An Ultrasonic/Optical Pulse Sensor for Precise Distance Measurements

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Goals

- Develop an ultrasonic transit time distance sensor with an optical sync signal.
- Demonstrate a pulse cancellation technique for shaping transmitted and received ultrasonic pulses.
Ultrasonic Transmitter/Receiver Transducers

- Transducers are piezoelectric crystals (quartz, ceramic, piezofilm)
- Single or separate transmitter and receiver transducers may be used
- Typical Frequencies used for air transmission are 40 to 100 kHz
- Single pulse produces ringing because of crystal mechanical resonance

- Often a pulse train (4 to 20 cycles) is applied to transmitter to increase transmitted sound amplitude
Conventional Ultrasonic Echo Sensors

Speed of sound in Air @ 20 °C
343 Meter/sec
Typical US Echo Waveforms
Limitations of US Echo Sensors

- Sound intensity decreases rapidly with distance (inverse square) – limit is 5 to 20 meters under ideal conditions
- Sound (echo) is small for many objects (e.g. cloth)
- Focused beams increase signal strength (and distance) but aiming is a problem
- Wind and air currents deflect sound (refraction) causing signal dropout (often after 1-5 meters)
- Slow rise of reflected signal amplitude limits distance resolution to 2 to 10 wavelengths (2 to 8 cm @ 40kHz)
Optical Transmitter and Receiver
Optical Pulse Filtering

- Room illumination larger than optical sync pulses but dc or low frequency (mostly < 120 Hz)
- Sync pulse must be short, i.e., have only high frequency components
- Optical amplifier must have high pass filter
Ultrasonic Driver Circuit
Delayed Pulse Shaping Method

Transducer – single pulse

Driver

Transducer – dual pulse

Measured Transmitter Voltage
Ultrasonic Receiver Circuit

Optical signal amplifier is similar
Received Ultrasonic Signal Waveform
US Comparator and Transit Time Determination
Microcomputer Circuit
Ultrasonic/Optical Sensor Circuit boards

Ultrasonic Receiver (optical transmitter)

Ultrasonic transmitter (optical receiver)
Measured Precision
Application ---
An x-ray Dose Monitor Positioning Sensor
Suggested Applications

- Virtual Reality
  Locate relative position of hands and other objects
- Robots
  Locate position of robots or small vehicles in a room
- Machine motion
  Position of moving parts of a machine can be measured
References

Summary

- An ultrasonic pulse shaping technique based on two delayed transmitted pulses was described.
- An optical pulse technique for synchronizing ultrasonic pulses was described.
- The precision of the combined ultrasonic transit time distance sensor with optical pulse synchronization was demonstrated.

*Further information: designer@eesensors.com*