TD2000

Ultrafast Timing Discriminator

User Manual

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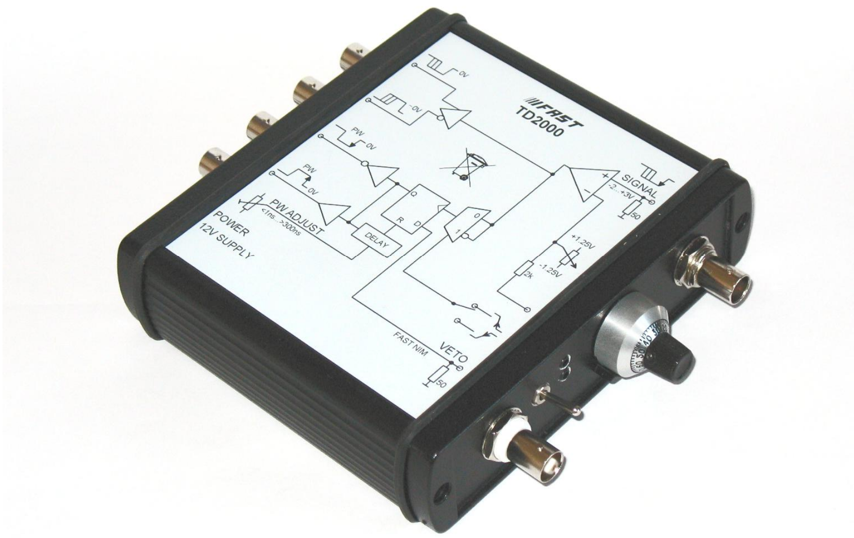

Version 1.5, August 5, 2013

Warranty

Equipment manufactured by FAST ComTec GmbH is warranteed against defects in materials and workmanship for a period of twelve months from date of shipment, provided that the equipment has been used in a proper manner as detailed in the instructions manuals. During the warranty period, repairs or replacement will be made to FAST ComTec's discretion on a return to factory basis. The transportation costs, including insurance to FAST ComTec is the responsibility of the customer except for defects discovered within 30 days after receipt of the equipment, where shiping expense will be paid by FAST ComTec.

The information in this manual describes the hardware and the software as accurately as possible, but is subject to change without notice.

Table of Contents

Table of Figures

1. Introduction

The TD2000 is a fast leading-edge timing discriminator intended for signal conditioning of fast detector pulses. Applications are ultra high count rate Single Photon Counting, LIDAR, TOF Mass-Spectrometry, ultra high count rate multiscaling etc.

A total of 4 outputs enables versatile connections to subsequent data acquisition devices. There is both an inverting and a non-inverting unshaped fast-NIM output delivering a 3dB bandwidth of approximately 2.4GHz. In some electronic environments these outputs may be useful for data rates of over 3GHz.

The pulsewidth of the shaped outputs is screwdriver adjustable over a wide range from <1ns (typ. 750ps) to more than 300ns. “Shaped” in this context means the output pulsewidth is not dependent on the input pulsewidth but only on the screwdriver adjusted time intervall. The leading edge of the output pulse indicates the input threshold crossing and may be used for timing. These shaped outputs provide a pulse pair resolution of 2.5ns which corresponds to a continous wave operation capability of 400MHz. A fast-NIM (negative) and a positive voltage follower output (typ. +2V) are available for the shaped signals.

The fast NIM compatible VETO input enables inhibiting the shaped outputs. Using this, even a single pulse can be gated out of an outgoing (e.g. 400MHz) pulse train.

2. Hardware Description

NOTE: To safely avoid damage to the TD2000 and the signal source as well, the TD2000 discriminator should be powered ON before connecting active input signals.

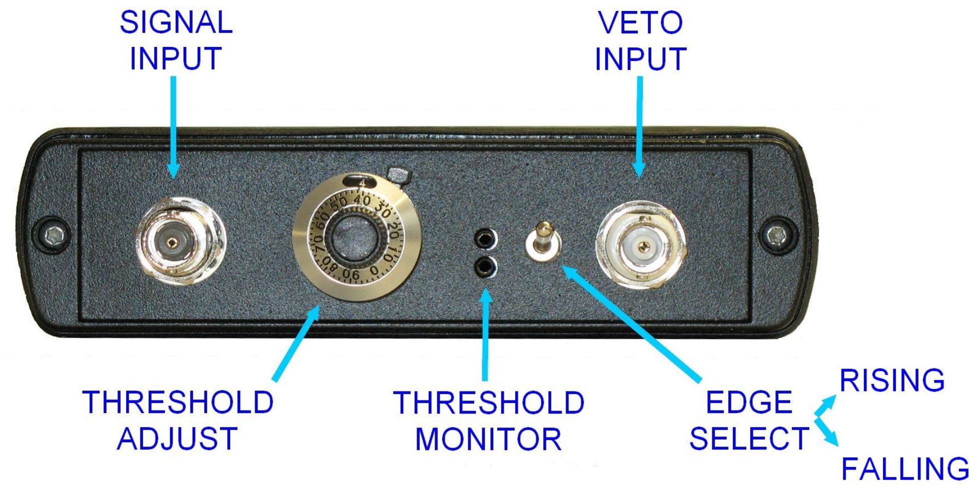

Fig. 1: Input panel

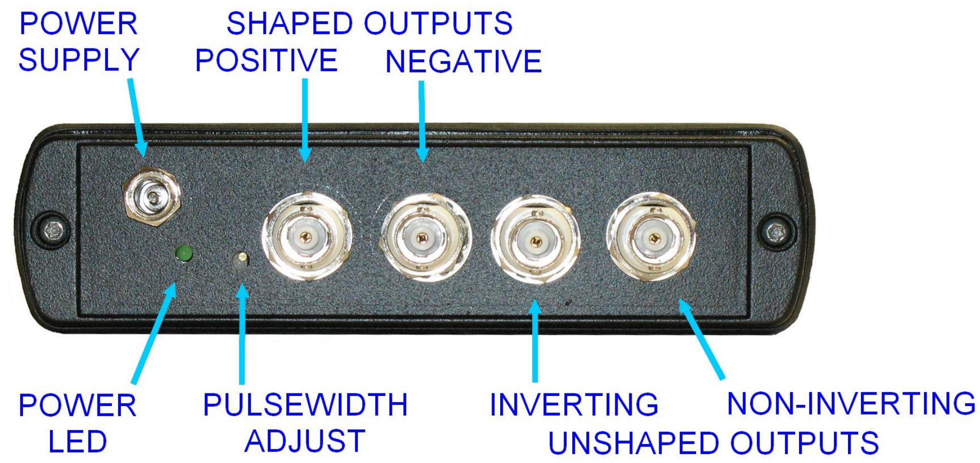

Fig. 2: Output panel

The TD2000 ultra fast discriminator consists of 2 major component elements.

First, there is the non-shaping discriminator that produces a fast 1 bit digital output depending on whether the input signal is below or above the threshold level. The non-inverting output will produce a 0V level if the input is above the threshold and –800mV (into 50Ω) when the input is below the threshold. Thus, the non-inverting output “follows” the input signal. An inverting output is available as well.

Second, there is a shaping, leading-edge discriminator. The simplified principle of operation is as follows: the switch selected rising or falling edge (threshold crossing) of the input signal sets a flip-flop. To obtain a specific output pulse width the output of the flip-flop is delayed and fed back into the flip-flop’s reset input, effectively forming a one-shot. The pulse width is adjustable by changing the delay. Turn the small trimmer screw (ref. Fig. 2) clockwise to reduce the pulse width, anti-clockwise for wider pulses.

NOTE: Only the leading edge (falling edge for the fast-NIM output and rising edge for the positive output) of the shaped outputs is intended for timing purposes. The trailing edge of the shaped output signal is not practical for timing measurements because there are situations were the pulse width is not precisely stable e.g. in the case of a second input pulse arriving with only a short delay of less than the sum of the shaped pulsewidth and approximately 1.5ns, the output pulse might be wider than expected (ref. Fig. 23). The leading edge of the output pulse nevertheless stays correct.

The VETO input inhibits the start of the one-shot (ref. 2nd input pulse in Fig. 4) if the VETO input is below the fixed threshold of approximately –300mV which is compatible to fast NIM signals. In Fig. 25 you can see an example of a single pulse gated out of a 400MHz pulse train.

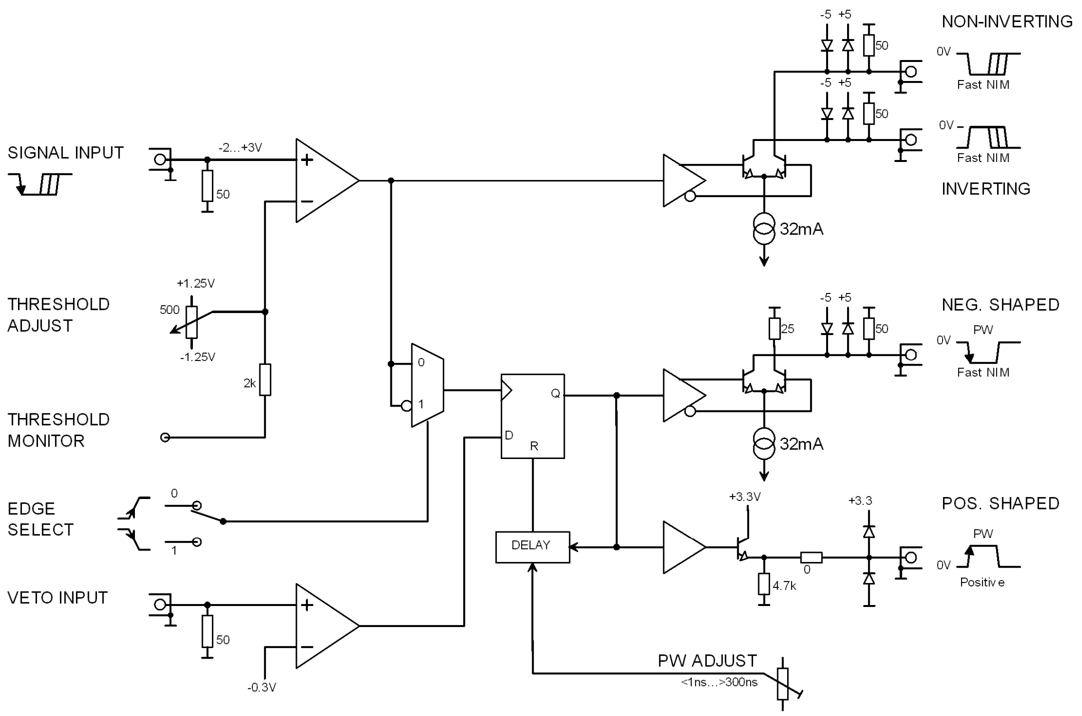

Fig. 3: Simplified schematic

For precise control of the threshold level a monitor output can be connected to a high impedance voltmeter by 2mm banana plugs or appropriate test tips. Referring to Fig. 1, the lower jack is ground (GND) while the upper jack delivers the threshold voltage. Turn the precision potentiometer anti-clockwise for a lower (more negative) threshold, clockwise for more positive levels.

Generally the threshold level should be set well in the middle of the input signal amplitude. For best timing accuracy it should be set in the steepest portion of the input slopes.

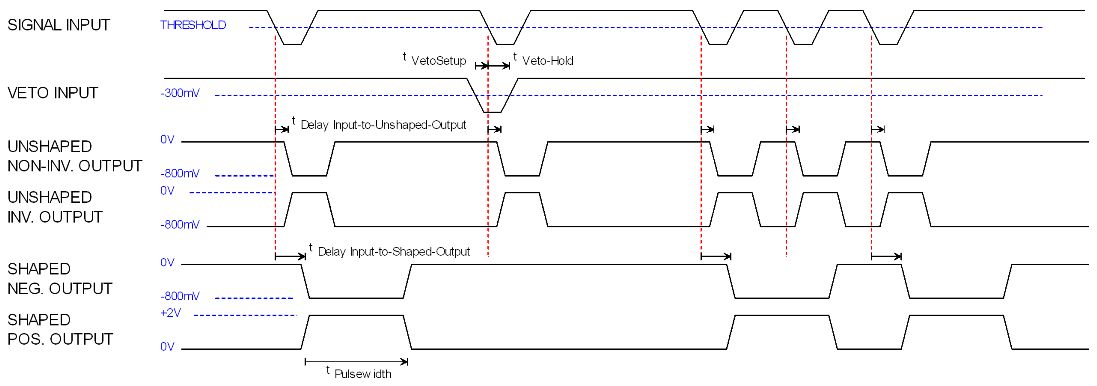

Fig. 4: Theory of operation for falling-edge shaper sensitivity

The negative going outputs are current mode / fast NIM outputs delivering -16mA into external 50Ω to GND.

The positive output is formed by an emitter follower.

NOTE: The positive output is generally slower than the fast NIM signals. It is NOT short circuit protected, so use caution when connecting this output!

3. Specifications

3.1. Performance characteristics

Fast NIM Output Bandwidth:	3dB, ref. Fig. 20	typ. 2.4GHz
Shaped outputs data rate:	continous wave operation, ref. Fig. 24	max. 400MHz
Pulse pair resolution:	(shaped outputs)	typ. 2.5ns
Propagation delay:	input-to-unshaped-output, ref. Fig. 17	typ. 1.7ns
	input-to-shaped-output, ref. Fig. 18	typ. 3.3ns

3.2. Absolute maximum ratings

Power supply:	100ms max.	25V
Signal input:		-3.0 to +4.0V
VETO input:		-3.0 to +4.0V
ESD rating:		1500V HBM
Positive shaped output:	sink current	max. 120mA
		NOT short circuit protected

3.3. Recommended operating conditions

Power supply:	(from external power source)	$+12V_{DC}$
Output termination:	(except threshold monitor)	50Ω
Voltmeter impedance:	(for threshold monitoring)	≥10MΩ
Input signal slew rate:		≥5V/µs
Ambient temperature:		0 … +50°C

3.4. Technical data[1]

3.4.1. Signal input

Connector:		female BNC
Impedance:		50Ω
Input voltage range:		-2.0 to +3.0V
Input sensitivity:	ref. Fig. 16	$<10mV_{PP}$
Slew rate requirement:		≥5V/µs
Threshold voltage:		±1.25V
		adjustable by a 10-turn precision potentiometer

[1] All data is taken with output terminations of 50Ω to GND if not otherwise noted

3.4.2. Threshold monitor

Connector:		female 2mm jack
Signals:		threshold voltage / GND
Impedance:		2kΩ

3.4.3. VETO input

Connector:		female BNC
Impedance:		50Ω
Input voltage range:		-2.0 to +3.0V
Slew rate requirement:		≥5V/µs
Threshold voltage:		-300mV
Setup time:	VETO to SIGNAL edge	-265 / -375 / -545ps[2]
Hold time:	VETO after SIGNAL edge	+465 / +575 / +745ps

3.4.4. Unshaped outputs

Connectors:	inverting & non-inverting	female BNC
Impedance:		back-terminated 50Ω
Output signal:	fast NIM / current mode	-16mA into external 50Ω
Fall time:	90% to 10%, ref. Fig. 6	typ. 180ps
Rise time:	10% to 90%, ref. Fig. 7	typ. 500ps
	20% to 80%, ref. Fig. 8	typ. 220ps
Jitter[3]:	RSMΔ = standard deviation, ref. Fig. 27	approx. $2ps_{RMS}$
		< $20ps_{Pk-Pk}$ (typ. $17ps_{Pk-Pk}$)

3.4.5. Shaped outputs

Pulsewidth:	ref. Fig. 9	min. <1ns (typ. 750ps)
	ref. Fig. 15	max. ≥300ns
		10-turn screwdriver adjustable

Fast NIM / negative shaped output

Connector:		female BNC
Impedance:		back-terminated 50Ω
Output signal:	fast NIM / current mode	-16mA into external 50Ω
Jitter (falling edge):	RSMΔ = standard deviation, ref. Fig. 29	approx. $2ps_{RMS}$
		< $20ps_{Pk-Pk}$ (typ. $17ps_{Pk-Pk}$)
Jitter (rising edge):	RSMΔ = standard deviation, ref.Fig. 30	approx. $5ps_{RMS}$
		typ. <$65ps_{Pk-Pk}$

[2] Setup and hold times (min./typ./max.) are calculated from component datasheets and PCB transmission line delays. They are dependent on input overdrive, slew rate, temperature etc.

[3] The jitter of the scope timing is specified to be typ. $1.1ps_{RMS}$+ 4ppm of position. Thus, the input signal for the jitter test already shows a jitter of $1.9ps_{RMS}$ (ref. Fig. 27) indicating an actually lower jitter of the output signal than measured

Postive shaped output

Connector:	....	female BNC
Impedance:	emitter follower	low impedance
Output signal:	V_{OL}..	<500mV
	V_{OH}	≥2.0V
	V_{OH} at min. pulsewidth, ref. Fig. 14	>1.2V
Fall time:	90% to 10%, ref. Fig. 12	typ. 400ps
Rise time:	10% to 90%, ref. Fig. 11	900ps
Min. Pulsewidth:	V_{OH} ≥ 2V, ref. Fig. 13	typ. 2ns
Jitter (rising edge):	RSMΔ = standard deviation, ref. Fig. 31	approx. $2.3ps_{RMS}$
	....	typ. $20ps_{Pk\text{-}Pk}$
Jitter (falling edge):	RSMΔ = standard deviation, ref. Fig. 32	approx. $3.1ps_{RMS}$
	....	typ. $32ps_{Pk\text{-}Pk}$

3.5. Diagrams[4, 5, 6]

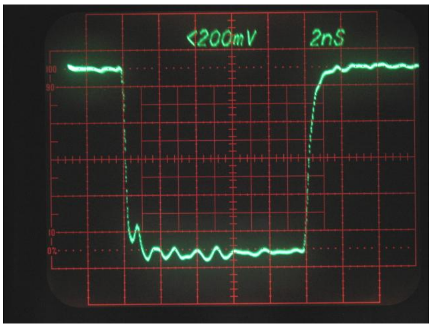

Fig. 5 Unshaped output pulseform

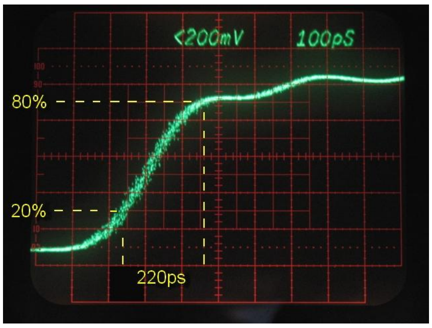

Fig. 8: Unshaped output rise time

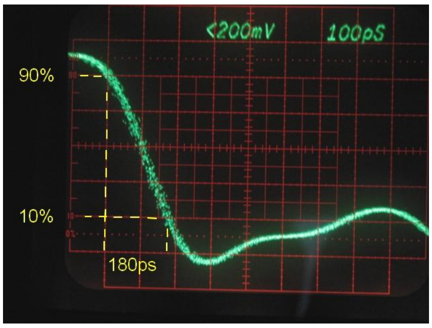

Fig. 6: Unshaped output fall time

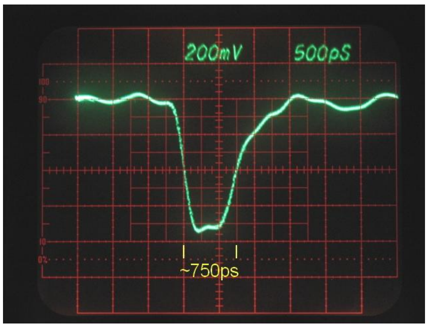

Fig. 9: Shaped neg. out min. width

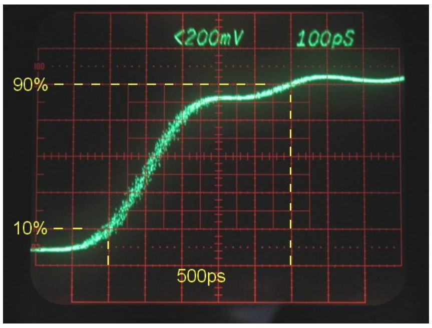

Fig. 7: Unshaped output rise time

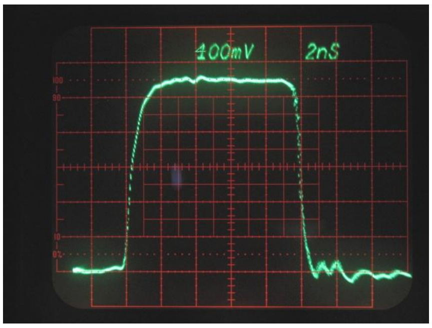

Fig. 10: Positive output pulseform

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[4] Scope pictures (fotographs) of output signals are taken using a 14GHz 50Ω sampling head, input signals with a 12GHz loop through head

[5] A “<” in the mV/Div indicator means you can’t derive absolute voltages

[6] Hardcopy scope pictures of output signals are taken using a 12.5GHz 50Ω low noise sampling head (Fig. 27, …, Fig. 29)

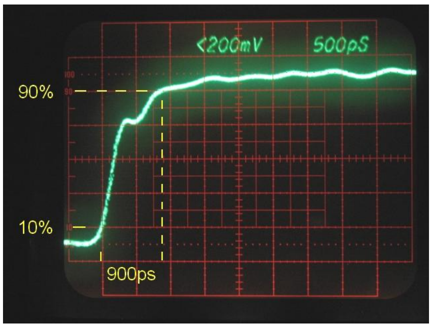

Fig. 11: Positive output rise time

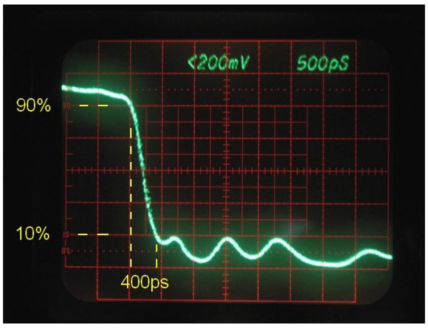

Fig. 12: Positive output fall time

Fig. 13: Positive output small width

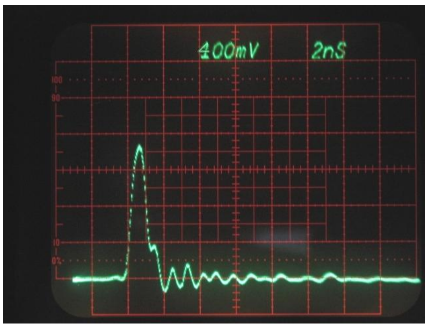

Fig. 14: Positive output min. width

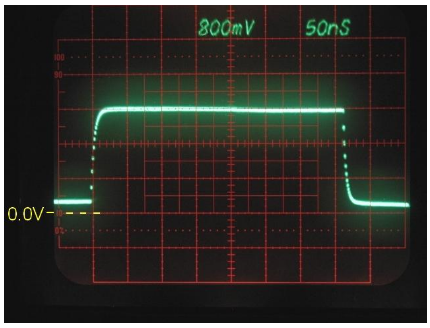

Fig. 15: Positive output max. width

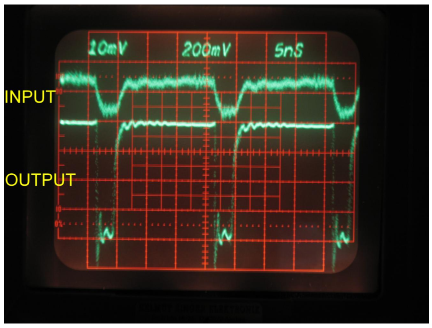

Fig. 16: Input sensitivity

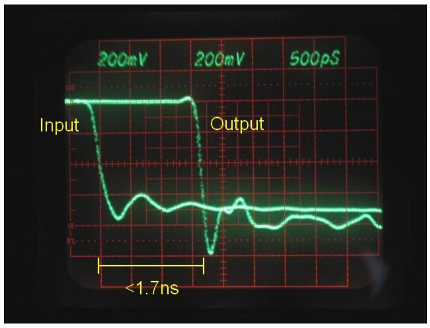

Fig. 17: Input to unshaped out delay

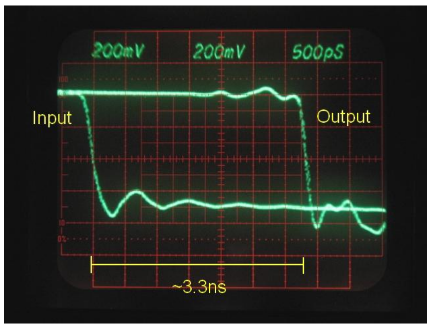

Fig. 18: Input to shaped out delay

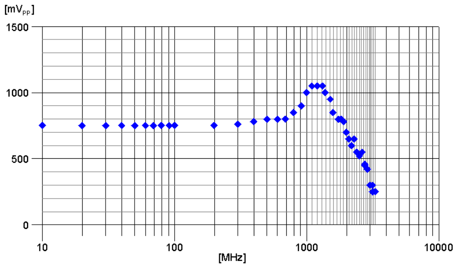

Fig. 19: Fast NIM output amplitude (log. frequency scale)

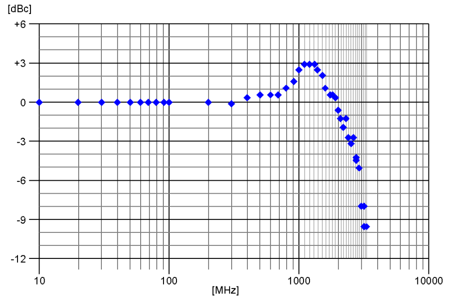

Fig. 20: Fast NIM output attenuation (log. frequency scale)

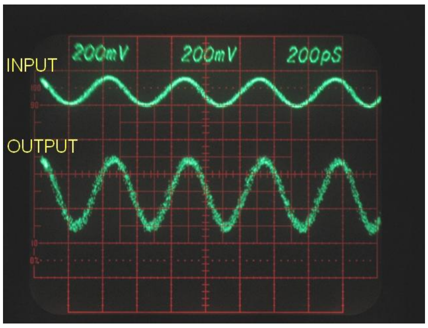

Fig. 21: 2.3GHz signal example

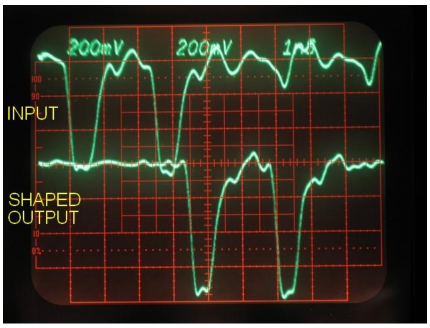

Fig. 22: Double pulse behavior

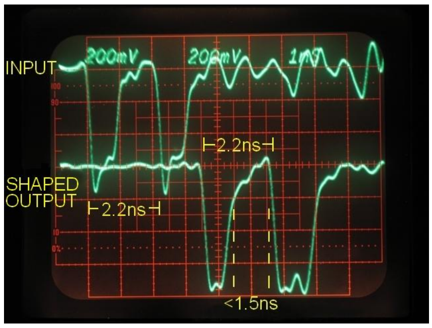

Fig. 23: Min. double pulse time delay

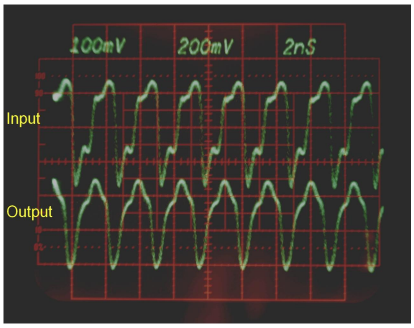

Fig. 24: Shaped neg. out at 400MHz

Fig. 25: VETO input pulse example

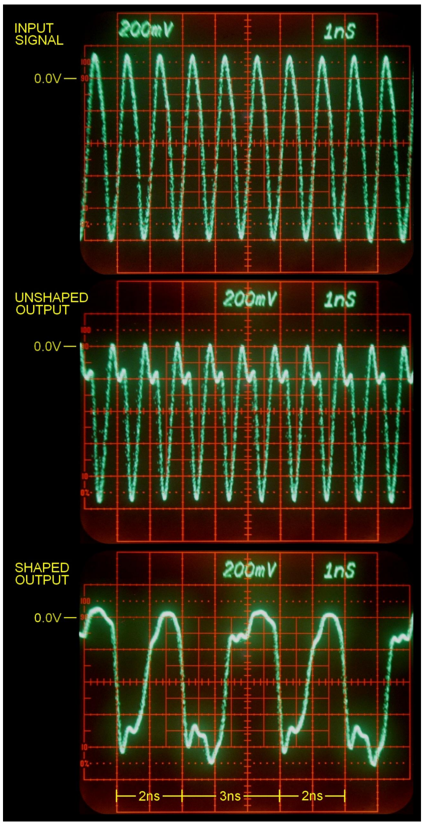

Fig. 26: Compare 1GHz signals

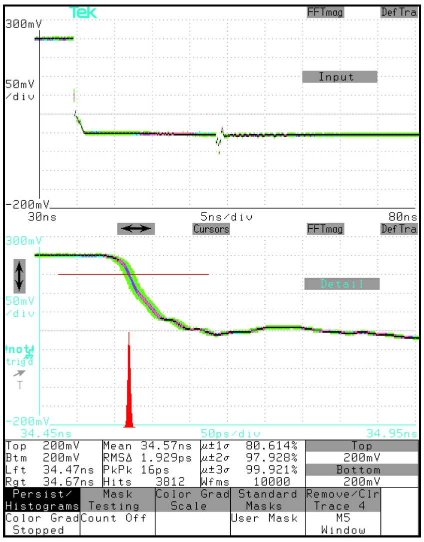

Fig. 27: Jitter test input signal

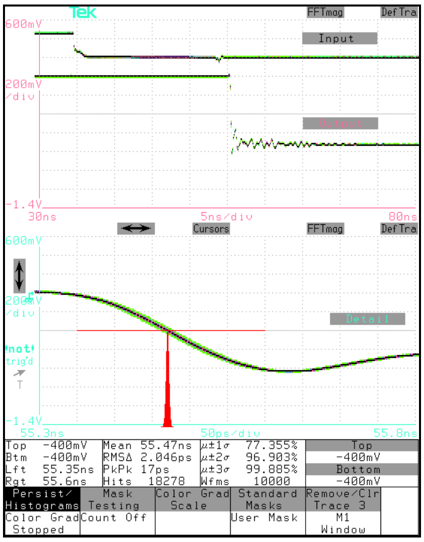

Fig. 28: Jitter of unshaped output

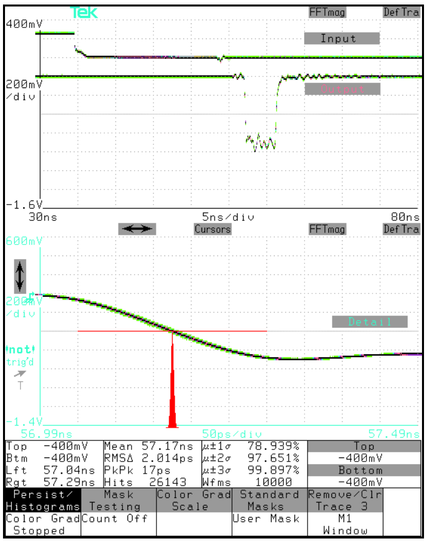

Fig. 29: Jitter of shaped neg. output (falling edge)

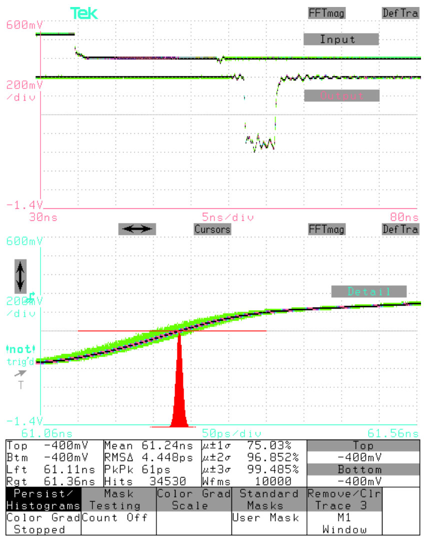

Fig. 30: Jitter of shaped neg. output (rising edge)

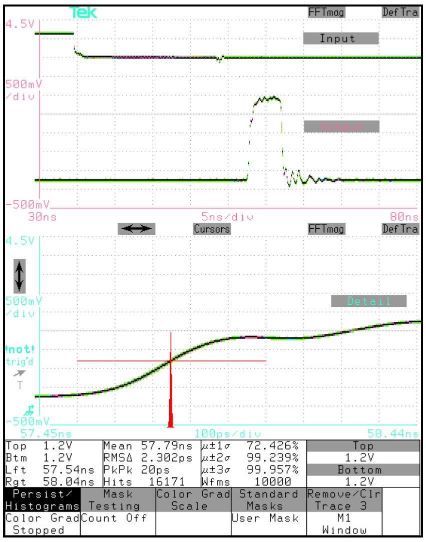

Fig. 31: Jitter of shaped pos. output (rising edge)

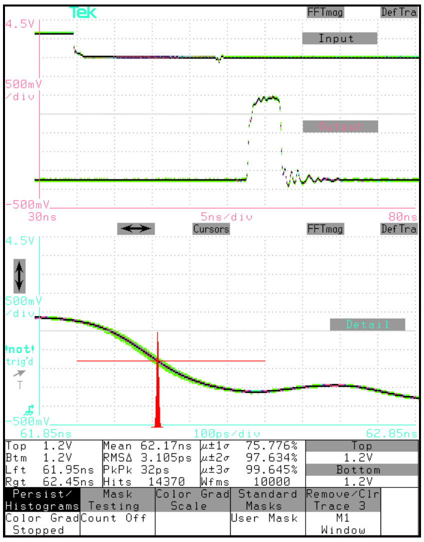

Fig. 32: Jitter of shaped pos. output (falling edge)

3.6. Power requirements

Supply connector: (+) at center pin ....2.1mm center pin

Supply voltage: ....nominal +12V_{DC}
voltage range: ....+10 … +18V_{DC}
.... reverse polarity protected

Supply power: 6W

3.7. Metal Case

Case material: .... extruded aluminium sheath, Al Mg Si 0.5

Lid material: .... die cast, GD-Al Si 12

Size: .... 121/153 x 142 x 37mm

Weight: 500g

3.8. Accessories

- External wall power supply (included)
- Precision 1.2mm screwdriver (included)
- L-clips (order no. AB-WL) for wall-/screw-mounting (optional)