Range Gate Generator with Pulse Position Modulation Capability Hiroo Kunimori*1) Masaaki Abe*2) and Koji Ohi*3) *1) National Institute of Information and Communications Technology (NICT) 4-2-1 Nukui-kita, Koganei, Tokyo, 184-8795 Japan *2) PDC Inc. 2-7-10-104 Kajigaya Takatsu-ku, Kawasaki, Kanagawa Prefecture, 213-0015 Japan, *3) Autex Inc. Shinjuku Takasago Building 16-5 Tomihisa-cho Shinjuku-ku, Tokyo 162-0067 Japan.

Introduction:

NICT has been in development of an optical communication integrated to the satellite laser ranging by using the fiber (optical communication) technology in a ground network. It aims to integrate the technology of the optical communications, the quantum detector and time frequency, and laser ranging, and serves as an element of the ground station fundamental technology which supports various demands in the future satellite missions.

Pulse Position Modulation (PPM) has been considerd as one of optimal modulation for super long distance (or lossy) communication channel under power limit condition since 1980s, and implimentation have been undertaken on the space mission and ground station. A high rate PPM communkcation and ranging was examined by NASA and ESA have succeeded in the up-link and down-link experiment between the moon and the earth by up to about 600 Mbps [1] [2].

This paper describes the design of range gate generator (RGG) which enhanced provide with Pulse Position Modulation function to control pulsed laser as well as gate to support a future communication and navigation space system.

Specification of RGG:

Table 1 show the major specification newly designed RGG based on FPGA. It has three operation modes, namely SLR, PPM, and PPM in SLR mode. PPM mode parameter M, denoting M-ary symbol where M=2, 4, 16 and 256.

Table 1 Specification of RGG

Item	Specification
Reference Freq	External 10 MHz,1pps(UTC)
PRF	1Hz－1MHz
Target Mode	-Fixed or -Moving up to 40,000,000km
Operation Mode	-SLR mode -PPM mode M=2-256 SLOT RATE 311.04MHz PPM rate= 1MHz 1 frame=8-256 Byte PsudoRondomNoise15degree Or User Supplied Data -PPM in SLR mode
UTC sync. Mode	-sync at station clock -sync at target (SLR mode only)
Collision Avoidance	Each shot shift fire timing falls in collision band

Data rate can be up to 8 Mbps where M=256 without Forwared Error Correction. PPM in SLR mode enable SLR once in a frame period (for example 1/1024 times repletion rate). A start gate channel disable start pulse other than SLR in order to give a proper start to event timer to find a pair of each Start and Stop event.

RGG has a 10 MHz and 1PPS input which synchronized to UTC with sufficient accuracy in order to maintain ranging accuracy. The output channels are used for a trigger for laser(s) and camera, a stray light prevention shutter control in a maximum of five channel and each TTL pulse by which the daisy chain was carried out by delay in between each pulse. A gate output gives the timing to which a return pulse arrives at a ground station with the predicted value in consideration of a both-way distance to a target.

When the target is moving at this time, it gave for every second in real time, and it gave that predicted value to RGG via the interface (LAN) of PC, and the Gate output is updated in the RGG side, carrying out linear interpolation by a FIFO buffer.

When it is expected beforehand that receiving timing collides with transmission from the predicted value in a buffer, the measure (Collision Avoidance) of shifting that timing forward and backward.

References:

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[2] B.S. Robinson, D.M. Boroson, D.A. Burianek, D.V. Murphy, “The Lunar Laser Communications Demonstration”, 2011 IEEE International Conference on Space Optical Systems and Applications, pp. 54-57, 2011.

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