A CPE 305 PROJECT

on

COMPARATORS AND PARALLEL IN/SERIAL OUT REGISTERS

GROUP 6

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COMPARATORS

A comparator in an electronic circuit, compares the two inputs that are applied to it and produces an output. The output value of the comparator indicates which of the inputs is greater or lesser. Please note that comparator falls under non-linear applications of ICs. A comparator circuit compares two voltages and outputs either a 1 (the voltage at the plus side) or a 0 (the voltage at the negative side) to indicate which is larger. Comparators are often used, for example, to check whether an input has reached some predetermined value. In most cases a comparator is implemented using a dedicated comparator IC. A comparator consists of a specialized high-gain differential amplifier. They are commonly used in devices that measure and digitize analog signals, such as successive-approximation ADCs, as well as relaxation oscillators.

WORKING PRINCIPLE

Generally, in electronics, the comparator is used to compare two voltages or currents which are given at the two inputs of the comparator. A comparator circuit compares two voltages and outputs either a 1 (the voltage at the plus side; VDD in the illustration) or a 0 (the voltage at the negative side) to indicate which is larger. The operational amplifier can be used as a comparator theoretically without negative feedback. However, the open-loop gain of the operational amplifier is very high, so it can only process signals with a very small input differential voltage. Moreover, in general, the delay time of the op amp is long, which cannot meet the actual requirements. The comparator can be adjusted to provide a very small time delay, but its frequency response characteristics will be limited. To avoid output oscillation, many comparators also have internal hysteresis circuits. The threshold of the comparator is fixed, some have only one threshold, and some have two thresholds.
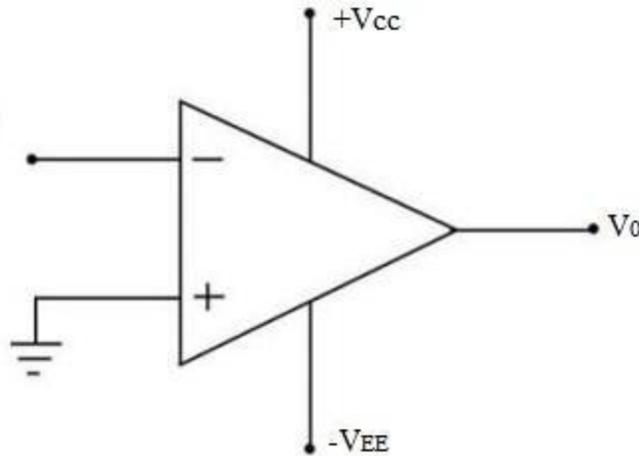
MAIN PARAMETERS

Hysteresis Voltage

The voltage between the two input terminals of the comparator will change the output state when it crosses zero. Because the input terminal is often superimposed with a small voltage fluctuation, the differential mode voltage generated by it will cause the comparator output to change frequently. In order to avoid output oscillation, the new comparator usually has a hysteresis voltage of several mV. The existence of it requires two switching points of the comparator: one is used to detect the rising voltage, the other is used to detect the falling voltage. The difference of the voltage threshold (VTRIP) is equal to the voltage hysteresis (VHYST). The offset voltage of hysteresis comparator is the average of TRIP and VTRIP-. The input voltage switching point of the comparator without hysteresis is the input offset voltage, not the zero of the ideal comparator. In addition, the offset voltage generally varies with temperature and power supply voltage. And the power supply rejection ratio is usually employed to express the influence of power supply voltage changes on the offset voltage.

Bias Current

The input impedance of an **ideal comparator** is infinite. Therefore, there is no effect on the input signal theoretically. However, the actual input impedance of the comparator cannot be infinite. There is a current at the input end that flows through the internal resistance of the signal source and flows into the comparator, thereby generating an additional voltage difference. The bias current (Ibias) is defined as the

median of the input currents of the two comparators and is used to measure the effect of input impedance.

Super Power Swing

To further optimize the operating voltage range of the comparator, Maxim uses the parallel structure of the NPN tube and the PNP tube as the input stage of the comparator. Thus the input voltage of the comparator can be expanded. In this case, the lower limit can be lower to the lowest level, and the upper limit is 250mV higher than the power supply voltage to reach the Beyond-the-Rail standard. The input of this comparator allows a larger common-mode voltage.

Drain-source Voltage

The comparator has only two different output states (zero level or power supply voltage). Its output stage of the comparator with full power swing characteristics is an emitter follower, which makes its voltage difference smaller between input and output signals. The voltage difference depends on the emitter junction voltage under the saturation state of the internal transistor of the comparator, which is equal to the drain-source voltage of the MOSFFET.

Output Delay Time

It includes the transmission delay of the signal through the components and the rise time and fall time of the signal. For high-speed comparators, such as MAX961, the typical value of the delay time can reach 4.5ns and the rise time is 2.3ns. Pay attention to the influence of different factors on the delay time when designing, including the influence of temperature, capacitive load, input overdrive and so on. Although the comparator has different types. The design and construction of each should take care of ordinary uses without affecting its measuring accuracy. The instrument should be very sensitive and withstand a reasonable ill usage without permanent harm.

High Gain Comparator

Square wave
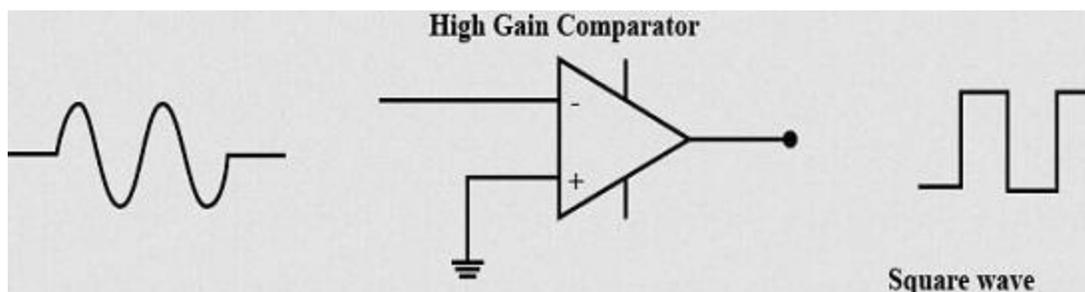
COMPARATORS CLASSIFICATION

Comparators are classified into various kinds, such as electronic, electrical, mechanical, optical, sigma, digital and pneumatic comparators. These are used in various applications. Here we are talking about electronic comparator.
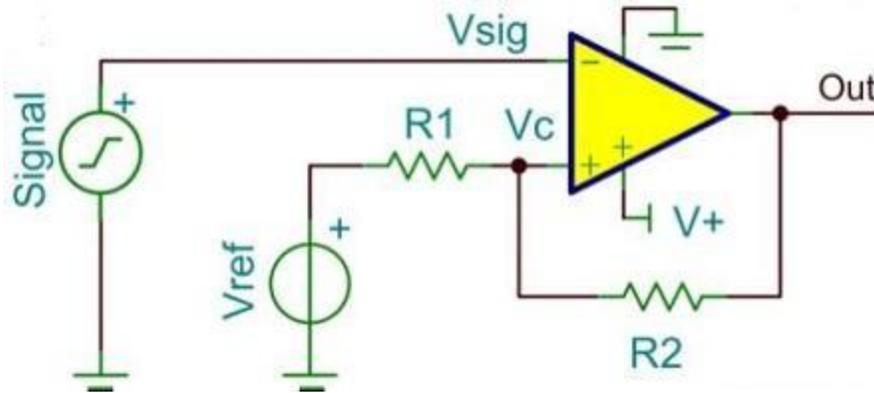
Voltage Comparator

A voltage comparator is a circuit that discriminates and compares input signals, and is a basic unit that forms a non-sine wave generating circuit. Voltage comparators are commonly used including single-limit comparators, hysteresis comparators, window comparators, and three-state voltage comparators. Voltage comparator can be used as an interface between analog circuits and digital circuits, as well as waveform generation and conversion circuits.

Window Comparator

Combine two comparators to form a "window comparator", which is widely used. The window comparator can set the upper limit voltage and lower limit voltage of the input at the same time, within limited voltage range, or outside the range, which we need. When the potential level of the high-level signal is higher than a certain specified value VH, it is equivalent to the positive saturation output of the comparator circuit. When the potential level of the low-level signal is lower than a certain specified value VL, it is equivalent to the negative saturation output of the comparator circuit. The comparator has two thresholds, and the transmission characteristic curve is window-shaped, so it is called a window comparator.

Hysteresis Comparator

It is a comparator with hysteresis loop transmission characteristics, and can be understood as a single-limit comparator with positive feedback. When the input voltage vI gradually increases from zero and VI is less than VT, the comparator output is a positive saturation voltage, and VT is called the upper threshold (trigger) level. When the input voltage VI>VT, the comparator output is a negative saturation voltage, and VT is called the lower threshold (trigger) level.

COMPARATOR APPLICATIONS

Zero-crossing Comparator

The zero-crossing comparator is used to detect whether an input value is zero. The principle is using a comparator to compare two input voltages. One of the two input voltages is the reference voltage Vr and the other is the voltage to be measured Vu. Generally, Vr is connected from the non-inverting input terminal, and Vu is connected from the inverting input terminal. According to the result of comparing the input voltage, the forward or reverse saturation voltage is output. When the reference voltage is known, the measured result of the voltage can be obtained. When the reference voltage is zero, it is a zero-crossing comparator.

The zero-crossing comparator has a small measurement error. When the product of the voltage difference between the two input terminals and the open-loop magnification is less than the output threshold, the detector will give a zero value. For example, when the open-loop magnification is 106 and the output threshold is 6v, if the voltage difference between the two input stages is less than 6 microvolts, the detector outputs zero. This can also be considered the uncertainty of measurement.

Relaxation Oscillator (ROSC)

Comparators can construct relaxation oscillators by using positive feedback and negative feedback. Positive feedback is a Schmitt trigger, which forms a multivibrator. The RC circuit adds negative feedback to it, which causes the circuit to start to oscillate spontaneously, making the entire circuit from a latch to a relaxation oscillator.

Level shifting uses open-drain comparators (such as LM393, TLV3011, and MAX9028) to construct a level shifter to change the signal voltage. Choosing an appropriate

pull-up voltage can flexibly get the converted voltage value. For example, use the MAX972 comparator to convert ±5V signals into 3V signals.

A/D Converter

The function of the comparator is to compare whether an input signal is higher than a given value. So it can convert the input analog signal into a binary digital signal. Almost all digital-to-analog converters (including delta-sigma modulation) contain comparators circuit to quantize the input analog signal.

Voltage Comparator

The voltage comparator can be regarded as an operational amplifier with an infinite amplification factor. The function of the voltage comparator: compare the magnitude of two voltages (using the high or low level of the output voltage to indicate the magnitude relationship between the two input voltages): When the voltage at the "+" input terminal is higher than the "-" input terminal, the voltage comparator output is high level; when the "+" input terminal voltage is lower than the "-" input terminal, the voltage comparator output is low level. It can be used as an interface between analog circuits and digital circuits, and can also be used as a waveform generation and conversion circuit. A simple voltage comparator can change the sine wave into a square wave or rectangular wave with the same frequency. The simple voltage comparator has a simple structure and high sensitivity, but its anti-interference ability is poor, so people have to improve it. The improved voltage comparators include: hysteresis comparator and window comparator. Operational amplifiers are used to determine "operational parameters" through feedback loops and input loops, such as magnification. The feedback amount can be part or all of the output current or voltage. The comparator does not need feedback and directly compares the quantity of the two input terminals. If the non-inverting input is greater than the inverted phase, the output is high, otherwise it outputs low. The input of the voltage comparator is a linear quantity, and the output is a switch (high and low level). In typical applications, a linear op amp can sometimes be used to form a voltage comparator without negative feedback.

OP-AMP

In principle, operational amplifier can be used as comparator without negative feedback. However, because of its high open-loop gain, it can only process signals

with very small input differential voltage. Moreover, in this case, the response time of the operational amplifier is much slower than that of the comparator, and it also lacks some special functions, such as hysteresis, internal reference and so on. Comparator usually can not be used as an operational amplifier. Comparator can provide minimal time delay after adjustment, but its frequency response characteristics are limited to some extent. Operational amplifier makes use of the advantage of frequency response correction to become a flexible and versatile device. In addition, many comparators also have internal hysteresis circuit, which can avoid output oscillation, but it can not be used as an op amp.

PARALLEL IN / SERIAL OUT SHIFT REGISTAR

A shift register is a type of digital circuit using a cascade of flip flops where the output of one flip-flop is connected to the input of the next. Shift registers are formed by the serial combination of D flip-flops, where each flip-flop in the arrangement holds single data bit. The serial arrangement permits the output of one flip-flop to act as input to other and this allows the shifting of data bit inside the register. There 4 types of shift registers **SISO**: **Serial-in Serial-out, SIPO**: **Serial-in Parallel-out, PISO**: **Parallel-in Serial-Out, PIPO**: **Parallel-in Parallel-out.** The Parallel-in to Serial-out shift register acts in the opposite way to the serial-in to parallel-out one above. The data

is loaded into the register in a parallel format in which all the data bits enter their inputs simultaneously, to the parallel input pins PA to PD of the register. The data is then read out sequentially in the normal shift-right mode from the register at Q representing the data present at PA to PD. This data is outputted one bit at a time on each clock cycle in a serial format. It is important to note that with this type of data register a clock pulse is not required to parallel load the register as it is already present, but four clock pulses are required to unload the data.
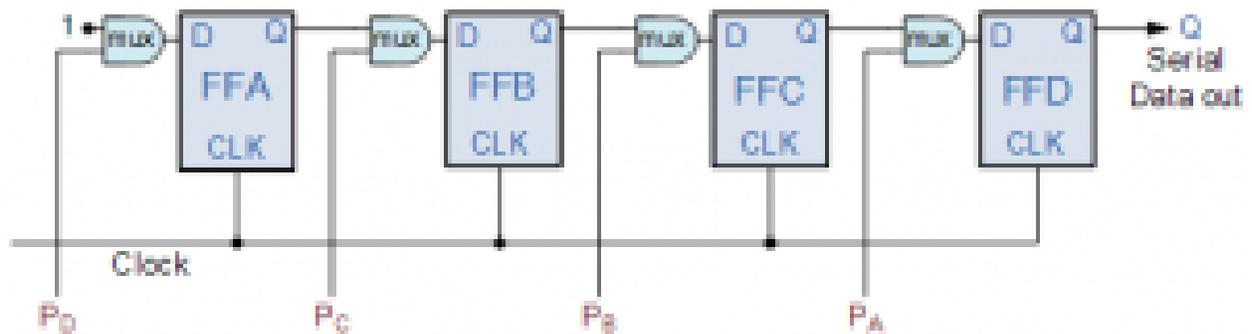
As this type of shift register converts parallel data, such as an 8-bit data word into serial format, it can be used to multiplex many different input lines into a single serial DATA stream which can be sent directly to a computer or transmitted over a communications line. Commonly available IC's include the 74HC166 8-bit Parallel-in/Serial-out Shift Registers.

Applications of Shift Registers

The different configurations of shift registers provide uses in various fields like a SISO shift register is used to generate time delay in digital circuits. A SIPO shift register can act as serial to parallel converter. In a similar way, PISO shift register changes parallel input into serial output thereby performing the job of a parallel to serial converter.

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