THE VERSATILE Z86C08: THREE KEY FEATURES OF THIS Z8® MICROCONTROLLER

IF YOU NEED D/A CONVERSION, OR A ZERO CROSSING DETECTOR, OR A CURRENT SENSING DEVICE ... USE THE Z86C08'S DUAL COMPARATOR.

DUAL ANALOG COMPARATOR

Using the dual analog comparators on the Z86C08 in conjunction with several on-chip features, provides a cost effective way to monitor power failures and frequency excursions (comparator used as a zero crossing detector), as a blood pressure tester and digital readout (comparator used as a A/D converter), or as a current sensing device in automotive design to detect and subsequently shut off any short circuiting of relays, lights, monitors, etc.

In many microcontroller applications, the digital designer is often concerned with sampling and controlling non-digital elements within the system. However, when the designer is forced to deviate from the precise world of TTL logic and regulated 5 volt supplies, frequently, microcontroller architectures and specifications fall short in the areas of cost sensitivity and consumer orientation. Therefore, using the analog comparators in these specific areas are a few of the reliable, inexpensive design applications for the Z86C08.

Comparator Basics

The dual comparators share a common inverting terminal with non-inverting terminals bonded directly to external I/O ports (Figure 1). The comparators are enabled by a bit in the I/O port mode/control register. If bit D1 of R247 is zero, then the comparators are in digital mode. If D1 is one, then they are in analog mode. With the comparators disabled, the I/O ports are available for normal activities. These particular I/O ports can be used to generate external interrupt requests to the Z8®. With the comparators enabled, interrupts can also be generated.

The ideal comparator is a three terminal device (Figure 2). V1 is a non-inverting terminal. Signals entering at V2, the inverting terminal, exit V_{OUT} 180° out of phase. Since a comparator is essentially an operational amplifier, it has an associated gain. The open look gain (no feedback) of a comparator is defined as the Voltage Out (V_{OUT}) over the Differential Input Voltage. The Differential Input Voltage is the voltage at the non-inverting input with respect to the inverting input. Thus gain is:

GAIN = V_{OUT}/V1 – (V2) = Voltage Out/Differential Input Volt

The Inset Offset Voltage, the difference between V1 and V2, forces V_{OUT} to a specified level. The Input Offset Voltage is typically below 50 mV.

Zero Crossing Detect Applications

The dual comparator can be used as a zero crossing detector to monitor 110 VAC (or other power line parameters) and its frequency (Figure 3). Each time the voltage passes through zero an interrupt is generated. The outputs of the comparators on the Z86C08 connect directly to the on-chip CPU. When using the comparators to detect zero crossing of the signal, interrupts are generated at every crossing of a signal, interrupts are generated at every crossing. Interrupt subroutines can then calculate period and phase angle relationships between any two analog signals. The phase angle being critical when calculating power factor in power line circuits.

In the case of 110 VAC, 60 Hz power line, an interrupt is generated every 1/120 of a second. This means that whenever the monitor stops (no interrupts), there is a power fail or other problem which can be translated by a control device recovery action (Figure 4).

Frequency checks can also be made by zero crossing detection. Whenever frequency drifts from the normal monitoring zero points, interrupts are either increased (higher frequency) or decreased (lower frequency) from the norm. If necessary, appropriate action is then taken.

Zero Crossing Detect Applications (Cont'd.)

Another application is threshold detection for low voltage battery operated devices. Whenever the VBB drops below the Zener reference voltage level, an interrupt is generated to alert a control device or alarm.

The addition of two on-chip counter/timers further complement the above mentioned applications. Crystal precision timing is done on the period of zero crossings. The sum or difference of two separate analog signals can then be calculated. For example, negative or positive feedback is returned from the Z86C08 in closed loop calculations. In power circuits, a time-of-day clock could be implemented with a timer. Then, date and time of power failures and frequency excursions can be recorded. CMOS technology allows for battery backup.

Analog to Digital (A/D) Conversion

Accurate low speed A/D conversion is implemented with the Z86C08 using the dual slope or ratiometric method. With this method, a dv/dt is applied to the inverting terminal of a comparator. The analog input (V_{INPUT}) signal is applied to the non-inverting terminal. The charge rate of the RC circuit is a dv/dt (Figure 5). As V_{REF} ramps upward from zero volts during time T1, V_{REF} will exceed V_{INPUT}. This causes the comparator to change state and produce an interrupt. By using the on-chip timer, time T1 can be quickly determined.

The RC circuit is immediately discharged over fixed time T2 (Figure 6), where T2 is determined by the time constant Tc = RCn. Since the product of RC is only an approximate indicator of discharge time, a value of n should be multiplied to improve accuracy. A general guideline should equate n to 1.4. Then, T2 = 1.4 RC. The dual slope A/D converter measures voltage by converting voltage into time intervals. Or,

$T2/T1 = V_{INPUT}/V_{REF}$, then, $V_{INPUT} = V_{REF} = T2/T1$

By using an I/O port on the Z86C08 as the V_{REF} input, interrupts generated by the comparators can alternately switch V_{REF} ON or OFF to perform the conversions.

Example: Blood Pressure Tester

A pressure transducer in a blood pressure tester is a good example of the dual slope A/D conversion method. A minimum system consists of display logic, Z86C08 circuitry and a transducer signal input (Figure 7). P00 outputs the appropriate signal to the RC ramp circuit of the V_{REF} input. The output from the pressure transducer (Figure 8) is a linear voltage response to the applied pressure. This signal is input to An2, the non-inverting terminal of the comparator.

In this configuration, the sampling cycle for the A/D conversion begins when a logical 1 is output on P00 and a timer is enabled. When the comparator transitions, an interrupt is generated, the timer is stopped and P00 is toggled to discharge the RC circuit. By storing the count T1 and resetting the timer, the converter is now ready to take another sample. The value of V_{IN} is mathematically determined later and software algorithms are used to determine corresponding pressure.

The display is driven from a simple multiplexer circuit. The Z86C08 can sink large I_{OC} currents which reduces or eliminates buffering.

Current Sensing

The dual comparator is used as a current sensing device in many application areas, e.g., in automotive relays, lights, monitors, etc. In the automotive arena, current sensing is used in a typical case as shown in Figure 9a. If the functional block shorts, then current (I) surges causing voltage (V) to fall. When V reaches 2.5V, the comparator triggers an interrupt which allows software to enable an emergency shut off.

Comparator Basics

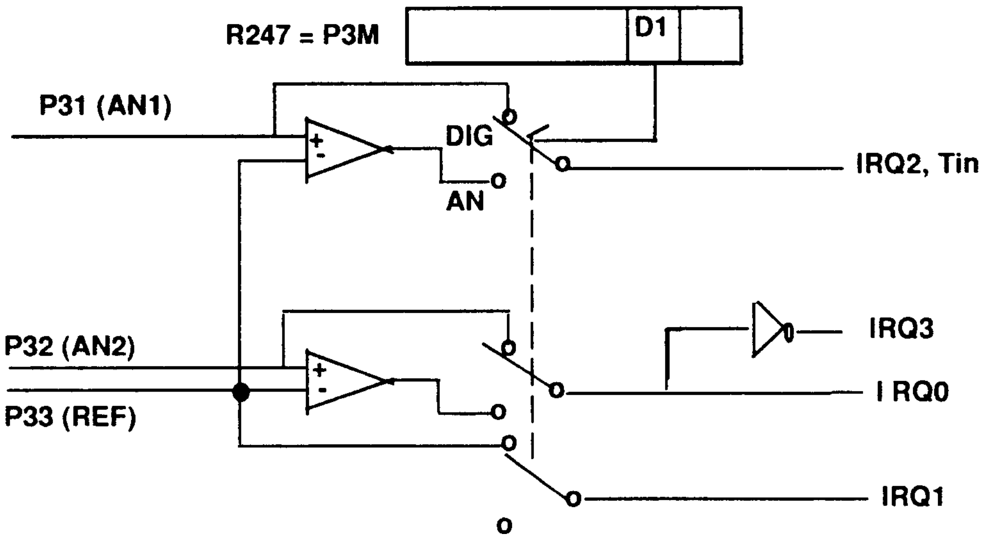


Figure 1. Dual Analog Comparator

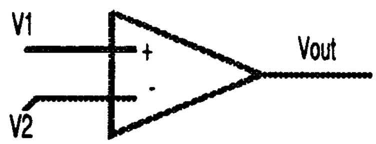


Figure 2. Ideal Comparator

Zero Crossing Detect Applications

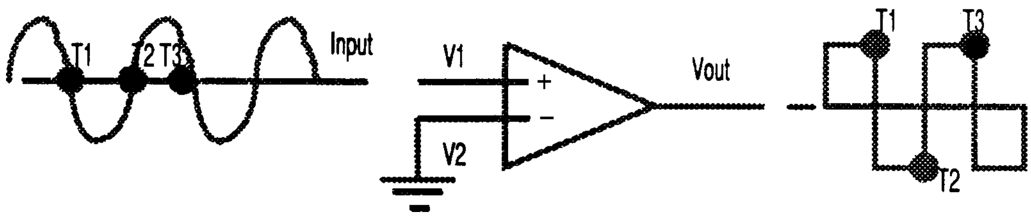


Figure 3. Zero Crossing Detector

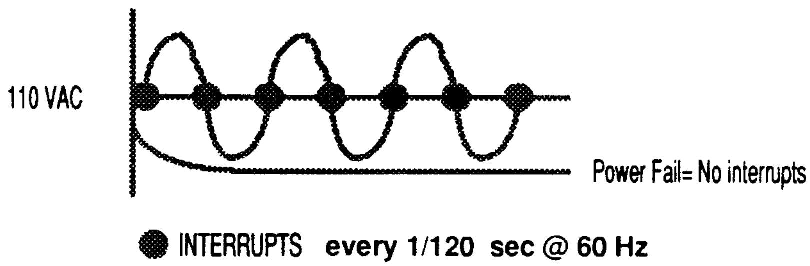


Figure 4. Interrupt After Power Failure

Analog to Digital (A/D) Conversion

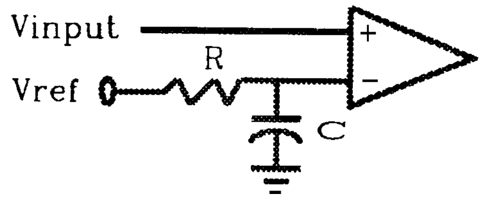


Figure 5. A/D Converter

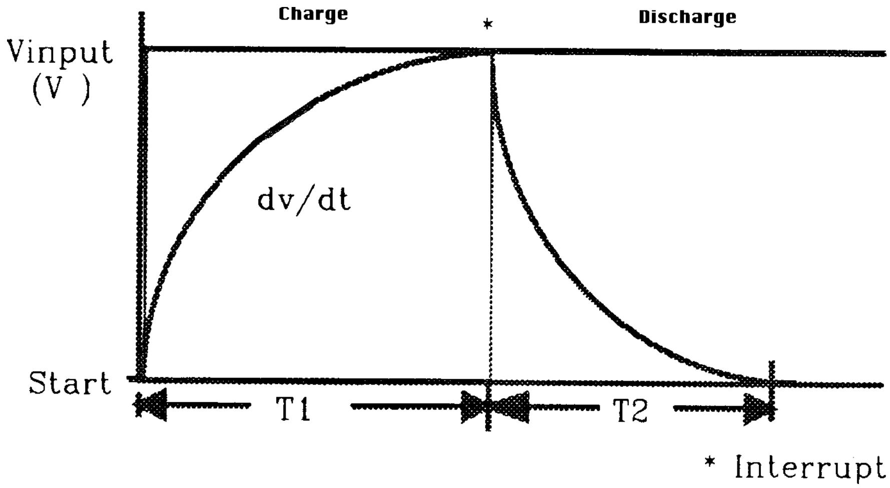


Figure 6. Voltage vs. Time

Blood Pressure Tester

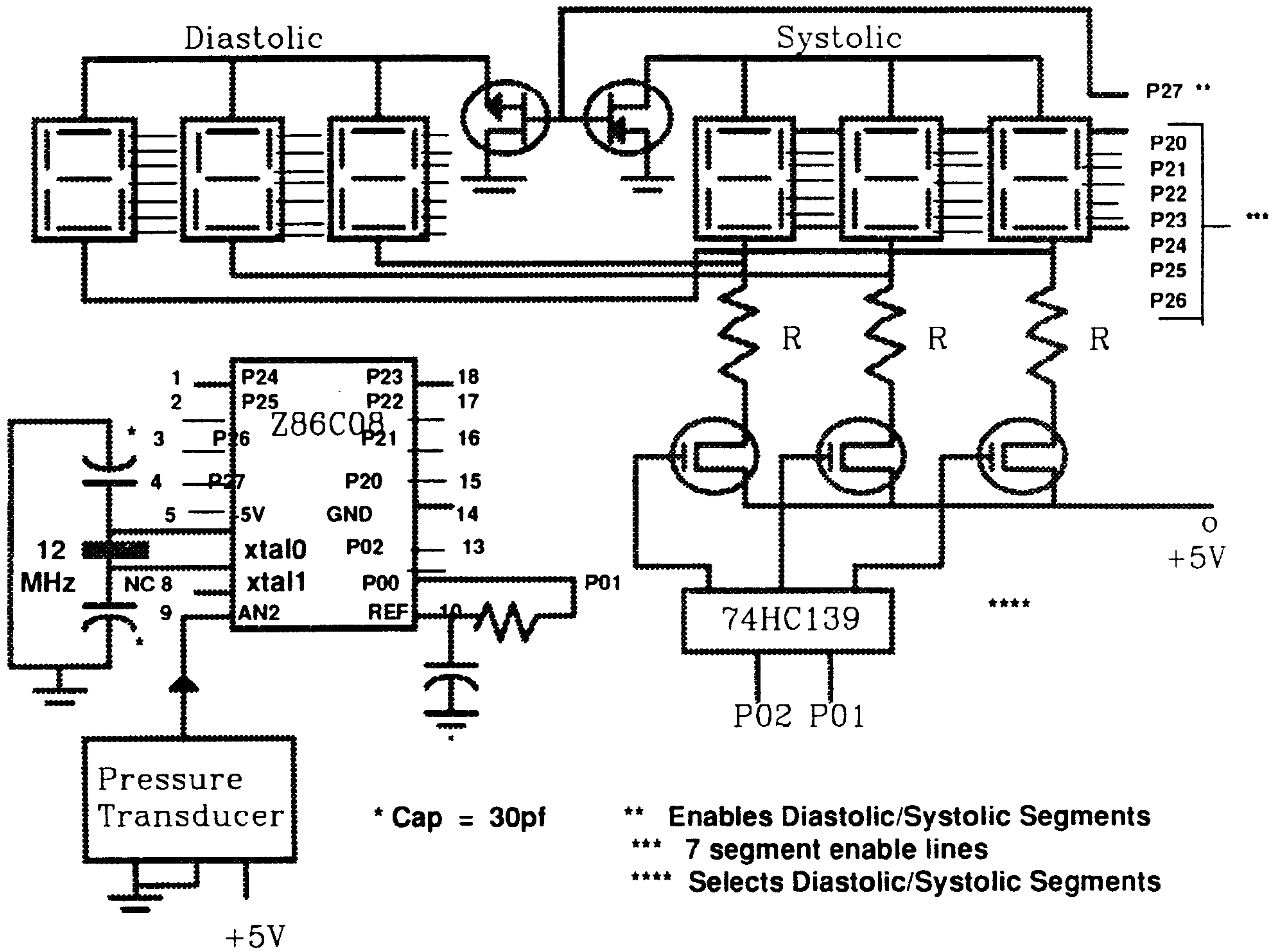


Figure 7. A/D Blood Pressure Test and Readout

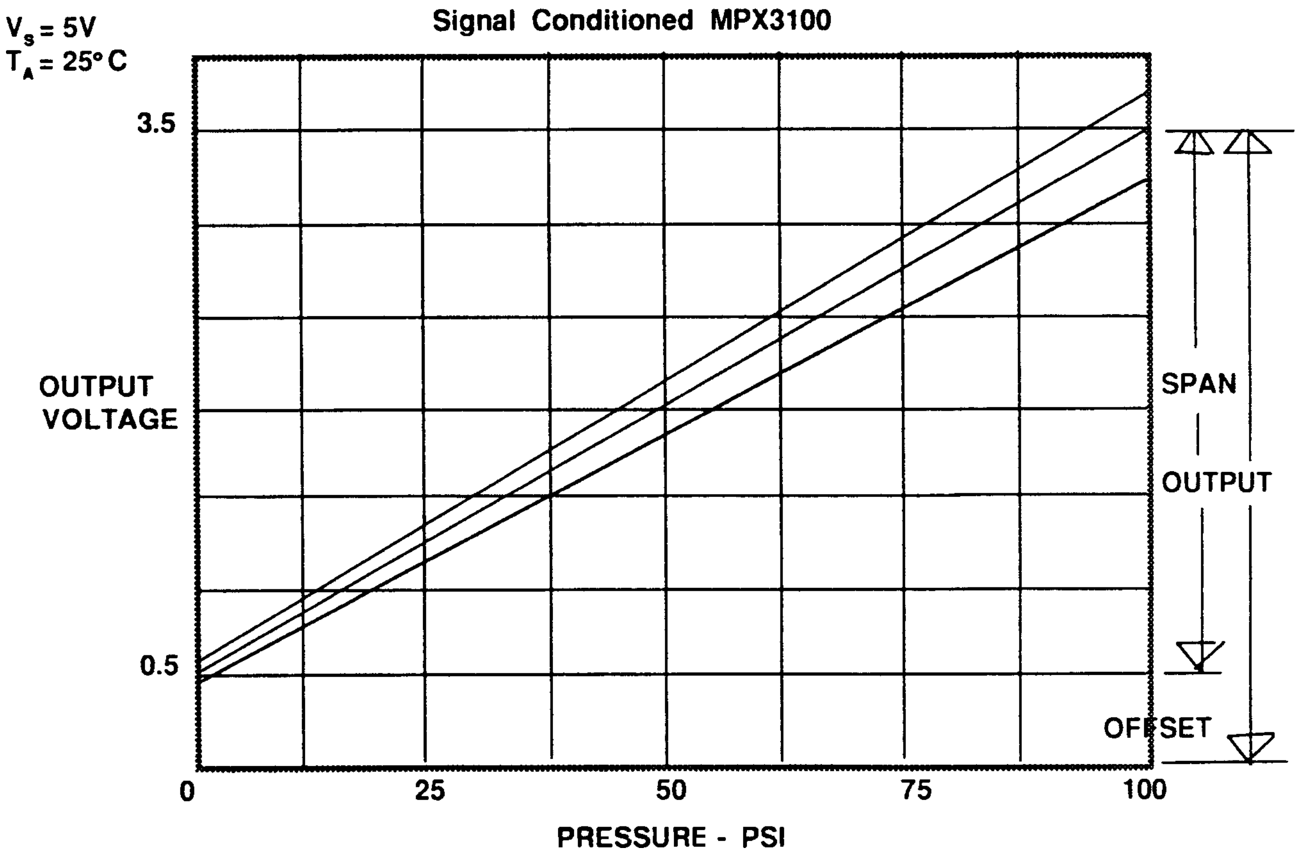


Figure 8. Silicon Pressure Transducer

Current Sensing

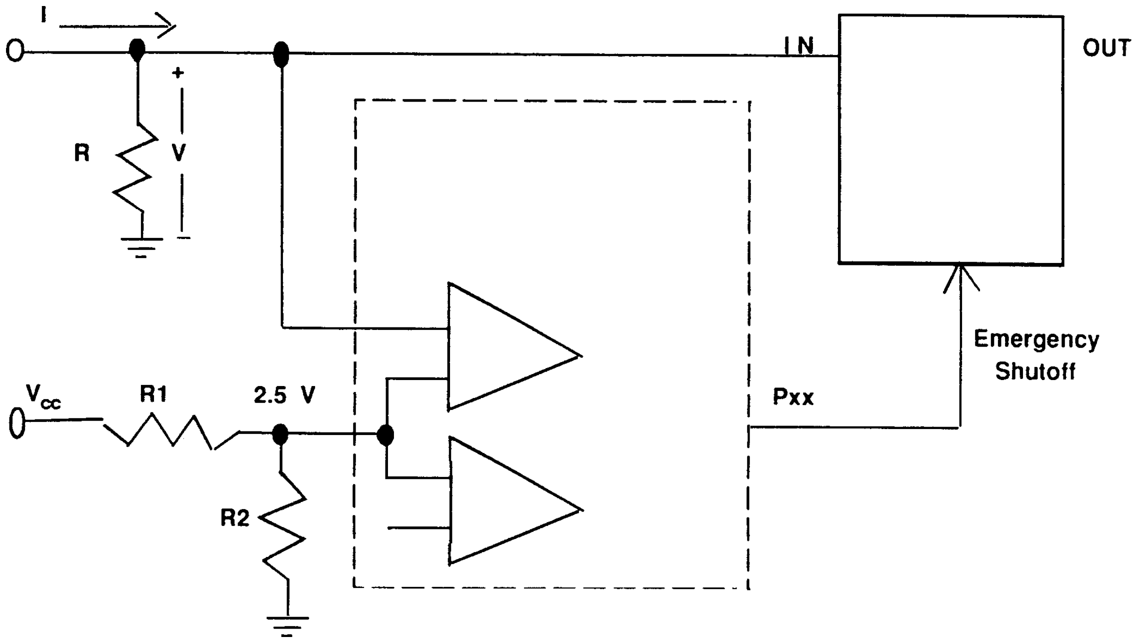
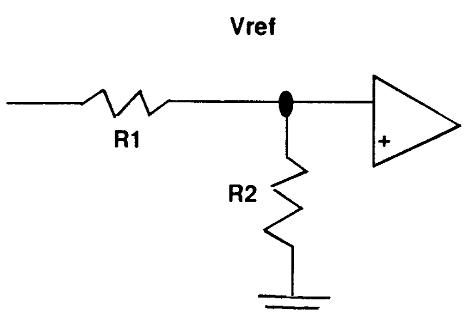


Figure 9a. Current Sensing

Note:

R is large compared to the equivalent impedance of the Functional Block input. R1 and R2 are user-selectable and are generally in a 10K to 100K range of power dissipation considerations. R1 and R2 are determined from the following formula (Figure 9b.).



$$\frac{R2}{R1 + R2}$$

Figure 9b. Power Dissipation Formula

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