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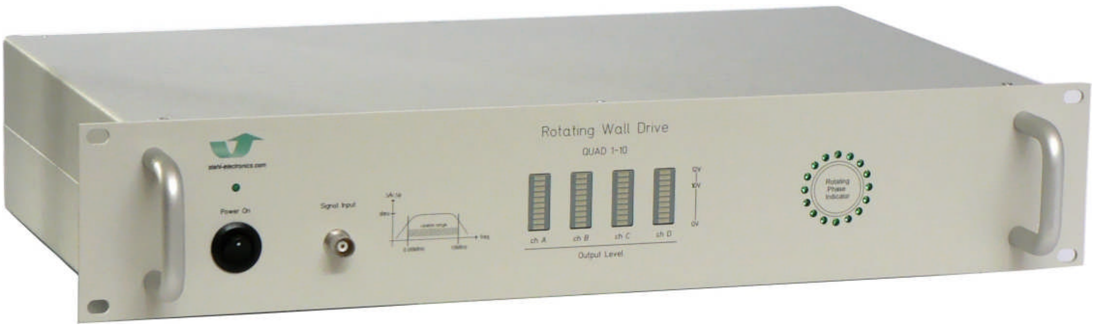
QUAD 1-10

Rotating Wall Drive for Ion Compression in Traps



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Data Sheet
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General Information and Overview

The QUAD 1-10 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 loaded into the trap. The QUAD 1-10 represents a tool to handle a wide range of ions/plasma rotation frequencies with respect to this novel application.
As indicated in the picture below, an input signal, for instance a sinusoidal 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, whereas 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 80kHz to 10MHz, at a nominal output amplitude range of $0V_{pp}$ to $10V_{pp}$. The signal input is 50 Ohm compatible, whereas the outputs do not require a 50 Ohm termination.

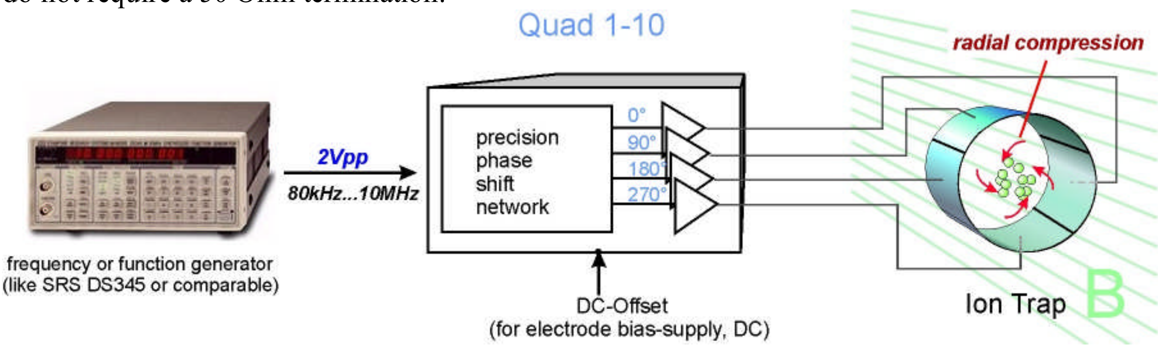

Fig. 1 Ion trap setup including a QUAD 1-10 rotating wall drive

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 (80kHz to 10MHz; 0 … $2V_{pp}$) 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. For complex input signals, having many frequency components in the spectrum, all components will be phase-shifted *individually* without interfering with other spectral components.

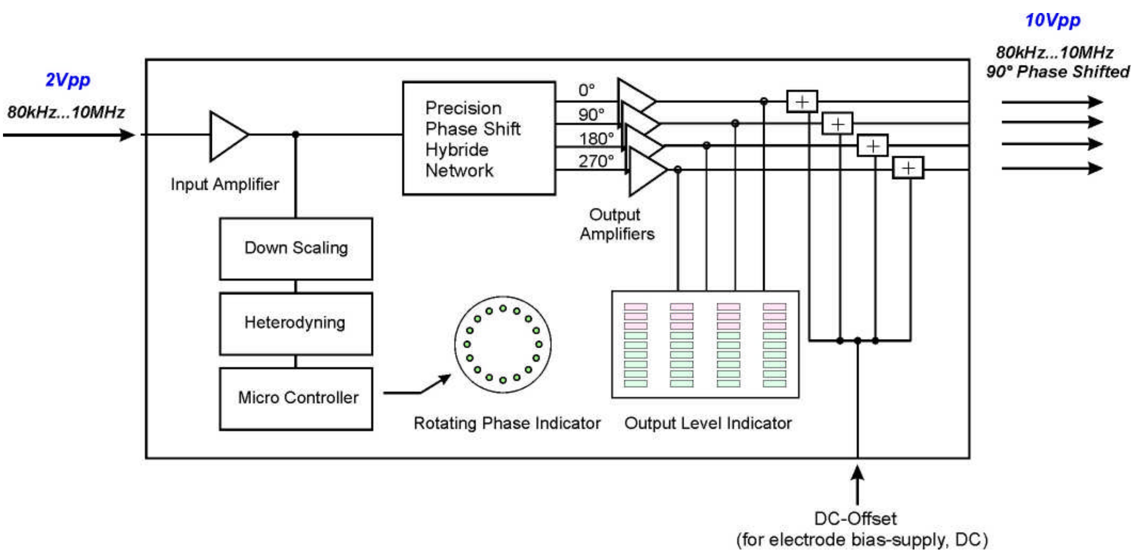

Fig. 2: Internal structure of the QUAD 1-10 device

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This linear operation 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 in a direct way without changing the device configuration or reprogramming. Also complex spectra like SWIFT functions, sweeps, artificial noise and multi-tone signals may be applied.
Four output buffers drive the outputs at the rear side, following the internal phase shift network and allow 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 +/-150 V on an additional DC level. LED indicators on the front plate show the presence of a suitable input signal and the corresponding output voltage level.

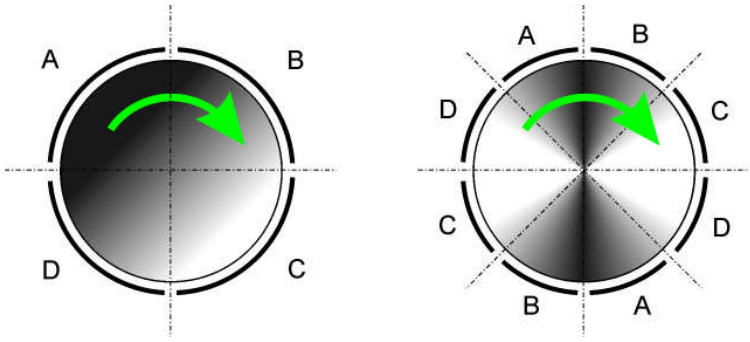
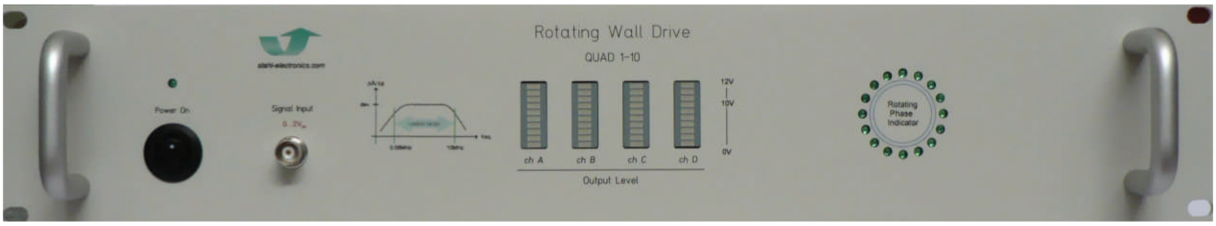


Fig. 3
Graphical illustration of electric dipole/quadrupole creation. For an electric dipole, connect the lines (A,B,C,D) as shown in the left picture, for a quadrupole as shown in the right picture. Please observe the correct order while connecting the cables. Shading in the pictures above illustrates the momentary electric potential (dark: low; light: high).

Elements on front and rear plate



Front Side Power Switch & Power-On LED   Input   LED bargraph indicating output amplitudes   rotating phase indicator

Fig. 4.1: Front plate

DC Offset-Input   4 Outputs, 90°-shifted   Ventilation Fan   Mains Switch

Fig. 4.2: Rear plate

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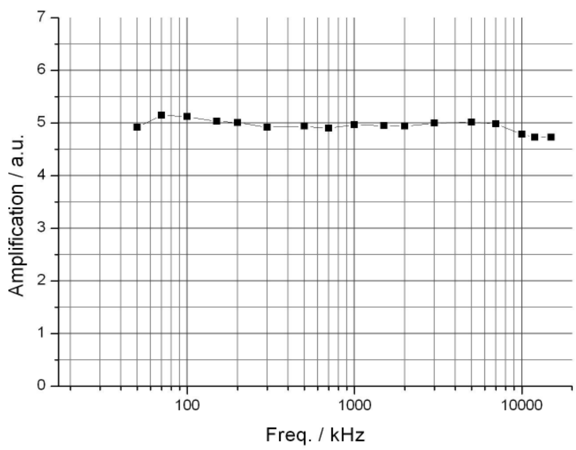
Specifications

	Parameter	spec. Value	Condition/Remark
	Ext. Power Supply	AC input $230V_{AC}$, 50Hz. Typical Power Consumption: 35W	The power entry module is EMI/RFI-filtered.
	Input (BNC connector) Input Impedance Voltage Range Coupling Mode Frequency Range	 60 Ohm $0...2V_{pp}$ AC 80 kHz … 10 MHz	
	Outputs (BNC connectors) Functionality Voltage Range Amplitude mismatch between outputs Phase mismatch between outputs	 4 Outputs, 90° Phase Shifted $0...10V_{pp}$ nominally max. $12V_{pp}$ (overrange) typ. < 0.25dB max. ± 5° typ. 2.5°	 output load 150pF each channel " f = 80 kHz .. 10 MHz " "
	Input/Output - Voltage Gain Gain flatness over freq. range	 nominally 5x (14.0dB) typ. ±0.5dB	 f = 80 kHz .. 10 MHz, each channel 150pF loaded "
	Nominal Freq. Range	80kHz...10MHz	output load 150pF each channel
	Rotating Phase Indicator	min. signal level typ. $10mV_{pp}$	f = 80 kHz .. 10 MHz
	Wideband Output Noise, any channel	1.7mV $_{rms}$	bandwidth 1kHz … 60MHz
	Ext. DC-Offset range	± $150V_{DC}$	remark: the applied external offset (DC) voltage is internally added to the ac output voltages
	Storage Temperature	-55C° to +105C°	
	Recommended Operating Humidity & Temperature	noncondensing relative humidity; temperature between +15°C and +30°C	
	External Magnetic Field	max. 10mT	External magnetic field at metal case must never exceed value.
	Physical Dimensions	approx. 485mm x 92mm x 310mm	
	Weight	approx. 3.5 kg	

Typical performance charts



Gain flatness versus frequency; amplitudes are averaged over all output channels (A,B,C,D)

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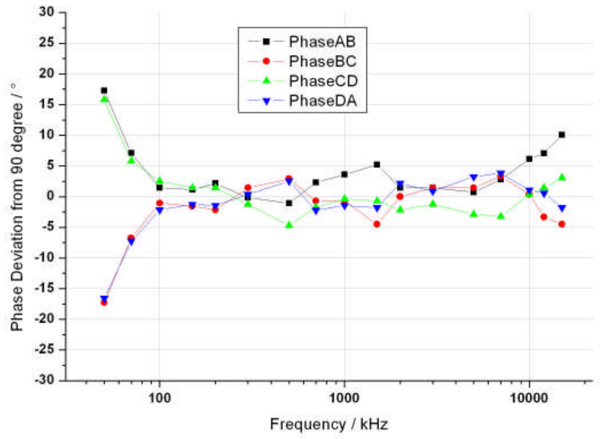
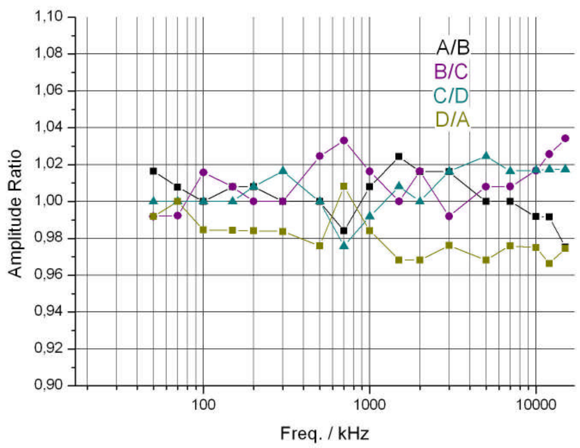


Phase error vs. frequency. Graph shows deviation from the nominal 90° shift between output channels load on each channel: 150pF // 1MOhm; measurement device: oscilloscope TDS 210 (Tektronix)



Amplitude mismatch vs. frequency; graph shows voltage ratios between output channels load on each channel: 150pF // 1MOhm; measurement device: oscilloscope TDS 210 (Tektronix)

Device Variety

Currently there are two main members of the QUAD 1-X series device family:

Device Name	***Versions***	***Characteristics***
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)
Quad 1-10	Quad 1-10	Frequency Range 80kHz…10MHz Output Amplitude 10Vpp (entire frequency range)

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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