EE4435 Fall 2001
Design Project 3
An Analog Telemetry System

Object

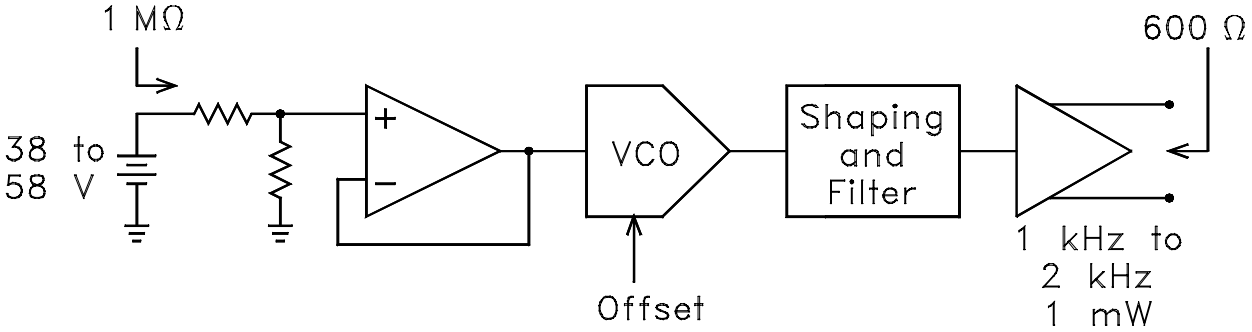
The object of this experiment is to design, implement, and test an analog telemetry system that will transmit an audio frequency representing a battery voltage level over a telephone line or over a voice-frequency radio link. In this situation, the battery is the standby power supply at a remote communications site. It provides the power required to operate the site equipment for a minimum time if all external ac power is lost. Such equipment is often used at remote mountain-top locations of microwave repeater equipment. A power-line or solar battery charger keeps the battery charged. Typically, a 48 V lead-acid battery is used. Because the condition of the auxiliary power battery is important, some means of remotely checking its condition is necessary.

Proposed Circuit

A block diagram of a possible circuit is given in the figure. The voltage is sampled by a high-impedance voltmeter having an input resistance greater than 1 MΩ. The signal from the voltmeter controls a voltage-controlled oscillator (VCO) which functions as a voltage-to-frequency converter. For 38 V $\leq V \leq$ 58 V, the VCO has an output frequency given by

$$f(V) = 1000 + 50(V - 38)$$

This formula gives $f(58) = 2$ kHz and $f(38) = 1$ kHz.



The output of a typical op amp VCO is either a square wave or a triangle wave. These waveforms are unsuitable for transmission over a telephone line and must be converted to a sine wave. You may use a wave shaping circuit and a low-pass filter to generate the sine wave from the square wave or triangle wave. Because the range of frequencies is 1 to 2 kHz and the lowest harmonic of a square wave or a triangle wave is the third harmonic, the filter cutoff frequency must be between 2 kHz and 3 kHz. An elliptic filter is suggested to obtain the sharpest cutoff.

Telephone lines require balanced signals with a source impedance of 600 Ω. Therefore, your circuit should have a balanced output having an output resistance of 600 Ω. It should be

able to deliver a power of 1 mW into a 600 Ω load, which is the input resistance of the telephone line.

Specifications

- Input voltage range: 38 to 58 V.
- Output frequency: $f\,(38\text{V}) = 1$ kHz ± 10 Hz, $f\,(58\text{V}) = 2$ kHz ± 20 Hz, $f\,(48\text{V}) = 1.5$ kHz ± 15 Hz, linear response between these values.
- Output power: Differential output, 1 mW into a 600 Ω balanced load from a 600 Ω balanced source.
- Output flatness: Output power shall not deviate from 1 mW by more than ± 0.5 dB over the $1 - 2$ kHz frequency band.
- Spectral purity of output: Total harmonic distortion (THD) shall not exceed 2%.
- Operating voltage: ± 15 V.

Simulations

- You should verify the operation of your VCO and wave-shaping circuits with SPICE. Show that the VCO covers the desired frequency range for the specified input voltages. Use realistic models for all op amps and comparators.
- Determine the THD of your circuit as a function of frequency and verify that it meets the specifications.
- Verify that the output power is correct. Verify that the output flatness meets specifications.

Tests of Final Circuit

- Make measurements that duplicate the required simulations. Measure all performance criteria and show that your design meets the specifications.
- Present your circuit to the lab instructor for final approval.