

design ideas

Edited by Bill Travis and Anne Watson Swager

Simple circuit prevents processor latch-up

Michal Kobylecki and Wojda Wlodzimierz, MK Design, Warsaw, Poland

The circuit in **Figure 1** uses a Dallas Semiconductor DS1820 one-wire digital thermometer in a multipoint temperature-measurement system. The DS1820 sensor allows distributed temperature measurement and uses only one wire for both data communication and the power supply. You can easily connect the one-wire interface to a μC (in this example, a PIC16C63). The application accommodates as many as 16 DS1820 sensors in a 100m-long network, dubbed MicroLAN by Dallas. Unfortunately, with such long wires near high-current power cables, inductively coupled high-voltage peaks can cause μC latch-up, because the transient-voltage suppressor, D_1 , cannot limit the line voltage below 9.8V. The interface circuit in **Figure 1** prevents such faults.

The sensor needs only one data line, but the interface circuit in **Figure 1** needs two CPU-control signals. The first is the inverted-output data line, connected to transistor Q_1 through resistor R_3 . If this line is at logic 1, the sensor's data line connects to ground. Otherwise, resistor R_4 pulls the sensor's data line to 5V. If the

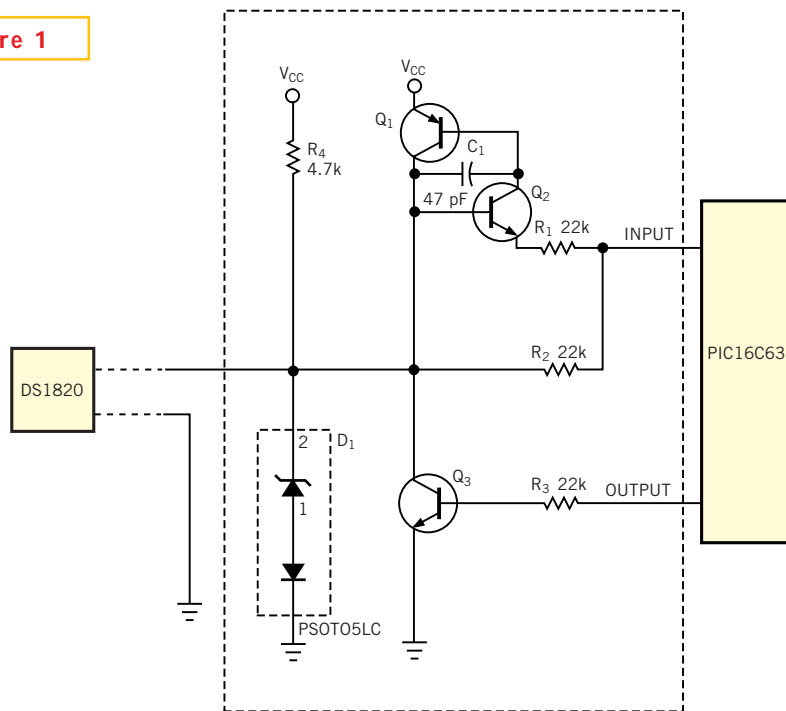
sensor transmits data, the μC captures the data via R_2 . If an overvoltage peak occurs, R_2 prevents μC latch-up by limiting the current to the μC pin. During the temperature conversion, the DS1820 needs an effective pullup circuit to provide an accurate conversion. Transistors Q_1 , Q_2 , and R_1 provide an effective pullup function, which the μC activates by grounding the input signal to Q_3 .

The pullup function also improves the rising edge of the transmitted data. If the sensor connects to the μC through a long wire, the capacitance of the line degrades the rising edge of the data signals, because

of the line-capacitance- R_4 time constant. The short pulse from the pullup circuit improves the signal's rising edge. It's obvious that, when the pullup circuit turns on, Q_3 must be off. However, the circuit protects itself against unintended signal corruption. If Q_3 is open, the power voltage does not connect to the sensor's data line. If you replace R_4 with a 1-mA current source, you can obtain effective data transmission with lengths as great as 500m (empirically verified). (DI #2317).

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Figure 1



A simple three-transistor circuit provides both latch-up protection and signal conditioning in this one-wire sensor/ μC interface.

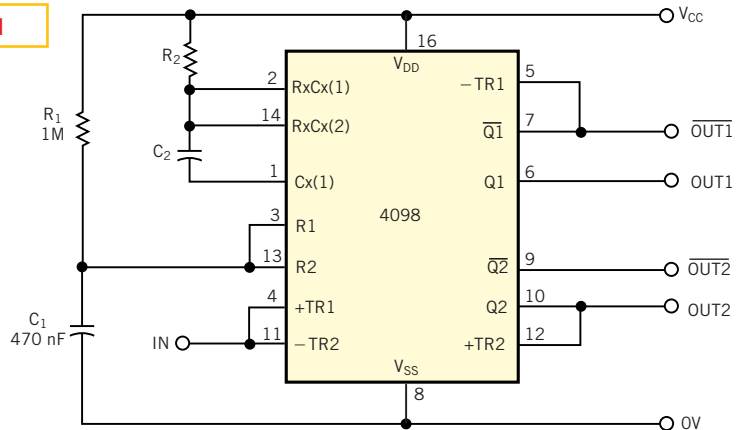
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Dual one-shot makes rising- and falling-edge detector

Santo Camonita, Catania, Italy

The design in **Figure 1** is an upgraded version of the circuit in a previous Design Idea (“Edge detector runs off single supply,” *EDN*, Dec 4, 1997, pg 140). It has fewer components, draws less current, and has higher input impedance. The circuit uses a 4098 dual monostable multivibrator with both sections connected. The circuit generates a pulse on both the rising and the falling edges of a signal. The duration of the output pulse is $T=0.5R_2C_2$. R_1 and C_1 provide power-on reset. The circuit has another advantage: It provides two independent true outputs (Q1, Pin 6 and Q2, Pin 10) and two independent complementary outputs ($\overline{Q1}$, Pin 7 and $\overline{Q2}$, Pin 9). (DI #2316).

Figure 1



A dual monostable multivibrator provides a convenient means of detecting a signal's rising and falling edges.

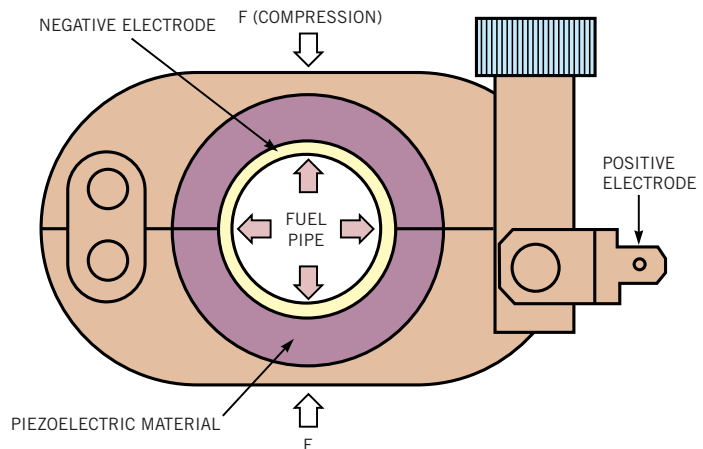
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Simple circuit measures diesel's rotations per minute

David Magliocco, CDPI, Scientrier, France

You may find it useful to measure a diesel engine's rotations per minute to accurately adjust the idling or to compare the motor's speed under hot and cold conditions, for example. Not all cars or trucks come with a tachometer. The scheme in **figures 1** and 2 allows you to measure rotations per minute with a DMM or an oscilloscope. In **Figure 1**, a piezoelectric sensor and an alligator clip, fastened directly to one of the four metal fuel pipes, detect the fuel-injection pulses. The piezo element generates a signal that connects to the signal-conditioning electronics in **Figure 2** through a coaxial cable. The circuit uses a charge amplifier.

Figure 1



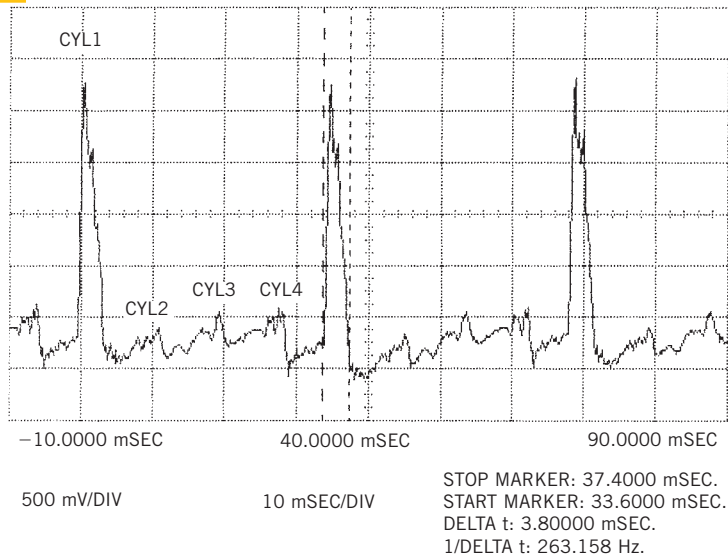
A piezoelectric sensor and an alligator clip provide an easy means of measuring the rpm of a diesel engine.

IC₁, a versatile ICL7611 chosen for its high input impedance, low bias current,

and reasonable power consumption, acts as an inverting current-to-voltage converter. C_1 integrates the high- dV/dt sensor signal. R_1 ensures that the output of IC_2 is high in the absence of a signal. You must use high values for R_2 , R_3 , and R_4 . The two diodes at the input protect the amplifier against overvoltage spikes. R_5 and R_6 create a virtual ground, so the circuit uses the full common-mode input range of IC_1 . **Figure 3** shows an oscilloscope trace of the amplifier's output. The three small peaks between the main pulses are parasitic and come from the injection pulses of the other cylinders. You can fine-tune the shape of the signal with C_1 . A value near 1 nF yields a smooth signal with low amplitude; a value lower than 100 pF gives a noisy signal with narrow pulses. The value for the trace in **Figure 3** is 100 pF.

From one vehicle to another, the amplitude of the signal can vary over an approximately 2-to-1 ratio. You can't use a fixed threshold to shape the signal; either the threshold is too low, and you shape the parasitic pulses, or it's too high, and you obtain nothing. Thus, the signal-conditioning method compares the peak value to the average value: Only the main peaks are higher than the average value. C_2 and R_7 ignore the dc component of the charge amplifier's output signal, and

Figure 3



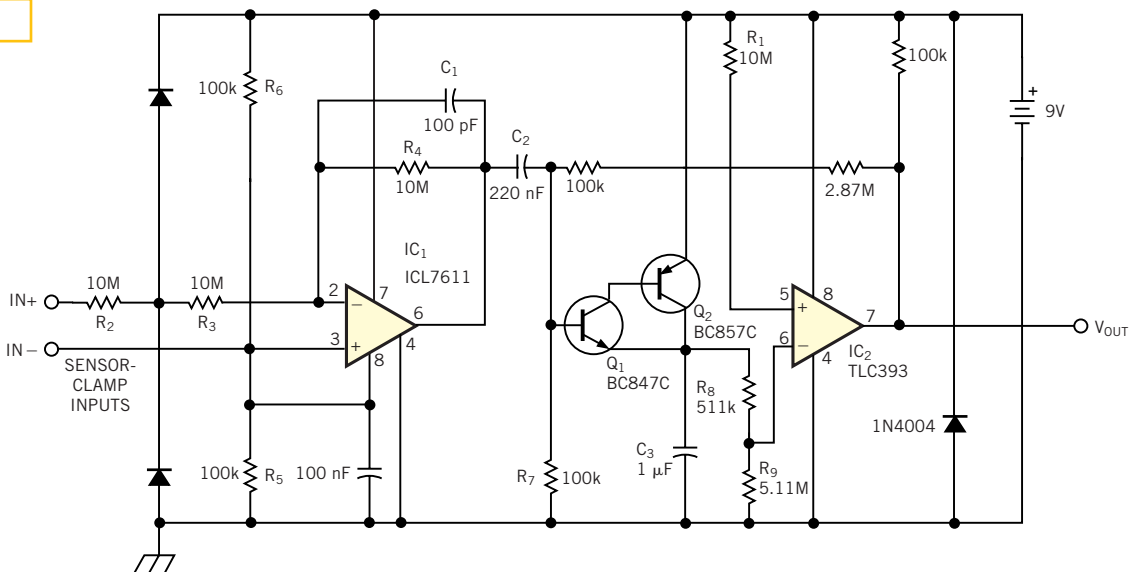
After conditioning, the main peaks in the sensor signal come from the cylinder under test; the secondary peaks, from the other cylinders.

transistors Q_1 and Q_2 charge C_3 to the peak value of that signal. You adjust R_8 and R_9 for a 90% ratio, which gives IC_2 , a low-power CMOS comparator, a large enough signal to shape. IC_2 delivers a logiclike signal that you can measure with a DMM (using the frequency/period

range, or the rotations-per-minute range on an automotive DMM), or with an oscilloscope. (DI #2318).

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Figure 2



A CMOS integrator and comparator condition the signal from Figure 1's sensor for interpretation by a DMM or an oscilloscope.

Fast, compact routine interfaces EEPROM to μC

Grzegorz Mazur, Institute of Computer Science, Nowowiejska, Poland

The code in Listing 1 provides the interface between any MCS-51 family of μCs and a 24C01a/2/4/8/16 I²C EEPROM. The interface is purely software-driven, so any μC port pins can control the EEPROM. This code is approximately two times smaller and approximately 20% faster than similar routines published by Atmel Corp (www.atmel.com). Careful coding of low-level routines and structural optimization pro-

duce the performance improvements.

The code is tuned for a -51 running at 12 MHz, but you can also use it at lower clock speeds. For higher speeds, you must adjust low-level routines by inserting “nop” instructions to match I²C-specified timings. The maximum data rate while reading memory content as 16-byte blocks is as high as 8.1 kbytes/sec. With minor modifications, you can use the routines to interface any I²C slave device

to a -51 μC .

Listing 1 is available for downloading from EDN’s Web site, www.ednmag.com. At the registered-user area, go into the “Software Center” to download the file from DI-SIG, #2329. (DI #2329).

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LISTING 1—I²C EEPROM- μC -INTERFACE ROUTINE

```

DEVADDR    equ    0a0h ; EEPROM I2C device address

scl bit    p3.4
sda bit    p3.5

; register usage
; r0 buf_ptr      ; pointer to internal RAM buffer for block transfers
; r1 count        ; byte count for block transfers
; r2 addr_lo      ; 2-byte memory address (up to 11 bits used)
; r3 addr_hi
; r4 scratch     ; used internally

write_block: ; write block from RAM to EEPROM
    acall send_full_address
    jc    fin
wblock:
    mov  a, @r0
    inc  r0
    acall shift_out
    jc  stop
    djnz r1, wblock
    sjmp stop

write_byte: ; write single byte from ACC to EEPROM
    push acc
    acall send_full_address
    pop  acc
    jc  fin
    acall shift_out
    sjmp stop

read_block: ; read block from EEPROM to RAM
            ; 342 + 102 * nbytes
    acall send_full_address
    jc  fin
    acall send_devaddr_rd
    jnc rbl
    ret

rblock:
    mov  a, #0ffh ; input data from SDA and send ACK
    acall shift
    setb sda
    mov  @r0, a
    inc  r0
rbl:  djnz r1, rblock ; 2 + 102 * nbytes
    acall shift_in_nak
    mov  @r0, a
    inc  r0
    sjmp end_read

read_random: ; read random byte from EEPROM to ACC
            ; 448 C
    acall send_full_address
    jc  fin

read_current: ; read next byte from active EEPROM page to ACC
            ; 224 C
    acall send_devaddr_rd
    jc  fin
    acall shift_in_nak

end_read:   ; 10 C
    clr  c
stop:      ; Send STOP
            ; 9 C
    clr  sda
    setb scl

nop
nop
nop
nop
setb  sda ; 4.7us after SCL
            ; SCL & SDA high.

ret

send_full_address: ; 220 C
    clr  c
    acall send_devaddr ; send device address
    jc  fin
    mov  a, r2
    sjmp soasc

send_devaddr_rd: ; 112 C
    setb c
send_devaddr: ; 111 C
            ; Send START
    setb scl

    jnb  scl, bbsy ; Check if bus available
    jnb  sda, bbsy
    clr  sda ; min. 4.7 us after SCL high
    mov  a, r3
    rlc  a
    orl  a, #DEVADDR
    clr  scl ; min. 4.0 us after SDA low
            ; SCL & SDA low.
            ; send device id, 3 msbits of address and rw bit (from c)
soasc:    ; 101 C
    acall shift_out
    jc  stop
fin:      ret

bbsy:    ; bus not available
    setb c
    ret

; Shift out/in a byte from/to A, msb first and ACK bit from/to C.
; SCL low, SDA high on entry and exit.

shift_in_nak: ; 96 C
    mov  a, #0ffh ; all ones - input data from SDA
    shift_out: ; 95 C
    setb c ; 9th bit - output NAK/release SDA fo
            ; 94 C
    mov  r4, #9 ; 8 bits + ack
shlop:   ; 3.5 us CLK low to data valid
    rlc  a ; move bit into C
    mov  sda, c
    setb scl
    nop
    mov  c, sda
    clr  scl ; min. 4 us
    djnz r4, shlop
    ret ; ACK in C

end

```

Photodetector sorts objects

Alan Erzinger, Harris Semiconductor, Palm Bay, FL

Most object-sensing systems have problems detecting the presence of an object. The system in **Figure 1** uses an oscillator to ease detection problems and allow sorting. The oscillator reduces power dissipation in the photodiode by operating the diode at 50% duty cycle. The oscillator also enables a 50% increase in the noise-filter time constant, and it functions as a time-base to allow object sorting. The oscillator chops the photodiode's bias. The signal the photodetector receives is a square wave; thus, a filter can remove optical noise. You normally need filtering when light shines through fans onto the optical detector. When required, you can place a bandpass filter in series with Q_3 's output.

The oscillator frequency has two limits: the response time of the phototransistor and the accuracy of the object-sensing system. Q_4 and Q_3 are connected in a cascode configuration to minimize the Miller effect in Q_4 . This connection reduces the pair's optical transient response to nanoseconds, thus allowing os-

illator periods of submicroseconds. Objects on a conveyor belt travel at relatively low speeds. You can calculate their expected time in front of the photodetector, t , from $t=d/s$, where s is the conveyor speed in feet per second and d is the object width in feet.

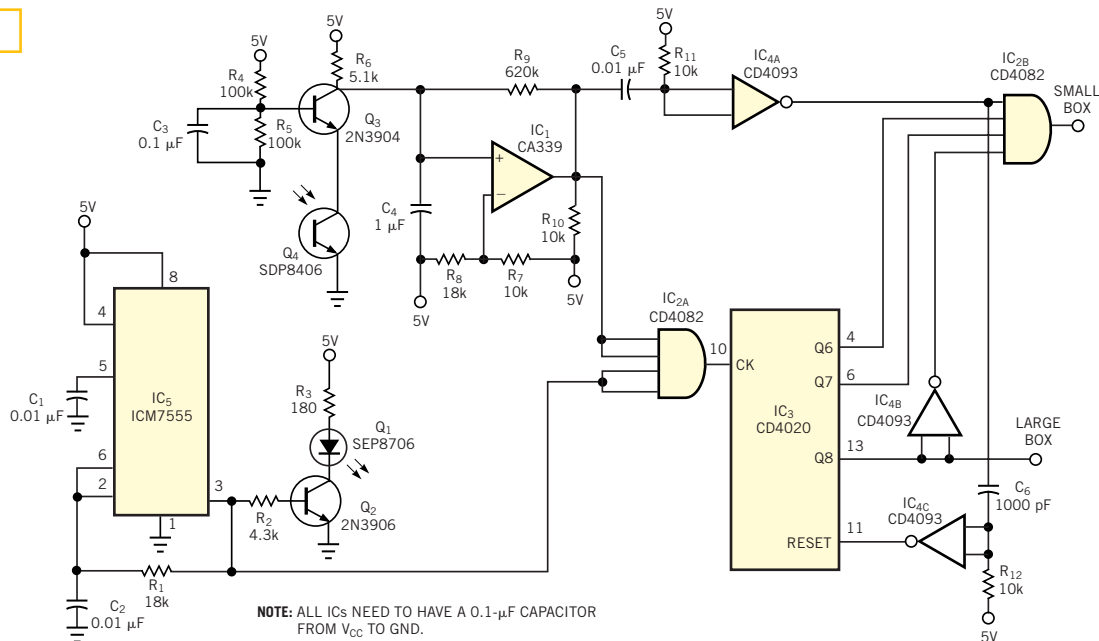
An object 2 in. long with a belt speed of 3.5 ft/sec blocks the detector for 47.6 msec. If the oscillator period is 250 μ sec, the object blocks the detector for approximately 200 periods, so each period equates to 0.5% length accuracy. The system senses two objects—one 2 in. long and one much longer—so 0.5% accuracy is more than adequate. When the detector is unblocked, the inverting input of IC_1 is dominant, and it keeps the output of IC_1 low. The low state prevents the oscillator's output from reaching the counter (IC_3). Blocking the detector allows C_3 to charge to 5V through R_6 , and the noninverting input of IC_1 becomes dominant, starting the count. When the detector is unblocked, the one-shot comprising R_{11} , C_5 , and IC_{4A} pulses IC_{2B} with

an end-of-object pulse. The one-shot's trailing edge triggers the counter-reset one-shot comprising R_{12} , C_6 , and IC_{4C} .

C_4 and R_6 form a nuisance filter that rejects short optical noise. The timing is such to enable a 2-in. object to clear the detector while both Q_6 and Q_7 are high. When the end-of-object pulse coincides with Q_6 high, Q_7 high, and Q_8 low, the output of IC_{2B} indicates a 2-in. object. This situation is the only time window that can indicate a 2-in. object. If the object is longer than 2 in., Q_8 goes high, indicating a large object. When the object clears the detector, the reset one-shot resets the counter for another cycle, and Q_3 quickly discharges C_4 in preparation for another cycle. With the component values shown, the system can sense and discriminate between objects as short as 2 in., separated by 0.1 in. (DI #2325).

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Figure 1

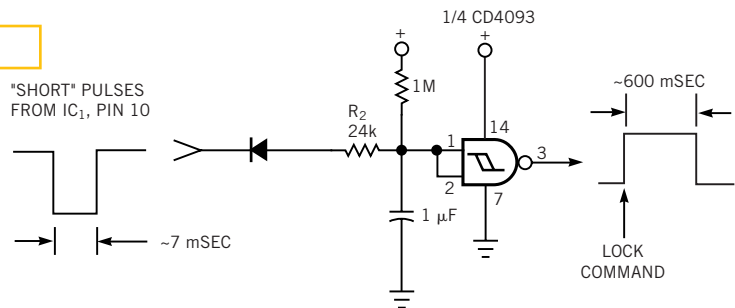


An oscillator circuit allows a photodetector to both count and sort objects according to size.

quence would also be secure; you can implement a shorter code by simply taking the unlock pulse from a lower count on IC₆. IC₆'s output returns low after 10 sec when T₂ resets. If desired, you can generate a lock command, which need not be secure, by adding the simple circuit in **Figure 3**. (DI #2327).

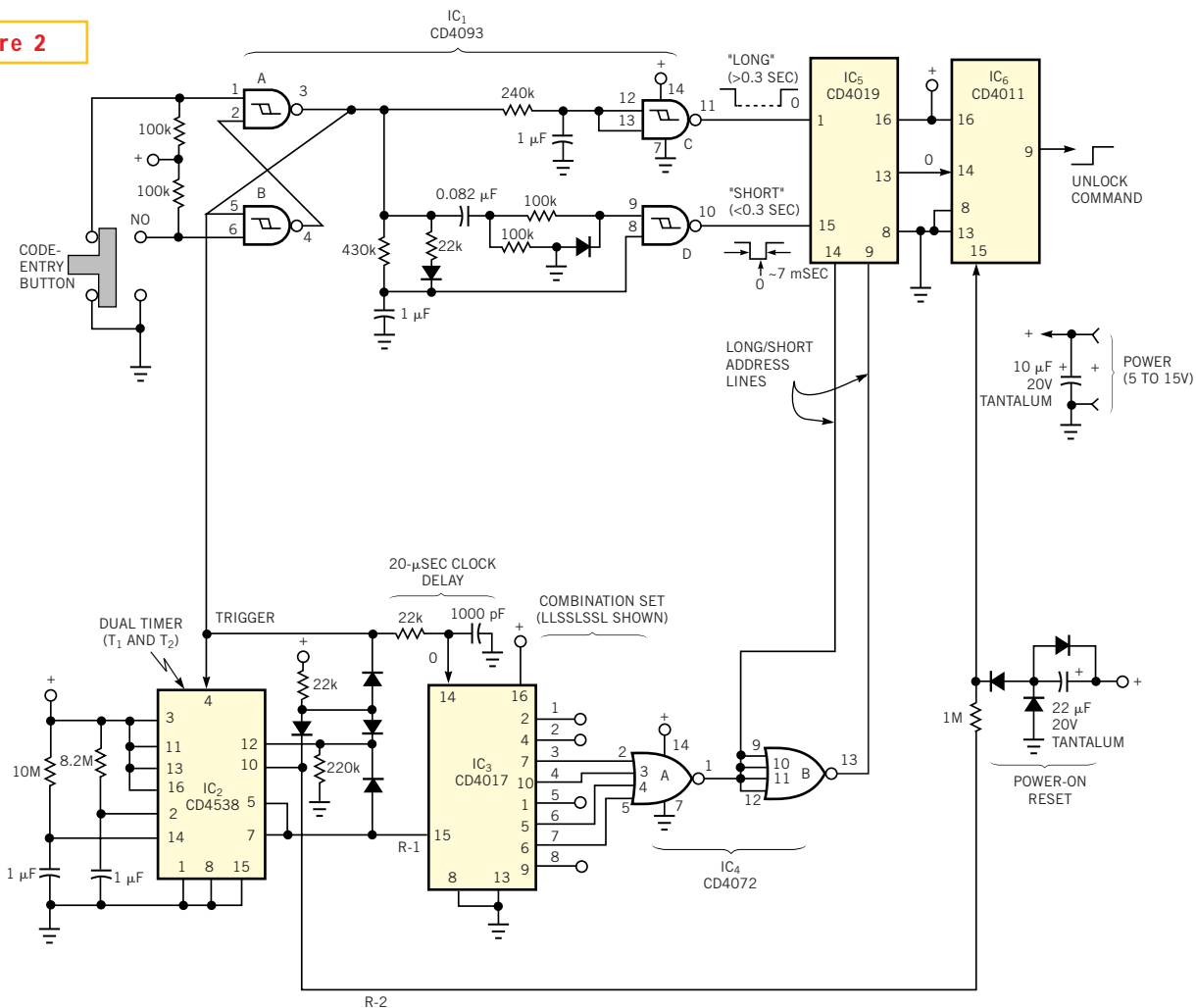
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Figure 3



You can generate a lock command with this additional circuit by rapidly entering four or more short pulses.

Figure 2



NOTE: ALL DIODES=1N4148.

You program your combination by hard-wiring the IC₃-IC₄ output-to-input connections, LLSLSSSL, where L and S are long and short inputs, respectively, in this example.

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