pls. contact your TDK sales contact person.

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3 Installation

The driver boards are designed to drive the different PowerHap types of TDK. As described in the picture above, the main parts on the demonstrator are the base board, the step up converter, the output driver boards (up to five output driver boards are possible) and the CPU unit.

Configuration software comes with the demonstrator board. With this software, a lot of parameters can be adjusted (like the shape of the waveform, driving voltage, frequency, etc.) More details can be found in the software section.

3.1 Hardware installation (connector and board diagram)

The following sections provide an overview of the board including main features, key data, pin assignment and mechanical dimensions.

Example: One channel driver board

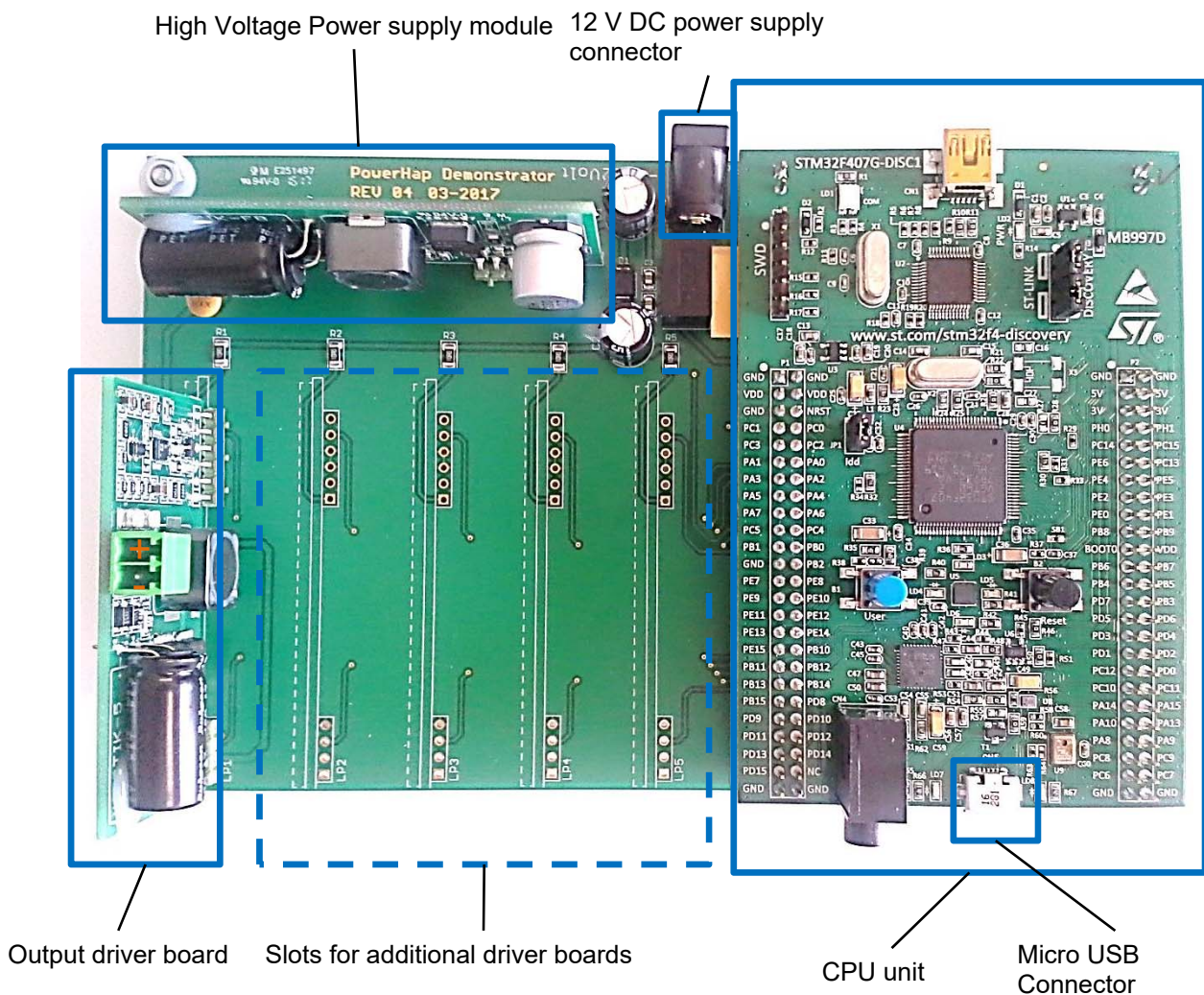


Figure 3: PowerHap 1-channel driver board connection diagram

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3.2 Initialization

After the driver board is powered up an initialization process is running. This takes some seconds. During this time it is recommended not to press any connected PowerHap

The initialization process is finished when the green LED (LD4) on the STM32F407G-DISC1 board is on. The LD4 is located between the blue and the black switch on the board.

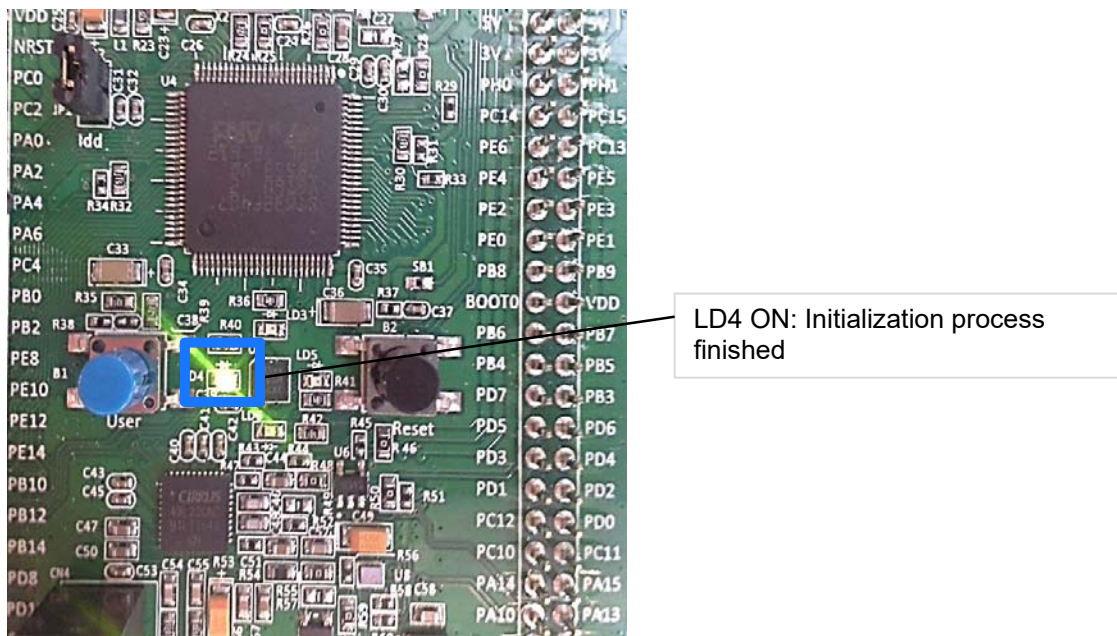


Figure 4: Driver board with control LED between blue and black switch.

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3.3 Dimensions of the driver boards

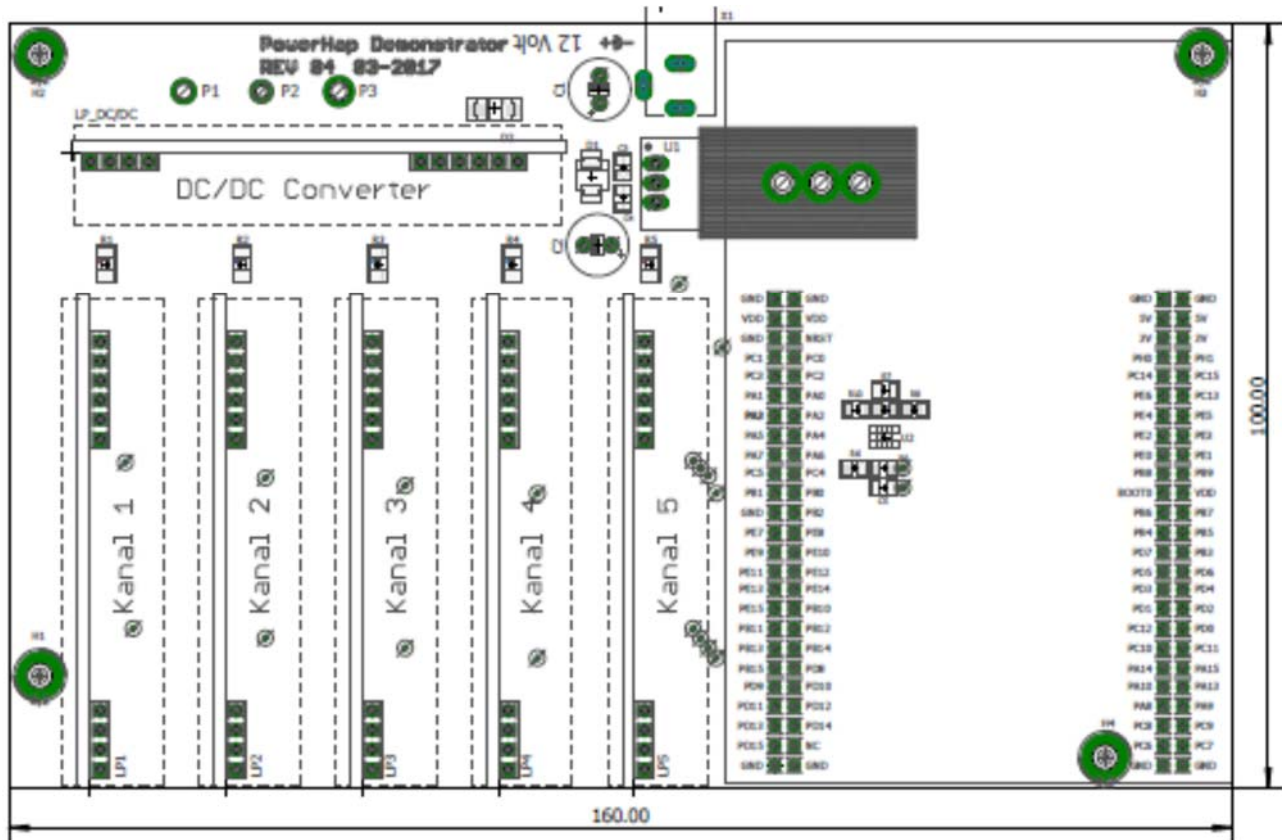


Figure 5: Outer dimensions of the baseboard (Length x Width $L \times W = 160.0 \times 100.0$ mm)

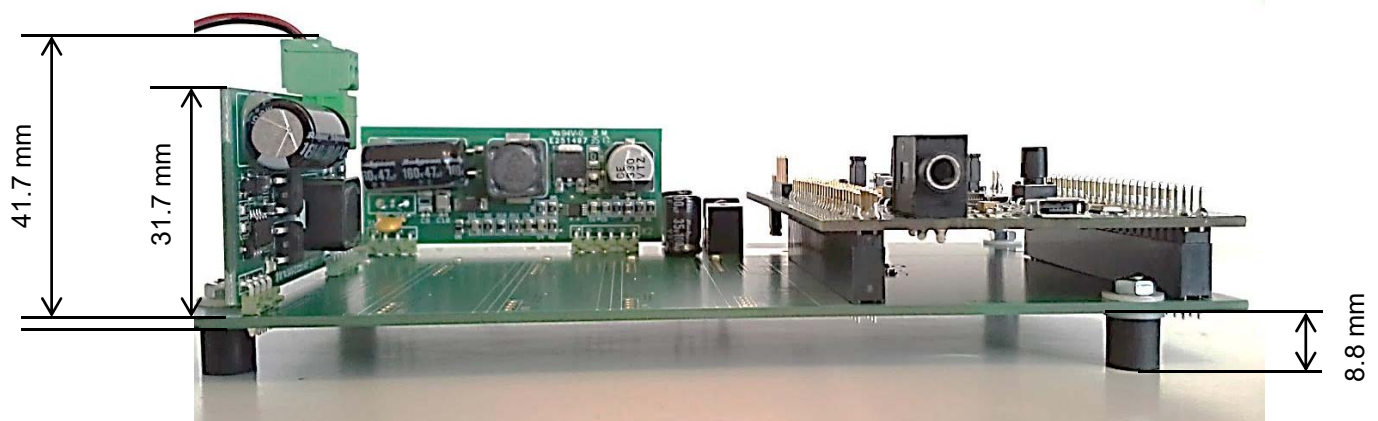


Figure 6: Height of the driver (total height: 41.7 mm; height PCB: 31.7 mm)

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3.4 Software Installation

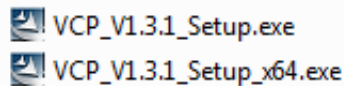
3.4.1 Software Installation

The software will work with Windows 7 versions and higher. For the installation of the software you will need administrator rights on your computer

USB driver installation

Before connecting the board to a computer, the USB driver for the system must be installed. The relevant driver can be found on the USB stick in the folder "USB Driver"

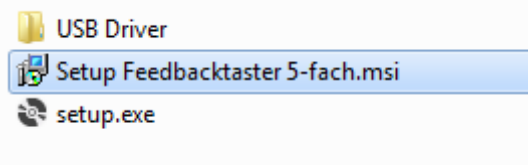
- a. For 32 bit Windows versions execute the file "VCP_V1.3.1_Setup.exe"
- b. For 64 bit Windows versions execute the file "VCP_V1.3.1_Setup_x64.exe"



- c. Follow the installing instructions on your computer

Installation of the configurator software

- a. In the folder "Configurator_V1.2.0.0" execute the file "Setup Feedback taster 5-fach.msi"
- b. Follow the installation instructions on your computer



- c. A restart of the computer after the software installation is recommended

3.4.2 Software Setup

- The software is ready to use after successful installation of the USB driver and the PowerHap Signal configurator. Before opening the PowerHap configurator you have to perform the following steps:
 1. Connect the demo board with a micro USB cable to your computer; use the micro USB port (see also section 3.1 for further details).
 2. Connect the piezo PowerHap device(s) to the output drivers(s)
 3. Power up the demo board by applying 12 V DC
 4. Open the PowerHap Signal Configurator software on your computer
 5. Select the COM-port of the USB connection
 6. Click the "Connect" button to establish the USB connection between demo board and PC

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4 “PowerHap Signal Configurator” software description

Functionality of the PowerHap Signal Configurator

Configuration of the feedback signals

Manual trigger

Data transfer via USB

Upload of a signal configuration from a csv file

Saving of the configuration

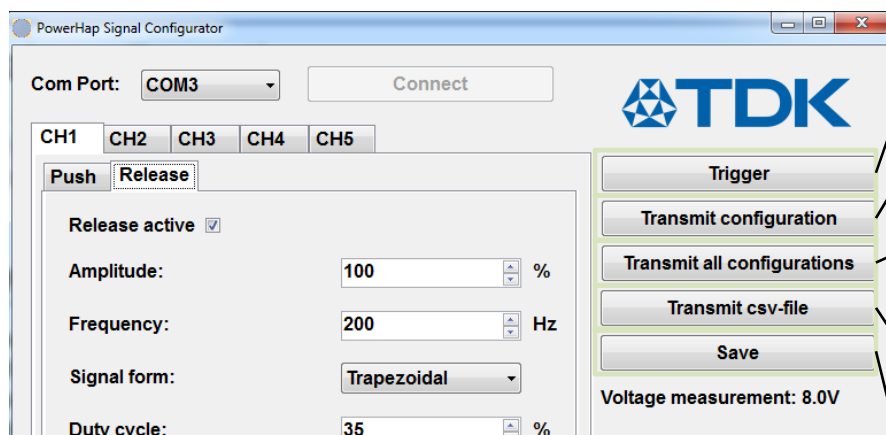


Figure 7: „PowerHap Signal Configurator” software detailed description

A software trigger can be given to the selected output; for the „Push” signal.

The settings of the selected channel are transmitted to the driver board

The settings of all channels are transmitted to the driver board

A csv file configuration can be transmitted to the selected channel of the driver board. Please note that the parameters from a csv file are not displayed in the fields of a channel. See also section 5.4 for further details

With the „Save button” all adjustments are saved. When the board is powered up it comes with these saved values, otherwise the adjustments are lost when the system is switched off.

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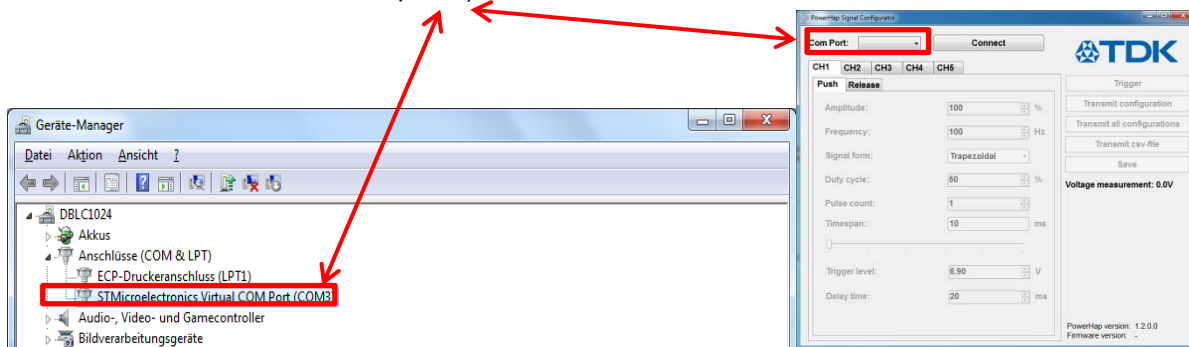
4.1 Choosing the right COM port

If there are other evaluation driver boards are connected to your computer you will have the possibility to choose more than one COM port.

You can find out the right port which is used for the PowerHap demonstrator port in the “Control Panel” of your computer

Control Panel -> Device Manager -> (Ports (COM & LPT))

In this window you can see which COM port is assigned to the PowerHap demonstrator board (see picture below; in that case it is the COM port 3)

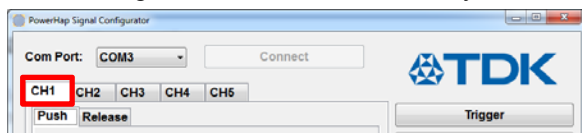


„Figure 8 “PowerHap Signal Configurator “software” COM Port selection

4.2 Signal configuration

The configuration always refers to the selected channel (1 to 5); each channel has its own tab.

For the single channel driver board only channel 1 is functional.



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4.3 Configuration for „Push“

- Amplitude: 5 to 100% (100% correlates to about 100 V)
- Frequency: 20 to 300 Hz
- Signal form: Selection among Trapezoidal / sine square wave / Saw tooth
- Duty cycle: 35 to 75%; available for the waveform "Trapezoidal"
- Pulse count: 1 to 1000; Outputs the adjusted amount of positive voltage pulses to the at set channel output.
- Trigger level: 0 to 12 V
- In idle state, a voltage level of example 8.4 V is displayed on the according channel. This voltage is decreased by the generated voltage from the PowerHap when it is pressed. When this voltage is lower than the adjusted trigger level, the haptic feedback is triggered. It is recommended to set the trigger level about 1 V to 1.5 V below the idle state voltage. The lower the trigger level the harder you have to press the PowerHap to trigger the haptic feedback.
- "Delay time: During the time span defined by the delay time the system is not active and will therefore not detect a force applied to the piezo element. The delay time measurement starts as soon as the previous actuation mode has finished.

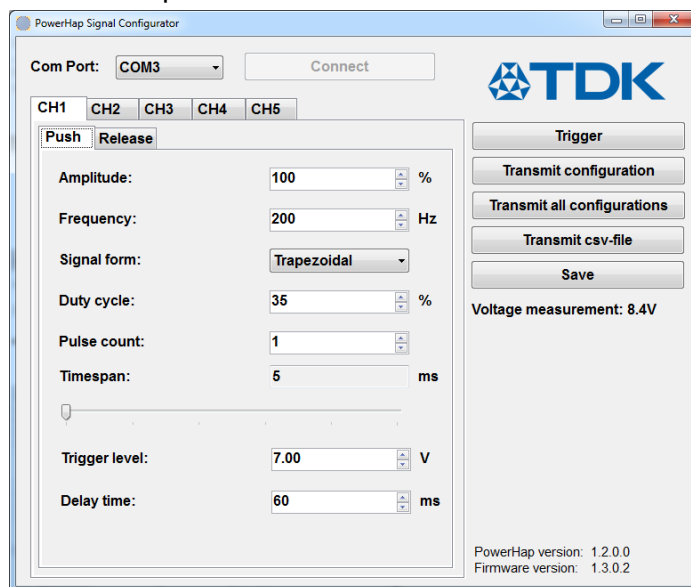


Figure 9: "PowerHap Signal Configurator" Push settings

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4.4 Configuration for „Release“

If the “Release active box” is checked, a second haptic feedback will be triggered when the force from the PowerHap is removed.

Comment: For normal haptic feedback applications we recommend to switch off the “release active” box.

- Amplitude: 5 to 100% (100% correlates to about 100V)
- Frequency: 20 to 300Hz
- Signal form: Selection among trapezoidal / sine square wave / saw tooth
- Duty cycle: 35 to 75%; available for the waveform “Trapezoidal”
- Pulse count: 1 to 1000; with the pulse count the amount of pulses per trigger event can be chosen.
- Release timeout:
- If the release of the button is not detected within the adjusted time, no “Release” signal will be given to the output. After this adjusted time, the board is ready to detect a “push” signal from the button
- Release gradient:
When releasing the button, the gradient of the input voltage vs. time is measured by the demo board. If the voltage change exceeds the adjusted value, the release output signal is triggered. A value of 1 corresponds to a gradient of 0.3 V/s.

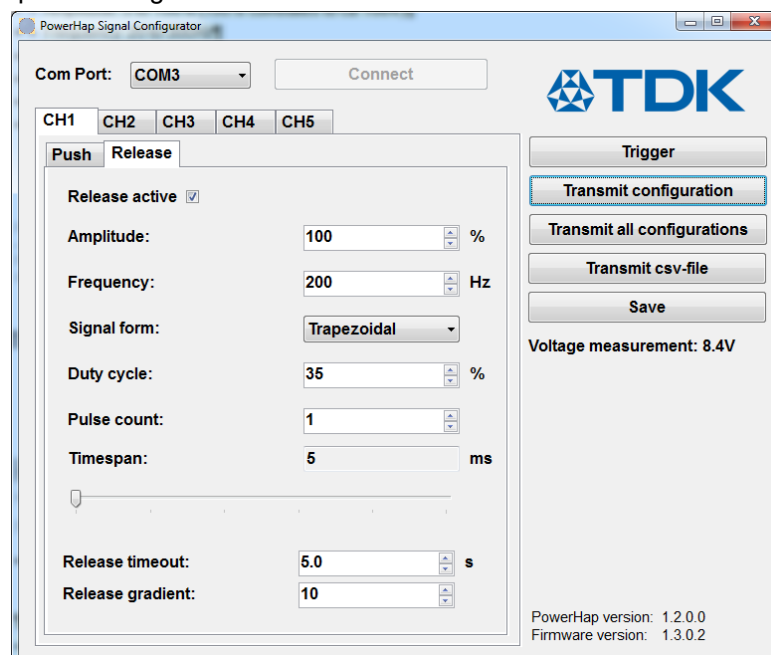


Figure 10: “PowerHap Signal Configurator” Release settings

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5 Preferred software settings for 2.5G, 7G, and 15G types

5.1 Typical signal parameter for the 2.5G Type

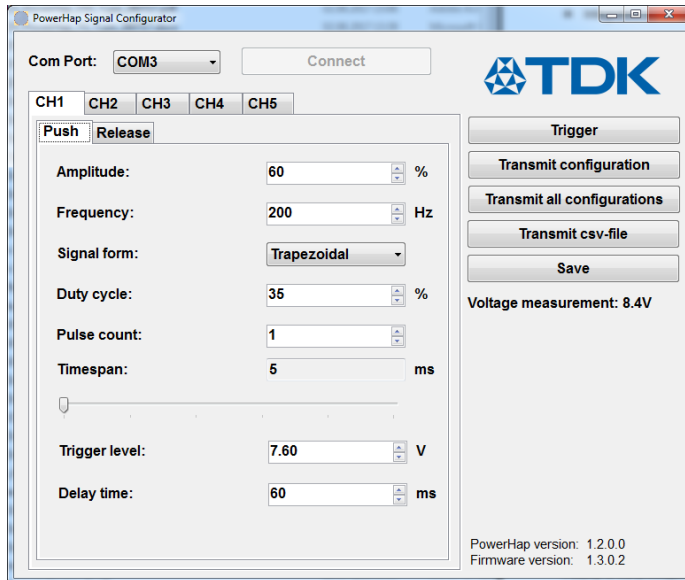


Figure 11; recommended settings for 2.5G type.

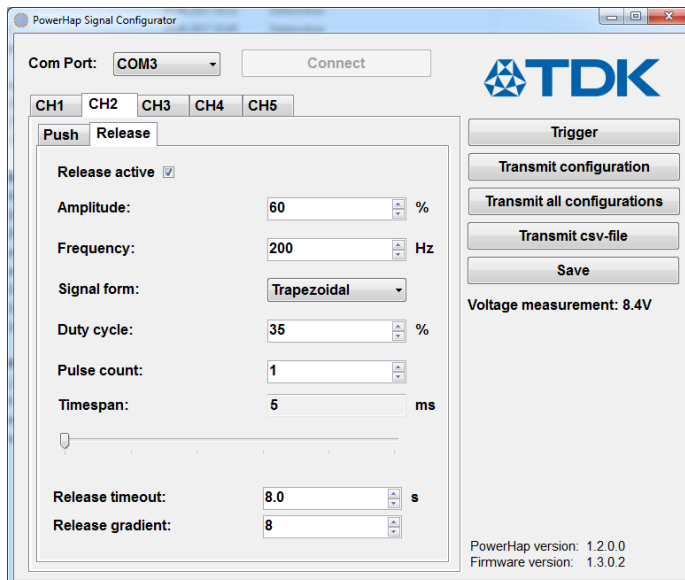


Figure 12: Optional setting: (In case no second pulse is required when releasing the pressure remove the check mark in the box “Release active”).

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5.2 Typical signal parameter for the 7G Type

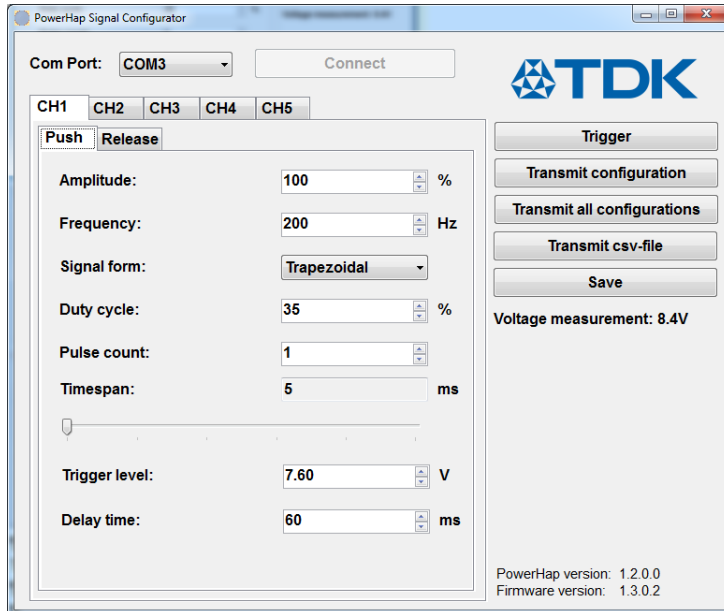


Figure 13: Recommended settings for 7G type.

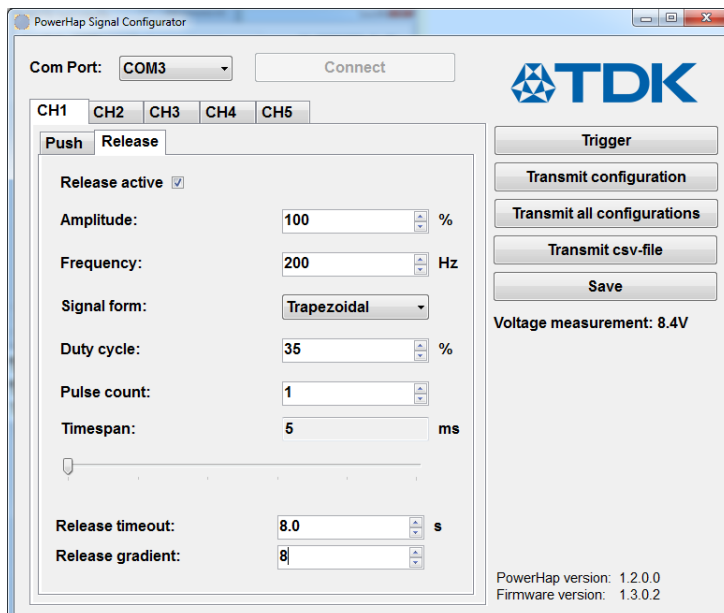


Figure 14: Optional item: (Normally no second pulse is required when releasing the pressure. In this case remove the check mark in the box “Release active”).

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5.3 Typical signal parameter for the 15G Type

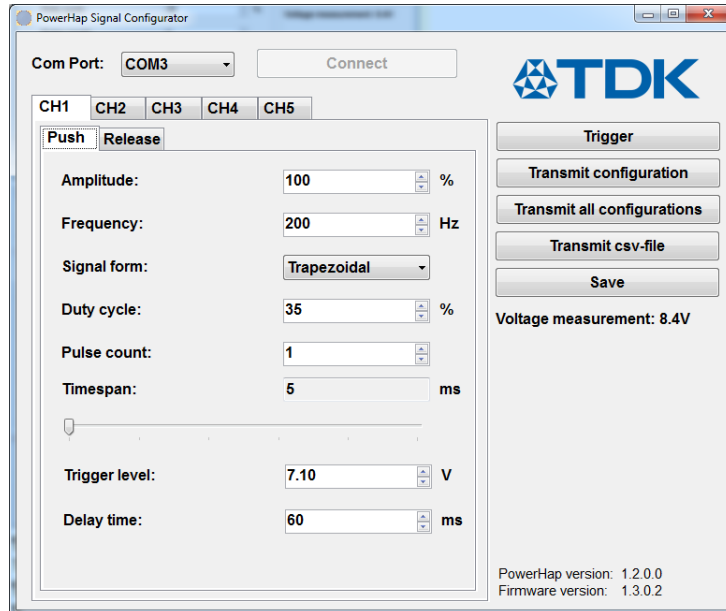


Figure 15: Recommended settings.

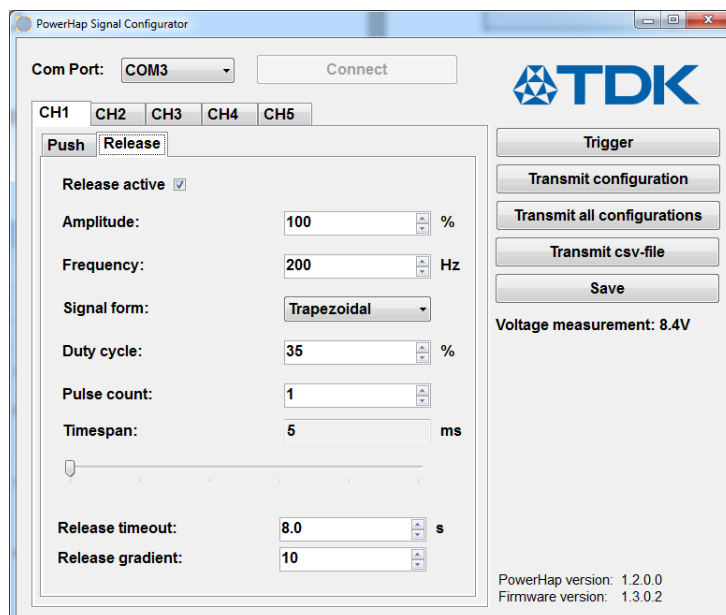


Figure 16: Optional item: (In case no second pulse is required when releasing the pressure remove the check mark in the box “Release active”).

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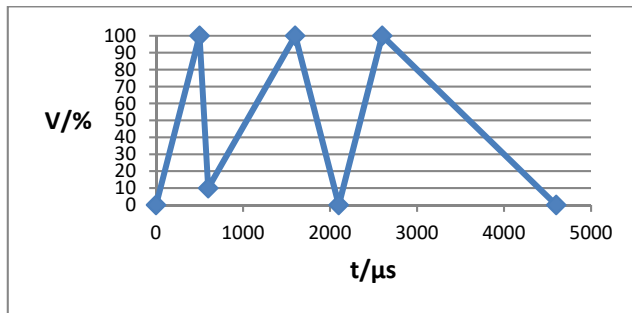
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5.4 Configuration of a *.csv file

- A customized waveform configured via a *.csv file can be transmitted to the PowerHap demonstrator board.
Format of a *.csv file: semicolon is required as separator.
- The values of a *.csv file can be changed i.e. with Excel or Notepad
 - Maximum amount of time / voltage values: 20
 - Linear interpolation between two “time and voltage” values (see also below diagram).
 - “Repetition: how often is the “push” or “release” waveform given to each single output.
 - Time / voltage columns:
 - A certain voltage value can be adjusted at a certain time as shown in below table.
 - The time column defines the duration until the target voltage level (defined in voltage column) is reached. The example shown in below diagram and table show the total timeline of voltage levels (“waveform”) which is applied to the PowerHap. In the shown example the total timespan of the defined waveform is 4600µs.



- Unit for time: µs
- Unit for voltage: V
- With the button “Transmit *.csv-file” the values of the selected file will be transmitted to the board
- With the “save” button the configuration is stored on the **non-volatile** memory of the demonstrator board. This means that after powering up the board this saved configuration is available

	A	B	C	
	1	Mode	Wiederholungen	
	2			
Means „push“	3	"druecken"	4	Repetition of the „push“ signal
	4			
	5	Zeit	Sollspannung	
	6	Mikrosekunden] [Volt]		
	7	500	100	
	8	100	10	
time column for push	9	1000	100	Voltage column for the push signal
	10	500	0	
	11	500	100	
	12	2000	0	
	13			
	14			
	15	Mode	Wiederholungen	
	16			
Means „release“	17	"loslassen"	1	Repetition of the „release“ signal
	18			
	19	Zeit	Sollspannung	
	20	1000	100	
time column for release	21	5000	0	Voltage column for the push signal
	22			

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6 Detailed description of hardware

6.1 Electrical Description

Base board

12 V_{DC} power supply:

High voltage power supply:

Output driver:

Slots for additional driver boards:

CPU unit:

unit.

Micro USB connector

On the base board the different units are installed

Connect a 12 V DC power supply to this jack

Step up converter; 124 V DC for the output driver are generated

The PowerHap actuators are connected to this output stage.5 output drivers are installed for a 5 channel driver board.

Up to five output driver boards can be driven

A STM32F407G407G-DISC1 evaluation driver board is used as CPU unit.

Changes of the configuration can be done with this interface

6.2 Circuit diagram of driver board

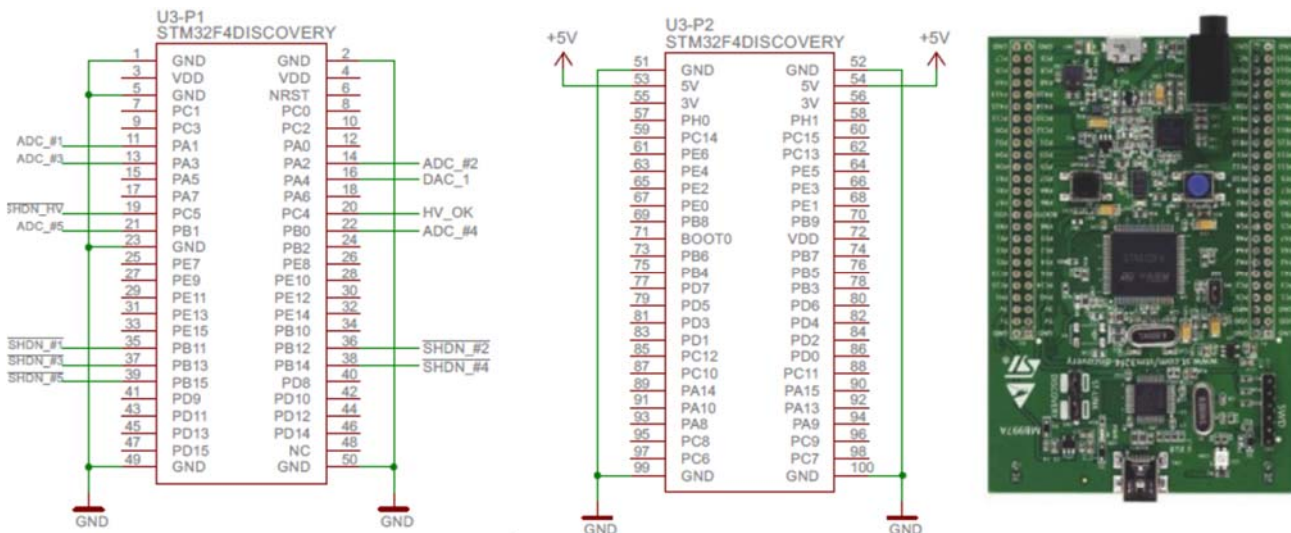


Figure 17: STMicroelectronics evaluation driver board STM32F407G-DISC1

Pin Description:

ADC_#1 to ADC_#5:

Via these inputs the system monitors the voltage across the piezo elements (5 inputs for potentially 5 piezo elements) in order to detect when force is applied to the piezo element, resulting in a compression (sensing function).

SHDN_#1 to SHDN#5:

Selection of the driver board

DAC_1:

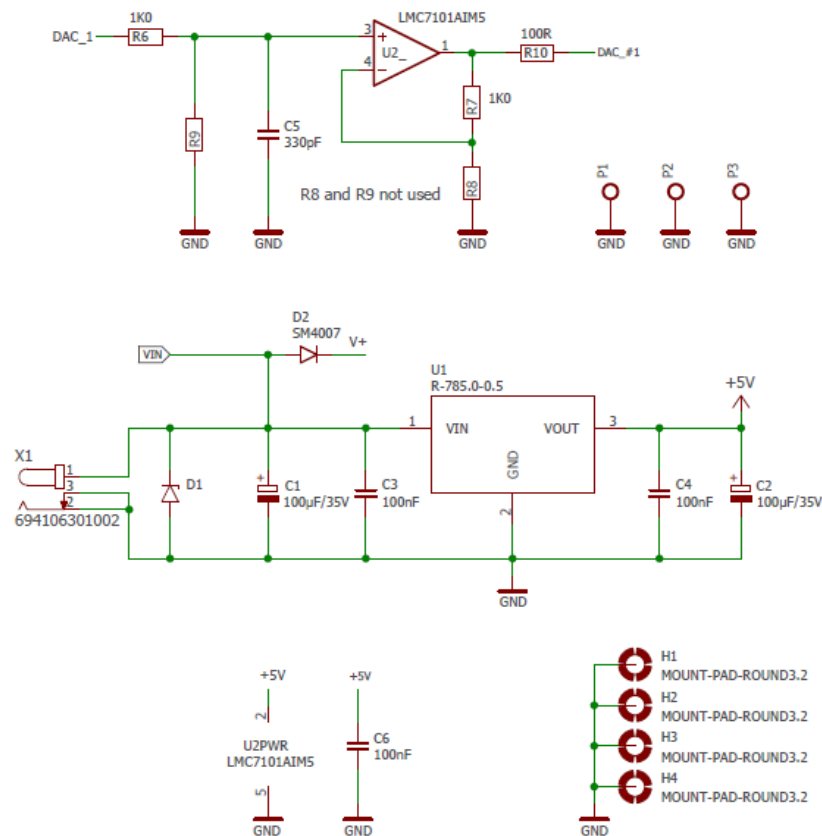
Analogue output, shape of the waveform is given on this output:

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Signal conditioning of the analog output
Resistors R8 and R9 not used

5V Power Supply

Figure 18: Schematic of 5 V supply; DAC amplifier

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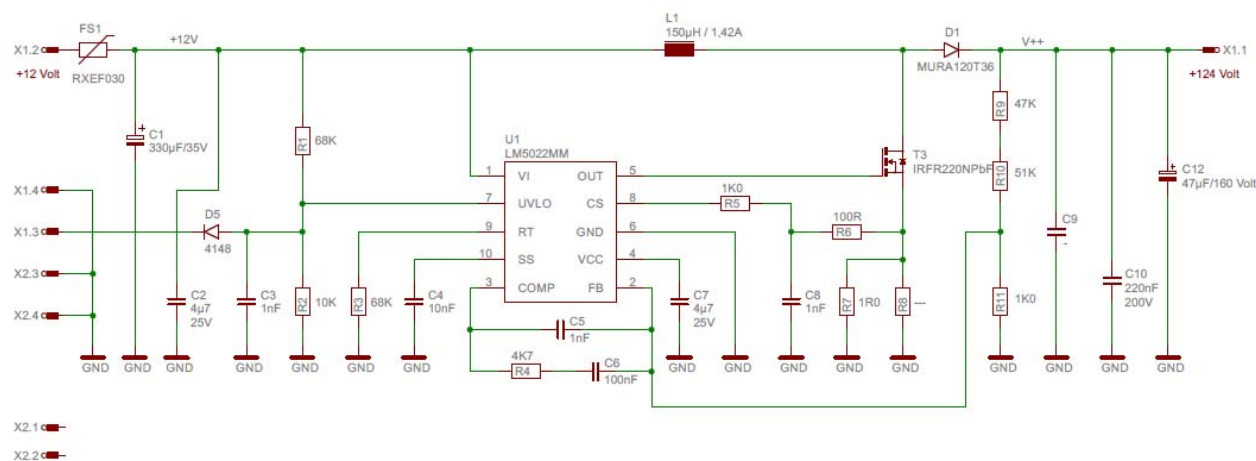


Figure 19: Schematic of the high voltage power supply module

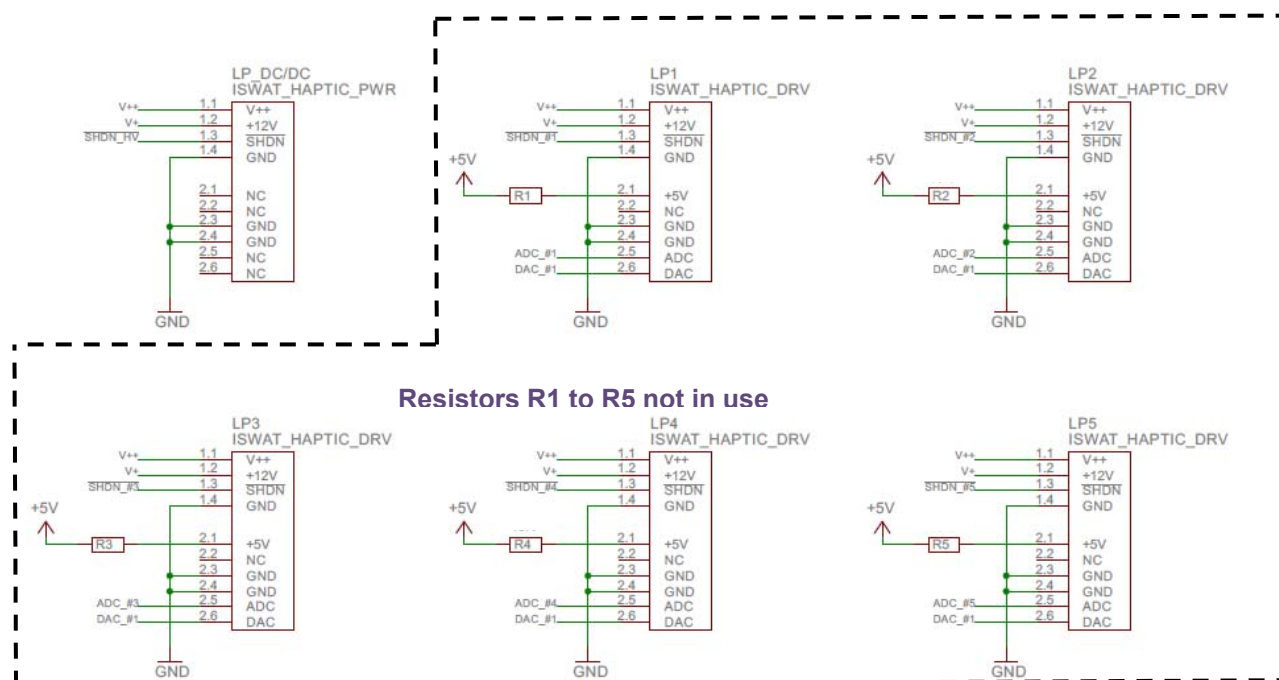


Figure 20: On this distribution board up to five output driver boards can be placed and controlled shown with the dashed line on the schematic above

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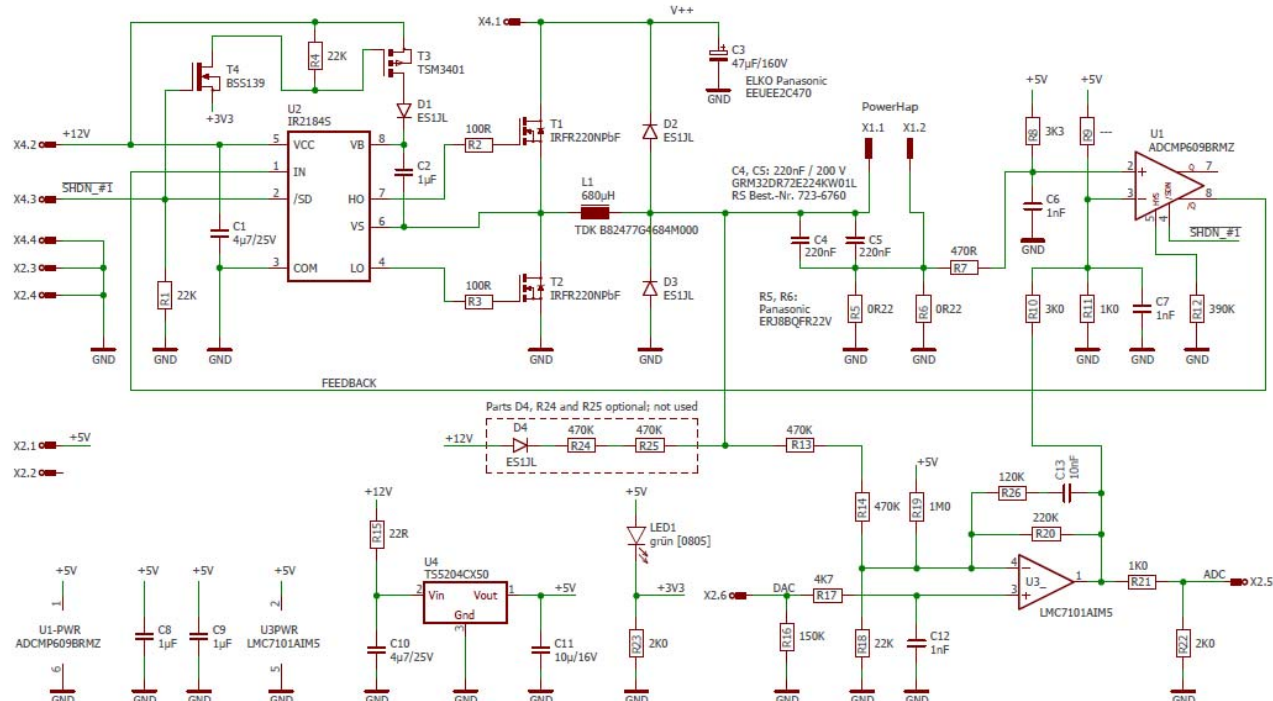


Figure 21: Schematic of one output driver board

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6.3 External trigger function description

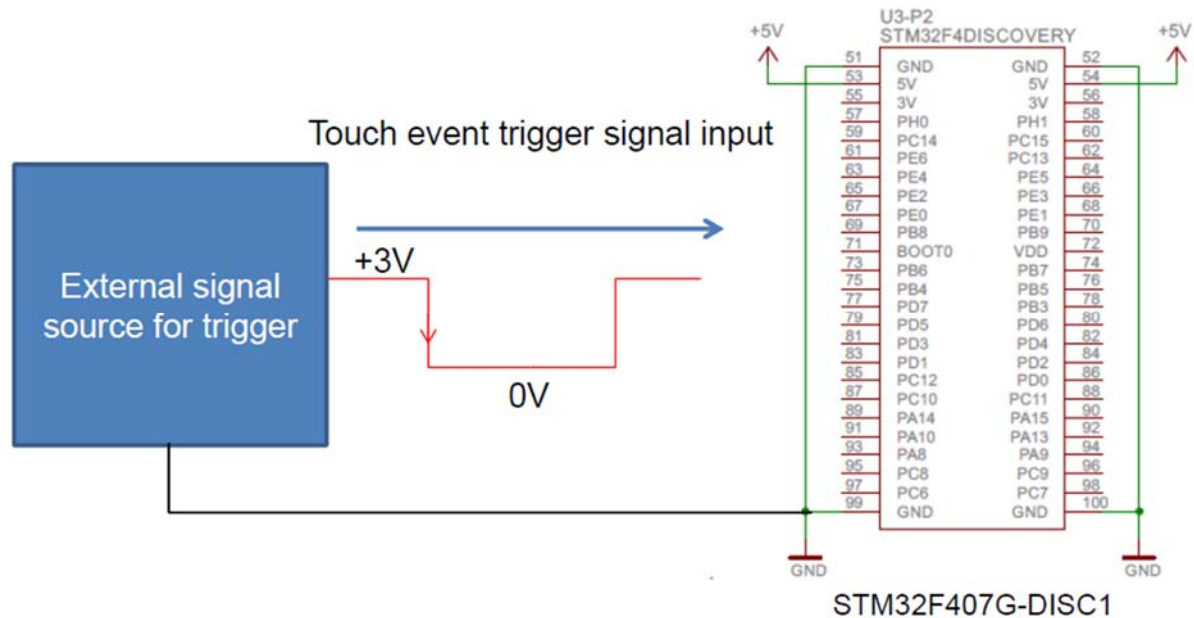


Figure 22: There is the possibility to trigger the PowerHap with an external signal as described below.

Input pins on the microcontroller for triggering

Input "PE1"	Trigger on channel 1
Input "PE2"	Trigger on channel 2
Input "PE3"	Trigger on channel 3
Input "PE4"	Trigger on channel 4
Input "PE5"	Trigger on channel 5
Input "PE6"	Trigger on channel 1 to 5 simultaneously; the adjusted waveform of channel 1 is given to all 5 channels

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Trigger signal description

With the external trigger signal the adjusted waveform which is adjusted with the “PowerHap Signal Configurator” is given to the output driver. E.g. a trigger on the input PE1 gives an output signal on the output driver 1.

- A falling edge on the trigger signal (3 V to 0 V) gives the adjusted “push” signal to the output
- If a “release” signal is adjusted in the “PowerHap Signal Configurator”, the release signal is given to the output with a rising edge on the trigger level “0 V to 3 V”
- A trigger signal on the input PE6 triggers all 5 channels simultaneously. The waveform given to all channels is the configured waveform of channel 1
- Voltage level on the input pins on the microcontroller:
 - 0 V low
 - 3 V high
- The external trigger and the trigger with the PowerHap work in parallel
 - If only the external trigger should be used, it is recommended to set the trigger level to 1 V in the configuration software
 - This makes sure that the output cannot be triggered with the sense function of the PowerHap

Important notes when connecting input pins on the microcontroller

- The signal ground (GND) from the trigger source has to be connected to the ground (GND) level of the microcontroller board
- The ground (GND) level must not be connected to earth
- The trigger signal can also be applied with a photo coupler with the advantage of a galvanic isolation between the signal source and the PowerHap demonstrator

6.4 Parallel operation on one output channel for test purpose

For test purpose, it is possible to connect more than one PowerHap on one output channel. Depending on the mode of operation (amplitude and frequency of the output signal, type of PowerHap) it is listed below how many parts can be connected.

If two PowerHap of the 15G types are connected to one output of the driver, it is recommended to drive it less than 30 s continuously when the output is adjusted to the maximum frequency of 300 Hz and amplitude of 100%.

15 G type:	2 parts on one output channel (f = 300 Hz; amplitude = 100%)
7 G type:	4 parts in parallel on one channel (f = 300 Hz; amplitude = 100%)
2.5 G type:	4 parts in parallel on one channel (f = 300 Hz; amplitude = 50%)

When multiple pulses are given to the output with two connected 15 G types, please note that the amplitude of the output voltage will decay with each pulse. The reason for this behaviour is the higher load on the output.

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7 Software revision history list

Firmware version	Date	Remark
1.3.0.2	30.6.2017	--

Revision of the firmware

Configurator version	Date	Remark
1.2.0.0	30.6.2017	--

Revision of the PC configurator

The revisions of the firmware and PC configurator software are shown in the bottom of the configurator software. The firmware is shown when the board is connected.

Important notes

The following applies to all products named in this publication:

1. Some parts of this publication contain **statements about the suitability of our products for certain areas of application**. These statements are based on our knowledge of typical requirements that are often placed on our products in the areas of application concerned. We nevertheless expressly point out **that such statements cannot be regarded as binding statements about the suitability of our products for a particular customer application**. As a rule we are either unfamiliar with individual customer applications or less familiar with them than the customers themselves. For these reasons, it is always ultimately incumbent on the customer to check and decide whether a product with the properties described in the product specification is suitable for use in a particular customer application.
2. We also point out that **in individual cases, a malfunction of electronic components or failure before the end of their usual service life cannot be completely ruled out in the current state of the art, even if they are operated as specified**. In customer applications requiring a very high level of operational safety and especially in customer applications in which the malfunction or failure of an electronic component could endanger human life or health (e.g. in accident prevention or life-saving systems), it must therefore be ensured by means of suitable design of the customer application or other action taken by the customer (e.g. installation of protective circuitry or redundancy) that no injury or damage is sustained by third parties in the event of malfunction or failure of an electronic component.
3. **The warnings, cautions and product-specific notes must be observed.**
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7. **Our manufacturing sites serving the automotive business apply the IATF 16949 standard**. The IATF certifications confirm our compliance with requirements regarding the quality management system in the automotive industry. Referring to customer requirements and customer specific requirements ("CSR") TDK always has and will continue to have the policy of respecting individual agreements. Even if IATF 16949 may appear to support the acceptance of unilateral requirements, we hereby like to emphasize that **only requirements mutually agreed upon can and will be implemented in our Quality Management System**. For clarification purposes we like to point out that obligations from IATF 16949 shall only become legally binding if individually agreed upon.

Important notes

8. The trade names EPCOS, CeraCharge, CeraDiode, CeraLink, CeraPad, CeraPlas, CSMP, CTVS, DeltaCap, DigiSiMic, ExoCore, FilterCap, FormFit, LeaXield, MiniBlue, MiniCell, MKD, MKK, MotorCap, PCC, PhaseCap, PhaseCube, PhaseMod, PhiCap, PowerHap, PQSine, PQvar, SIFERRIT, SIFI, SIKOREL, SilverCap, SIMDAD, SiMic, SIMID, SineFormer, SIOV, ThermoFuse, WindCap are **trademarks registered or pending** in Europe and in other countries. Further information will be found on the Internet at www.tdk-electronics.tdk.com/trademarks.

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