

# Fully Compensated Start Pulse Detection

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## Abstract

Our usual start pulse detection uses a fast photo-diode and a fast discriminator, triggering at the leading edge of the first pulse of the SemiTrain. Although the design is simple and reliable, it has some intrinsic disadvantages: Due to its Leading-Edge-Discrimination, its timing is dependent on the Laser Pulse Amplitude; and it is drifting with temperature. Although these effects are more or less calibrated out of the SLR results, they tend to shift the calibration constant; these shifts could easily cover other problems within the system, which possibly are NOT calibrated out; this is one of the reasons why we always try to have a calibration constant which is REALLY A CONSTANT.

We considered and tested various methods to remove any temperature dependence, and any laser pulse amplitude effects: Constant Fraction Discriminators; using both rising and falling edges of the pulses; using the Acousto-Optic Pulses in correlation with the actual laser pulses etc.

The method giving the best results was using an integration scheme for the SemiTrain pulses, to derive a correction voltage, which is applied directly to the trigger threshold of a fast comparator device; this reduces the start pulse time walk effect - for a 1:10 dynamic range - from almost 200 ps to about +/- 4 ps. For the temperature compensation, we used a second comparator on the same chip; controlling the trigger threshold of this comparator with the correction voltage from a temperature sensor - mounted on the chip's housing - reduced the temperature shift from 240 ps down to +/- 1 ps, for a temperature range of 40 Degrees; this eliminates effectively all temperature drifts, including also the complete warm-up drift.

The same methods can be adapted also for single pulse systems.

## 1.0 The method

The start pulse is monitored with a fast photodiode; the output signal is split into 2 parts (Fig.2, Fig. 6); one part is delayed by about 30 ns with a simple cable (Fig. 6: J2-J3); the other part is integrated by an RC-combination, producing a voltage proportional to the amplitude of the first 4 SemiTrain pulses (which have a constant spacing of 8755 ps in Graz); this voltage is applied as a correction to the reference voltage of a fast comparator; when the delayed part of the start pulse appears here, the comparator will trigger slightly later or earlier, according to the amplitude of the correction voltage.

## 2.0 Detailed description of Start Pulse Time Walk Compensation

The SemiTrain pulses are charging C4 (Fig. 6); C5 allows a better variation of the total capacity; R5 adjusts the amplitude of the final integration voltage. R6 slowly discharges the integrator, so that for the next shot (100 ms later) everything starts from ZERO again.

R8 defines the basic trigger threshold of the IC1A comparator, which is slightly corrected then on a shot-by-shot basis by capacitively applying the final integration voltage above this. IC1A comparator then produces an ECL output pulse which is very well time walk compensated for input pulse amplitude variations from 10% to 100%. While the standard circuit without compensation shows a time walk of up to -177 ps for the full range, this is reduced now to a few ps (fig. 3).

## 3.0 Temperature Compensation

Especially the comparator chips show some temperature sensitivity; the transit delay is drifting with about 6 ps/°C, with slight variations between different chips; although our laser is within an air-conditioned room, there are still temperature changes of up to 4°C, warm-up effects etc.; to completely eliminate this temperature sensitivity, we use a second comparator on the same chip (IC1B), and a temperature sensor (AD590) mounted directly on this chip (fig. 4); this temperature sensor produces directly the reference voltage for IC1B; if temperature is rising, the sensor current increases, which in turn decreases the reference voltage; this results in earlier triggering of IC1B, thus compensating the increased transit time of BOTH comparators. Because the slope of IC1A output is well known (1 V / 2.4 ns) and of course very stable, this scheme works also very efficient and very stable; we have measured this compensation over a range of 40°C (far above what we should expect in the laser room ...); the original temperature drift of a single comparator (240 ps) was reduced to  $\pm 1$  ps (fig. 5).

### 3.0 Monitoring Laser Pulse Amplitudes

Although the parameters for the laser pulse amplitudes and the start pulse detection are rather broad (10% to 100% of nominal amplitude), we wanted to keep our laser operational within tighter limits (80% to 100%); if the laser falls below the 80% amplitude limit, we wanted to get some information or warning from the routine ranging programs.

This is implemented via additional circuitry in the start pulse detection circuit (fig. 6); a part of the SemiTrain start pulses is directed to an additional comparator (IC2); trigger threshold is adjusted so that only pulses with at least 80% of the nominal amplitude will trigger this comparator; its output will set a Monoflop; the time constant of this Monoflop is set to about 50 ms; a few ms after the laser shot the PC checks the status of the Monoflop output, counts the numbers of shots with amplitudes above and below the limit value, and indicates the percentage of shots above the limit during all ranging and calibration programs.

### 4.0 Conclusion

The Time Walk Effects of the standard leading edge discriminator can be eliminated from almost 200 ps to a few ps only, for a dynamic range of 10% to 100% of the nominal laser pulse amplitude (fig. 3), with a relatively simple, stable and easy-to-adjust circuit; the temperature drifts of this circuit have been reduced from 240 ps down to  $\pm 1$  ps for a range of 40°C; this also eliminated the full warm-up drift.

In addition, the circuit delivers an easy-to-check signal for our ranging PC if any single laser shot is above the preset limit or not.

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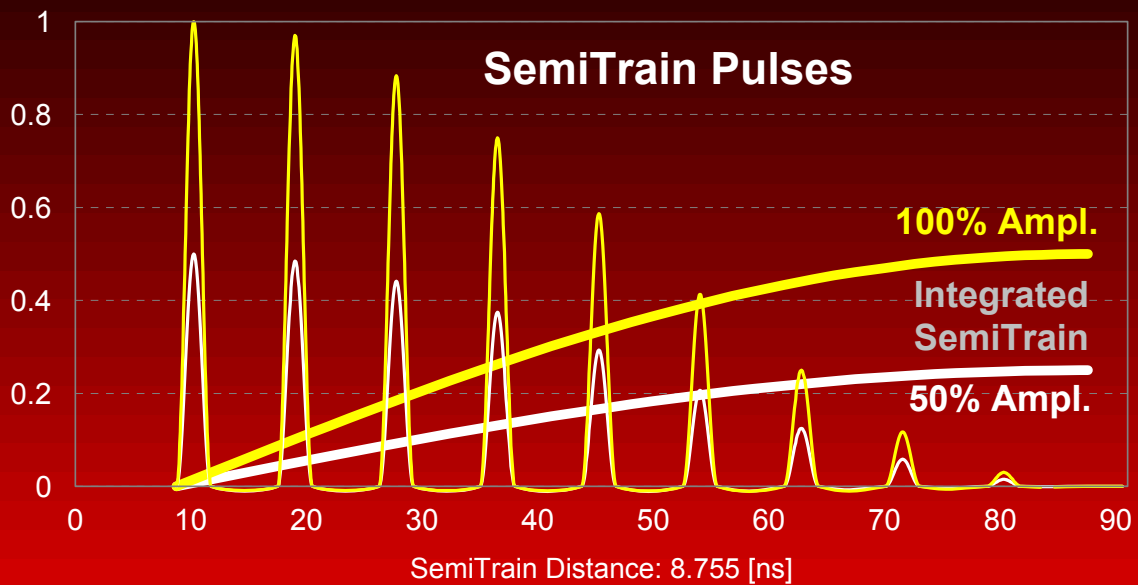
Fig. 4: Block Scheme of the Start Pulse Temperature Compensation

Fig. 5: Results of the Start Pulse Temperature Compensation

Fig. 6: Electronic Scheme of the Fully Compensated Start Pulse Detection

# Integration of SemiTrain Start Pulses:

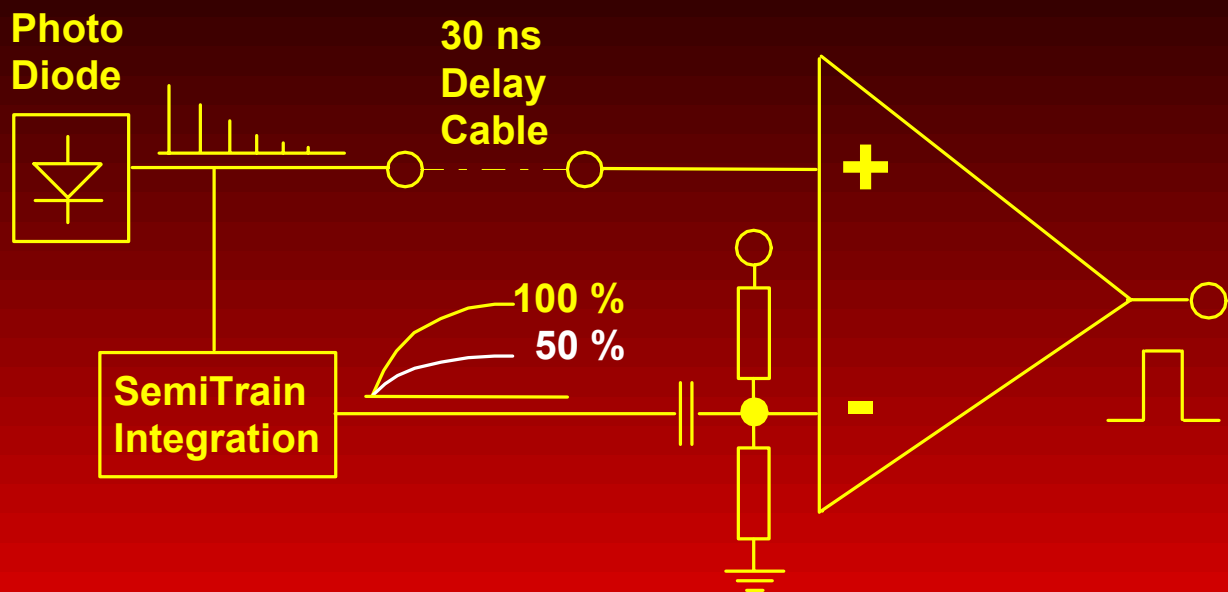
Produces a Voltage according to Pulse Amplitude



<KG/KF>

Fig. 1: Integration of the SemiTrain Start Pulses

# Start Pulse Amplitude Compensation



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Fig. 2: Block Scheme of the Start Pulse Amplitude Compensation

# Leading Edge Discrimination

Start Pulse Time Walk - caused by Amplitude Variations - is completely compensated now

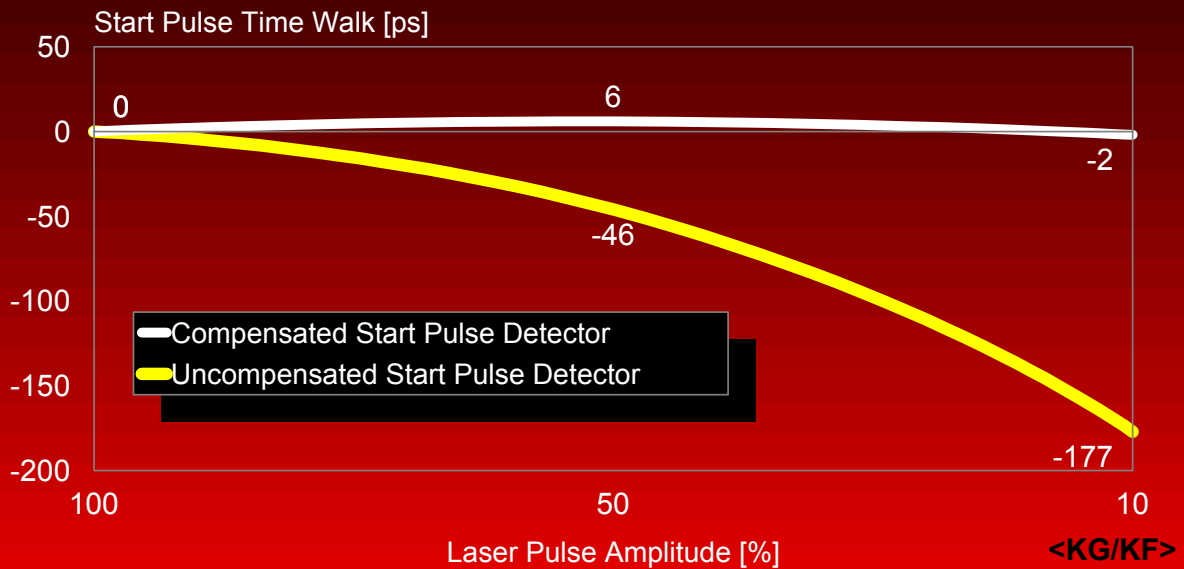


Fig. 3: Results of the Start Pulse Time Walk Compensation

# Start Pulse: Temperature Compensation

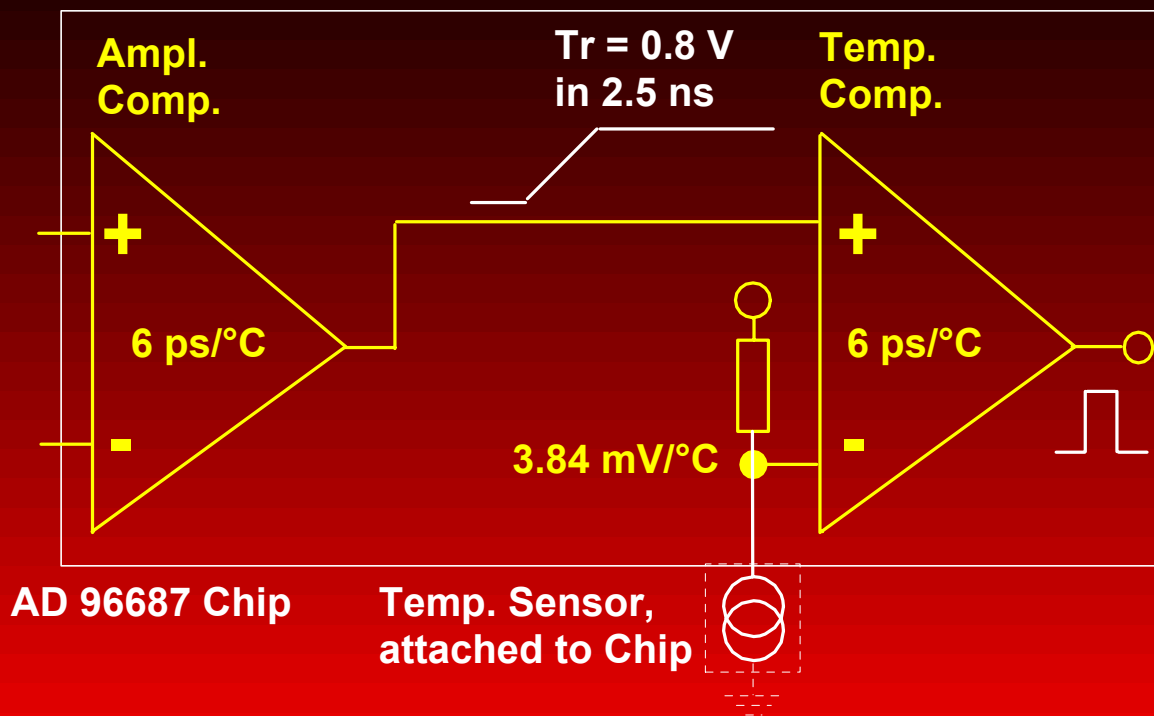


Fig. 4: Block Scheme of the Start Pulse Temperature Compensation

# Start Pulse shows Temperature Drift

Each Comparator drifts with 6 ps/°C;  
this is completely eliminated now

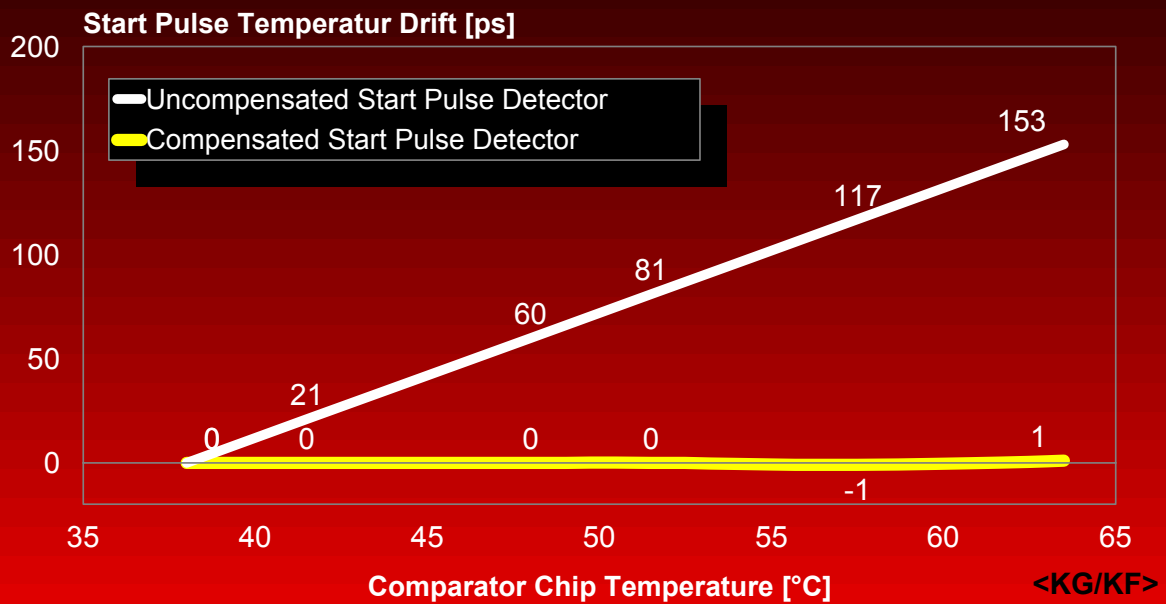
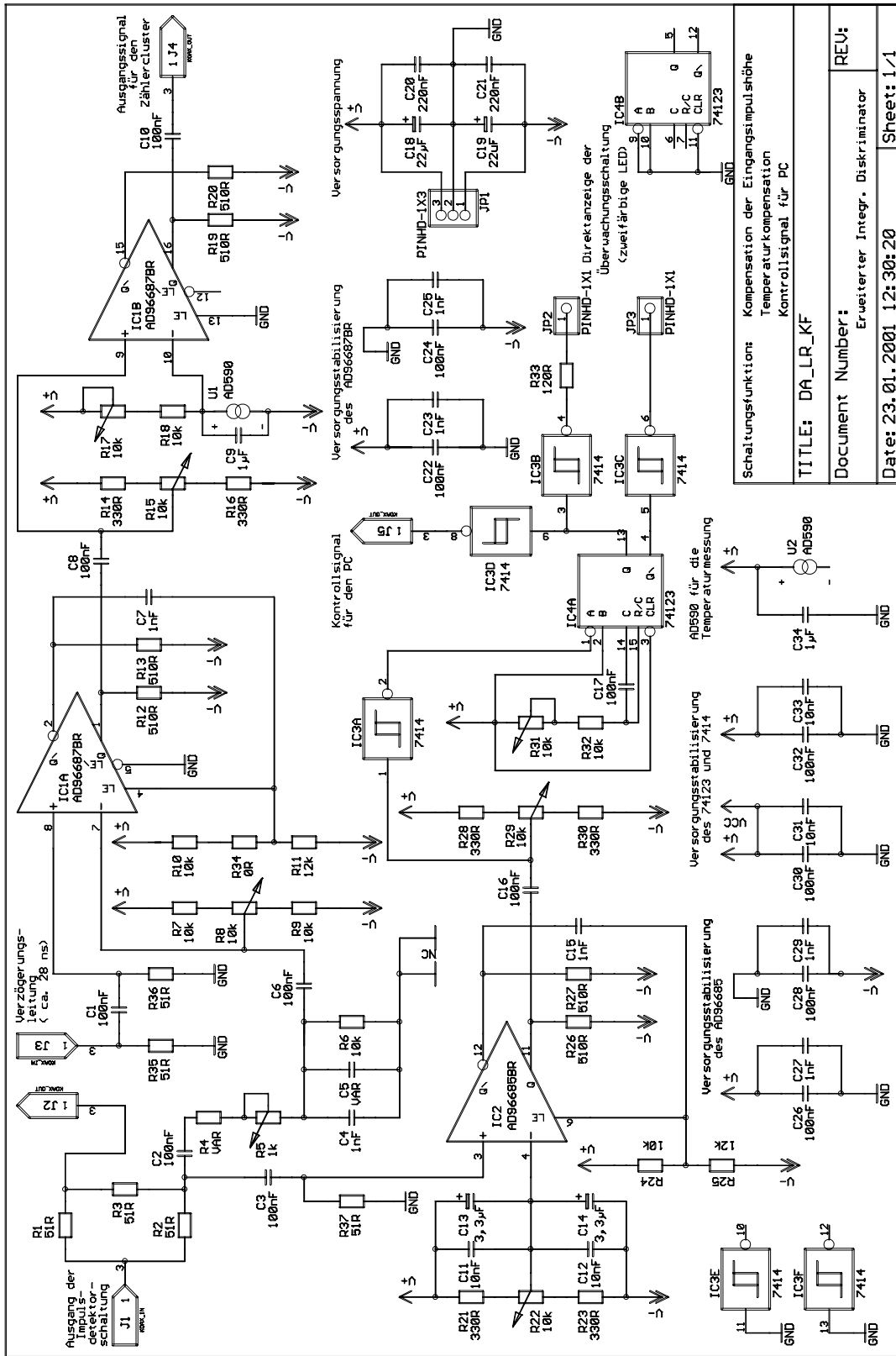


Fig. 5: Results of the Start Pulse Temperature Compensation



Schaltungsfunktion:	Kompensation der Eingangsimpulshöhe Temperaturkompensation Kontrollsignal für PC
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Fig. 6: Electronic Scheme of the Fully Compensated Start Pulse Detection

