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HF-DRB series

RF Generator for Ion Traps

and Quadrupole Structures

HF-DRB_PaulDrives_Manual1_30.doc
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Datasheet and Manual

Rev. 1.30

Models

HF-DRB 170-10/400, HF-DRB 350-2/100, HF-DRB 300-10/400
HF-DRB 125-10/2000, HF-DRB 800-2/40, HF-DRB 800-2/60, HF-DRB 190-2/1000

Main Features:

- amplitudes up to 1600Vpp (differentially), model dependent
- frequency 10kHz to approx. 2MHz, model dependent
- quick-response non-resonant design
- precision voltage stabilisation (device option)

Attention: this device outputs dangerous high voltages. Operation is admissible only by trained, qualified personnel !

Purpose and Description of the Device

The purpose of the RF drive HF-DRB series is to supply AC voltages to Paul Ion Traps and other Quadrupole-type electrode setups for ion storage and manipulation. Unlike standard RF (radio- frequency) power amplifiers, the device is capable to handle capacitive loads, which are related to vacuum setups for ion trapping and storage and transportation.
The two outputs provide sine wave signals, which differ by 180° in phase, thus effectively doubling the voltage seen by a trapped particle. The HF-DRB device is designed to deliver voltages of several hundred volts AC on each output over a very wide frequency range (typically between 10kHz and 1 to 2 MHz, model dependent) into a 20pF to 50pF load, like ion trap electrodes; admissible load depends on version.
Note, that a different model is also available for voltages in the kV region (resonant output), see HF-DR version instead of HF-DRB version.
This generator is housed in a standard 19-inch rack-mount case and features a remote control section, by which the user can control the device via a standard USB connection.

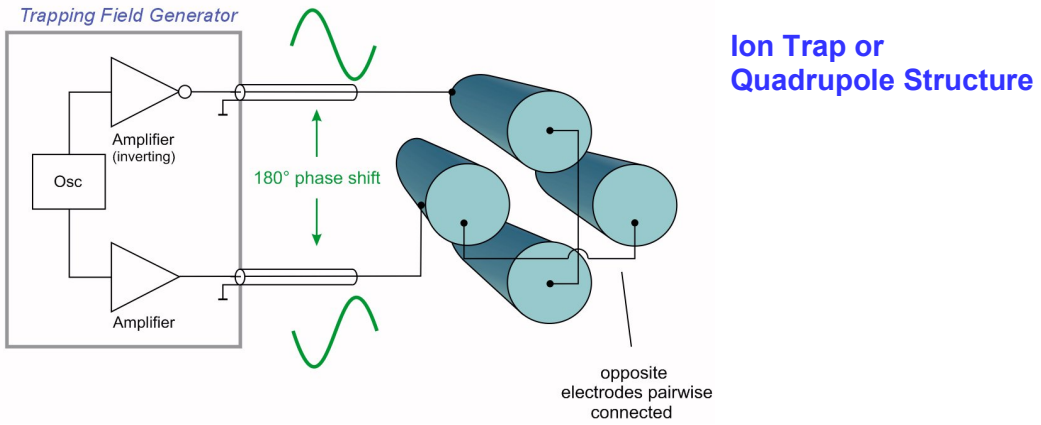

Fig. 1a: Typical RF drive application: supply of Paul Traps or RF Ion Guides. The twin output doubles the effective voltage due to the 180° phase shift.

Device Nomenclature and Parameter Range

Examples: (1) HF-DRB 170 - 10/400

- 170 → nominal peak-peak output voltage each output
- 10/400 → lower / upper limit of frequency range in kHz

corresponding to: 2x 170Vpp each output, f = 10 to 400kHz

(2) HF-DRB 350-2/100
corresponding to: 2x 350Vpp each output, f = 2 to 100kHz

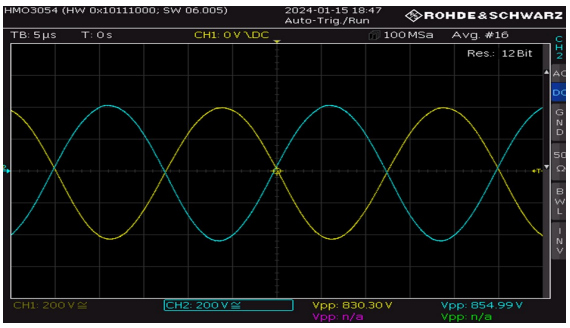

fig 1b: typical output waveforms, 800Vpp

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Functional Principle and Block Diagram

The following picture (fig. 2a) displays a block diagram of the internal structure, illustrating the functional principle. A digital oscillator provides a sine wave of freely adjustable and precise frequency. An inverter circuit creates the inverted signal, or in other words a 180° shift. These two signals are fed into power amplifiers (one for each channel) and the resulting signals are presented at the output (typ. a few hundret volts of voltage).
The device features an offset DC input, by which the output voltages can be shifted. Voltages being applied to these input lines are added to the AC signal (RF) of the outputs (this feature is not shown in fig. 2a/b).
The USB section allows for remote control of essential functions of the device via a standard USB connection. Please refer to control elements on front plate in next chapter and command syntax for remote control in the appendix.

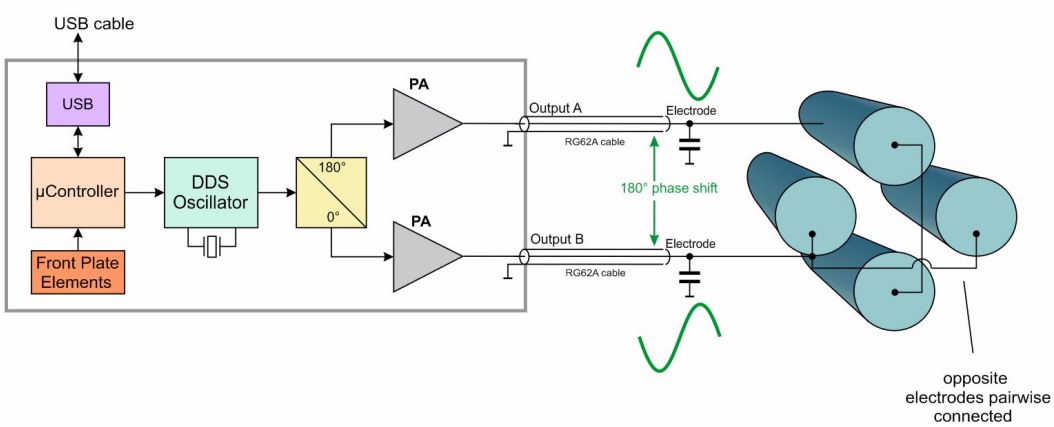

Fig. 2a: Block diagram of the internal structure, illustrating the functional principle.

Safety Hints

Operate carefully with respect to risk of **dangerous electrical shock** 	This device can produce high voltages at its output lines, which are highly dangerous in case of direct contact with the human body. Voltages may be even higher than expected, in case that an additional external voltage is applied to the DC-inputs at the rear side, or to an external mixer box. Great care must be taken to avoid unintentional touching of any output line by the human body or contact to any devices which might be endangered by high voltages.
Operation only in conjuction with ion traps or quadrupole structures	This device is intended to be operated in conjunction with ion traps or electrical quadrupole structures for ion manipulation and/or trapping, as outlined above. **No other applications are admissible. Never use this device for different purposes.**
Read all installation, operation, and safety instructions, void of liability	Prior to operation, thoroughly review all safety, installation, and operating instructions accompanying this equipment. Actions or operation in violation of outlined rules voids manufacturer's liability.
Rear side switch turns device completely off	If the device is not in use for a longer time, it is recommended to turn the mains switch at rear side off.
This equipment must be connected to an earth safety ground	This product is grounded through the grounding conductor of the power cord (protection class I). To avoid electrical hazard, the grounding conductor of the

	power cord must be connected to protective earth ground.
Do not modify the unit	Do not make electrical or mechanical modifications to this unit.
Change cabling only when device is off	Changing the cabling, when voltages are present at the outputs can lead to formation of harmful sparks. Change cabling only when device has been turned off for at least 60seconds.
Do not operate in wet/damp conditions	To avoid electric shock hazard, do not operate this product in wet or damp conditions. Protect the device from humidity and any direct water contact.
Do not operate in air, containing aggressive or flammable gas	Due to the risk of spark formation and possible explosion, operate the device under no circumstances in an environment, which could contain flammable of aggressive gases.
Beware of external magnetic fields	External magnetic fields can impair, damage or even destroy this device. A maximum external field strength of no more than B = 5mT is admissible. Having placed the device at any time into an external magnetic of bigger B = 5mT (regardless if power was turned on or off) can lead to severe overheating of the device and severely increased hazard of fire.
Service is to be performed by qualified service persons only	All servicing on this equipment must be carried out by factory-qualified service personnel only. Note that internal capacitors may carry very dangerous high voltages still a long time (many hours) after the device has been turned off. Appropriate safety measures are absolutely mandatory.
Do not block chassis ventilation openings, check temperature	Slots and openings in the chassis are provided for ventilation purposes to prevent overheating of the equipment and must not be restricted. The device should not be operated in ambient air above 26°C. All case vents should continuously be cleared, in order to prevent overheating. If in doubt about the sufficiency of air ventilation, provide a software readout of the internal temperature sensor for regular inspection, e.g. every 2 minutes. An internal temperature over 55°C indicates inadequate air ventilation. Safety hint: Check temperature (front display or via PC/USB readout) on regular base to avoid device damage and fire hazard.
Routinely cleaning from dust	After long operation (> 2 years), or operation in a dusty environment it is strongly recommended to have the internal parts of the device cleaned in regular intervals by the manufacturer, or by an appropriately qualified workshop in order to reduce the hazard of overheating. Note that internal capacitors may carry very dangerous high voltages still a long time (many hours) after the device has been turned off. Appropriate safety measures are mandatory, consult factory eventually.
Check mains voltage	The device must only be operated with mains supply, as stated on the rear side of the device.
No outdoor operation	Outdoor operation of the device is not admissible.

Operation and Control elements

Mains Supply Switch | LCD Display | Phase Output | Activate/ Deactivate Switch | Control Keys | Excitation Input

Fig. 3a The front plate contains the main control elements of the device:

Mains Supply Switch

The device is powered up after activating the rear-side mains supply switch and switching the power button on the front plate into the "on" position. A Power-on-LED (green) indicates proper operation of the internal circuitry. A warning beeper will temporarily sound, which is used for ventilation fan-speed monitoring. If the warning beeper permanently sounds, the device must not be put into operation. In general, if the device is not in use for a longer time, it is recommended to deactivate the rear side mains switch to cut the device completely off from mains supply. This is mainly for safety reasons.

Phase Output

The HF-DR devices feature an internal precision oscillator, which provides a logic level (i.e. 0V / 5V) output to monitor the oscillator's phase. This output is helpful e.g. in case of an ion extraction out of the trap and exact timing with small jitter (<1ns) is required. External triggers or pulse generators may be connected to this output, therefore.

Activate/Deactivate Switch

This input allows for activating and deactivating the output amplitude of the device. It may be operated
- manually with the switch on the front plate plate
- remotely via USB connnection or
- using the logic level being applied to the BNC input socket (left open: activated)

A low level at the BNC input socket here deactivates the RF power, high level activates it.
For safety reasons the manual switch position, being switched to 'off' overrides other settings.

Control Keys

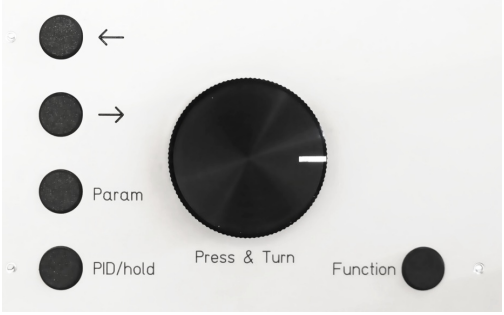

Fig 3b.

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The device is manually operated by the control keys and the selection wheel. Pressing the button 'Param' selects the parameter to be changed. This button 'rotates' through the following parameters:

- Frequency
- Signal Drive level (average over both outputs)
- Signal Drive level, output A only
- Signal Drive level, output B only

…and then back to Frequency.
Once the parameter is selected, use the arrows → and ← to choose the digit to be changed and rotate the wheel to change the parameter value. Pressing the wheel has the same effect as selecting the next right digit.
'Function' is reserved for special functions and also toggles the device from 'manual' to 'remote mode'. In the latter the device is controlled via the USB bus interface by a PC, and manual entries are locked out. For 'PID/Hold' function see below.

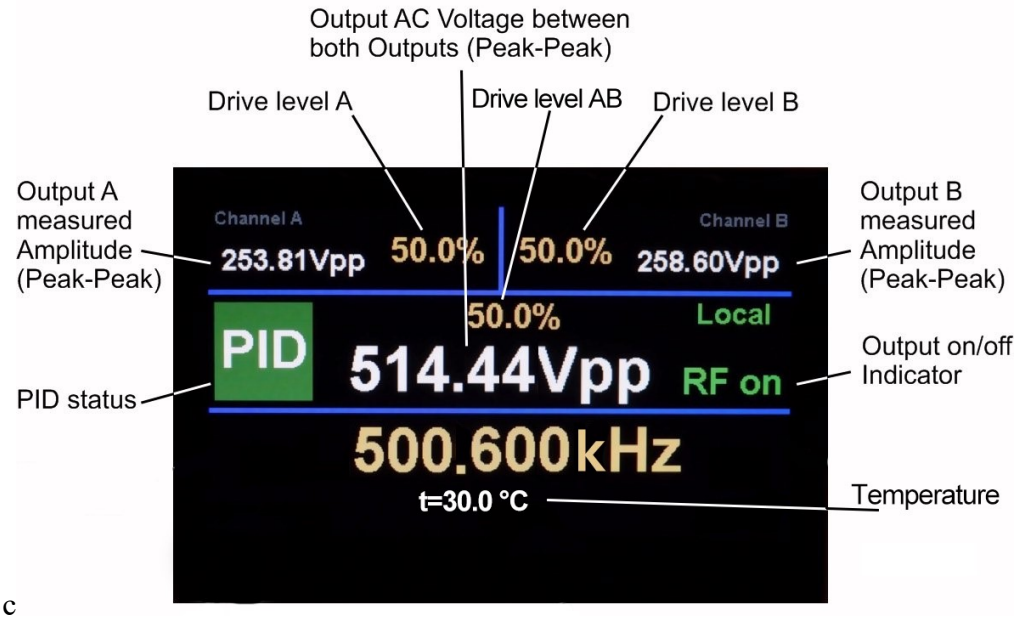

Fig. 3c

LCD Display

The LCD Display shows the main functions and parameters of the device, like chosen drive level, selected frequency, PID status. The display reduces light intensity after 60 minutes to prolongate its lifetime. For general operation of the device see below (picture above shows display of the Dual-Channel resonant version). Note that voltage accuracy is only guaranteed for high voltages having 35% or more of nominal max. output level.

Excitation Input

If this option is installed, the excitation input allows for adding a small voltage difference to one of the RF outputs. This serves for creating an additional (e.g. quadrupole) component for ion excitation. This voltage is linearly superposed to the RF field. A voltage up to 10Vpp (20Vpp for short durations) may be applied here. It will be transferred to one of the output with an attenuntion of approx. 1/500 in the frequency range between 2kHz and 1MHz. The LED indicator above the BNC input sockets lightens up at voltages larger approx. 7Vpp.

External DC Supply (option, for certain models)

For biasing reasons an external power source is required for some HF-DRB models. This source should provide a stable DC voltage of approx. 1.35 times the specified peak-peak voltage each channel. E.g. a HF-DRB 125-10/2000 device (delivering 125Vpp each output line) requires 170V_{DC} of external bias voltage. Normally the manufacturer provides such external stabilized power sources. This external source should have a safety current limit (300mA) and safety output power limit (50W). The external power supply needs to be connected to the HF-DRB device using 4mm (banana type) **safety connectors**. The HF-DRB indicated on the front display whether, or not, the external power supply is connected and delivers biasing voltage. In case the biasing voltage is too low or too high, a safety warning appears on the display. Beware of applying too high bias voltages over longer periods (minutes, hours), since overheating of the device may damage the device.

Connection to Ion Trap Setup

Please connect the output lines of the device at the rear side, in a proper manner to the ion trap or quadrupole setup and **ensure, that cabling is undamaged and safe**. Usually, SHV connectors are provided at both cable ends, optionally other connector types can be ordered. The corresponding sockets are the trap setup **must be mating in a safe and appropriate way** to the connectors at the cable end. Note that the *return path* of electrical current **must** be provided through the cable shields. The cable shield (= outer conductor of SHV plugs) must be therefore connected in an electrically conductive manner to the common ground of the trap/quadrupole setup. Free wiring with lose cables **must be avoided**, for safety reasons, also the ground (GND) path needs a safe and stable connection from trap setup to cable shields.
Not following these instructions may result in lethal injuries.

Warning: - lethal danger –

connect the output of this device only in a safe and appropriate way to the mating connectors at the ion trap / quadrupole setup. Also, connect the setup ground to the cable shield in a safe and reliable way. If in doubt, if these conditions are met, consult qualified personnel or manufacturer.

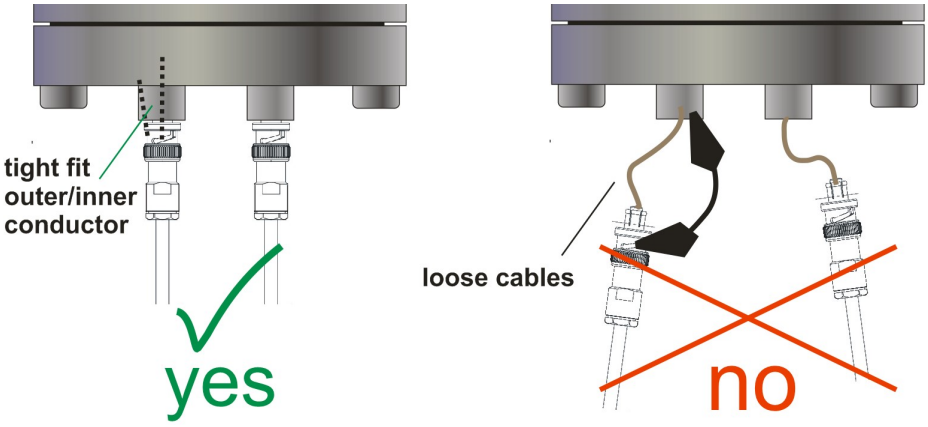

Fig 3d: Only use properly mating plugs/connectors, **never** use loose cables or clamps!

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Basic Device Operation

To operate the device, first complete wiring to the Ion Trap (or Quadrupole Structure), make sure there are no shortcuts and that the grounding/shielding is properly provided. Connect setup to the device high voltage outputs (rear side) using appropriate cabling (coaxial cables), which can sustain the voltages and protect from unintentional touching at any time. Note that during turning the device on/off, additional temporary voltage transients of +/-500V may occur at the outputs. The attached setup should be able to tolerate these transients.
Always ensure before switching on, that cabling is complete and safe. Always observe all corresponding safety measures with respect to handling of dangerous high voltages.

Warning: dangerous high voltages, always apply appropriate safety measures to avoid damages to attached devices or lethal injuries.

In order to start operation, turn the device on and put the 'Activate/Deactivate Switch' to the 'enable' position. The display should show 'RF on' now. Increase the drive level (by pressing the 'Param' button, turning the selection wheel and using the → / ← buttons) to a low value, say 25%. The amplitude indicators should start to show some amplitude value (e.g. 70Vpp). Press the 'Param' button to select the frequency settings (cursor blinking).
In case a short cut to GND or very heavy load is detected at one the outputs, one will observe a too low amplitude, being indicated on the front display. Otherwise, the device is now ready for operation. Note that essentially the output voltage scales almost linearly with the set drive level, 0% drive level corresponds to (almost) zero amplitude, 100% drive level corresponds to the max. amplitude.
Please observe that the drive level only coarsly defines the output voltage, thereor adjust the desired output voltage by adaptation of the drive level. This adaptation can also be executed in a half-automated way, see chapter 'PID loop' below.
The parasitic capacitances, which are connected to the output lines should not be excessively high, to allow the device to achieve the desired high output voltage level. E.g. for device variants reaching as high as 2 MHz, a maximum load being not higher as 25pF each channel are recommended. Higher loads will not damage the device but the outputs may not entirely reach the desired high level of output AC voltage.

Use of Offset

Optionally, the device provides Offset DC inputs at the rear side (two inputs, each for outputs A and B), DC voltages applied here are forwarded through each a 1 to 2 MΩ-resistor to the respective output. A decoupling capacitor at each input of approx. 20nF to GND is used to buffer the DC offset voltages. Note that the internal high voltage AC amplifiers are normally coupled to the outputs through 22nF coupling capacitors.
Note that in case the offset inputs are *not* being used, one should short cut these inputs to GND, through short cut plugs or 50 Ohm terminations. Otherwise, they may charge up to an undefined DC level.

PID loop

The device features a regulation loop, which is activated by pressing the corresponding PID/Hold button (press again to turn off again). In the instance of pressing this button, the current amplitude reading (A-B) of the differential amplitude between both outputs is measured and internally stored. Subsequently the drive levels of both channels are adjusted such that this differential amplitude value is kept constant. The increased stability of this value is advantageous for maintaining more stable conditions at the setup being connected. The subsequent graphs show a typical stability.
As long as the regulation loop is capable of maintaining the same differential amplitude value, the indicator will be green on the display, red otherwise. Grey color means that the PID loop is not activated.

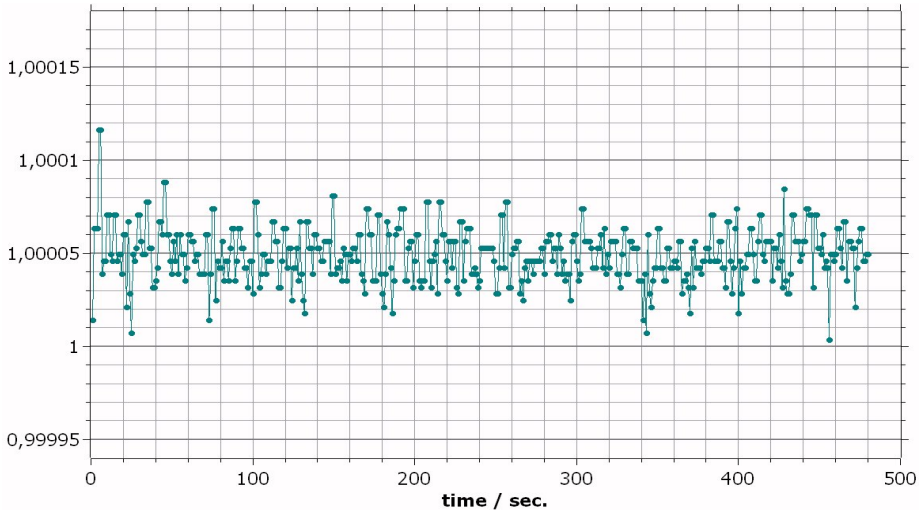


fig. 4a: Typical stability of output amplitude at medium load (AC voltage difference between both outputs at 400Vpp) with PID being activated. Within a 8 minute interval the instability (relative amplitude deviation) is only on a level of 25ppm rms, i.e. in the 10^{-5} range.

Fan/Temperature Warning

In case there is a problem with the ventilation fans or signs of overheating inside the device, the latter is indicated by a display reading. Eventually the output is intentionally disabled for safety reasons. In this case, turn the device immediately off and check for (obvious) reasons. In case of unclear situation please contact manufacturer.
The device is equipped with several temperature sensors; the device will automatically shut down the outputs if temperature surpasses a certain level (higher than 71 degrees Celsius); also, under certain conditions the display will show the message: "Temperature too High!"

Remote Operation

The device can be remotely controlled using the USB connection at the rear side. By pressing the ‘function’ button the modes are switched between local and remote. In ‘remote mode’ manual pressing of the control keys on the front plate is disabled. Standard programming compilers/interpreters like C++, Python or Pascal/Delphi dialects may be used by self-written code for this purpose and even simple command-line terminal programs may be used. Please refer to appendix for command syntax.

Specifications

Amplifier and Output		
Output voltage	each line 200Vpp (peak-peak) to 800Vpp @ approx. 35pF load at cable (model depending), i.e. up to 1600Vpp differentially between output lines Note: observe **safety hints** on first pages of this document!	
Frequency	model depending; typ. 10 kHz to 2MHz	
Output Power	typ. 10W, < 26W	
Safety relevant electrical currents at output lines	Up to 110mA peak each output line, AC **(attention: lethal electrical currents, apply greatest care to avoid accidents)**	
Output connector type	SHV or Amphenol multipin connectors (customizable), note: only correctly mating connectors are admissible for safety reasons	
DC Offset (option)	max. +/-200V DC (optionally +/-500V) (applied to rear side offset BNC input, connected through 1 to 2 MΩ to the corresponding output channel)	
Capacitive load capability each output	≤ 55pF recommended, load to be connected to output leads	
Auxiliary Excitation (Option) **Input** (front plate)	0 to 20Vpp, 50Ω transfer function: approx. 1/500 of amplitude is superposed to RF amplitude, Channel A	
Front Plate Display Readings		
Voltage Accuracy: (voltages > 35% of full scale)	Typical	maximum error
Scale error each channel	2.5%	4.5%
Offset error each channel	4V	7V
Voltage Difference		
Scale error	3%	4.5%
Offset error	2V	
Phase Accuracy voltage larger 100Vpp Error, equal connected capacitive loads	Typical 2°	8°
Frequency	20ppm	35ppm
Environmental Conditions		
Magnetic Field	max. 5mT admissible	
Storage Temperature	-55 °C to +85 °C	
Operating Humidity & Temperature	noncondensing relative humidity up to 75% temperatures between +0°C to +26°C.	
Power Supply		
AC Supply Rating	AC input voltage 230V_{AC} +/-5%, at 50Hz or 60Hz, or 100 to 120V, (model depending) typ. 62W consumption at max. amplitude. The power entry module is EMI/RFI-filtered. Fuse: medium fast blow 1.6A (230V), 3.5A (100V to 120V)	
Case dimensions	19.00” wide x 10” to 20” deep, model dependent. Front-panel mounting holes are configured for M6 rack configurations	
Weight	approximately 8.1 kg	
External Power Source	An external DC power source (50W rating) is required for several models, see chapters above, fuse (rear side) 500mA, medium-fast	

Note 1): Capacitive loads must be minimized for achieving highest amplitudes. Note that dissipative effects of loads can significantly reduce maximum amplitudes; this is specially true for high output frequencies above 400kHz.

Software installation

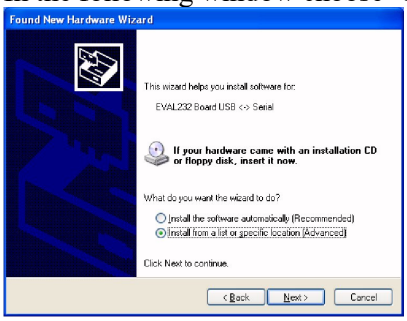
USB-Driver

The device uses the USB bus for connecting to a control PC. After proper cabling of the USB connection (see section before) Windows should automatically identify the connected device. Depending on the Windows version, please allow up to **two minutes** to automatically identify the connected device and to install drivers. In case this fails, follow the described steps below. The automatic or manual installation will install the USB-CDM drivers from FTDI Ltd., which is the manufacturer of the USB bus interface circuitry.
The supplied installation USB stick also provides suitable drivers for operation under Windows XP. Latest drivers, also for different other operating systems (Linux, Mac OS, other Windows versions) can be downloaded from http://www.ftdichip.com/FTDrivers.htm.

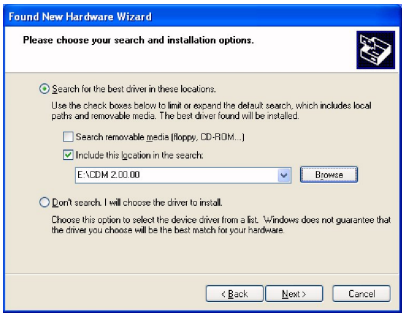
In case of Windows XP systems, USB drivers may not be installed automatically and of the "Found New Hardware Wizard" may open up,

in which you activate the last button "**No, not this time**" and continue with "**Next**".

In the following window choose "Install from a list or specific location" => "**Next**"



And afterwards you choose "**Search for the best driver in these locations**" and "**Include this location in the search**". Browse now to the Installation CD and select the appropriate path with the USB drivers.

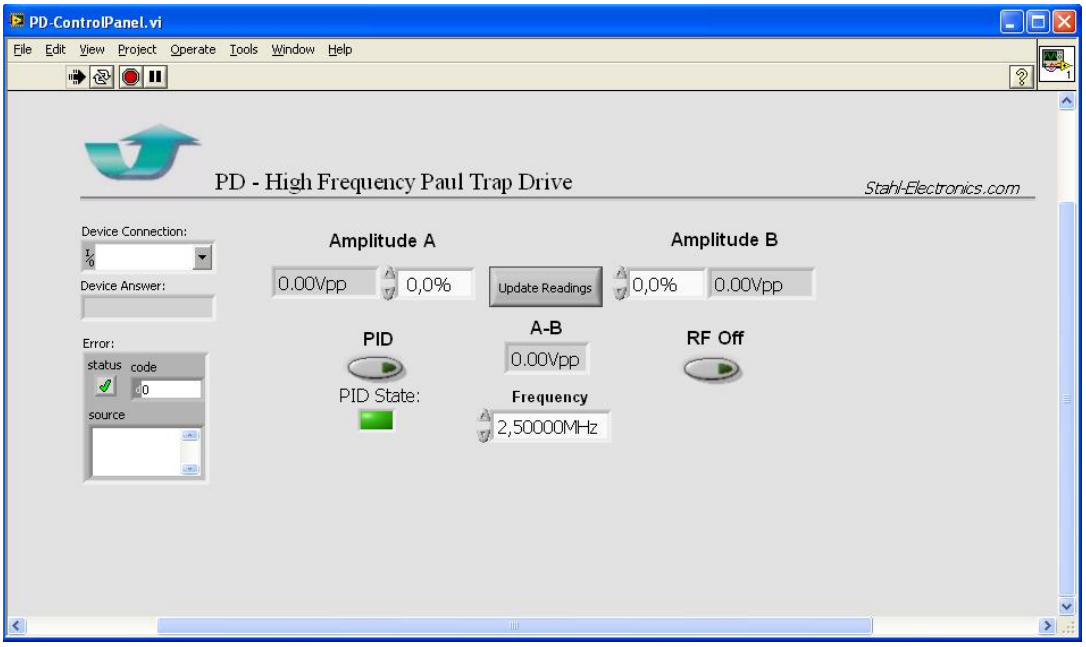


Click "**OK**" and "**Finish**" to complete the first driver installation.

After a few seconds the first window will show up again ("Found New Hardware Wizard"). This is because the driver comes in two separate parts, which both have to be installed. Go through the installation steps in the same way as before. After completion, the USB drivers are ready for use and indicate this by showing "HV Series: Device Ready" (or similar) in the lower right screen corner of your PC for a couple of seconds.
Windows usually recommends to restart Windows now, but for immediate use of the HV-Series devices one can skip this point. Nevertheless the PC should be restarted at a later point and latest before installing any other piece of hardware or software.

LabVIEW™ control program

Assuming that LabVIEW™ in Version 18 or higher is available on the target PC, copy the path containing the LabVIEW™ source code VI's from the installation CD to a place of your choice on a local drive. By double-clicking on the corresponding file the control panel for the device will open, which can immediately be put into operation by clicking on the start-arrow in the upper left corner.

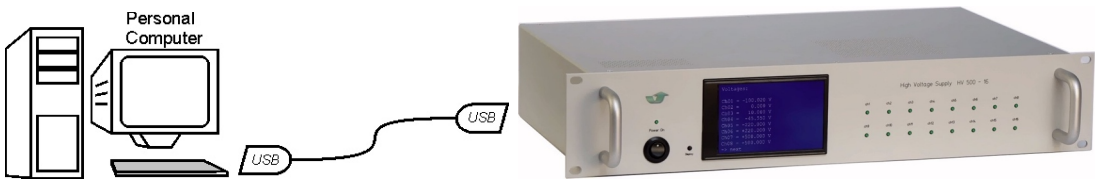


The device parameters may be entered in the corresponding numeric fields, after choosing the established COM-connection to the device and serial number ('PD' + last three digits).

Note that the provided LabVIEW control program is only a rudimentary version and intended to give an beginner's example, how to operate the device. On regular base, self-written programs may use common programming languages, like Matlab, C, or Python, based on the command syntax described below.

Remark:
One known problematic point with National Instruments drivers is the fact that they tend to collide sometimes with other drivers, especially for Tektronix oscilloscopes. If in doubt the other drivers should be temporarily removed and installed again.

Appendix



User-Defined Remote-Control and List of Commands

Introduction

The device can be controlled using the provided LabVIEW™ cource code blocks, or by self-written program code. Standard program compilers/interpreters like C++, Python or Pascal/Delphi dialects may be used for this purpose and also simple command-line terminal programs (e.g. HyperTerminal™) will do. The physical line connection to the device (USB-connection 1.0 protocol, but also 2.0 compatible) needs to be established beforehand, like described in section 3.2.1. USB-drivers for Windows™ versions, Mac OS and Linux are provided. Please check eventually the USB-manufacturers homepage (www.ftdichip.com) for latest updates.

Note that the physical communication acts like a so-called RS232 device, communicating with standard settings (115200 Baud, 8N1 protocol, no handshake). In self-written code the 115200 Baud rate parameter needs to be set accordingly. In Windows™ operating systems the device appears on a 'COM'-port, as soon as connected to the control PC (after driver installation). The COM-Port number is assigned by Windows upon connecting the device by USB cable and may change from time to time. The COM-Port settings may be checked by the user inside the Windows™ system control panel.

Command List

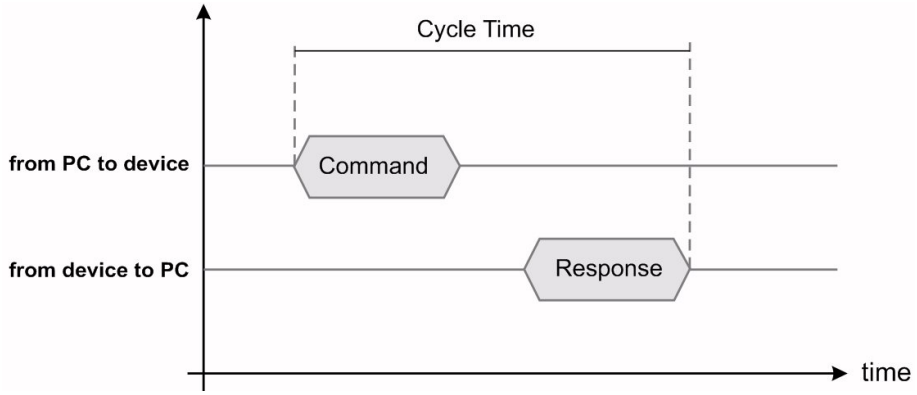
Inside this table the abbreviation "DDDDD" represents the name of the device including its serial number, e.g. "PD001" means a device with serial number "001". All commands must be terminated with an CR ('carriage-return') symbol "↵" (escape sequence '\r' or 13 in ASCII code or hexadecimal 0x0D). First, after establishing the USB link to the HV device and turning it on, the IDN identifier should be sent in order to retrieve the serial number, since this serial number will be used to address the device correctly. See also examples and more details after the table.

Command Function	**ASCII Strings** sent to device or received + CR ('carriage-return') at string ends	**Observations and comments**
Identify device	sent IDN received DDDDD … … …	The device replies with its name, serial number (DDDDD) and further information. See also examples below this table.
Set Frequency	sent DDDDD F XXXXXXXX received ACK (ASCII Acknowledge, 0x06)	The frequency of the output signal is set. XXXXXXXX is a decimal number between 00000000 and 10000000 which represents the the Frequency in Hz, leading zeros must not be omitted, Example:00500000 means 500kHz Note: Device must be in Remote Mode!
Set Amplitude	sent DDDDD X YYY.YYY received ACK (ASCII Acknowledge, 0x06)	The amplitude of Channel X('AB' or 'A' or 'B') is set. YYY.YYY is a decimal number between 000.000 and 100.000 which represents the percentage of the maximum voltage of the internal DAC for the selected Channel. Device must be in Remote Mode!

Activate/ deactivate software PID loop	sent DDDDD PID ON or DDDDD PID OFF received PID Started or PID Stopped	This command activates deactivate the PID loop to hold the output amplitude constant
RF ON/ OFF	sent DDDDD ENABLE or DDDDD DISABLE received RF Enabled or RF Disabled	ENABLE enables the RF output and DISABLE disables it. Caution: Switching from remote in local mode automatically enables the RF output, if not disabled by the front panel switch or BNC input. Device must be in Remote Mode.
Read Amplitude	sent DDDDD R X received X.XX or XX.XX or XXX.XX	Reads the amplitude of channel A, B or the differential amplitude (X = 'A','B' or 'D'). Caution: the return string has no fixed length. For example an amplitude of 86.29Vpp will return 4 digits and an amplitude of 239.04Vpp will return 5 digits. Device can be in any mode.
Read PID state	sent DDDDD R PID received PID OFF or PID OK or PID OUT OF RANGE	Reads the state of the PID loop. Device can be in any mode.
Read back Frequency	sent DDDDD F? received XXXXXXXX	Reads back the frequency in Hz with leading zeros (8 digits).
Read back set Amplitude	sent DDDDD X? received X.XXXX or XX.XXXX or XXX.XXXX	Reads back the currently set Amplitude of A or B X(‘AB’ or 'A' or 'B') in percent of the maximum Voltage of the internal DAC. Caution: the return string has no fixed length.
Device in Local Mode	sent DDDDD L? received 0 or 1	Checks if device is in Local Mode. 0: Remote Control 1: Local Mode

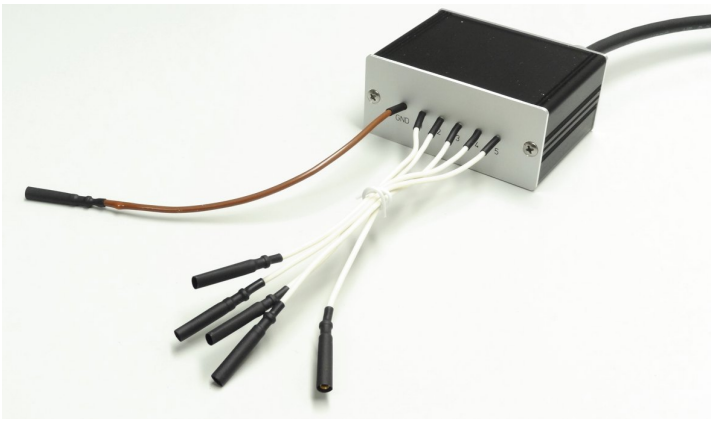
Communication Speed

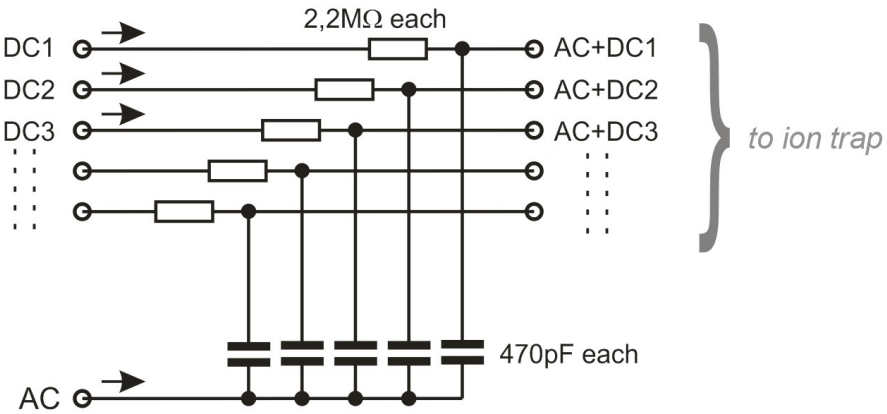
The device has a transmission speed of 115200 Baud (115200 Raw-Bits per second). Note that this speed grade corresponds to the 'Fast-Mode' regarding the HV- or BS-Series devices from Stahl-Electronics. However, the cycle time as illustrated below can be up to 25ms. In self-written program allow sufficient time to pass to avoid data collsision and ‘jamming’ of the serial connection.



Special Output Connectors

As an option, there are several types of special output connectors available, which are suited for connecting to a vacuum flange, like Amphenol / Ceramaseal types. Also, AC/DC combiners can be mounted to allow for adding DC offsets to the AC output signals, without adding excessive additional parasitic capacitance.
The subsequent picture and diagram illustrate such a coupling box.





As depicted in the diagram, the AC signal from the Paul Drive device is added (superposed) to DC signals of typically -100V to +100V to provide mixed AC + DC signals for trapping electrodes. Typically, SMA inputs are used to apply the required DC voltages from an additional external DC supply.

Please note that for all output connector types, reliable and safe wiring is in the full responsibility of the user of the device. Attention: dangerously high voltages are present at the wiring lines and thorough protection of dangerous voltages is mandatory. It is only admissible to operate the device, once wiring has been completed in a fully safe way, such that unintentional contact to the wires potentially carrying high voltages is impossible. Also, the ground line (GND) is mandatory to be connected to the vacuum setup in a rugged and safe way.
Violating these rules may result in severe damage or even death. Always observe all applicable safety measures with respect to handling of dangerous (lethal) high voltages.

DECLARATION OF CONFORMITY

Manufacturer's Name: **Dr. Stefan Stahl**
- Electronics for Science and Research -

Manufacturer's Address: **Kellerweg 23**
67582 Mettenheim
Germany.

Declares, that the product

Product Name: **HF-Drive (Paul Traps)**
Model Number: **HF-DRB**

Product Options: **This declaration covers all options of the above product(s)**

Conforms with the following European Directives:

The product herewith complies with the requirements of the:

1. Low Voltage Directive 73/73EEC;

2. EMC Directive 89/336/EEC (including 93/68/EEC) and carries the CE Marking accordingly

Date Of Issue _____

21. Jan 2019 **General Director**

www.stahl-electronics.com phone: +49 6242-597-2140, fax: +49 32123-504884