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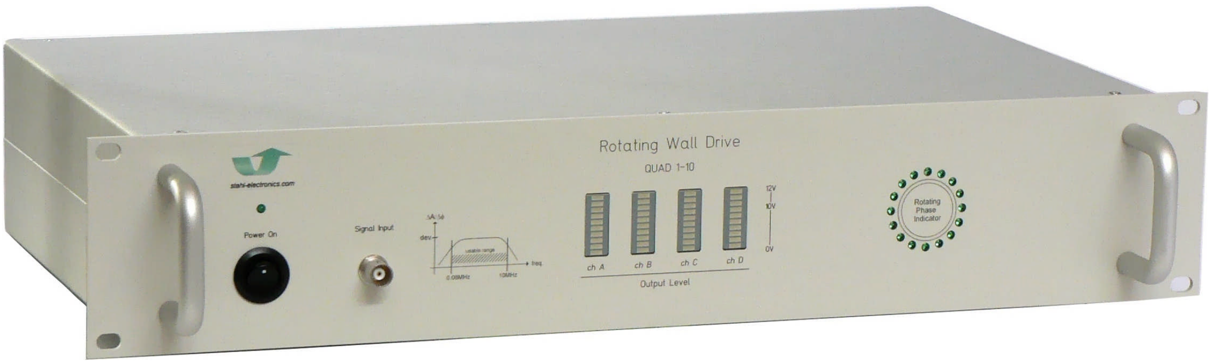
QUAD 1-5b

Rotating Wall Drive for Ion Compression

in Traps



30 Aug. 2017

User Manual

including 100V$_{pp}$ output option

Rev. 2.31

Main Features:

- completely linear operating device

- provides 4 times 90°-phase shifted outputs

- voltage range 0 to 10V$_{pp}$ or 0 to 100V$_{pp}$

- frequency range 100 kHz to 5 MHz

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1. General Information and Overview

1.1 Introduction

The QUAD 1-5 rotating wall drive is designed to create a rotating dipole or quadrupole electrical field inside a Penning Ion Trap. The resulting electrodynamical “rotating wall” enables fast compression of big ion clouds (see refs. [1], [2], [3]) after being loaded into a trap. The QUAD 1-5 represents a tool to handle a wide range of ion/plasma rotational frequencies with respect to this novel application.
As indicated in the picture below, an input signal, for instance a sinusodial wave, will be converted into an amplified 4-channel signal. All 4 channels have a phase relation of 90° and equal amplitude. In case a 4-segmented ring electrode is connected, a rotating dipole field is created, an 8-segmented ring will provide a rotating quadrupolar field. The nominal frequency range, in which a proper 90° phase shift from output to output is provided, covers about 100kHz to 5MHz, at a nominal output amplitude range of $0V_{pp}$ to $100V_{pp}$. The signal input is 50 Ohm compatible, whereas the outputs do not require a 50 Ohm termination. Since the device is completely linear in terms of electronic signals, any combination or superposition of signals may be applied, e.g. dual-frequency signals or SWIFT signals. The rotating wall drive will individually create a phase shift of 90° at each frequency component.

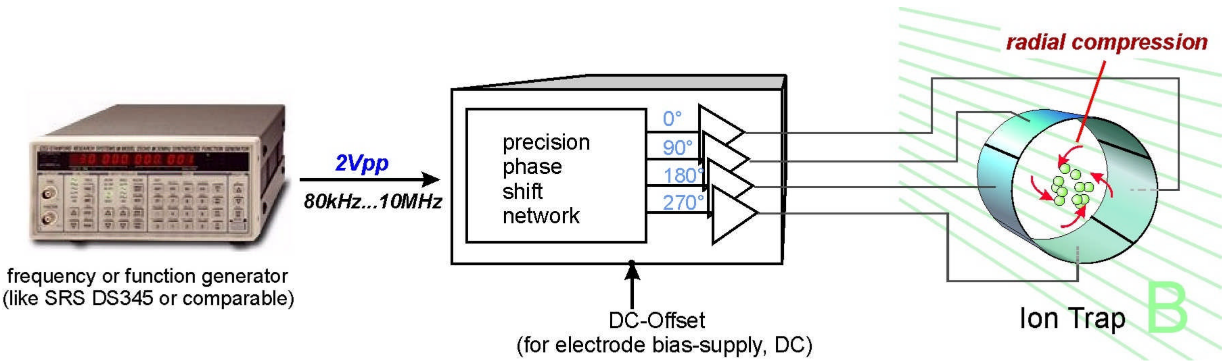

Fig. 1.1 Ion trap setup including a QUAD 1-5 rotating wall drive

1.2 Functional Principle and Block Diagram

The following picture displays the internal structure. After passing through an input amplifier, which performs a frequency response correction, an analog precision phase shift hybrid network creates 4 individual output lines having 90° of phase shift and equal amplitude. In principle ***any*** signal at the input, which lies within the nominal frequency and voltage range (100kHz to 5MHz; 0 … $5V_{pp}$) is suited for this application and will experience a 4-fold 90° phase shift. The internal analog phase shift network acts as a linear device in the electrodynamical sense and does not rely on non-linear effects or mixing processes.

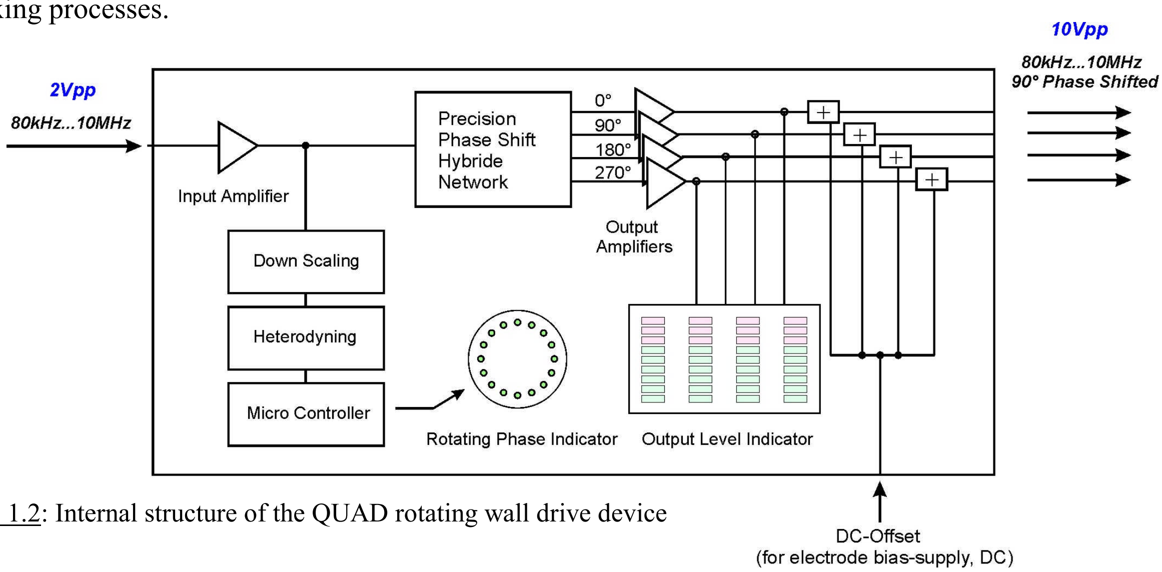

Fig. 1.2: Internal structure of the QUAD rotating wall drive device

For complex input signals, featuring many components in the frequency spectrum, all components will be phase-shifted *individually* without disturbing the other spectral components. This represents a considerable advantage over other ways of creating a rotating wall drive, like using several individual function generators. There is freedom to apply any signal in the nominal frequency and amplitude range without changing the device configuration or reprogramming. Complex spectra like SWIFT functions, sweeps, artificial noise and multi-tone signals may be applied, as pointed out already above.

After creating the individual phase shifts, four output buffers drive the outputs at the rear side, and allow for interfacing to an ion trap. A 50 Ohm termination at the output lines is not recommended.
As an additional feature, a common DC-Offset-Input (rear side) for DC-Bias allows floating the 4 outputs up to an additional DC level (max. 7kV if this option is selected). LED indicators on the front plate show the presence of a suitable input signal and the corresponding output voltage level.

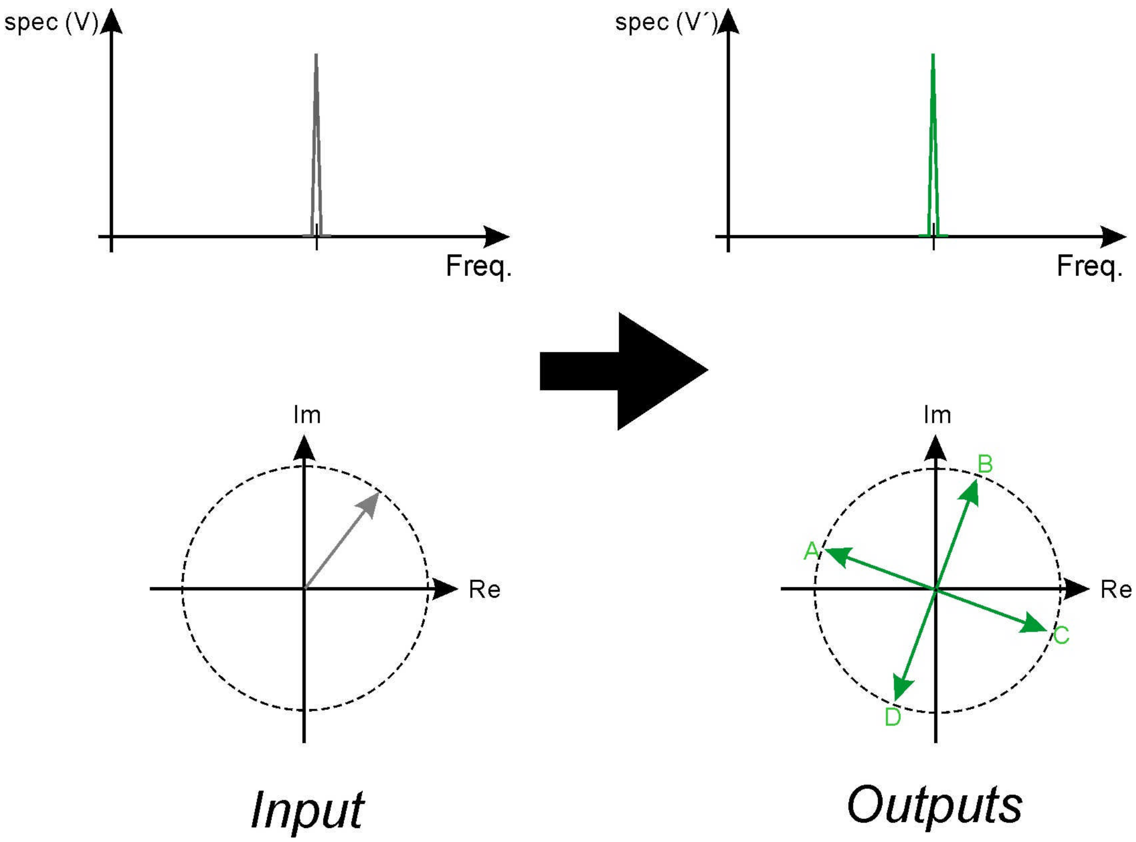

Fig. 1.3: Illustration of device functionality by comparing the input signal with the output signals. A sine wave with certain amplitude and frequency, fed in at the input, is converted into four 90° phase-shifted signals at the four outputs A-B-C-D. A constant phase relation of 90° and equal amplitude of the four output signals is maintained over a wide frequency range.

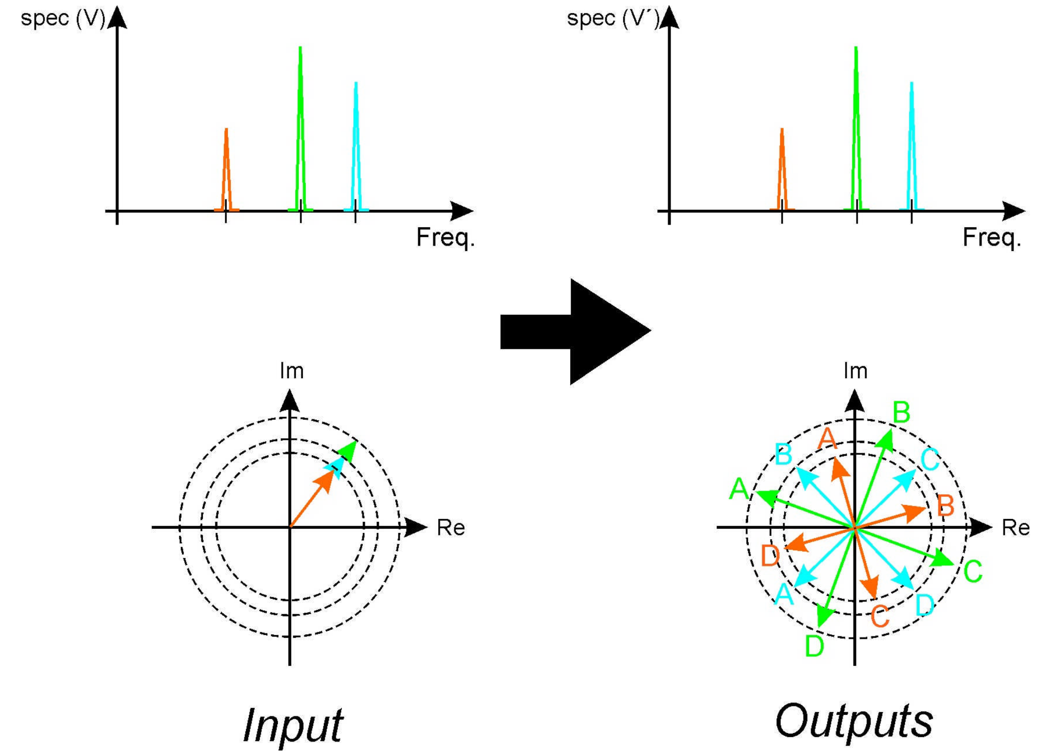

Fig. 1.4: Illustration of device functionality at a more complex input spectrum, here a 3-tone signal containing three sine waves with individual amplitudes, frequencies and phases. The device, due to its linear transfer function, is able to treat all input components individually, converting all of them one-by-one into four 90° phase-shifted signals at the outputs A-B-C-D. Phases and amplitudes of the spectral components do not disturb each other, but stay fixed (referring to phases), or proportional to the input components (referring to amplitudes) respectively.

1.3 Device Variety

Currently there several members of the QUAD 1-X series device family, in general the device parameters can be customized to user demands, in case necessary.

Device Name	***Versions***	***Characterstics***
Quad 1-5	Quad 1-5	Frequency Range 100kHz…5MHz Output Amplitude up to 20Vpp (at low frequencies)
	Quad 1-5b	Frequency Range 100kHz…5MHz Output Amplitude 20Vpp (entire frequency range) optionally max. 100Vpp
Quad 1-10	Quad 1-10	Frequency Range 80kHz…10MHz Output Amplitude 10Vpp (entire frequency range)
	Quad 1-10c	as Quad 1-10, floating up to +/-5kV offset
Quad 1-50		Frequency Range 1MHz…50MHz
Quad 30-100		Frequency Range 30MHz…100MHz

Literature :

[1] X.-P. Huang, F. Anderegg, et al., Phys. Rev. Lett. 78, 875 (1997)
[2] E.M. Hollmann et al., Phys. Plasmas 7, 2776 (2000)
[3] Funakoshi et al.; Phys. Rev. A 76, 012713 (2007)

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2. Safety Hints

Read all installation, operation, and safety instructions	Prior to operation, thoroughly review all safety, installation, and operating instructions accompanying this equipment.
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 the 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. To avoid electrical hazard, the grounding conductor must be connected to protective earth ground.
Do not modify the unit	Do not make electrical or mechanical modifications to this unit.
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 or direct water contact.
Beware of external magnetic fields	External magnetic fields can impair, damage or even destroy this device and cause fire hazard. A maximum external field strength of 5mT is admissible.
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.
Disconnect power before servicing	To avoid electric shock hazard, disconnect the main power by means of the power switch and power cord prior to servicing.
Do not block chassis ventilation openings	Slots and openings in the chassis are provided for ventilation purposes to prevent overheating of the equipment and must not be restricted. All case vents should continuously be cleared (fan inlet at rear side, air outlet at rear side), in order to prevent overheating.
Operate carefully with respect to risk of electrical shock	In case the "DC Offset Input" at the rear side is used, voltages up to +/-150V_{DC} will appear at the output lines, which are harmful in case of direct touch with the human body. Care must be taken to avoid unintentional touching of any output line by humans or any devices which might be endangered by high voltages. Even higher voltages may be present if device is equipped with high voltage offset input.
Routinely cleaning from dust	After long operation, or operation in a dusty environment it is strongly recommended to have the internal parts of the device cleaned by the manufacturer, or an appropriately qualified workshop in order to reduce the hazard of overheating and related risk of fire.
No outdoor operation	Outdoor operation of the device is not admissible.

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3. Installation

3.1. Mechanical Installation

Sufficient air cooling of the device has to be provided in order to prevent overheating. Rack mounting into a standard 19” rack is as well possible as resting the device on a table. All case vents must permanently be cleared (fan inlet at rear side, air outlet at rear side). 100Vpp-version: leave 5cm free space above the device, since the upper surface needs additional air convection cooling.

Fig. 3.1 rear side view (10Vpp version):
Offset Input | Outputs Channels | Air Inlet | Mains Socket/switch

3.2 Electrical Installation

Connecting to mains power:

Connect the device to the mains power supply by using an appropriate power cord with protection ground outlet. The power cord must be rated to at least 5A current. Please note that the 100Vpp version of this device takes an inrush current of up to 30 Amperes from the 230V mains supply.

Cabling of voltage outputs to ion traps:

Standard BNC cables (SHV in case of high DC offsets), or low capacitance cables may be used to connect the device to the experimental setup. Cables should be short in order to keep parasitic capacitances small and rf reflections down, which might otherwise impair the devices performance. Capacitive loads on the 4 outputs should be roughly matched (+/-15pF) and are recommended not to exceed 300pF per cable (120pF for 100Vpp output option). This restriction limits the cable length for standard BNC/SHV cables (e.g. RG58) to few meters, the cable length for low capacitance cables, like MIN-RG59 or RG62, is correspondingly higher. Locating the device close to the trap setup is therefore necessary. Before turning the device on, ensure that the cabling can withstand the voltage being applied to the offset input.
A maximum external magnetic field of up to 5mT is admissible, in case the device is placed in the vicinity to a strong (e.g. superconducting) magnet with considerable fringe field. Higher B-fields can impair or even destroy magnetic parts like the ventilation fan and the internal power supply.
The “DC Offset-Input” at the rear side can be used to add a constant DC voltage to all outputs simultaneously. Please observe admissible DC ratings (maximum voltage) at this input. A stabilized DC voltage source with current limitation set to approx. 10µA may be connected. In case this Offset Input is used, always be aware of the potential danger of high electrical voltages at the outputs to human beings and sensitive objects. A maximum admissible rate of voltage change of 300V/sec should be observed, high voltage pulses and rf signals must not be applied to this input. In general wiring changes must be done only when the device is turned off, and external DC offset set to zero.

Phase orientation

The order, in which the QUAD 1-5 output phases propagate, is: A→B→C→D, see also the following picture and figure 4.4. This orientation has to be matched to the ion species and direction of magnetic field inside the trap.

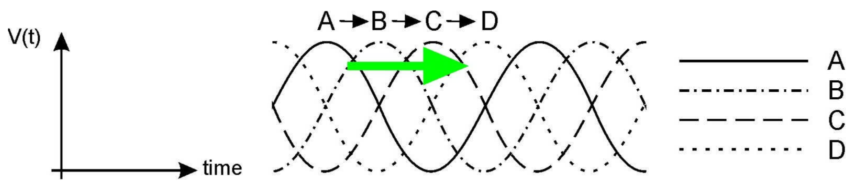

Fig.3.2
Phase orientation of the output signals. The direction of phase travel is A→B→C→D.

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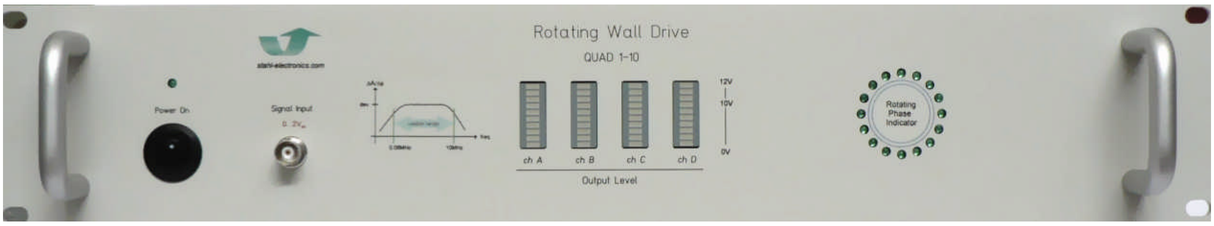
4. Operation and Control Elements

4.1 Elements on the Front Plate



Front Side Power Switch & Power-On LED | Input | LED bargraph or LCD display | rotating phase indictors

Fig. 4.1: Front plate

The front plate contains several control elements for the device.

Power Mains Switch

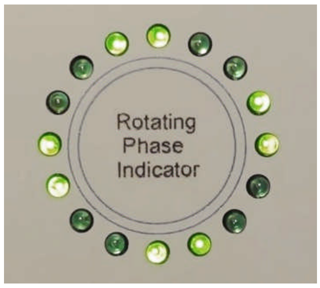
The device is powered up after turning on both the rear-side mains supply switch and also the power switch on the front plate. The Power-on-LED (green) indicates proper operation of the internal +30V supply circuitry.
If the device is not in use, it is recommended to switch it completely off with the rear side mains-switch. This will put the power consumption completely to zero and will avoid small supply currents which flow, when the rear side switch is kept on. Also for safety reasons (e.g. overvoltages occasionally occurring on the mains supply line) it makes sense to shut off the device completely by the rear side mains switch.

Signal Input

The Signal Input at the left hand side of the front plate is used to accept signals between 100kHz and 5MHz. The input impedance is roughly 50 Ohms, the input may be driven by a 50 Ohm output device like a standard function generator or RF signal generator. Voltage range is 0 to 5V_{pp} nominally.
Please observe that the applied input signal must not be outside the specified range (100kHz to 5MHz) in order to avoid overheating of the device.

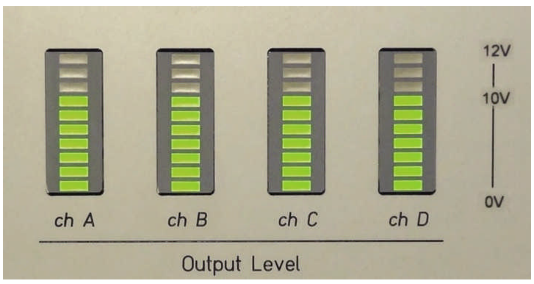
Rotating Phase Indicator

The Rotating Phase Indicator on the front side shows the principle function of the device and starts to rotate if a continuous input signal of at least 25mV_{pp} amplitude is present. It rather is meant to give an impression of the devices basic functionality than being a precision indicating device. By means of internal frequency downscaling and heterodyning, the input frequency (100kHz to 5MHz) is brought to a visible frequency regime, otherwise the rotation would be too fast for noticing with the bare human eye.



Level Indicators

The output voltage level indicator is implemented either as LED Bargraph or LCD display on the front side. Exceeding the nominal range (about 10V_{pp} or 100V_{pp}, depending on device version) and going into the red range means bringing the output amplifiers to higher voltages while slowly going into saturation. This is a “smooth” and not a sudden process, which means that a slight overdrive at outputs might be still acceptable.
Note that the device must not be operated permanentely at voltages exceeding the nominal value (10V_{pp} or 100V_{pp}).



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4.2 Rear side elements

Fig. 4.2 rear side view, 10Vpp version:
Offset Input 4 Phase Shifted Outputs Air Inlet Mains Socket/Switch

The **outputs A, B, C and D** are implemented as standard BNC or SHV sockets and deliver the amplified and 90°-phase shifted signals for driving a rotating wall. The output impedance (AC-wise) is roughly 50 Ohms, nevertheless, there is no output 50 Ohms termination required or even recommended. In case a 50 Ohm termination is accidentally added, the output amplitudes will be decreased by a factor of two. **Attention: do not connect 50 Ohm terminations to the device in case of the 100Vpp output voltage option**, otherwise the internal output stages may easily overheat and get damaged quickly.
A capacitive load of no more than 120pF is expected at each output in case of the $100V_{pp}$ output voltage version. Larger loads may damage the device, therefor it is recommended to carefully check the capacitance connected to the device with a standard multimeter before operation.
In case a DC-voltage is applied to the **external DC offset** voltage input, all AC output signals for rotating wall creation are linearly added (superposed) to this DC-voltage (max. +/-$150V_{DC}$, higher if specially rated). If no DC-Offset is required and this input is left open, the output signals A, B, C, D will be centered around zero volts. Note that this input is intended for *constant* DC offsets and not for pulses or RF signals. In case voltages higher +/-150V are applied to the DC offset input, make sure, they comply to a maximum admissible rate of voltage change of 300V/sec, in order to avoid excessive charging currents.

4.3 Operation

After completing the wiring of the setup (see above) the power can be turned on (switch at rear side and switch on front plate) and the green "power on" LED should lighten up. Arbitrary signals, e.g. from a function generator or rf-generator, in the frequency range between 100kHz and 5MHz and $5V_{pp}$ may be applied to the input. All spectral signal components are individually converted into four 90° phase-shifted signals at the outputs. The output level on each channel can be monitored at the level display at the front side and normally should be equal on all channels. For every signal component the phase relation between the four outputs (A-B-C-D), is 90° and the amplitudes are equal (further specifications see section 6 and appendix). The amplification factor is set to nominally V = 3 V/V and a 150pF-loaded output (no 50 Ohm termination at outputs) is assumed, or 20 V/V in case of the 100Vpp output voltage option.
Amplitude mismatch between neighbouring outputs is typically 1 to 4% (see diagrams A10, A11 in appendix) and phase mismatch around 2 to 5 degrees.
A typical input signal might be a swept sine wave, in order to "sweep" the rotational plasma frequencies inside the cloud of stored ions, being applied at a reasonable amplitude (e.g. $1V_{pp}$) and for a duration of a few seconds (also see fig. 4.3). A bandwidth-limited "white noise" signal is another example of an excitation signal, which in this case allows to excite all relevant plasma frequencies at the same time. Please see literature for further details.
In case the voltages at the outputs become too high or an internal over-temperature is detected the device will protect itself by temporarily disabling the outputs for several seconds.

Lit. : [1] X.-P. Huang, F. Anderegg, et al., Phys. Rev. Lett. 78, 875 (1997)
[2] E.M. Hollmann et al., Phys. Plasmas 7, 2776 (2000)
[3] Greaves, Surko, Phys. Rev. Lett. 85, 1883–1886 (2000)
[4] Funakoshi et al., Phys. Rev. A 76, 012713 (2007)
[5] Saitoh et al., Phys. Rev. A 77, 051403 (2008)

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Attention: Make sure that the device is not permanently operated
(1) in overrange-regime (bar indicators on flont plate in red region),
(2) with input amplitudes larger than 5 V_{pp} (5 Volts peak-to-peak)
(3) with input frequencies below 80kHz or above 10MHz
(4) Furthermore please observe the admissible DC voltge rating in case of using the DC offset input and maximum slew rate when changing the offset voltage.
Note that failure to comply with these limits may cause permanent damage of the device.

Signal Example: Swept sine wave

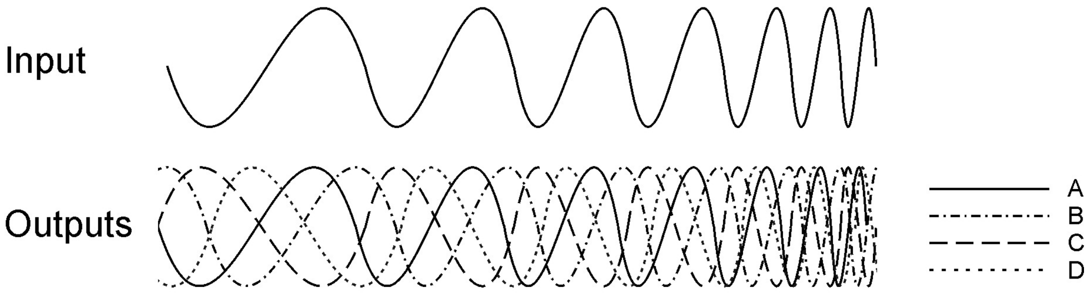

fig. 4.3 Example for a possible waveform; a swept sine wave may cover a broad frequency range in order to meet the plasma rotational frequencies, which might not be known precisely at the beginning.
The sweep may be repeated several times to achieve the desired result of ion compression.

Output assignment for dipole and quadrupole creation

Depending on the intended application, the phase shifted outputs of the QUAD 1-5 device can be connected in different ways to a split electrode of a (e.g. cylindrical) Penning Trap. The following figure shows the principle assignment of the devices outputs (A,B,C,D) to electrode segments in case for a rotating dipole, and a rotating quadrupole arrangement. The rotational direction will be given by the phase order of the QUAD 1-5 outputs, namely A→B→C→D. Please observe that the plasma rotational orientation in a Penning Trap depends on the charge sign of the ion (or: charged particle) species and the magnetic field direction inside the trap, according to the direction of the Lorentz-force. Wrong orientation of the rotation will prevent success of the compression scheme.

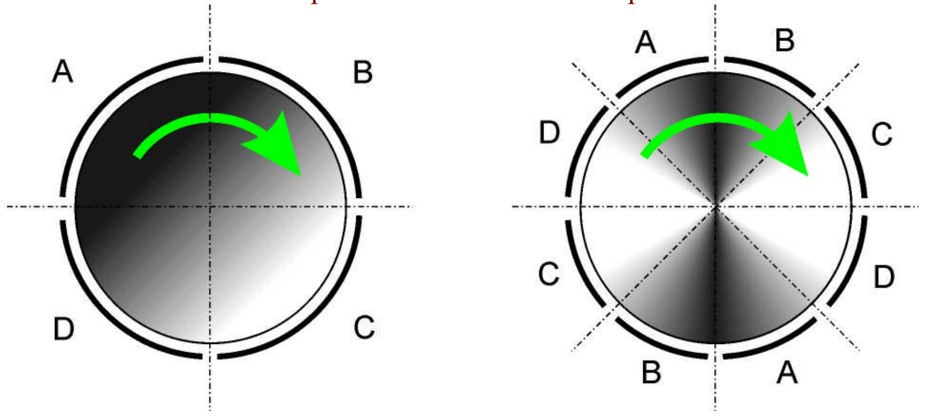

fig. 4.4
Graphical illustration of electric dipole/quadrupole creation. For a rotating electric dipole, connect the output lines (A,B,C,D) as shown in the left picture, for a quadrupole as shown in the right picture. Please observe the correct order while connecting the cables. The shading in the pictures above illustrates the momentary electric potential (dark: low; light: high).

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5. Maintenance

The QUAD 1-5 is designed for long term reliable operation. Under normal operating conditions, it should not require electrical maintenance, but routinely cleaning of dust, and in longer time intervals, periodic replacement of the rear ventilation fan (see below). If any further question should arise, please contact the manufacturer. Please note that the 100V_{pp} output voltage version requires good air cooling and free space above the device (min. 5cm) to allow air convection to cool the upper device lid. Otherwise device lifetime may significantly degrade due to permanent operation at elevated temperatures.

Routine cleaning

All ventilation openings should be checked periodically for obvious obstacles and kept free of dust and other obstructions. A vacuum cleaner may be used to clean these vents when the unit is powered off. The front panel may be cleaned periodically with a clean cloth. It is recommended to send the device to the manufacturer routinely in 2-year intervals of operation for internal cleaning from dust. Visual inspection of the degree of internal pollution and accumulated dirt is possible, but should be carried out by qualified personnel. In this case wait at least 20sec. after switching power off (rear side switch), and disconnecting all external high voltage lines and the mains cable. After removing the 6 screws of the upper lid, the latter is removable and allows a view on the internal electronics boards. Very careful cleaning by qualified personnel and using a small miniature vacuum cleaner is admissible. Before continuing operation, ensure that the lid is placed correctly and that all 6 lid screws are placed and tightened again. In any doubt of possible internal damage contact manufacturer before continuing any further operation.

Fan life time

The ventilation fan at the rear side of the housing is a part which shows considerable deterioration in time. Exchange of this part is recommended after latest 50.000 hours of operation. Please contact manufacturer for replacement after long term operation. Complete failure might lead to overheating and destruction of the device. A temperature fuse and other protection measures ensure a certain degree of safety against fire hazard in this case. Nevertheless, it is strongly recommended to regularly check the correct operation of the rear fan by simple visual inspection and checking of unexpected noise while in operation.

Fire hazard

Please note, that excessive accumulation of dust inside the case of the device can lead to overheating and increases the risk of fire. Routinely cleaning the device from dust minimizes this risk. It is therefore recommended to send the device to the manufacturer routinely in 2-year intervals for internal cleaning from dust, or to have it cleaned by an accordingly qualified electronical workshop. Ambient air conditions containing oil mists (e.g. proximity to a vacuum forepump or mechanical machines) place a severe danger, since inflammable substances could enter the device through the ventilation holes and cause fire. If in doubt, cleaning by a qualified electronical workshop or the manufacturer is strongly recommended.

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6. Specifications

Specifications Rotating Wall Drive QUAD 1-5 / 1-5b:

	Parameter	spec. value	Condition / Notes
	Input **Input Impedance** **Voltage Range** **Frequency Range**	50 Ohm (AC) 0...5V_{pp} 100 kHz … 5 MHz	Do not exceed 5V_{pp} permanently nor apply signals outside the specified frequency range
	Outputs **(BNC/SHV connectors)** **Functionality** **Voltage Range** **10V version** **100V version** **Amplitude mismatch** **between outputs** **Phase mismatch** **between outputs**	4 Outputs, 90° Phase Shifted 0...10V_{pp} nominally max. 13V_{pp} (overrange) 0...100V_{pp} nominally max. 120V_{pp} (overrange) typ. < 0.2dB 10Vpp version typ. < 0.3dB 100Vpp version max. ± 5° typ. 2.5°	output load <150pF each channel output load <120pF each channel '' f = 100 kHz .. 5 MHz '' '' ''
	Input/Output Relation **Voltage Gain** **Gain flatness** **over freq. range**	nominally 3x (9.5dB) 10Vpp version nominally 20x (26dB) 100Vpp version typ. ±1.5dB, 10Vpp version typ. ±1.8dB, 100Vpp version	each channmel output load < 150pF output load < 120pF
	Nominal Freq. Range	100kHz...5MHz	
	Rotating Phase Indicator	min. input signal level typ. 25mV_{pp}	f = 100 kHz .. 5 MHz
	Wideband Output Noise, any channel	2.2mV_{rms} 10Vpp version 25mV_{rms} 100Vpp version	bandwidth 1kHz … 10MHz
	Ext. DC-Offset range (BNC or SHV connector)	± 150V_{DC} other on request	remark: the applied external offset (DC) voltage is internally added to the ac output voltages and will appear at the outputs as DC offset
		up to +/-5kV or +/-7kV on request admissible rate of offset voltage change max +/-300V/sec.	Applicable if device is specially equipped with a high voltage offset stage and SHV connectors. Observe rating label on device.
	DC-Offset input isolation resistance vs. GND	typ. 100M to 10 GOhm depending on version; +/-7kV version 300MΩ	
	Power Supply	AC input 230V_{AC} , 50Hz to 60 Hz. The power entry module is EMI/RFI-filtered. Fuse: slow blow 2A. (10Vpp version) Fuse: slow blow 8A. (100Vpp version) typ. power consumption: 21 Watt (10Vpp version), 125 Watt (100Vpp version)	Note that the 100Vpp version of this device takes an short-term inrush current of up to 30 Amperes from the 230V mains supply.
	Storage Temperature	-55C° to +105C°	
	Recommended Operating Temperature	ambient temperature between 0°C and +28°C	
	External Magnetic Field	max. 5mT	External field must <u>never</u> (at any time) exceed value given.
	Physical Dimensions	width x height x length approx. 485mm x 92mm x 310mm	
	Weight	approx. 4.0 kg	

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7. Related Devices

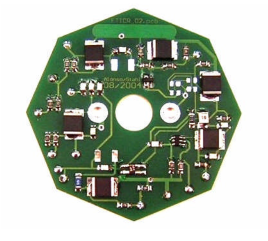
Voltage Sources

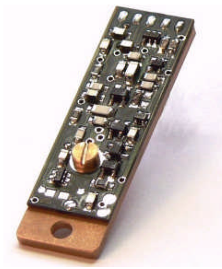
Stable multichannel voltage DC- and AC supplies for **Ion Traps, Ion Lenses, Quadrupoles and Beam Steerers** are also provided by the manufacturer. A special feature of the HV-Series devices (DC Supplies up to +/-400V) are the **bipolar** outputs with continuous zero crossing. This property makes the device well suited for ion optics like electrostatic steerers, benders or lenses. Computer control is provided by a USB connection and an easy operational graphical user interface.

HV Series
16 channel bipolar voltage source +/-400V for ion optics and Penning Traps

Image Charge Detection

Detection electronics are provided, including cryogenic versions for non-destructive image charge detection and FT-ICR applications.





FT-ICR Octagon **NexGen*3* - 4.2K-amplifier**

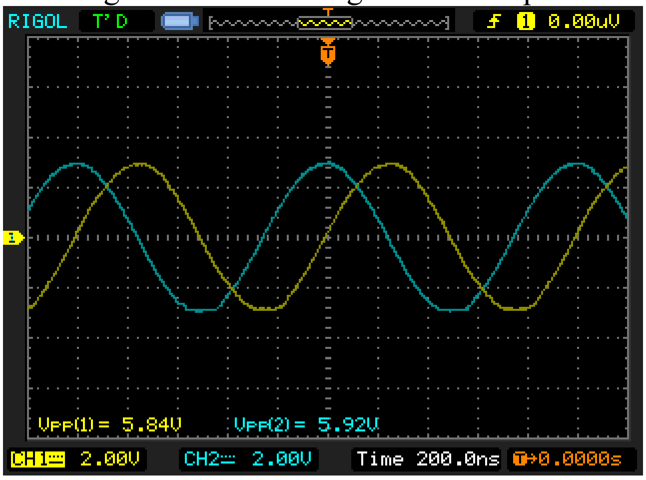
Ultra stable DC- supplies

play a key role in high precision ion trap experiments, like g-factor determinations or ultra high precision mass measurements. The **UM 1-14** offers an unrivalled short term stability in the order of a **few times 10^{-8}** (about $0.03ppm_{rms}$) Providing three ultra highly stable 25Bit-resolved channels of +/-14V range, this device represents a cost effective solution for DC-electrode supplies at precision ion traps. Computer control is provided by a USB connection and an easy operational graphical user interface.

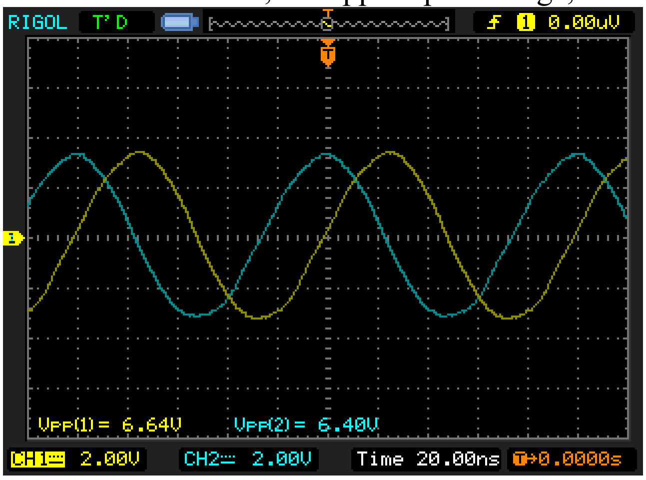
Appendix

Typical performance charts

Output Waveforms
Measurement device for figures A1 to A7: Rigol oscilloscope DS1302CA

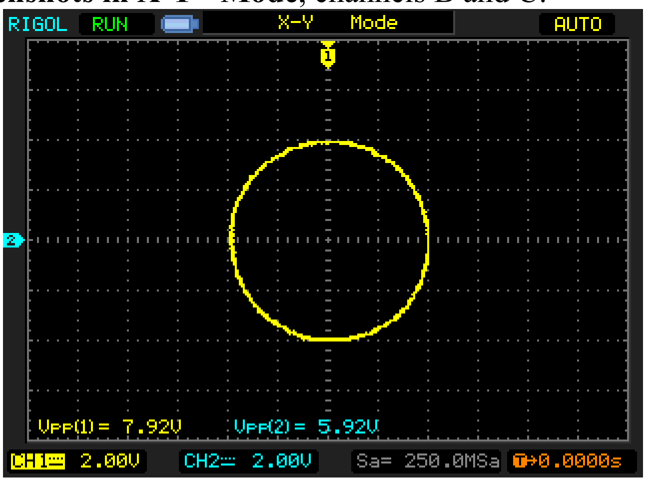


A1: Typical output waveform at 1MHz, 5.9Vpp output voltage, channels B and C



A2: Typical output waveform at 10MHz (Quad 1-10), 6.4Vpp output voltage , ch. B and C

Oscilloscope screenshots in X-Y - Mode, channels B and C:



A3: f = 100kHz

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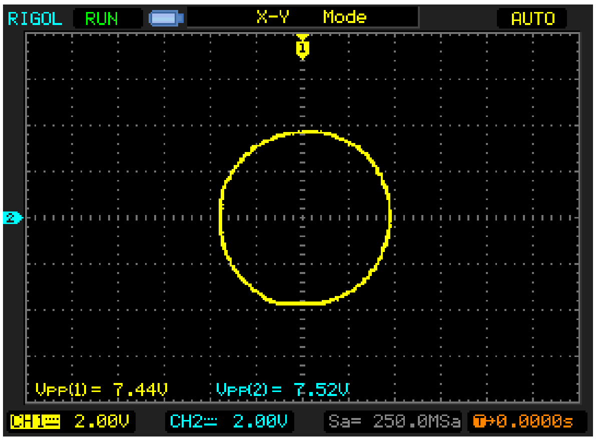
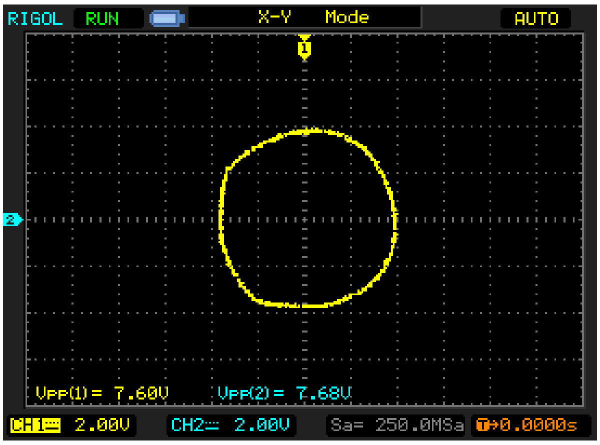
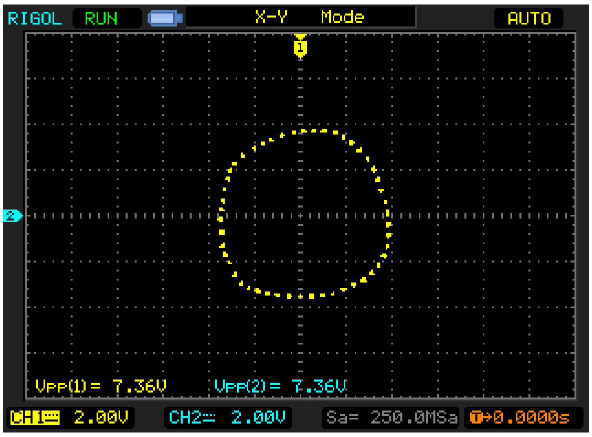


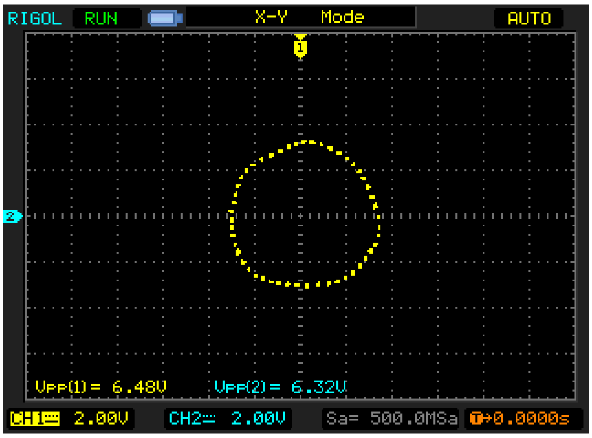
A4: f = 500kHz



A5: f = 2MHz



A6: f = 5MHz



A7: f = 10MHz

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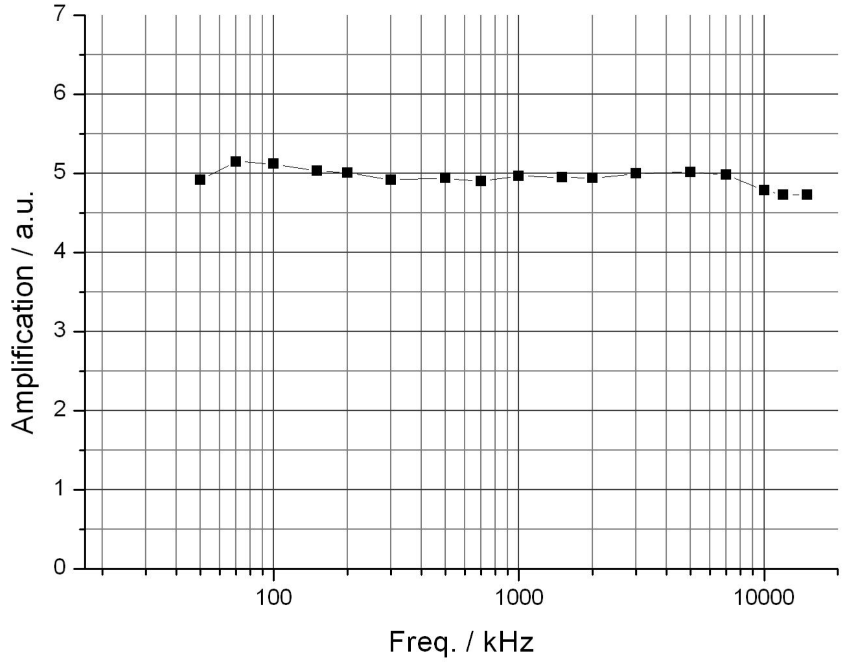

Fig. A8: Gain flatness vs. frequency
amplitudes are averaged over all output channels (A,B,C,D);
measurement device: oscilloscope TDS 210 (Tektronix)

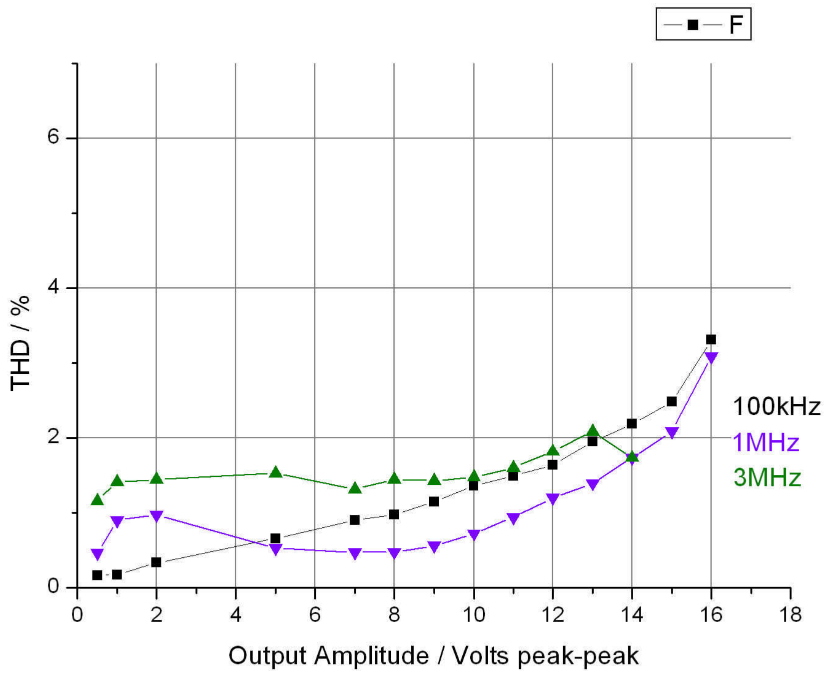

fig. A9: Non-linearity at high output levels (total harmonic distortion, THD), 10Vpp version
load on output: 150pF // 10 MOhm, measurement device: Picoscope 3224

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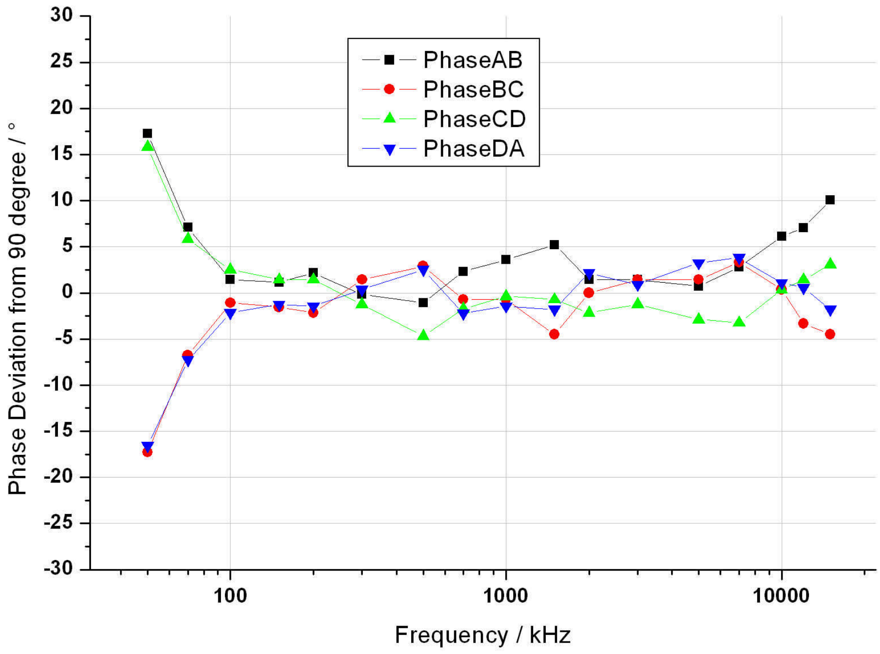

fig. A10: Phase error vs. frequency
Graph shows deviation from the nominal 90° shift between output channels
measurement device: oscilloscope TDS 210 (Tektronix)

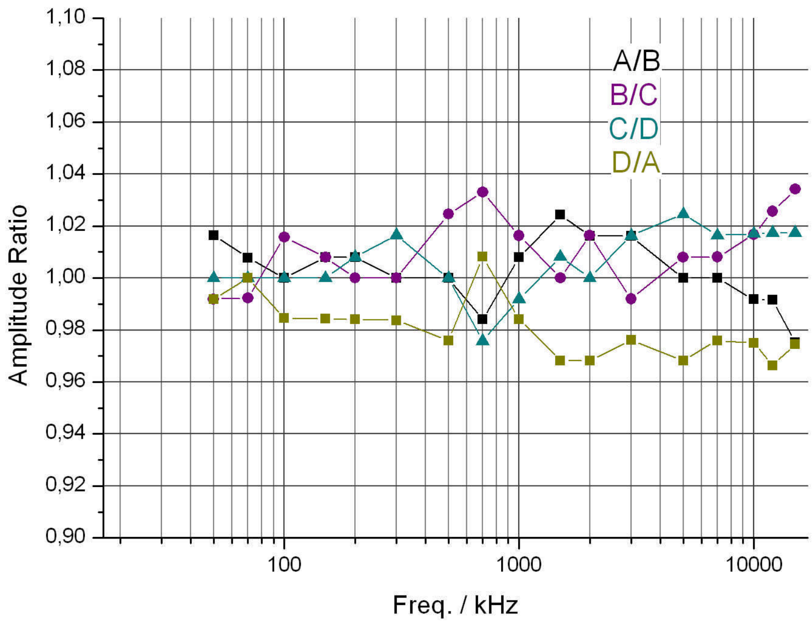

fig. A11: Typical amplitude mismatch vs. frequency
Graph shows voltage ratios between output channels
measurement device: oscilloscope TDS 210 (Tektronix)

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Offset Circuitry

10Vpp version:

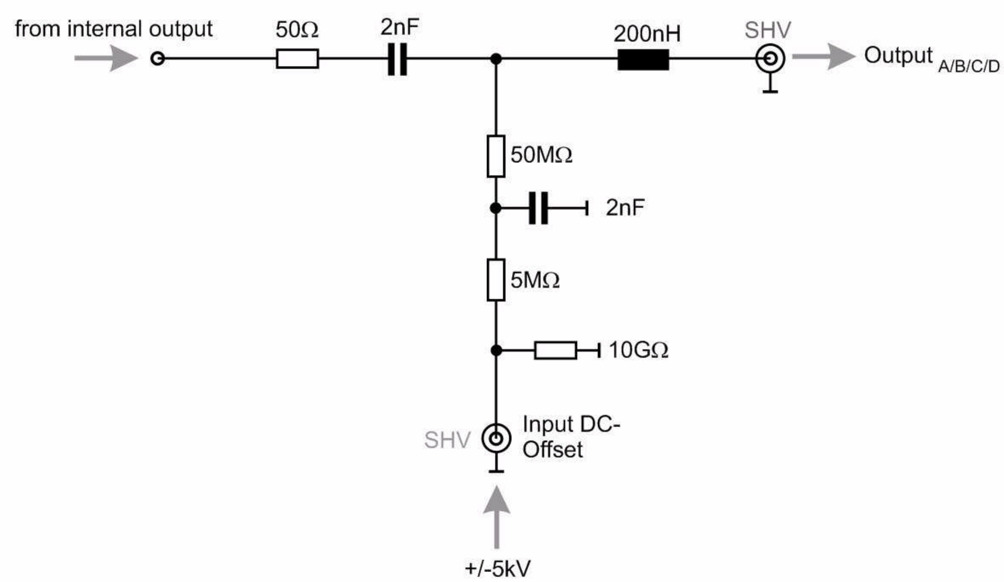

fig. A12: Circuit diagram of high voltage offset output stage. An externally supplied DC offset of up to +/-5kV (max. value depends on rating) is filtered by a 5MΩ x 2nF low pass and subsequently superposed to the AC signals from the internal phase shifter. Diagram shows one of four branches.

100Vpp and +/-7kV floating version:

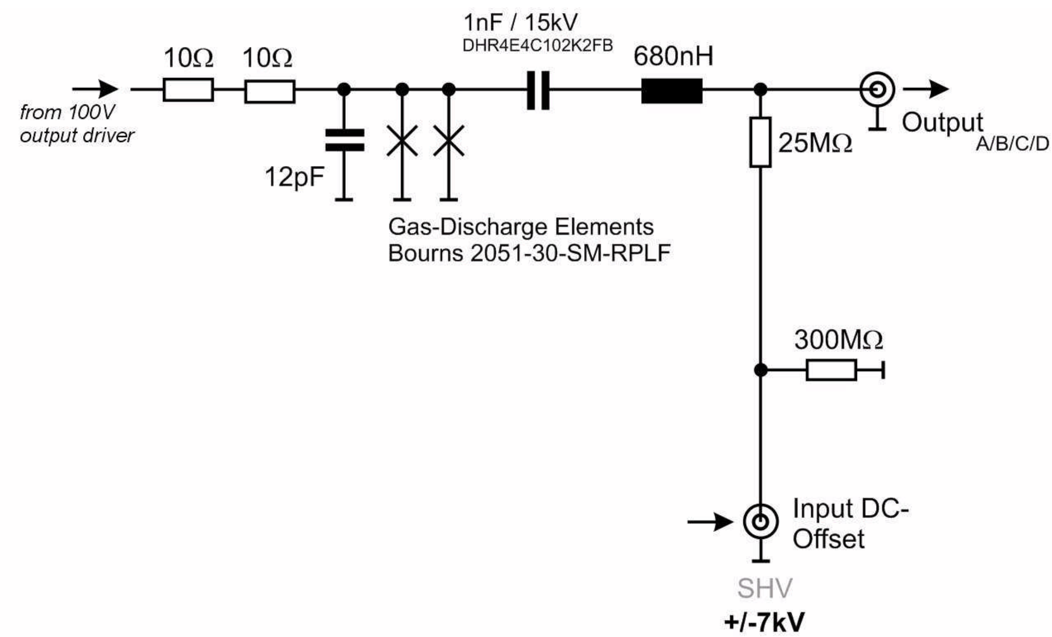

fig. A13: Circuit diagram of high voltage offset output stage +/-7kV floating version. An external DC offset of up to +/-7kV may be applied and is superposed to the AC signals from the internal phase shifter by means of a simple RC circuitry. Diagram shows one of four branches.

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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:	**Rotating Wall drive QUAD 1-5**
Model Number:	**QUAD 1-5, QUAD 1-5b and variants**

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. June 2017 **General Director**

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