

POSITION DETERMINATION USING PULSE DELAYS

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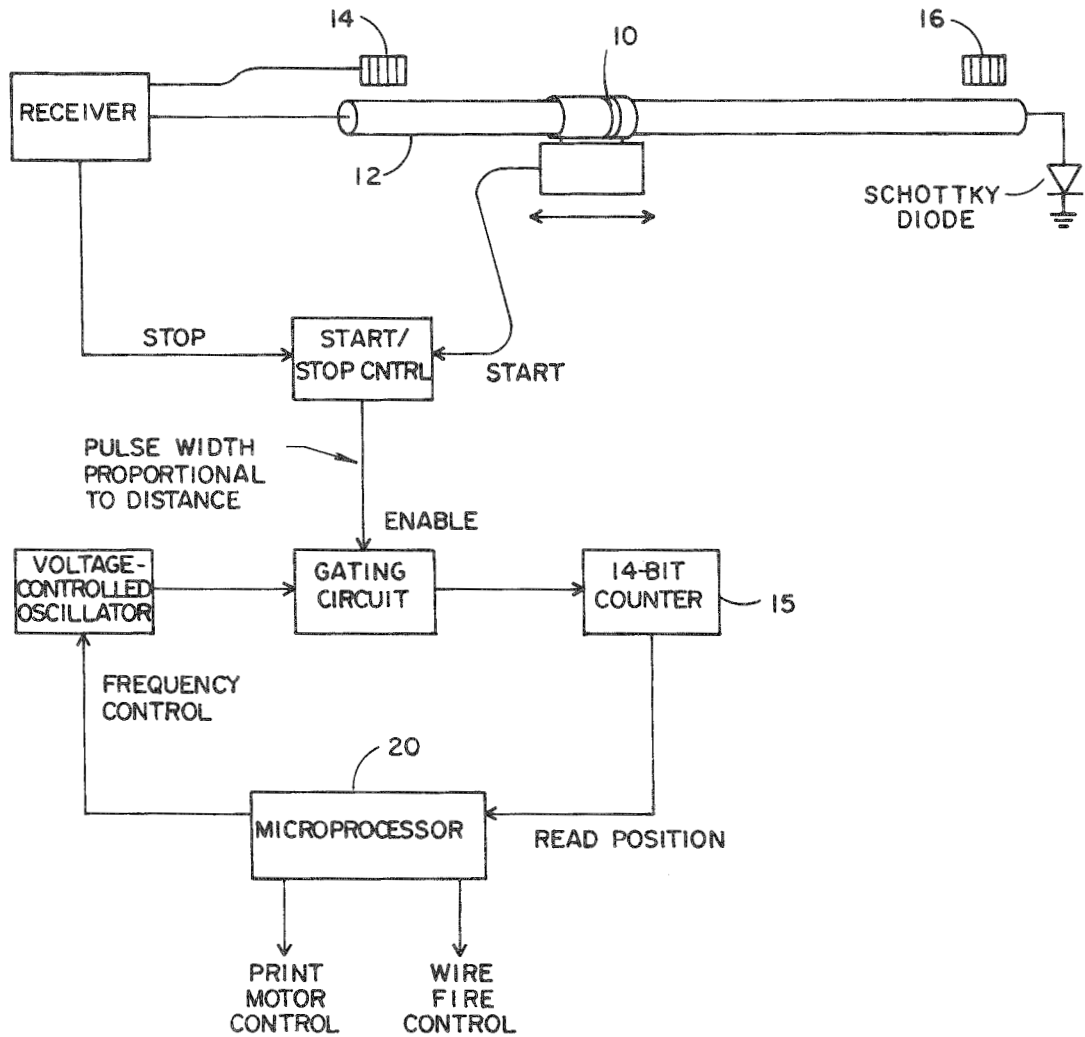


FIG. 1

This invention provides a means of accurately measuring distances in a very short period of time in order to know the velocity of the object and to implement variable character-per-inch densities.

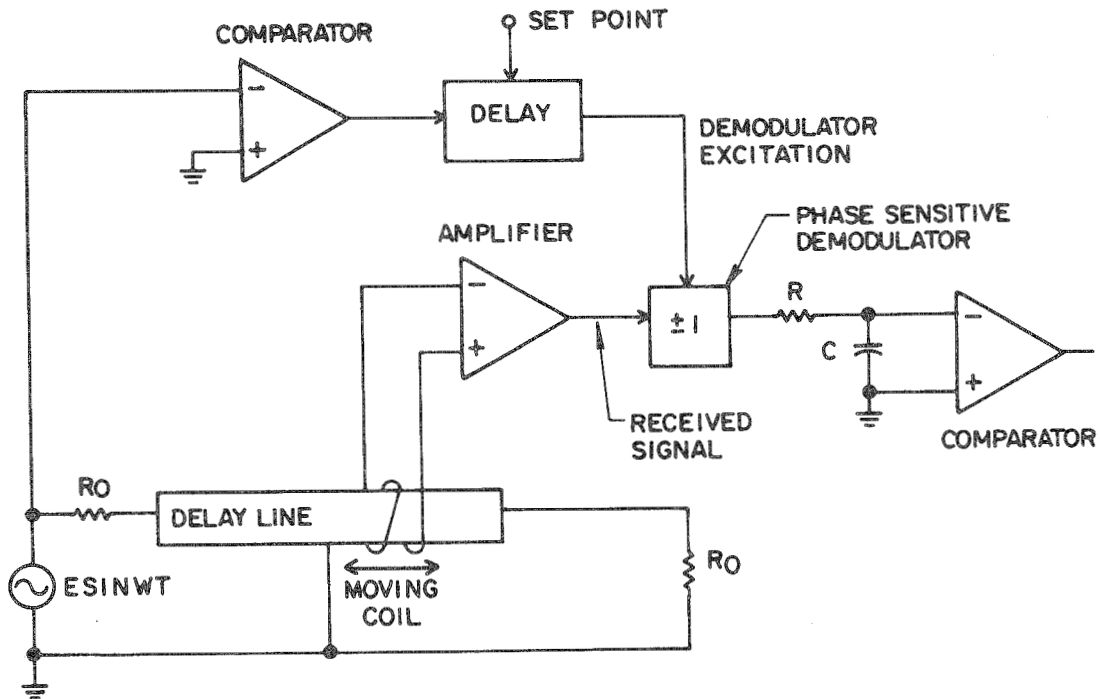


FIG. 2

The distance to an object can be determined by measuring the time delay of a pulse from its transmission to the reception of the pulse. A transmitter may be provided which produces a magnetic field that is transmitted to a receiving coil. The receiving coil blocks the electric field by using a conductor over it. As the magnetic field passes through the coil, it produces an electrical pulse that propagates to a receiver. Since the coil of the receiver is a very large inductor, the received pulse propagates very slowly. Typical pulse delays are about ten microseconds.

Referring to Fig. 1, the transmitting coil 10 consists of two turns of wire. A pulse of 1.5 amperes is applied for one microsecond. The receiver consists of a high frequency ferrite bar 12 with wire wrapped along its entire length. The coil is then put into an aluminum shell. The aluminum blocks all external electric fields, but allows the magnetic field of the transmitter through it. Since the transmitter is circular, no fixed distance from the transmitter to the receiving coil is needed. In other words, the induced voltage into the receiving coil remains the same, independent of any vertical movement of the transmitter. This allows for ease of manufacturing and wear of parts.

The accuracy of the measurement of the distance is controlled primarily by two factors. The first is the width of the wire used on

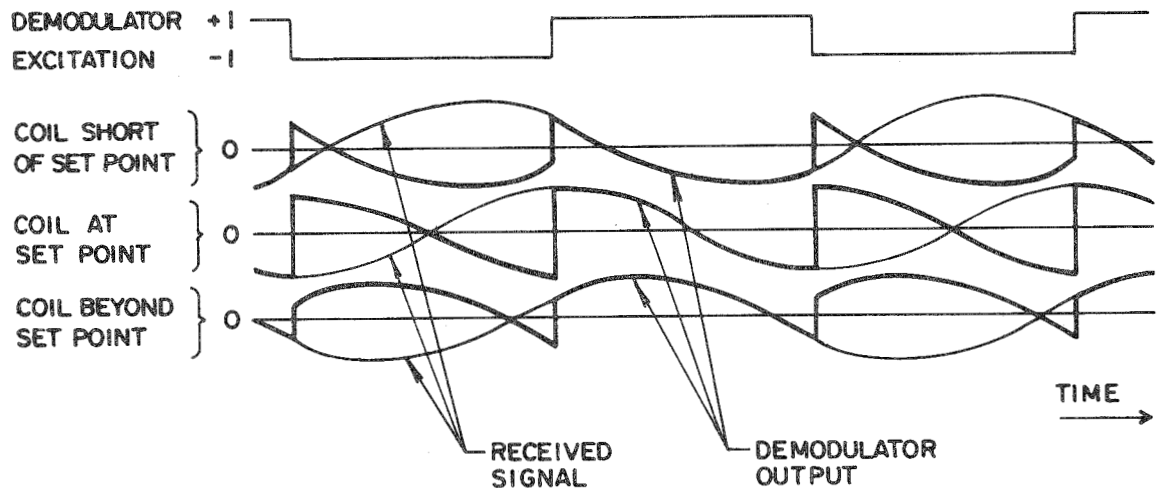


FIG. 3

the receiving coil. The desired resolution is 300 lines-per-inch. The coil is wound with a spacing of 400 turns-per-inch. To minimize fringe effects, the transmitter is located at a minimum of two wire diameters away from the receiving coil. The other factor that determines the accuracy is the measurement of the width of the received pulse.

Where the desired horizontal accuracy is 300 lines-per-inch, and the width of travel is about 15 inches, the number of points is

$$300 \text{ lines/inch} \times 15 \text{ inches} = 4500 \text{ lines.}$$

The delay through the coil is ten microseconds. Therefore, the oscillator to measure the pulse should be

$$4500/10^{-5} = 450 \text{ MHz.}$$

The digital counter is measuring the number of counts in ten microseconds will be 4500 counts.

Variable character-per-inch fonts are easily implemented by changing the frequency of the measuring clock. For example: At ten characters-per-inch and ten dots-per-character and 132 characters-per-line, there are 1320 dot options per 13.2 inches. If the oscillator is adjusted so that 1320 counts are measured in the ten-microsecond gating period, then each count represents one dot option. If the character-per-inch density is doubled to 20 characters-per-inch, then the oscillator is adjusted for a count of 2640. In reality, the counts are set for double the needed resolution.

To be able to calibrate the oscillator correctly, two sensors 14 and 16 are needed. They are located at either end of the receiving rod 12. One sensor is needed to adjust the zero offset of the counter. To minimize the effect of variations of coil length during manufacturing, one sensor is used to determine the maximum count value. If a microprocessor 20 is connected to this mechanism, then the microprocessor 20 can perform these adjustments automatically.

The microprocessor may also perform several additional functions. The distance between the end sensors is fixed and constant. Therefore, the velocity of the head can be calculated. This velocity information can help control the printhead motor. The other function that the microprocessor may perform is the readjustment of offset and maximum count value. These values can change slightly due to temperature variations, and the microprocessor 20 can readjust these values when it determines recalibration is needed. Another function the microprocessor can perform is to adjust the wire delays based on the velocity of the head. The amount of delay is inversely proportional to the velocity of the printhead. This allows for automatic compensation of wire-fire timings based on printhead velocity variations.

As mentioned before, the measurement of the distance is very fast. When a printhead is traveling at 400 characters-per-second, the position must be known every 63 microseconds. The sampling time is primarily limited by the inductance of the receiver. In the present scheme, this sample time is approximately limited to 40 microseconds.

An alternate circuit is shown in Fig. 2. Operation is somewhat different than in Fig. 1. In this circuit, an expected delay of a known set point position is programmed into the logic circuits. The demodulated slider signal will pass through zero only when the DELAY logic and the DELAY line signals are 90 degrees out of phase. Therefore, the system does not give a continuous position readout but can only indicate when a known position has been reached. This is done to avoid the quantization problem.

Fig. 3 shows how the phase sensitive demodulator works. This kind of a circuit has the ability to totally reject DC offset and any even harmonics which might be present on the input signal. Also, the resistor-capacitor (RC) network filters and attenuates any odd harmonics present. The RC network filters the resulting waveform, applying an essentially DC signal to the comparator which detects the polarity change which occurs when the desired position has been reached. When the coil is short of the set point, the net DC level out of the demodulator is negative so the comparator output is an up level. When the coil is exactly at the set point, the net DC content of the demodulator output is zero, and the comparator is indeterminate. When the coil passes the setpoint, the demodulator average level goes positive and the comparator output goes to a down level.