

# Theory of Operation

## 2-1. FUNCTIONAL DESCRIPTION

2-2. The HP 82153A Wand design (see figure 2-1) consists of four primary electrical components:

- a. The optical sensor.
- b. The converter circuit.
- c. The interface IC (integrated circuit).
- d. The ROM (read-only memory) IC.

2-3. CMOS (complementary metal-oxide-semiconductor) circuitry is used in the hybrid circuit, which consists of the interface IC and the ROM. The hybrid circuit is contained in the plug-in interface module. The converter circuit consists of a conventional bipolar IC and associated discrete components. This circuit and the optical sensor are contained in the wand case.

## 2-4. Optical Sensor

2-5. The optical sensor unit contains an LED (light-emitting diode) operating in the visible range, a photodiode detector, and precision optics. Light energy, when externally reflected back toward the sensor, activates the detector and generates a low-level current at its output.

## 2-6. Converter Circuit

2-7. A read switch on the wand activates the converter circuit and the optical sensor. This circuit amplifies the photocurrent from the sensor and converts it to a rectangular-shaped waveform. This output signal is essentially a two-level signal that indicates the presence or absence of a photocurrent from the sensor. The signal is low when sensor current is being generated (when light is being reflected back into the sensor); the signal is high when no current is being generated (when no light is reflected, or when the read switch is off).

## 2-8. Interface IC

2-9. The interface IC coordinates the transfer of data from the wand to the CPU in the calculator. It

consists of three basic sections: the controller, the counter, and the buffers.

2-10. Timing signals ( $\Phi 1$ ,  $\Phi 2$ , and SYNC) from the calculator are used by the controller section to synchronize its operation with the CPU. (Signal names are listed in table 2-1.) Instructions from the calculator on the ISA line are decoded and implemented by the controller. It also decodes the  $V_O$  signal from the converter circuit into a sequence of zeros and ones and passes it to the buffer section. The controller uses the FI line to inform the calculator that the wand is turned on and that data is ready to be sent to the CPU.

2-11. The counter section measures the time interval between transitions in the  $V_O$  signal, as detected by the controller section. The  $\Phi 2$  signal is used as the timing reference. A reference interval used to compare with the measured interval is stored in the counter section.

2-12. The buffer section contains two 128-bit primary registers and an 8-bit shift register. When eight bits have been accumulated in the shift register, the controller section shifts the bits into the proper primary register. At the appropriate time, the controller sends eight bits of data from a register to the CPU.

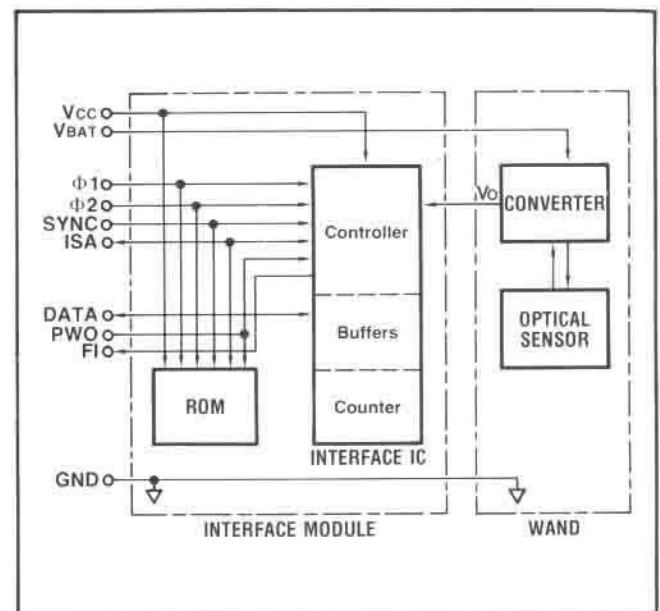


Figure 2-1. HP 82153A Wand Block Diagram

Table 2-1. Signal Names

| SIGNAL           | DESCRIPTION                |
|------------------|----------------------------|
| DATA             | Data Signal                |
| FI               | Flag Interface Signal      |
| GND              | Ground                     |
| ISA              | Instruction/Address Signal |
| PWO              | Power On/Off Signal        |
| SYNC             | Timing/Information Signal  |
| V <sub>BAT</sub> | Battery Voltage            |
| V <sub>CC</sub>  | System Voltage             |
| V <sub>O</sub>   | Optical Output Voltage     |
| Φ1               | Timing Signal              |
| Φ2               | Timing Signal              |

### 2-13. Read-Only Memory

2-14. The ROM contains 4096 10-bit microprogrammed instructions. These instructions are used by the CPU in the calculator to control the wand's operation.

### 2-15. SYSTEM OPERATION

2-16. The following paragraphs describe how the wand processes bar-code information and interacts with the calculator system.

2-17. Bar code (see figure 2-2) consists of a row of dark-colored bars printed on a light-colored surface. Each bar represents a binary bit. The value of the bit is determined by the width of the bar relative to the constant spacing between bars and widths of previous bars. A bar whose width is equal to the width of a space is equivalent to a "0"; a bar that is twice as wide as a space is a "1". The data in a line of bar code is formatted in multiples of eight bars (called a byte), including one byte for checksum verification. Two additional bars at each end of the line provide an initial timing reference and identify each end. The reference bars and left direction bar are all 0; the right direction bar is a 1.

2-18. When the read switch is pressed and the sensor is placed against a light-colored (reflective) surface, converter output V<sub>O</sub> goes low. If the calculator system is inactive (PWO is low), the interface IC sets the ISA line high, signaling the CPU to place the system in its active RUN mode (PWO high).

2-19. As the sensor is moved along the line of bar code, the interface IC establishes and continually up-

dates the reference interval (the number of clock counts to scan one space or one "0" bar). As each bar is decoded to a binary bit, it is passed to the eight-bit shift register. Each time eight bits are accumulated, they are passed to one of the primary buffers in the interface IC. The order of this transfer depends upon the direction that the bar-code line is scanned, which is indicated by the left/right direction bars. In this way, data is always stored in proper order, regardless of the direction in which it is scanned. One primary buffer can store data from a full line of bar code (up to 16 bytes, or 128 bits).

2-20. When the scan of a line has been completed, the interface IC senses the extended white "space," enables the primary register to send its contents to the CPU, and signals the CPU via the FI line that data is ready to be sent. The CPU sends a data-transfer instruction on the ISA line, and the interface IC then transfers the data from its enabled primary register on the DATA line. Data is transferred eight bits per word time (56 clock cycles). When all of the data has been sent, the FI signal is discontinued. The CPU then verifies the received data using the checksum byte, generating a short beep if the data is valid or a long beep if it finds an error.

2-21. While data is being transferred to the CPU from one primary register, the other primary register is able to receive decoded data from the shift register. The interface IC alternates the functions of its two registers as each line of bar code is scanned.

2-22. If the read switch is off and no data is waiting to be sent to the calculator, the absence of a signal on the FI line lets the CPU deactivate the calculator. When the calculator reverts to an inactive state, it sets PWO low. This signal disables the interface and ROM IC's so that they do not respond to spurious signals.

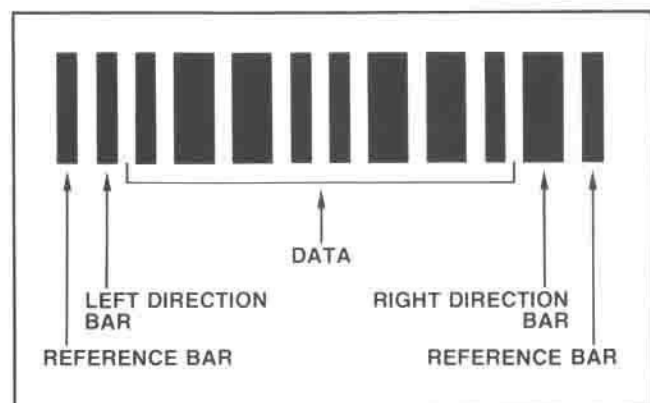


Figure 2-2. Bar Code Structure