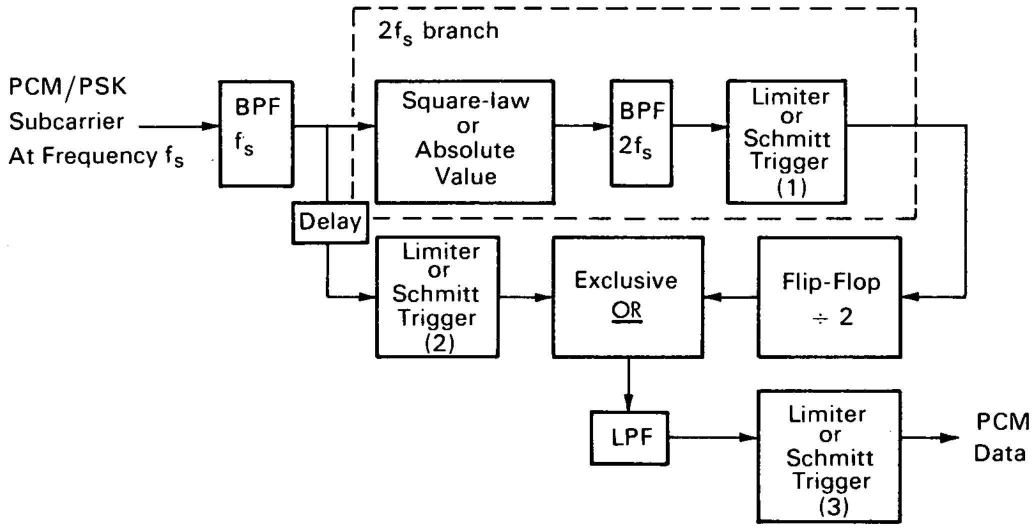
NASA TECH BRIEF

Simple Demodulator for Telemetry Phase-Shift Keyed Subcarriers



The use of phase-shift keyed (PSK) subcarrier techniques in digital pulse-code modulated (PCM) telemetry systems is widespread. Recovery of the PCM data from the receiver output is usually done with rather involved circuitry such as a narrow-band tracking loop. Such circuitry is required for operation at low signal-to-noise ratios (S/N), but is too complex or expensive for service in a high S/N environment, e.g., bench testing of a spacecraft telemetry system. A PCM/PSK demodulator, which can be easily constructed from microcircuit elements, has been designed as a simplified circuit having characteristics suitable for the high S/N environment. Other applications where low-cost, relatively high-level signal systems are used (i.e., where the ratio of signal energy per bit to noise spectral density is greater than 15 dB) may include microwave data links between stations of a network or between data processing facilities. A channel having an S/N of 9 dB, 3 kHz bandwith and a bit rate of 500 bps can be readily demodulated by the inexpensive new circuit.

The input to the demodulator is a PCM/PSK subcarrier at frequency f_s having the form $\pm \cos\omega_s t$, where ω_s is the frequency $(2\pi f_s)$ of the PSK signal and the "$\pm$" is the PCM data. A bandpass filter (BPF) may be included to separate the subcarriers in a multiple subcarrier system or produce a sinewave output from a squarewave subcarrier input. This filter can be a common active-filter type. In some applications the filter will not be necessary. The sinewave output of the bandpass filter (BPF) with center frequency at f_s is applied to the square-law or absolute value circuit in the $2f_s$ branch of the demodulator. The input $\pm \cos\omega_s t$ is squared by the square-law circuit, producing a double-frequency signal (note: $\cos^2\omega_s t = 1/2 (1+\cos 2\omega_s t)$ of constant phase. Physically, the

(continued overleaf)

square-law circuit may be an operational amplifier with the proper diode network. The bandpass filter with center frequency at $2f_s$ (double the subcarrier frequency) blocks the dc output of the square-law detector and, if necessary, "rings" at the double frequency ($2f_s$) during data transition transients. The $2f_s$ output of the bandpass filter is applied to the Limiter–Schmitt trigger circuit (1) where it is transformed into a logic level having a single polarity and twice the frequency of the subcarrier. This logic signal frequency is divided by two in the flip-flop, and the single polarity f_s output is applied to an exclusive *or* circuit functioning as a synchronous detector. The flip-flop and exclusive *or* blocks are standard integrated circuits. The double polarity signal $\pm f_s$ to be detected is applied to the other input of the exclusive *or* circuit and is delayed by a resistance-capacitance network to compensate for delay through the $2f_s$ branch so that the limited-level signal from the limiter (2) is coincident in time with the signal from the $2f_s$ branch.

The modulo 2 addition by means of the exclusive *or* circuit results in demodulation of the f_s signal. This signal is applied to a low-pass filter (LPF) to further reduce "glitches" due to time delay unbalance in the f_s and $2f_s$ branches.

Note:

No additional documentation is available for this Tech Brief.

References:

Bach, R. E. Jr. "Selecting RC Values for Active Filters," *Electronics*, May 13, 1967.

Application notes for Filters, Square-law detectors using operational amplifiers e.g., Philbrick, Fairchild, Burr–Brown.

Integrated circuit application notes, Texas Instruments, Fairchild, etc.

Patent status:

No patent action is contemplated by NASA.

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