LEDs help tune FSK demodulators

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Light-emitting diodes make excellent tuning aids for frequency-shift-keyed (FSK) demodulators. They can replace cathode-ray tubes or meters in both single-frequency-shift-keyed demodulators and dual-frequency-shift-keyed (DFS) demodulators. The LED display can be easily incorporated in existing demodulators or in yet-to-be-designed demodulators.

Many conventional FSK and DFS demodulators use CRTs to provide vector-like displays of the teleprinter mark (binary 1) and space (binary 0) signals. FSK and DFS modulation techniques normally make use of frequency shifts on the order of 200 to 800 hertz. One popular standard is to use a frequency shift of 850 Hz, with the space centered at 2,125 Hz and the mark centered at 2,975 Hz. The FSK demodulator, therefore, will have selective filters of 2,125 and 2,975 Hz to detect the respective space and mark signals.

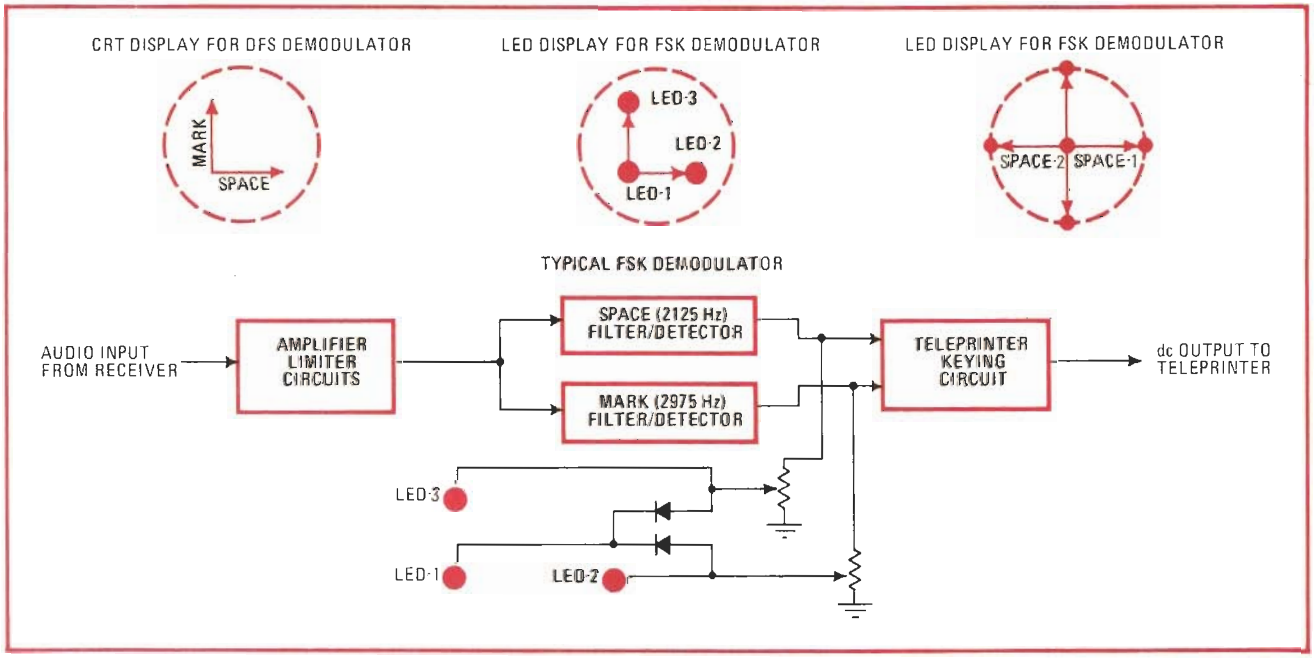
In radio-communications circuits, the mark and space signals are transmitted as individual signals that shift below and above the transmitter's center frequency. Thus, if a radioteletype signal is transmitted at a center frequency of 7,100 kilohertz with a total frequency shift of 850 Hz, the space signal will be transmitted 425 Hz below the center frequency (at 7,099.575 kHz), and the mark signal will be transmitted 425 Hz above the center frequency (at 7,100.425 kHz). For proper signal reception, the receiver must be tuned so that the space and mark signals are centered at 2,125 and 2,975 Hz.

With a CRT vector-like tuning monitor, the space signals are displayed horizontally, while the mark signals are displayed vertically. When the receiver is tuned to the teleprinter signal and the receiver's beat-frequency oscillator is adjusted so that the space and mark signals are centered, the CRT will display the space and mark vectors.

Light-emitting diodes, along with the appropriate logic-interface circuitry, can be substituted for this more expensive and less reliable CRT tuning aid. Three LEDs, when arranged as indicated for the FSK demodulator, provide a display for the tuning function. (Other arrangements may be more desirable in some instances.) When the receiver is tuned to the signal center frequency, LED-1 lights; when it is below the center frequency, LED-2 lights; and when it is above the center frequency, LED-3 lights.

The block diagram shows how this simple LED tuning aid can be added to a conventional FSK demodulator. The dc outputs from both filter/detector stages are applied to a resistive divider network that acts as a threshold detector for the LEDs. The isolating diodes are connected as an OR gate to allow these dc signals to be applied to LED-1 when the demodulator is tuned to the signal's center frequency. If the output level from either filter/detector stage is not sufficient to drive the LEDs, appropriate transistor switches or digital logic ICs may be used as interface devices.

The same sort of LED tuning aid can be devised for DFS demodulators. In this case, five LEDs are required to replace the CRT display. Most DFS demodulators use switchable filters and have individual outputs for each teleprinter channel. They also sometimes have combining circuits (different antennas) for use with space and frequency-diversity schemes. In any case, the LED interface circuitry can be connected to the individual detector outputs, and the display can be arranged to show the space-space, space-mark, mark-space, and mark-mark combinations. □



LED tuning aid. Light-emitting diodes can replace the vector-like CRT display commonly used for tuning a receiver to the signal center frequency. Three LEDs do the job for a single-frequency (FSK) demodulator, while five are needed for a dual-frequency (DFS) demodulator.

stant for a large swing in input voltage, as illustrated by the graph of E_o versus E_i in (a). LED voltage increases by only approximately 0.4 V as the input voltage goes from 3.5 to 15 V.

In (b), the influence of the load resistance on both the current drawn by the LED and the output current is plotted for an input voltage variation of 3.45 to 3.90 V. When the load resistance drops below approximately 37.5 ohms (and the series resistor is 50 ohms), LED voltage decreases to less than 1.6 V, and the output-voltage level is determined entirely by the load resistance, and not the LED.

To increase the level of the regulated output voltage, several LEDs can be connected in series, as is done in (c). This configuration produces a regulated output voltage as long as the input voltage to the LEDs does not drop below 1.6 V times the number of LEDs being used. Higher load currents can be achieved by connecting a number of LEDs in parallel, as is done in (d). Or, to raise the output voltage, as well as the current level, the LEDs can be connected in a series/parallel manner to get the desired results.

The value of the series-dropping resistor determines the input voltage level at which the LED starts to control the output voltage. The higher the value of this resistor (above 50 ohms nominal), the higher the input voltage must be to make the LED conduct.

How brightly the LED glows depends on the input-voltage level. The LED gets brighter as input voltage increases (for a fixed value of load resistance), but the load current remains almost constant, as illustrated by the graph in (e).

Usually, the luminous intensity of a LED is established at a given current level, which generally ranges from 5 to 30 mA, and at a nominal LED voltage of 1.6 to 1.7 V. Although a LED can still operate properly at continuous current levels as high as 50 mA, continuous current levels of 200 mA or so should be avoided. They cause the LED to exceed its safe operating temperature, reducing its average 20-year half-life.

Additionally, since a LED is a visual current-indicating device, it makes a handy front-panel circuit monitor. For example, it can indicate when circuit power is on, (LED lit), when the circuit input voltage is too high (LED bright), when the load current is too heavy (LED dim), and when the circuit is turned off (LED dark). □