90. Transmitter and Receiver for 1A Opto Pulses with Experimental Results Draft V1.2

UFO Doctor, April 11th,

1. Introduction and discussion about component specifications

The transmitter should generate 15.6kHz Opto pulses with quadric increasing pulse lengths from 0.5% to 50 % Duty Cycle. The minimum pulse length should be <300nsec with full 1A amplitude. This permits a linear optical distance range detection from 0.2 to 20m due to the $1/r^2$ attenuation. This Opto Sequence lasts 12.4 msec and is repeated all 88msec .(4-Aile-pulses)

- Comparator: Switching time < 300nsec, optimal would be a rail to tail comparator, min 8V supply. Experiments with TS3022 (max Vcc=5V) failed, it was killed by excessive input signals. (Sharp negative sparks , inductively coupled to the output loads, 2x1A).
Experiments with LS3011 failed by ringing problems due to layout problems with long, not terminated input lines. Good results were obtained with LM393, but it needs pull-up resistors of 2.2k for fast reactions, which consume 2x 3mA when the nMOSFET is 90% off.

- nMOSFET: Switching time < 300ns, Current >1 A at 50% Duty Cycle at 15.6kHz.
The tiny ZXMN3A03E6 works fine, but needs a cooling plate on the top of the SMD package if the average current is >0.5A. The fast switching requires a high gate current of about 1A (see datasheet: iDrain=3.5A, rise time 6.4nS and fall time 11.2ns, Ugs 10V with serial resistance of < 6Ohm)
The first experiments with buffer TC4427, both buffers connected in parallel, fulfils this job quite well. But better is the gate driver ZXGD3002E6TA.

2. Circuit Transmitter

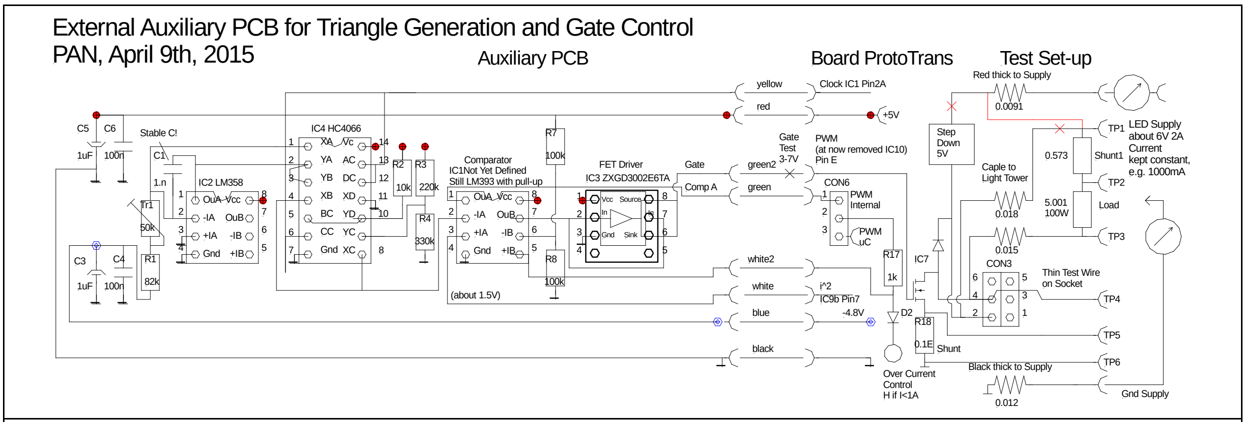

Fig. 1. Test Circuit with Test Load at nMOSFET IC7, Operating Load IR-LED SFH4233+5Ohm

3. Circuit Receiver

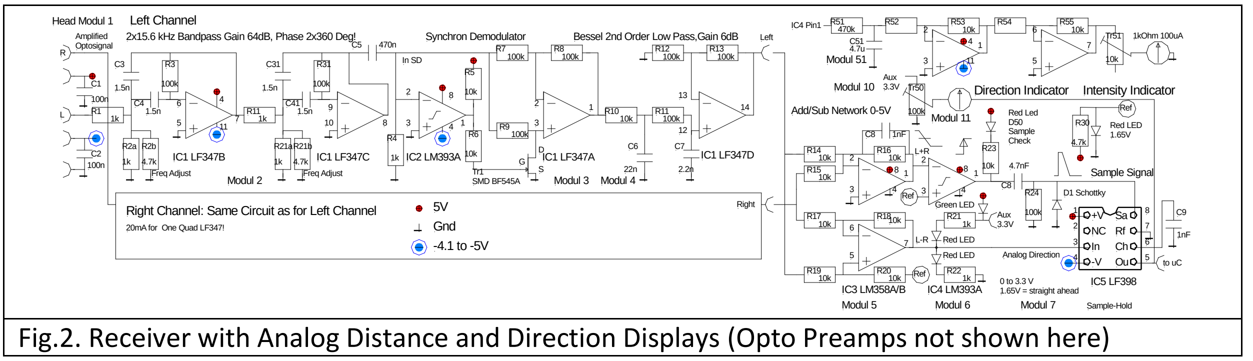

Fig.2. Receiver with Analog Distance and Direction Displays (Opto Preamps not shown here)

4. Test Setups

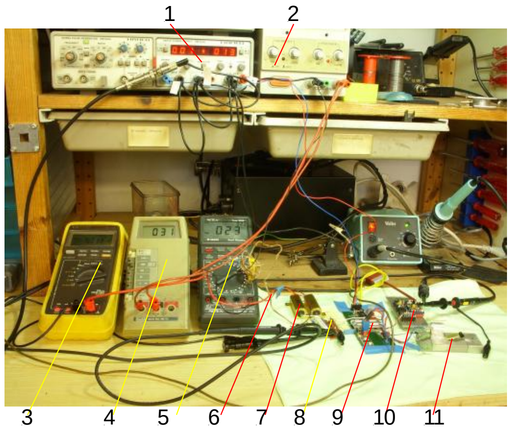

Fig.3: Test Setup Transmitter
1: Supply +5V/-4.8V; 2: Supply 5V, 2A
3: Vcc Load; 4: Average Current Load 32mA;
5: Temperature nMOSFET at cooler;
6: Twisted (low inductivity) cable to load;
7: Load 5Ohm 100W at nMOSFETs 1;
8: Test Points TP1 thru TP6;
9: ProtoTrans Board;
10: Auxiliary Wire Wrap Board;
11: Test Board IR-Led with 5 Ohm serial resistor and IR-Diode at 1kOhm termination, not good

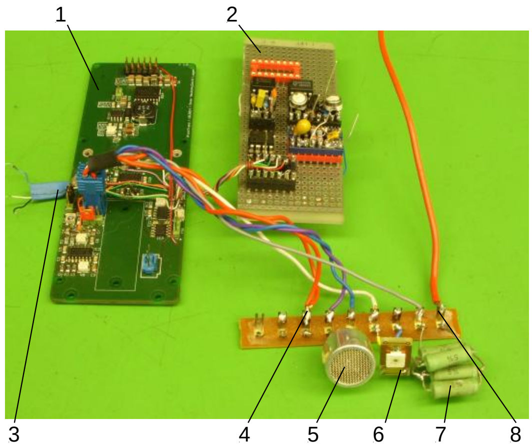

Fig. 4: IR Transmitter with loads
1: ProtoTrans
2: Auxiliary board
3: Test terminals T4, T5,T6
4: Internal 6V LED Supply, not used because the internal Step down converter shows oscillations at fast load change (2x1A-Current pulse to LED!)
5: US-Speaker
6: IR-LED +serial resistor 5Ohm at first nMOSFET
7: Load resistor 5Ohm at second nMOSFET
8: External Supply 4-6V, 1-2A

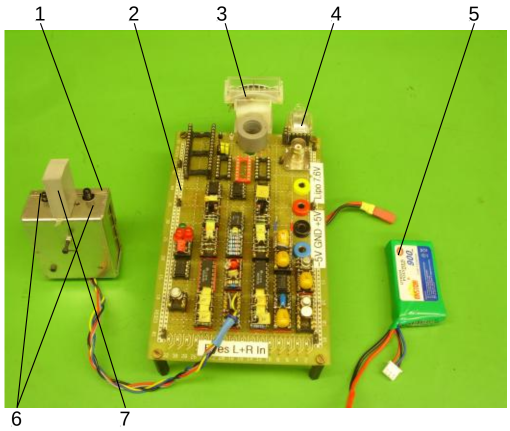

Fig. 5: IR Receiver
1: Shielded Opto-Preamplifier
2: Experimental Baby Opto Sensor Board
3: Direction Indicator
4: Distance Indicator
5: Lipo 2-cell, 7.4V 900mAh
6: IR-Diodes
7: Nose for shadowing the Left/Right IR-diodes

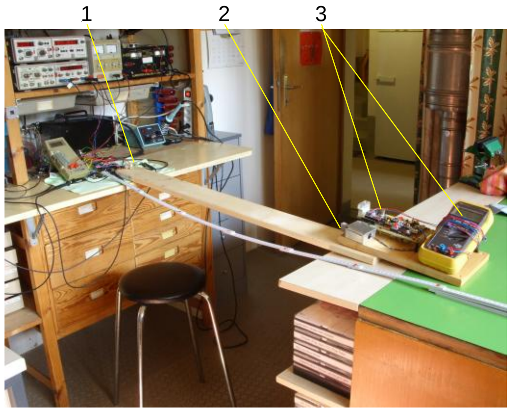

Fig.6: Test Setup for Distance Recording
1: Transmitter IR-LED directed to receiver
2: Receiver IR-Diode, directed to transmitter
3: Analog distance signal.

5. Experimental Results

5.1. Overview on optical transmission and reception

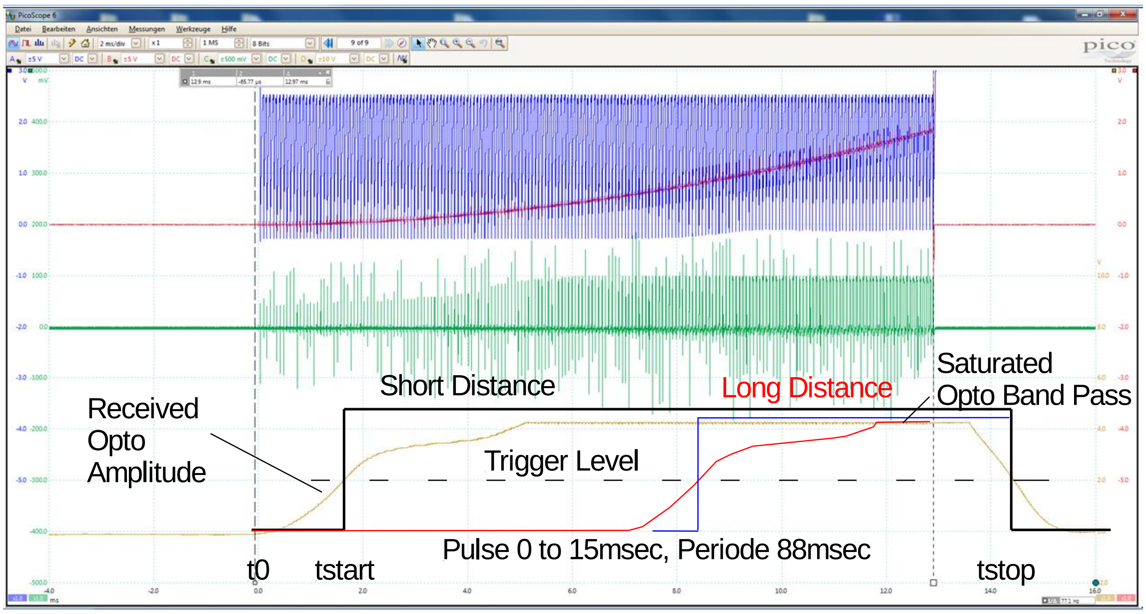

Fig. 7. IR Transmission distance about 3m, Time Scale 2msec/Div.
Top A: Triangle Signal,+/-5V, LP 1MHz
Top B: i^2 Signal, +/-5V, LP 1MHz
Middle C: Shunt Voltage at R0.1, +/-500mV, LP 5MHz (100mV means current of 1A)
Below D: IR-Receiver Analog Opto Out Left, +/-10V, LP 0.1 MHz

Comment:
Controlled by the i^2 Signal-Threshold the output pulse length varies
from 1 to 32us (1.5 to 50 % Duty cycle)

The receiver accepts the two increasing opto signals left and right, amplified by 2x32 dB gain band pass (BP) amplifier, tuned to 15.6KHz. The response time of these BPs is about 0.5msec.

Reaching the trigger reference level of 1.6V the following actions will be initiated:
- Sample left/right for direction detection.
- Generating a variable PWM pulse, duration "tstart to tstop" 0 to 12.5msec, period 88msec, for distance detection

After this trigger the band pass amplifier will get saturated, without consequences for tstart, but effects a delayed for tstop.

The state of the art is an approximate distance detection from 0.2 to 20m

5.2. Details of transmission/reception at 0, 5 and 10msec, same settings as in Fig. 7:

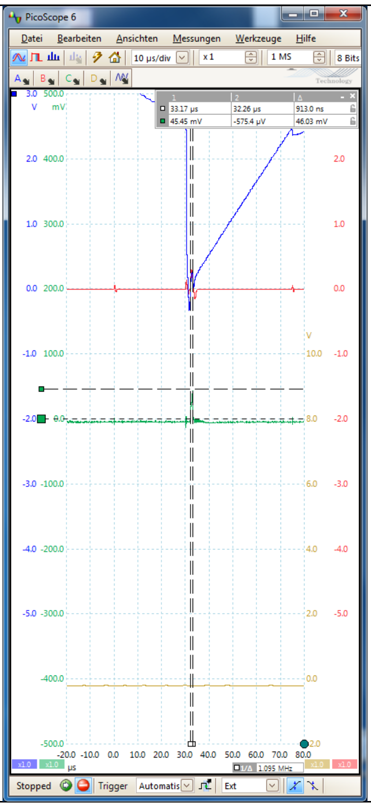

Fig. 8a: 10us/Div, Delay 0
Current Pulse 0.46A, 0.9uS

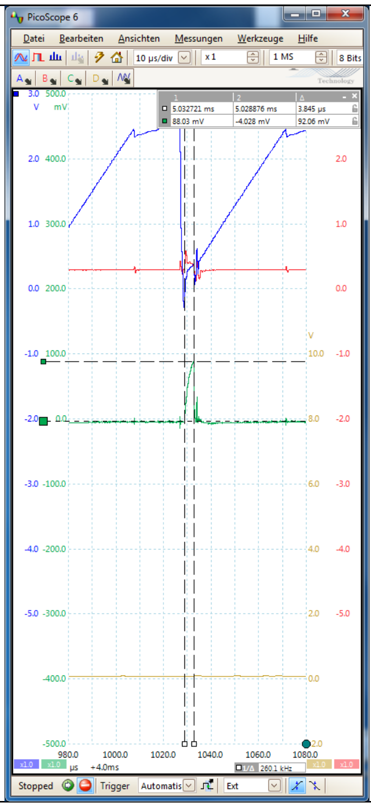

Fig. 8b: 10us/Div, Delay 5ms
Current Pulse 0.92A, 3.05us

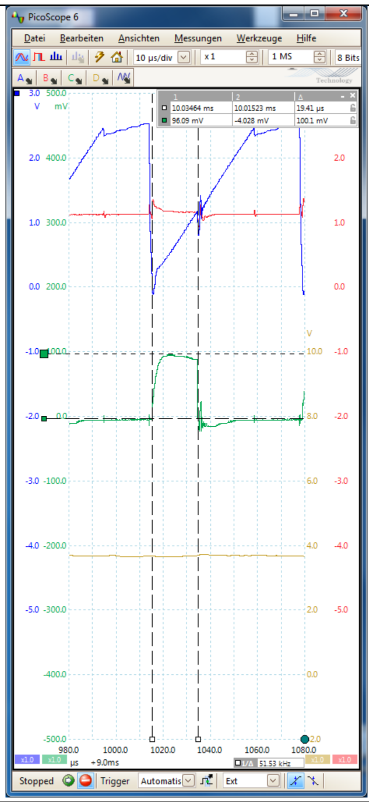

Fig. 8c: 10us/Div, Delay 10ms
Current Pulse 1.0A, 19.4us

Comment: The minimum Pulse length is 0.9us (not as small as 0.3us) as expected.
This means that the averaged IR-Power does not start with 0%, but with 3.2% and increases to 4.7% at 3msec. At short distances< 0.5m this could degrade the accuracy of distance measurement.
Note the little oscillation at i^2 at trigger time, perhaps by inductive coupling to the 1A power load.

6. IR-Intensity Transmission Control

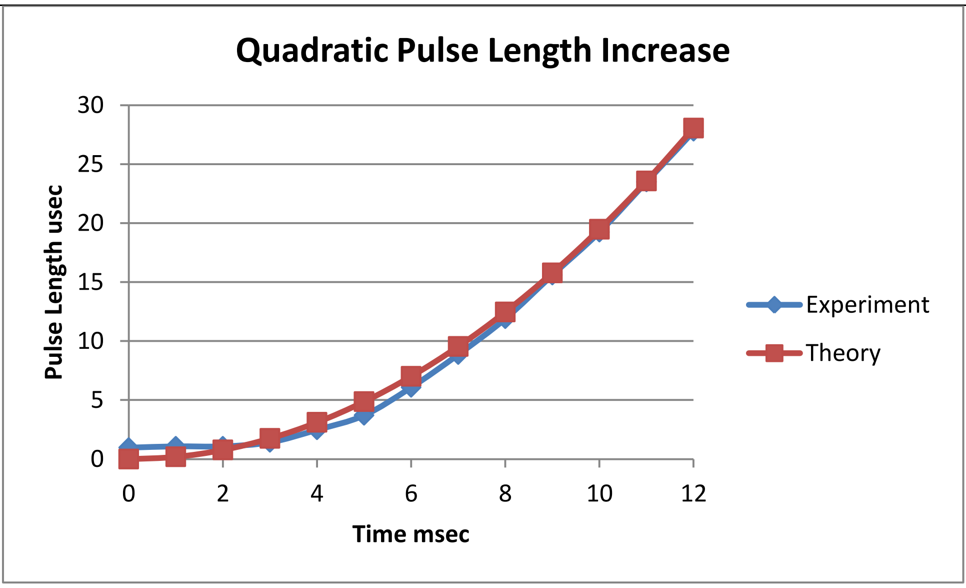

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Fig.9.
Quadratic Pulse Length Increase

Comment:
Experiment fits quite well with the theoretical proposed values!

However, already 3% amplitude at t=0 and increase not before 3msec

7. Experimental Distance Recording

(see first Test setup in Fig.6)

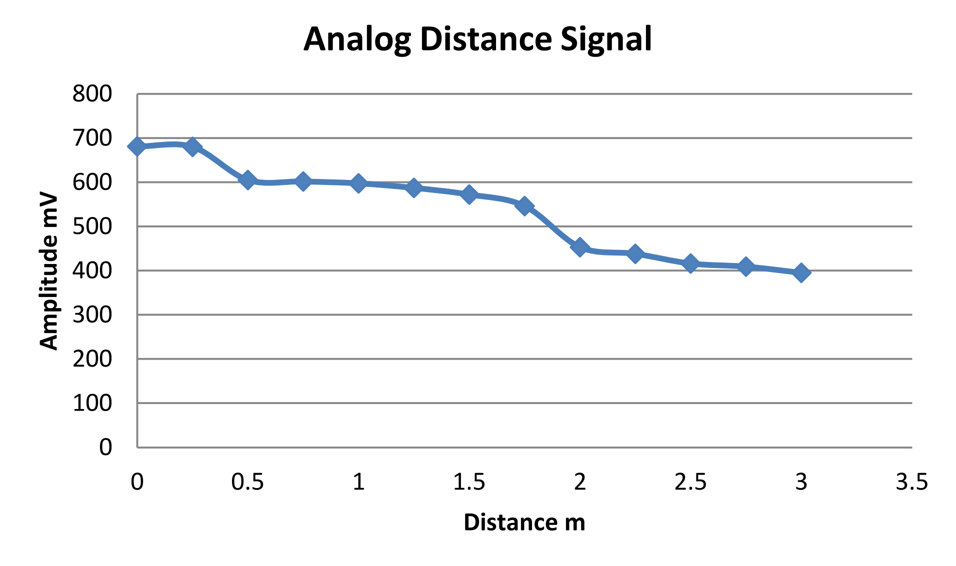

Fig. 10: First Distance Recording Experiment

The distance signal follows more or less the applied distance.

Comments:

Distance measurement by Opto-intensity control suffers in practice by following effects:

- Wrong signals if transmitter is not aligned to the receiver.
- Wrong signals if there are obstacles between transmitter and receiver.
- Wrong signals if there is dust on IR-LED and/or IR-Diode (received intensity not constant!)

Possible Application in practice (for example for Baby Duck Control)

- Good for appoximate direction measurement.
- Not applicable for accurate distance measurement.

Proposal 1

- Use this method for a first and fast approximate, but uniquely direction measurement.
- Use the ultrasonic precise phase detection, but not uniquely method for final direction measurement when the receiver is aligned within +/-30 degree to the transmitter.
- Use the omnidirectional Ultrasonic FSK method for a precise (+/- 5mm) distance measurement.

General Proposal 2

- Separate the power output stage from the analog circuits in the layout
- Since the average current of the 2 loads is below 35 mA, it make no sense to apply a step-down converter for maximum DC Power efficiency
- Better would be a constant current source of 1 A for the two nMOSFET

8. Altered Circuit ProtoTrans

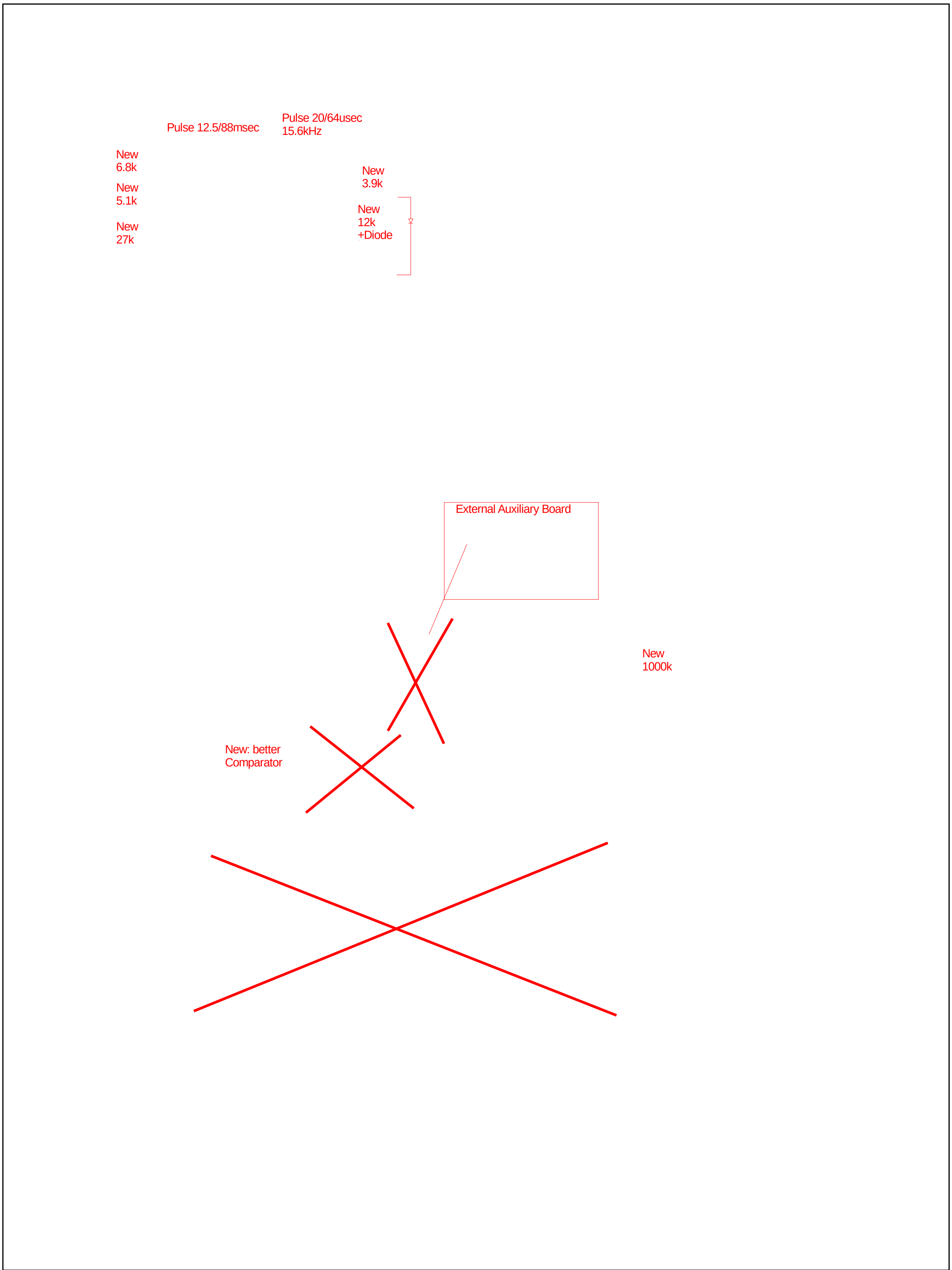

Fig. 11: ProtoTrans with alterations