



Optoelectronic System Measures Distances to Multiple Targets

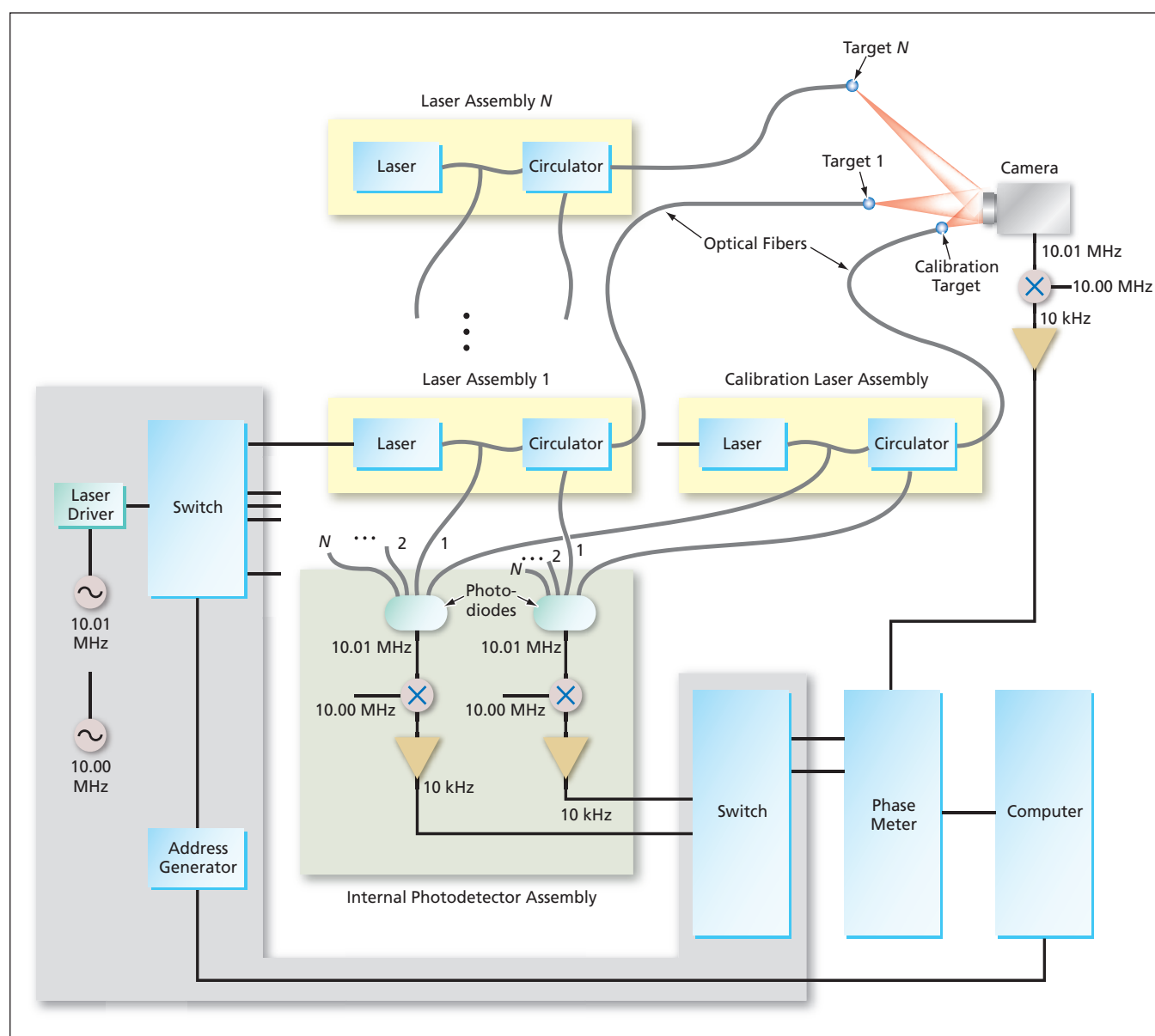
This system operates at an update rate >10 Hz.

NASA's Jet Propulsion Laboratory, Pasadena, California

An optoelectronic metrology apparatus now at the laboratory-prototype stage of development is intended to repeatedly determine distances of as much as several hundred meters, at sub-millimeter accuracy, to multiple targets

in rapid succession. The underlying concept of optoelectronic apparatuses that can measure distances to targets is not new; such apparatuses are commonly used in general surveying and machining. However, until now such ap-

paratuses have been, variously, constrained to (1) a single target or (2) multiple targets with a low update rate and a requirement for some *a priori* knowledge of target geometry. When fully developed, the present apparatus



This Apparatus Includes N Laser Assemblies (of which only the first and N th are shown here), for measuring distances to N targets. The lasers are turned on, one at a time, to illuminate their targets for short intervals in rapid succession to obtain a high update rate.

would enable measurement of distances to more than 50 targets at an update rate >10 Hz, without a requirement for *a priori* knowledge of target geometry.

The apparatus (see figure) includes a laser ranging unit (LRU) that includes an electronic camera (photo receiver), the field of view of which contains all relevant targets. Each target, mounted at a fiducial position on an object of interest, consists of a small lens at the output end of an optical fiber that extends from the object of interest back to the LRU. For each target and its optical fiber, there is a dedicated laser that is used to illuminate the target via the optical fiber. The targets are illuminated, one at a time, with laser light that is modulated at a frequency of 10.01 MHz. The modulated laser light is emitted by the target, from where it returns to the camera (photodetector), where it is detected.

Both the outgoing and incoming 10.01-MHz laser signals are mixed with

a 10-MHz local-oscillator to obtain beat notes at 10 kHz, and the difference between the phases of the beat notes is measured by a phase meter. This phase difference serves as a measure of the total length of the path traveled by light going out through the optical fiber and returning to the camera (photodetector) through free space.

Because the portion of the path length inside the optical fiber is not ordinarily known and can change with temperature, it is also necessary to measure the phase difference associated with this portion and subtract it from the aforementioned overall phase difference to obtain the phase difference proportional to only the free-space path length, which is the distance that one seeks to measure. Therefore, the apparatus includes a photodiode and a circulator that enable measurement of the phase difference associated with propagation from the LRU inside the fiber to the target, reflection from the fiber end,

and propagation back inside the fiber to the LRU. Because this phase difference represents twice the optical path length of the fiber, this phase difference is divided in two before subtraction from the aforementioned total-path-length phase difference.

Radiation-induced changes in the photodetectors in this apparatus can affect the measurements. To enable calibration for the purpose of compensation for these changes, the apparatus includes an additional target at a known short distance, located inside the camera. If the measured distance to this target changes, then the change is applied to the other targets.

This work was done by Carl Christian Liebe, Alexander Abramovici, Randall Bartman, Jacob Chapsky, John Schmalz, Keith Coste, Edward Litty, Raymond Lam, and Sergei Jerebets of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1). NPO-43240

Tachometers Derived From a Brushless DC Motor

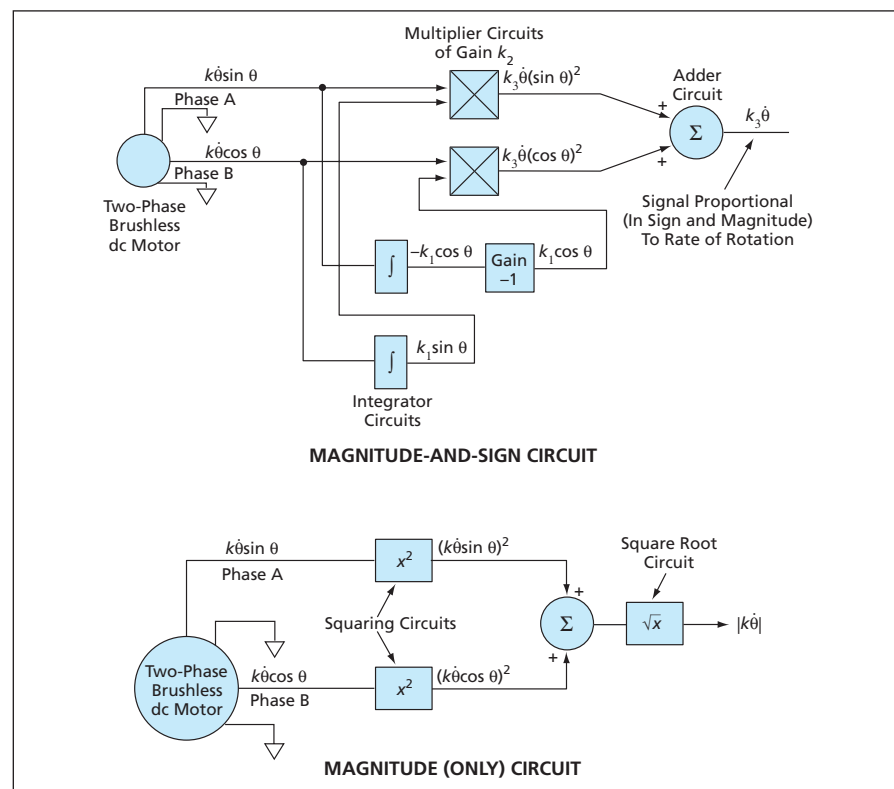
Neither excitation of the motor nor mechanical brushes is necessary.

Marshall Space Flight Center, Alabama

The upper part of the figure illustrates the major functional blocks of a direction-sensitive analog tachometer circuit based on the use of an unexcited two-phase brushless dc motor as a rotation transducer. The primary advantages of this circuit over many older tachometer circuits include the following:

- Its output inherently varies linearly with the rate of rotation of the shaft.
- Unlike some tachometer circuits that rely on differentiation of voltages with respect to time, this circuit relies on integration, which results in signals that are less noisy.
- There is no need for an additional shaft-angle sensor, nor is there any need to supply electrical excitation to a shaft-angle sensor.
- There is no need for mechanical brushes (which tend to act as sources of electrical noise).
- The underlying concept and electrical design are relatively simple.

This circuit processes the back-electromagnetic force (back-emf) outputs of the two motor phases into a voltage directly proportional to the instantaneous rate (sign \cdot magnitude) of rota-



These **Analog Tachometer Circuits** perform straightforward operations on the back-emf outputs of a brushless dc motor to generate voltages proportional to the rate of rotation of the shaft.