Phase Detector Utilising TRAC

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The TRAC family of totally reconfigurable Field Programmable Analog Devices offers an integrated path from signal processing problems to working silicon solutions - in minutes! Introducing a Top-Down, Structured design discipline, TRAC enables rapid implementation, prototyping and product release. Rather than designing at the component level, TRAC champions a Computational Approach. Using eight simple mathematical building blocks, any transfer function can be implemented on TRAC, and more besides!

With a combination of programmable silicon and design software, TRAC brings a truly Integrated Route to signal processing problem solving, providing designers with benefits formerly associated only with programmable digital devices, and offering a path to Custom Silicon for higher volume users.

Introduction

This application notes describes TRAC configured as a phase sensitive detector and will be shown as part of a lock-in amplifier designed to identify a small signal in an electrically noisy environment. This is achieved by operating as a narrow bandpass filter which will remove most of the unwanted noise whilst allowing through the signal to be measured.

The basic block diagram (Figure 1) shows a phase detector. The input signal and the reference switching signal are at the same frequency and in phase. At the output of the switch shown, we can then expect a full wave

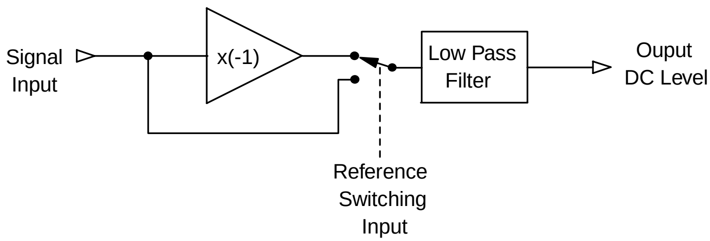

Figure 1
Block Diagram of a Phase Detector

rectified signal and, after the low pass filter, a DC level proportional to the AC signal level.

In practice the input signal will be very small and some pre-amplification is required to enable satisfactory detection.

Applications can be found in many areas of low signal detection such as radio astronomy, spectroscopy and other measurement situations. This would normally involve sweeping the reference signal through a range of frequencies and measuring the resulting DC output.

Alternatively, if detecting a single frequency, the reference signal must be at the same frequency as the input signal to be measured and, since the detector is also phase sensitive, maximum output will be achieved when the two signals are in phase.

The example chosen in this note to illustrate the phase detector is a battery state of charge indicator.

A small signal is injected into a battery under load with the object of determining the source impedance of the battery and hence estimate the state of discharge without disconnecting the varying load. This requires a sine wave oscillator, an amplifier, a phase detector and a filter.

Theory of Application

The battery state of charge detector circuit is shown in Figure 2. A small low frequency AC voltage of about 500 mV should be used as both the switching reference waveform and to inject a current of around 1 mA into the battery. This frequency is best chosen to be unrelated to the power supply frequency (or its harmonics) in use locally, (i.e. avoiding 50, 60, 100, 120 Hz etc) since this will hamper the detection.

Assuming a battery impedance of about 0.1 ohm, this will result in an e.m.f. of about 100μV. This small signal is

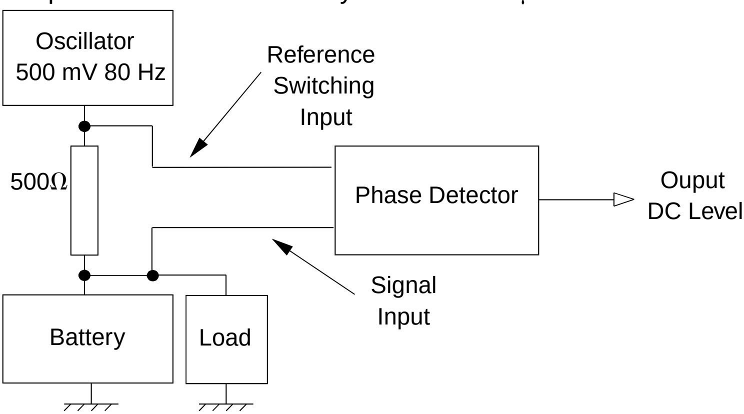

Figure 2
State of Charge Battery Tester

amplified and applied to the phase detector. A DC voltage proportional to the amplitude of this waveform will be produced at the output and used to monitor changes in the source impedance of the battery and hence determine its state of charge. It can be assumed that when the battery is approaching the discharged condition that its source impedance will increase resulting in a large increase in the DC level when measured at the output of the filter.

The phase detector and the low pass filter are implemented in the two TRAC devices.

Software

The TRAC design for the battery state of charge detector is shown in Figure 3. The external oscillator should be applied directly to I/O 2 (the switching reference input). The signal input is applied to I/O 1 and the DC output from the filter appears at I/O 40.

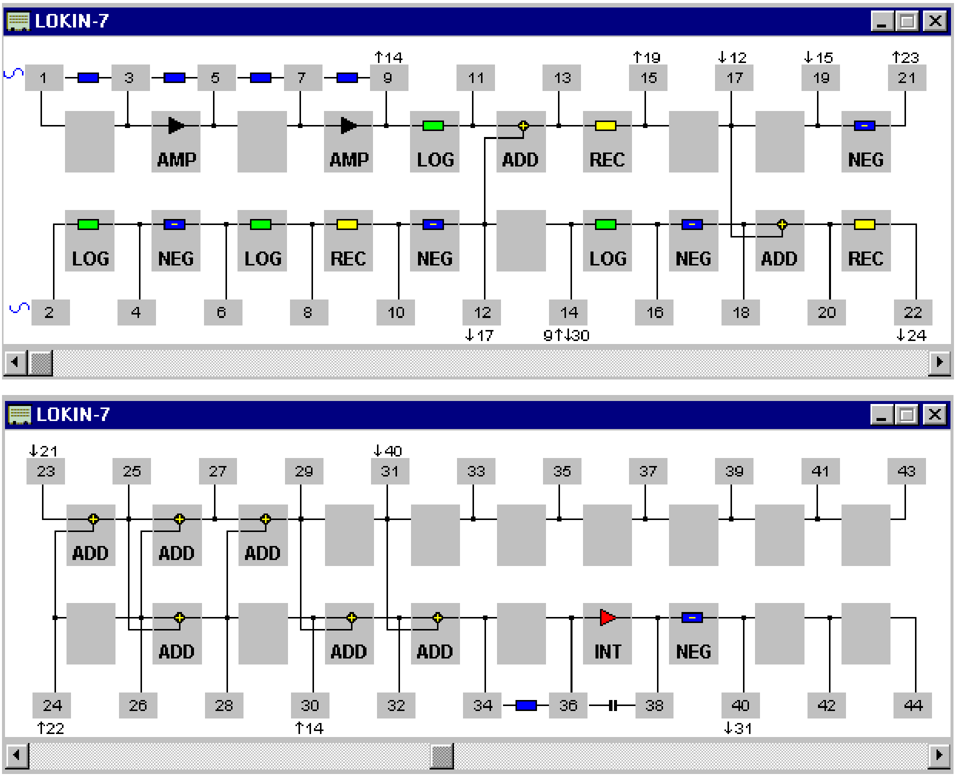

Figure 3
TRAC Design of a Battery Charge Indicator using the Phase Detector

Hardware

Some external components are required for the amplifiers and the filters. A suggested overall gain for the amplification stage is 1000 and this is realised by two stages each operating at a gain of 33. Assuming an oscillator frequency of about 80 Hz a suitable pole for the low pass filter would be at 0.2 Hz.

Suitable values to achieve these are given in the following table.

I/O Connection	Component	Value
1 - 3	Resistor	1 kΩ
3 - 5	Resistor	33 kΩ
5 - 7	Resistor	1 kΩ
7 - 9	Resistor	33 kΩ
34 - 36	Resistor	10 kΩ
36 - 38	Capacitor	100µF

The 100µF electrolytic capacitor on I/O pins 36 and 38 should be connected with the positive side to I/O 36.

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