Development of a High-Speed Differentiation Discriminator for Laser Ranging Systems

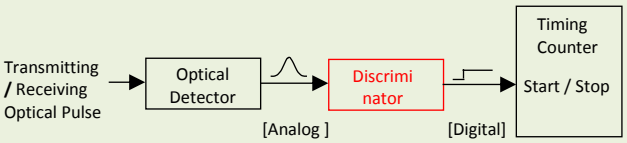
Yuji Miura, Yasuji Suzaki

Universe Ltd.
phone + 81-45-833-9360
501, Sunrise Kounandai,7-42-30, Kounandai, Kounan-ku, Yokohama , 234-0054 Japan

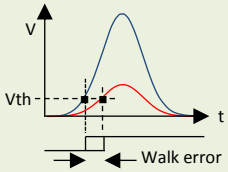
ABSTRACT

A timing discriminator is an electronic signal processing device for time-of-flight (T-O-F) measurements using Laser Ranging Systems (LRS). The discriminator is required to minimize walk errors caused by wide intensity fluctuations of the receiving pulse. A Constant Fraction Discriminator (CFD) has been used in many observation sites to achieve this purpose. But with the high-precision requirements of LRS in the future, it will be necessary to speed up the discriminator by an order of magnitude, since the minimum input pulse width of current CFDs is about 700 ps. Moreover, current CFDs have an inconvenience in that it is necessary to adjust an external delay line corresponding to the input pulse width. Therefore we have started to develop an adjustment-free high-speed discriminator. We have been developing a new high-speed discriminator that adopts a differentiation circuit as a method to avoid the above problem. Now we would like to report the present state of the breadboard model.

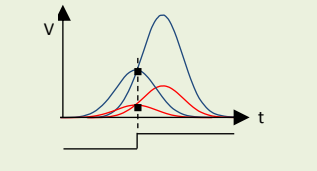
1. CONSTRUCTION OF T-O-F SYSTEM



TYPES OF FORMER DISCRIMINATORS

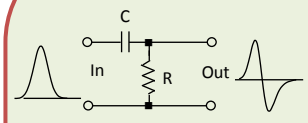


(1) Leading edge Discriminator



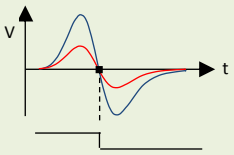
(2) Constant Fraction Discriminator

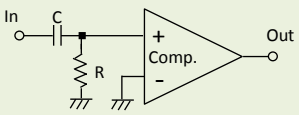
2. PRINCIPLE OF DIFERENTIATION DISCRIMINATOR



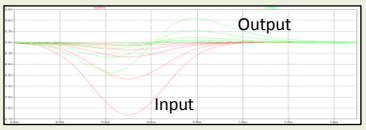
Differentiation Circuit

・In the differentiation circuit we have one condenser C and one resistor R, if the RC time-constant is shorter than the variation time of the input voltage, its output waveform is approximately the same as the time differentiation waveform and crosses the zero volt line.
・Since the differentiation circuit is a linear system, if the input pulse waveforms are of similar shape, the zero crossing point does not depend on the input pulse height and is constant.
・The Differentiation Discriminator detects the zero cross point.



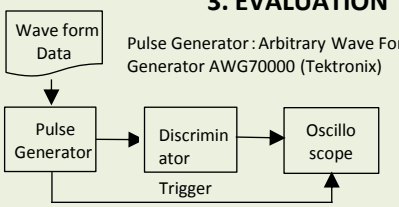


Differentiation Discriminator

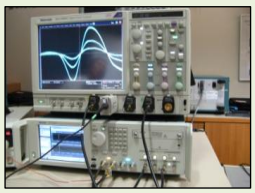


Circuit Simulation Wave Form

3. EVALUATION SYSTEM

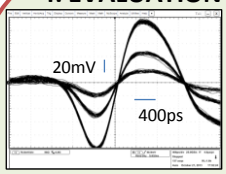


Pulse Generator : Arbitrary Wave Form Generator AWG70000 (Tektronix)

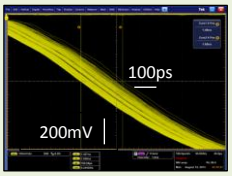


During the development of a new discriminator, it is important to establish a valid evaluation system. We measured the timing-walk characteristics by using a high-speed Arbitrary Wave-form Generator (AWG) with fast and precise measurements. If used in different situations, it should be able to compare the performances of several discriminators with actual observation conditions.

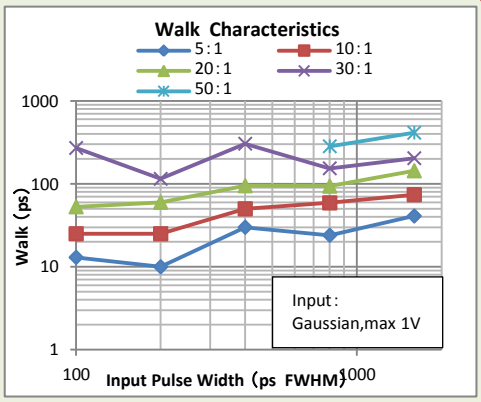
4. EVALUATION RESULTS OF THE BREADBOARD MODEL



Differentiated wave forms cross together at 0 Volt.



Spread of the output wave form (Input:200ps,30mV-1V)



On the first evaluation of the breadboard model, we acquired the walk characteristics working with 100 ps FWHM and a dynamic range of 30:1. A problem encountered was that we were not able to obtain measurements at the exact zero cross point because of noise. The main cause of the noise was that a part of the circuit has high-impedance wiring. We will be able to realize the walk error target specifications with the next model.

5. TARGET SPECIFICATIONS

- Minimum input pulse width: < 50 ps FWHM
- Walk error: < 20ps over 30:1 dynamic range
- Discrimination range: -20 mV to -2 V
- Adjustment: Free
- Other functions: Threshold Control, Gating Control
- Dimensions: 100 W, 100 H, 200 D (mm)

External view of the Bread board Model

CONCLUSION

We have been developing a high-speed differentiation discriminator for the next generation of Laser Ranging Systems. On the Breadboard Model we could confirm operation over a wide pulse width range of 1.6 ns to 100 ps and a 30:1 dynamic range with no adjustments. We will be going to make the next prototype model and try to limit the walk error with it. We hope that our Differentiation Discriminator will be used at sites not only as the next generation system, but also in current use as an alternative to existing systems.

REFERENCES

[1] T. Ruotsalainen . Integrated Receiver Channel Circuits and Structures for A Pulsed Time-of-Flight Laser Radar . Acta Univ Oul C 136 (1999)