# Research on Faint Signal Real Time Detection Technique in Laser Atmosphere Communication System

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**Abstract.** This Paper discussed the total constitute of communication system of large capacity CO2 and the basic principle and the key technology of communication system with power-driven, large capacity, high speed and long distance. Two key technologies about laser pulse detection were emphasis talked in this paper that were Floating voltage threshold value and AGC (Automatic gain control) technology. At last, test waveform is given.

**Keywords:** laser communication, faint signal detection, automatic gain control.

## 1. Introduction

Laser communication is a means of communication with a laser transmitting information. As the laser with characteristics of the high brightness, strong directivity, good monochromaticity, strong coherence etc. laser atmospheric communication has more superiority than other means of communication, so the technology is increasingly widely used in military and aerospace fields. Faced the technical difficulties in the field of laser communication is mainly due to the atmospheric channel attenuation and the influence of atmospheric turbulence, uneven random variation in the channel refractive index, which affects the communication quality. In order to achieve the system required bit error rate, system should be mainly to solve some key technologies, such as beam APT( acquisition, pointing and tracking), high power laser output and high bit rate modulation, High sensitivity (under complicated background) light direct detection, etc. Because of laser communication's high frequency, the signal seizure can only use direct detection method. So to reach the required BER, improving signal-to-noise ratio of the signal pathway is only method. In addition to improve the laser emission power, the methods applying to improve the S/N are driving down background noise by the electronics and optical means, such as stabilizing laser emission wavelength, adding atomic filter, Using adaptive control based on electronics in signal detection, etc.

Although narrowband filtering technology and sources of frequency stabilization technology mature, can exclude the interference of background light noise effectively, enhance the reliability of the system. But for the poor signal quality, that on-board large capacity of the laser atmospheric communication system received, much environment interference factors, spectrum distribution characteristics and stray light control put forward very high requirements for signal detection technique. In order to solve the strong light interference, improve the quality of communication system, reduce the BER, it is very necessary to choose laser emitting device with low driving power, high conversion efficiency, large laser output power, wide modulation bandwidth, and laser receiving device with high sensitivity, good noise characteristics, and using narrow-band light filtering technology to filter background noise. Using adaptive control and resistance to strong sunlight saturation technology, in the laser receiving signal processing system, is the effective measures to ensure the BER.

## 2. The design of laser atmospheric communication system photoelectric receiver

Laser atmospheric communication system uses digital communication mode, the system is mainly composed of CO2 laser, laser transmitter, laser receiver, laser APT (acquisition, pointing and tracking) system and central signal processor. Because of the CO2 laser with advantages of large output power, high energy conversion efficiency, output wavelength (10.6 microns) just in the atmospheric window, laser transmission system uses RF excited CO2 laser with radiation average power 10-30W. In the laser communication system, the design of high sensitivity photoelectric receiver is one of the key technology. The design of the receiver is decided by the link characteristics (including data rate, bit error rate, tolerance), the output power, pulse width, the background signal and other factors. Principle block diagram of laser receiver is shown in Fig. 1.

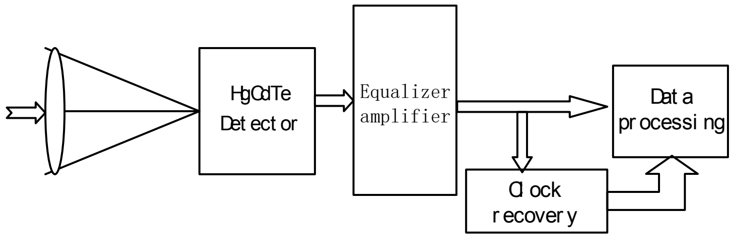


Fig. 1 Principle block diagram of laser receiver

A laser receiver is mainly composed of an optical detector, a preamplifier, an automatic gain control circuit, an equalization circuit, a phase locking circuit and a decision circuit of amplitude. The core of the signal receiver is the preamplifier and the automatic gain control circuit.

**A. The choice of photodetector**

Under the premise of laser emission power and receive field angle determined. The main factor in the choice of the optical detector to be considered is the response speed of the device ,sensitivity, size, minimum detection power index. The response speed of the device mainly depends on the pulse width of the signal and the channel transmission data rate; the sensitivity of the receiver must be able to provide the desired link tolerance; The size of the detector must be large enough to absorb photons effectively.

The photodetector is an important part of the optical receiver, and is a vital device that determines the system performance. Since the received optical signal is very weak, the light detector must meet the high performance requirements. For the direct detection method, the core issue is the choice of high sensitivity, low noise photodetectors. One of the most important part is The photodetector have high sensitivity, the minimum additional noise and fast response speed or sufficient bandwidth at a given wavelength range. According to the above requirements, the system select the HgCdTe detector for receiving CO2 laser signal. The minimum detectable power photodetector receiving can be expressed as:

$$P_R = \frac{4K\rho_W \cdot S \cdot \eta_R \cdot \eta_T}{\pi \cdot \theta^2 \times R^2 \cdot e^{\sigma R}} \quad (1)$$

K is light energy utilization coefficient; $\rho_W$ is laser radiation power; S is receiving objective area; $\eta_R$ is receiving optical system efficiency; $\eta_T$ is emission optical system efficiency; $\theta$ is laser beam divergence angle; $\sigma$ is atmospheric attenuation coefficients.

We should choose laser radiation power and other parameters reasonably according to HgCdTe photodetector parameters at the time of designing system.

**B. The weak signal detection and electronic adaptive control technology**

From the equation(1), we can know the minimum detectable power photodetector receiving is inversely proportional to the square of the distance after the optical system design have completed. Therefore, in order to enhance the vehicle laser communication systems'operating distance, the weak signal detection technique is a very important key technology.

In the method of short circuit current, HgCdTe detectors can get the best signal-to-noise-ratio. In order to obtain the method, we can use the following three scenarios:

(1)The compensation way of inverse bias voltage;

(2)The input work of transformer;

(3)The work of current type amplifier;

To ensure the reliability of the system data transmission, we should research and analysis quantum noise, thermal noise and shot noise carefully when designing optical receiver. In particular, we should also consider the problem of background light interference under the atmospheric transmission. Since the background light interference can make the light energy loss, the error rate increase, we use narrowband filter (NBF) to suppress background stray light interference on the receiver channel in the system designing. To meet the requirements of the best detection sensitivity under the condition of complex background light changes and effectively suppress background noise interference, we design real-time processing, intelligent noise compensation circuit and use electronic adaptive control technology and computer floating threshold control technology.

Due to the special requirements of laser atmosphere communication, we should consider the impact of atmospheric turbulence intensively. And it raise higher requirements to detect laser pulse in the receiving system. Since the influence of atmospheric turbulence, photodetector output signal's amplitude varies greatly, and its direct current level drift large. Meanwhile, because of using dynamic characteristics of the detector and the strict requirements on the phase of the signal in the laser digital communication. Therefore, we can not use the Alternating Current amplifier for some signal.However, if using a direct current amplifier, direct current drift will be an important factor affecting the performance of the amplifier. In order to overcome drift in the direct current level to obtain a stable output signal, floating threshold is an ideal solution.

AD603 is a low noise, broadband amplifier. In the -11dB to +31dB, AD603 provide a gain of bandwidth 90MHZ, and any intermediate gain may be obtained by change the value of external resistor. The input referred noise spectral density is only $1.3\text{nV}/\sqrt{\text{HZ}}$ and power consumption is 125mW at the recommended $\pm 5$V supplies. Fig. 2 is a principle block diagram of broadband AGC circuit.

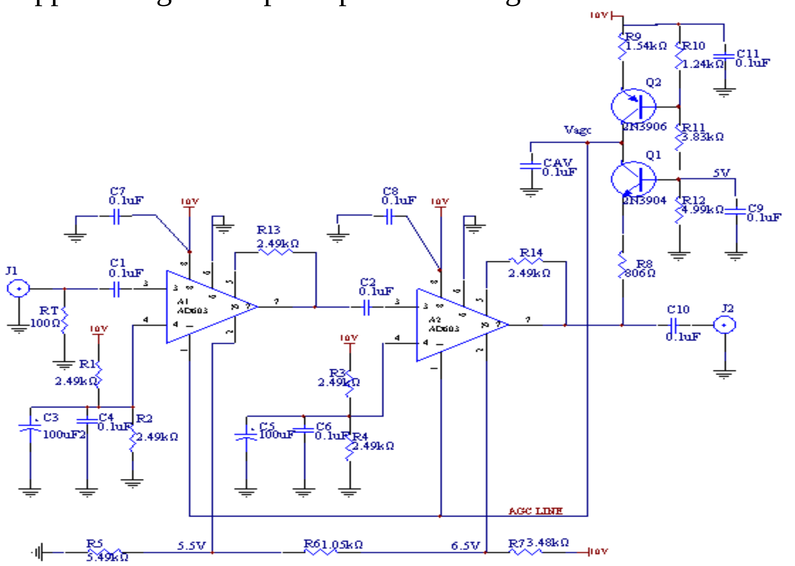


Fig. 2 Principle block diagram of broadband AGC circuit

The circuit operates from a single 10 V supply. Resistors R1, R2, R3, and R4 bias the common pins of A1 and A2 at 5 V. This pin 4 is a low impedance point and must have a low impedance path to ground, here provided by the 100 µF tantalum capacitors and the 0.1 µF ceramic capacitors.

The cascaded amplifiers operate in sequential gain. Here, the offset voltage between the pins 2 of A1 and A2 is 1.05V, provided by a voltage divider consisting of resistors R5, R6, and R7. The gain of both A1 and A2 is controlled by resistors R13 and R14, respectively, changes of R13, R14 can get different gain. Here take the R13 and R14 is 2.49K, each AD603 gain is about 42dB, thus the maximum gain of the circuit is twice that, or 84dB. A half-wave detector is used, based on Q1 and R8. The current into capacitor CAV is just the difference between the collector current of Q2 (biased to be 300 µA at 300K, 27 ℃) and the collector current of Q1, which increases with the amplitude of the output signal. The automatic gain control voltage, VAGC, is the time-integral of this error current. In order for VAGC (and thus the gain) to remain insensitive to short-term amplitude fluctuations in the output signal, the rectified current in Q1 must, on average, exactly balance the current in Q2. If the output of A2 is too small to do this, VAGC will increase, causing the gain to increase, until Q1 conducts sufficiently. The circuit of Figure 2 has been carefully debugging to get good results.

### C. Experimental test

Figure 3 are the original received signal of HgCdTe photodetector of actual communication system and signal waveform being processed using floating threshold value and broadband AGC techniques. All experiment were conducted in real atmospheric environment, and distance of 0.5km.

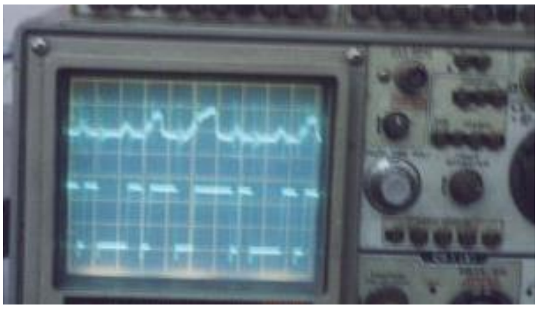

Fig. 3 Original signal waveform from HgCdTe sensor and disposed signal waveform

## 3. Conclusion

Laser communications signal detection system in vehicle is a weak signal detection system. No matter what photoelectric detectors adopted, the sensor output signal is must amplified. In order to make the signal is submerged by the noise, using the low noise amplifier is necessary. In order to make the signal isn't submerged by the noise, low-noise amplifier is necessary. According to the noise characteristics and impedance characteristics of sensor to design preamplifier, especially the first stage amplifier is the key of low noise amplification in signal channel. Cryogenic cooling is an effective method to reduce the noise of sensors and the amplifiers. According to the spectrum characteristics of signal to compress the bandwidth is also a way of reducing noise. Using the accurate shielding and grounding technology are effective measures to ensure the normal work of the test system. Among optical communication in vehicle, the only way to extract the signal from the noise is using modern signal processing techniques to improve the signal-to-noise ratio, under the premise of analysis of signal characteristics.

In the paper, through the study of large-capacity CO2 atmospheric laser communication system, to achieve self-propelled, high-capacity, high-speed, long-range laser atmospheric communications. Studying and establishing the laser atmospheric communication network technology, to transfer data and image information. Based on the in-depth study of the related theories, system modeling and simulation by means of comprehensive experiment. To further validation of the rightness and feasibility of large-capacity CO2 atmospheric laser communication system.

AGC technology and application in this field, with the improvement of digitized degree, especially the development of DSP technology, digital AGC technology is becoming more and more popular with the engineers, the AGC technology can largely enhance the anti-jamming of system, its application for laser pulse detection technology research is a qualitative leap.

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