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# NASA TECH BRIEF

## Goddard Space Flight Center



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### High-Sensitivity Receiver for CO<sub>2</sub> Laser Communications

#### The problem:

A wideband heterodyne receiver for a two-way satellite-to-ground CO<sub>2</sub> laser communication link must provide the following:

- (1) detection and demodulation of the incident frequency modulated (FM) laser signal,
- (2) search and acquisition circuitry to align the two stations,
- (3) tracking circuitry to maintain spatial alignment, and
- (4) a laser frequency monitor to frequency lock the transmit and local oscillator (LO) lasers.

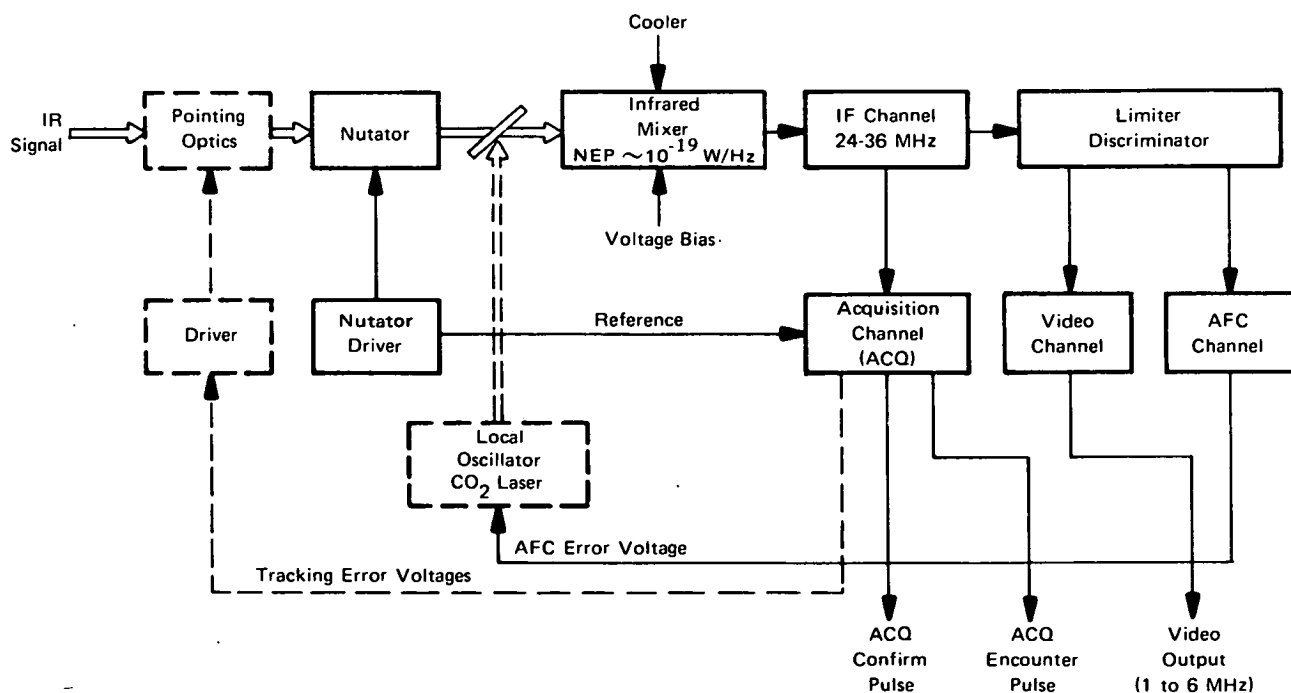
#### The solution:

These objectives are satisfied by a wideband, 10.6- $\mu\text{m}$  heterodyne receiver which includes a cooled

PV-HgCdTe photomixer, a spatial search and signal acquisition channel, a conical scanner for spatial tracking, and an automatic frequency-control (AFC) channel to maintain a fixed laser-frequency offset.

#### How it's done:

The front end of the infrared receiver uses a PV-HgCdTe photomixer and a low-noise IF pre-amplifier. Heterodyne measurements were carried out using two single-frequency stabilized lasers having an IF offset which was adjustable between 5 and 45 MHz. Measurements on a HgCdTe photomixer, interfaced with the matched low noise ( $\sim 1.5$  dB noise factor) wideband amplifier in a variable temperature cooler, resulted in a measured noise equivalent power (NEP)



High Sensitivity Receiver

(continued overleaf)

of less than  $10^{-19}$  W/Hz, over the 15- to 40-MHz IF band for mixer temperatures from 85 to 115 K. The measured 3-dB cutoff frequency of the photomixer was greater than 240 MHz over the 77 to 130 K temperature range, and the combined laser local oscillator and dc bias power was less than 8 mW.

The receiver, as shown in the figure, has the following features:

1. Detection and demodulation – An unusually wideband photomixer and discriminator (12-MHz linear bandwidth centered at 30 MHz) are provided to detect and demodulate the received FM laser signal. The unequalized receiver group delay of  $\pm 47$  nanoseconds has been reduced to  $\pm 5$  nanoseconds using a specially designed delay equalizer.
2. Spatial acquisition – To obtain maximum sensitivity during spatial acquisition, a narrowband acquisition channel with a matched filter was developed and tested. Measurement of the probability of encounter versus the video channel signal-to-noise ratio (S/N) resulted in a 100-percent probability of acquisition IF S/N as low as  $-24$  dB.
3. Spatial tracking – A conically scanned receive beam is used to generate spatial tracking error voltages when the two stations are not aligned. The error voltages position the receiver optics to maintain station alignment.
4. Frequency tracking – A wideband discriminator is used to generate an AFC error voltage over the 24-to 36-MHz IF frequency band. The AFC error voltage maintains a fixed frequency offset between the incoming signal and LO laser.

**Note:**

No further documentation is available. Specific questions, however, may be directed to:

Technology Utilization Officer  
Goddard Space Flight Center  
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**Patent status:**

NASA has decided not to apply for a patent.

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