

The proposal applies, more specifically, to an offset-QPSK receiver that contains a carrier-tracking loop like that shown in Figure 1. This carrier-tracking loop does not resolve or reduce the phase ambiguity. A carrier-

tracking loop of a different design optimized for the reception of offset QPSK could reduce the phase ambiguity from fourfold to twofold, but would be more complex. Alternatively, one could resolve the fourfold phase ambiguity by

use of differential coding in the transmitter, at a cost of reduced power efficiency. The proposed modifications would make it possible to reduce the fourfold phase ambiguity to twofold, with no loss in power efficiency and only relatively simple additional signal-processing steps in the transmitter and receiver. The twofold phase ambiguity would then be resolved by use of a unique synchronization word, as is commonly done in binary phase-shift keying (BPSK).

Although the mathematical and signal-processing principles underlying the modifications are too complex to explain in detail here, the modifications themselves would be relatively simple and are best described with the help of simple block diagrams (see Figure 2). In the transmitter, one would add a unit that would periodically invert bits going into the QPSK modulator; in the receiver, one would add a unit that would effect different but corresponding inversions of bits coming out of the QPSK demodulator. The net effect of all the inversions would be that depending on which lock point the carrier-tracking loop had selected, all the output bits would be either inverted or non-inverted together; hence, the ambiguity would be reduced from fourfold to twofold, as desired.

This work was done by Jeff Berner and Peter Kinman of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1). NPO-30384

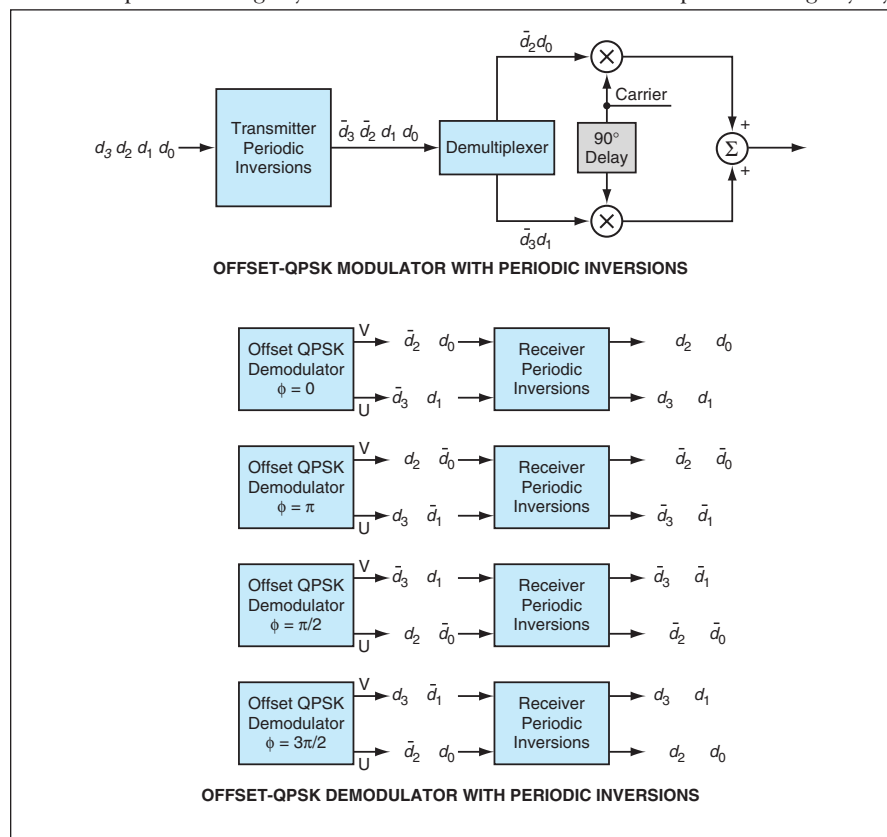


Figure 2. Inversions of Bits in cycles of four bits (d_0, d_1, d_2, d_3) would cause all the output bits to be either inverted or noninverted together, depending on the phase difference (ϕ) between the received carrier and the local-oscillator signal in the carrier-tracking loop. The loop could lock at any of four points ($\phi = 0, \pi/2, \pi, \text{ or } 3\pi/2$ radians).

Ambient light would be suppressed more effectively than by optical filtering alone.

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The ambient-light-canceling camera (ALCC) is a proposed near-infrared electronic camera that would utilize a combination of (1) synchronized illumination during alternate frame periods and (2) subtraction of readouts from consecutive frames to obtain images without a background component of ambient light. The ALCC is intended especially for use in tracking the motion of an eye by the pupil center corneal reflection (PCCR) method. Eye tracking by the PCCR method has shown potential for application in human-computer interaction for people with and without disabilities, and

for noninvasive monitoring, detection, and even diagnosis of physiological and neurological deficiencies.

In the PCCR method, an eye is illuminated by near-infrared light from a light-emitting diode (LED). Some of the infrared light is reflected from the surface of the cornea. Some of the infrared light enters the eye through the pupil and is reflected from back of the eye out through the pupil — a phenomenon commonly observed as the “red-eye” effect in flash photography. An electronic camera is oriented to image the user's eye. The output of the camera is digitized and processed by algorithms that

locate the two reflections. Then from the locations of the centers of the two reflections, the direction of gaze is computed. As described thus far, the PCCR method is susceptible to errors caused by reflections of ambient light. Although a near-infrared band-pass optical filter can be used to discriminate against ambient light, some sources of ambient light have enough in-band power to compete with the LED signal.

The mode of operation of the ALCC would complement or supplant spectral filtering by providing more nearly complete cancellation of the effect of ambient light. In the operation of the ALCC,

a near-infrared LED would be pulsed on during one camera frame period and off during the next frame period. Thus, the scene would be illuminated by both the LED (signal) light and the ambient (background) light during one frame period, and would be illuminated with only ambient (background) light during the next frame period. The camera output would be digitized and sent to a computer, wherein the pixel values of the background-only frame would be subtracted from the pixel values of the signal-plus-background frame to obtain

signal-only pixel values (see figure).

To prevent artifacts of motion from entering the images, it would be necessary to acquire image data at a rate greater than the standard video rate of 30 frames per second. For this purpose, the ALCC would exploit a novel control technique developed at NASA's Jet Propulsion Laboratory for advanced charge-coupled-device (CCD) cameras. This technique provides for readout from a subwindow [region of interest (ROI)] within the image frame. Because the desired reflections from the eye would typically occupy a small fraction

of the area within the image frame, the ROI capability would make it possible to acquire and subtract pixel values at rates of several hundred frames per second — considerably greater than the standard video rate and sufficient to both (1) suppress motion artifacts and (2) track the motion of the eye between consecutive subtractive frame pairs.

This work was done by John Michael Moorokian of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1). NPO-30875

Lightweight, Flexible, Thin, Integrated Solar-Power Packs

These systems could be attractive alternatives to conventional solar arrays and associated power circuits.

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Lightweight, flexible, thin, one-piece, solar-power packs are undergoing development. Each power pack of this type is a complete, modular, integrated power-supply system comprising three power subsystems that, in conventional practice, have been constructed as separate units and connected to each other by wires. These power packs are amenable to a variety of uses: For example, they could be laminated to the tops of tents and other shelters to provide or augment power for portable electronic equipment in the field, and they could be used as power sources for such small portable electronic systems as radio transceivers (including data relays and cellular telephones), laptop computers, video camcorders, and Global Positioning System receivers.

The three power subsystems in question are (1) an array of one or more photovoltaic cells (power-generation subsystem), (2) one or more storage batteries (energy-storage subsystem), and (3) electronic circuits to control the other two subsystems and the overall operation of the system [power-management-and-distribution (PMAD) subsystem]. The conventional approach to designing these subsystems results in impediments to the present goal of developing a highly integrated system: Conventional photo-

voltaic arrays are fragile and expensive; conventional storage batteries are bulky, must typically be able to withstand high pressures, and must be kept within fairly narrow ranges of operating temperatures; and conventional PMAD systems comprise high-power centralized conditioning and switching circuits that are formed on heavy, rigid printed-circuit boards and generate large amounts of waste heat. The structural, electrical, and thermal requirements that govern the design of a conventional power system usually make it necessary to mount each subsystem in a different location. For example, a photovoltaic array must be placed where it can face the Sun, the storage batteries must be mounted on a wall that can be kept at an acceptable temperature, and the PMAD subsystem must be mounted on a panel suitable for electronic circuitry.

A system of the type under development differs from a conventional power system in several notable ways:

- The power-generation subsystem is based on copper indium gallium diselenide (CIGS), which is a photovoltaic material well suited for flexible, thin-film photovoltaic cells and arrays. In comparison with conventional silicon-based photovoltaic arrays, thin-film

CIGS photovoltaic arrays offer potential advantages of flexibility, durability, high specific power, and low cost.

- The energy-storage subsystem consists mainly of flexible, thin-film lithium-based storage batteries. These are durable batteries that exploit long-life solid-state chemistry and can operate over a wide temperature range.
- The PMAD subsystem is implemented in thin, flexible electronic circuitry instead of conventional circuitry on rigid circuit boards.
- The integrated system can be made by laminating the three thin subsystems and forming vias (through-the-thickness electrical connections) among them.
- The weight and volume of the integrated system are much less than those of an equivalent conventional system that comprises three separate, wire-connected subsystems.
- Duplicates of the system, regarded as modules, can be combined into larger systems to satisfy larger power demands.

This work was done by Robert R. Hanson of ITN Energy Systems, Inc., for Johnson Space Center. Further information is contained in a TSP (see page 1). MSC-23007