

GENERAL DESCRIPTION

The CMOS MC145016 is an advanced smoke detector component containing sophisticated very-low-power analog and digital circuitry. The IC is used with an infrared photoelectric chamber. Detection is accomplished by sensing scattered light from minute smoke particles or other aerosols. When detection occurs, a pulsating alarm is sounded via on-chip push-pull drivers and an external piezoelectric transducer.

The variable-gain photo amplifier allows direct interface to IR detectors (photodiodes). One external capacitor C1 determines the gain settings. Low gain is selected by the IC during most of the standby state. Medium gain is selected during a local-smoke condition. High gain is used during push-button test. During standby, the special monitor circuit which periodically checks for degraded chamber sensitivity uses high gain also. The I/O pin, in combination with Vss, can be used to interconnect up to 40 units for common signaling. An on-chip current sink provides noise immunity when the I/O is an input. A local-smoke condition activates the short-circuit-protected I/O driver, thereby signaling remote smoke to the interconnected units. Additionally, the I/O pin can be used to activate escape lights, enable auxiliary or remote alarms, and/or initiate auto-dialers.

While in standby, the low-supply detection circuitry conducts periodic checks using a pulsed load current from the LED pin. The trip point is set using two external resistors. The supply for the MC145016 can be a 9.0 V battery.

A visible LED flash accompanying a pulsating audible alarm indicates a local smoke condition. A pulsating audible alarm with no LED flash indicates a remote smoke condition. A beep or chirp occurring virtually simultaneously with an LED flash indicates a low-supply condition. A beep or chirp occurring halfway between LED flashes indicates degraded chamber sensitivity. A low-supply condition does not affect the smoke detection capability if VDD = 6.0 V. Therefore, the low-supply condition and degraded chamber sensitivity can be further distinguished by performing a push-button (chamber) test.

MC145016

PHOTOELECTRIC SMOKE DETECTOR IC WITH I/O AND TEMPORAL PATTERN HORN DRIVER



N SUFFIX
PLASTIC PACKAGE
CASE 648-08



D SUFFIX
SOIC PACKAGE
CASE 751B-05



DW SUFFIX
SOIC PACKAGE
CASE 751G-04

NC	1	16	Test
C	2	15	NC
Detect	3	14	Vss
Strobe	4	13	R1
VDD	5	12	Osc
IREDD	6	11	LED
I/O	7	10	Feedback
Brass	8	9	Silver

FEATURES

- Operating Voltage Range: 6.0 V to 12 V, Average Supply Current: 8 μ A
- Operating Temperature Range: -10 to 60°C
- I/O Pin Allows Units to be Interconnected for Common Signalling
- Power-On Reset Places IC in Standby Mode (Non-Alarm State)
- Electrostatic Discharge (ESD) and Latch Up Protection Circuitry on All Pins
- Chip Complexity: 1600 FETs, 9 NPNs, 21 Resistors, and 13 Capacitors
- Ideal for battery-powered applications

ORDERING INFORMATION

Device	Temp. Range	Package
MC145016N	-55 to +125°C	16 Lead Plastic Dip
MC145016D		16 Lead SOIC

BLOCK DIAGRAM

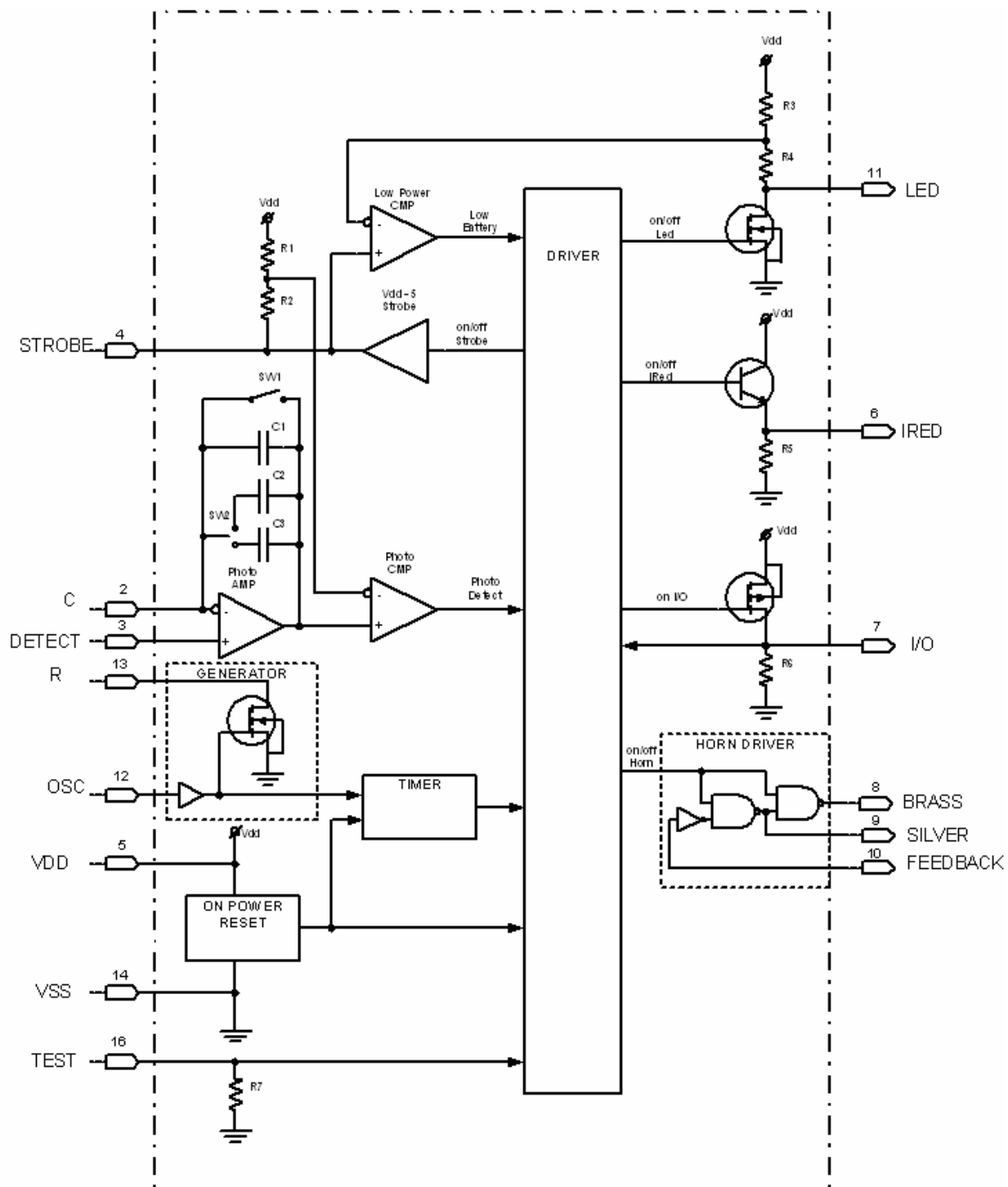


Figure 1. Block Diagram

Table 1

MAXIMUM RATINGS* (Voltages referenced to V_{SS})

Symbol	Parameter	Pin/Pad No	Value		Unit
			min	max	
V_{DD}	DC Supply Voltage	4	-0.5	+12	V
	DC Input Voltage C, DETECT	1, 2	-0.25	$V_{DD} + 0.25$	
V_{IN}	OSC	12	-0.25	$V_{DD} + 0.25$	
	I/O	6	-0.25	$V_{DD} + 10$	V
	FEEDBACK	9	-15	+25	
	TEST	14	-1.0	$V_{DD} + 0.25$	
I_{IN}	DC Input Current, per Pin	-	-10	+10	mA
I_{OUT}	DC Output Current, per Pin	-	-25	+25	mA
I_{DD}	DC Supply Current, V_{DD} and V_{SS} Pins	4, 13	-150	+25	mA
P_D	Power Dissipation in Still Air, 5 Seconds	-		1200**	mW
	Continuous			350***	
T_{STG}	Storage Temperature	-	-55	+125	°C
T_L	Lead Temperature, 1 mm from Case for 10 Sec	-	-	+260	°C

*Maximum Ratings are those values beyond which damage to the device may occur. Functional operation should be restricted to the limits in the Electrical Characteristics tables.

** Derating: -12 mW/°C from 25° to 60°C.

*** Derating: -3.5 mW/°C from 25° to 60°C.

This device contains protection circuitry to guard against damage due to high static voltages or electric fields. However, precautions must be taken to avoid applications of any voltage higher than maximum rated voltages to this high-impedance circuit. For proper operation, V_{IN} and V_{OUT} should be constrained to the range $V_{SS} = (V_{IN} \text{ or } V_{OUT}) = V_{DD}$ except for the I/O, which can exceed V_{DD} , and the Test input, which can go below V_{SS} . Unused inputs must always be tied to an appropriate logic voltage level (e.g., either V_{SS} or V_{DD}). Unused outputs and/or an unused I/O must be left open.

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Table 2

ELECTRICAL CHARACTERISTICS (Voltages Referenced to V_{SS}, T_A = -10 to 60°C Unless Otherwise Indicated)

Symbol	Parameter	Pin/ Pad No	V _{DD} , V	Min	Typ	Max	Unit	Test Condition
V _{DD}	Power Supply Voltage Range	4		6	9	12	V	
I _{DD1}	Average Operating Supply Current	4	12		4	12	uA	Standby Configured per Figure 8
I _{DD2}	Peak Supply Current	4	12		0.6	2	mA	During Strobe On, IRED Off Configured per Figure 8
					1.7	3	mA	During Strobe On, IRED On Configured per Figure 8
V _{IL} I/O	Low-Level Input Voltage	6	9			1.5	V	
V _{IL} FEEDBACK		9				2.7		
V _{IL} TEST		14				2.7		
V _{IH} I/O	High-Level Input Voltage	6	9	3.2			V	
V _{IH} FEEDBACK		9		6.3				
V _{IH} TEST		14		6.3				
I _{IN}	Input Current OSC, DETECT, FEEDBACK	11 2 9	12	-100		100	nA	V _{IN} = V _{SS} or V _{DD}
I _{IL}	Low-Level Input Current, TEST	14	12			-1	uA	V _{IN} = V _{SS}
I _{IH}	Pull-Down Current TEST, I/O	14 6	9	0.5		10	uA	V _{IN} = V _{DD}
			9	25		100		V _{IN} = V _{DD} No Local Smoke,
			12	-		140		V _{IN} = 17 V No Local Smoke,
V _{OL}	Low-Level Output Voltage LED, SILVER, BRASS	10 8 7	6.5			0.6 1.0	V	I _{OUT} = 10 mA I _{OUT} = 16 mA
V _{OH}	High-Level Output Voltage, SILVER, BRASS	8 7	6.5	5.5			V	I _{OUT} = -16 mA
V _{OUT}	Output Voltage STROBE	3	9	V _{DD} -0.1			V	Inactive, I _{OUT} = -1 uA
				V _{DD} -4.4		V _{DD} -5.6		Active, I _{OUT} = 0.1...0.5 mA
	Output Voltage IRED	5	9			0.1	V	Inactive I _{OUT} = 1 uA
				2.25 *		3.75 *		Active, I _{OUT} = 6 mA
I _{OH}	High-Level Output Current I/O	6	6.5	-4			mA	Local Smoke, V _{OUT} = 4.5V
			12			-16		Local Smoke, V _{OUT} = V _{SS} (Short Circuit Current)
I _{OZ}	Off-State Output Leakage Current LED	10	12	-1		+1	uA	V _{OUT} = V _{SS} or V _{DD}
V _{IC}	Common Mode Voltage Range, C, Detect	1 2		V _{DD} -4		V _{DD} -2	V	Local Smoke, Pushbutton Test, or Chamber Sensitivity Test.
V _{REF}	Smoke Comparator Reference Voltage, Internal			V _{DD} -3.08		V _{DD} -3.92	V	Local Smoke, Pushbutton Test, or Chamber Sensitivity Test

* T_A = 25°C only.

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Table 3

AC ELECTRICAL CHARACTERISTICS

(Reference Timing Diagram Figure 3, 4, 5, 6, and Figure 7)

(TA = 25°C, VDD = 9.0 V, Component Values from Figure 8: R1 = 330 KΩ, C3 = 1500.0 pF, R2 = 10 MΩ).

No	Symbol	Parameter	Clocks	Min	Typ	Max	Unit	Test Condition.
1	1/F _{OSC}	Oscillator Period	1	9.5	10	11.5	ms	Free-Running Sawtooth Measured at Pin 11.
2	t _{LED}	LED Pulse Period	4096	38.9	41	47.1	s	No Local Smoke,
3			Extinguished					Remote Smoke, but No Local Smoke
4			64	0.60	0.64	0.74	s	Local Smoke or Push-button Test
5	t _w (LED, STROBE)	LED Pulse Width and Strobe Pulse Width	1	9.5	10	11.5	ms	Smoke Test
6			1024	9.67	10	11.83	s	
7	t _{IRED}	IRED Pulse Period	4096	38.9	41	47.1	s	Chamber Sensitivity Test, without Local Smoke
8			32	0.302	0.32	0.370	s	Push-button Test
9	t _w (IRED)	IRED Pulse Width	T _f *	94	100	116	us	
10	t _r (IRED)	IRED Rise Time		-		30	us	
	t _f (IRED)	IRED Fall Time		-		200	us	
11	t _{mod}	Silver and Brass Modulation Period	32	2.97	3.2	3.63	ms	Remote or Local Smoke
12	t _{on} /t _{mod}	Silver and Brass Filling Period	24/8	73	75	77	%	Remote or Local Smoke
13	t _{CH}	Silver and Brass Chirp Pulse Period	4096	38.9	41	47.1	s	Low Supply or Degraded Chamber Sensitivity
14	t _w (CH)	Silver and Brass Chirp Pulse Width	1	9.5	10	11.5	ms	
15	t _{RR}	Rising Edge on I/O to Smoke Alarm Response Time	-	-		800	ms	Remote Smoke, No Local Smoke
16	t _{stb}	Strobe Out Pulse Period	1024	9.67	10	11.83	s	Smoke Test.
17			4096	38.9	41	47.1	s	Chamber Sensitivity Test, without Local Smoke
18			4096	38.9	41	47.1	s	Low Supply Test, without Local Smoke
19			32	0.302	0.32	0.370	s	Pushbutton Test

Oscillator period T (= T_r + T_f) is determined by the external components R1, R2, and C3 where T_r = (0.6931) R₂ C₃ and T_f = (0.6931) R₁ C₃. The other timing characteristics are some multiple of the oscillator timing as shown in the table.

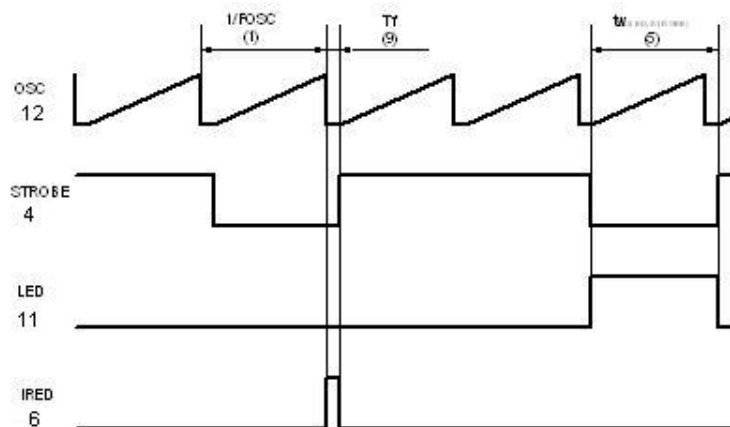


Figure 2. Timing Diagram of OSC (pin 12)

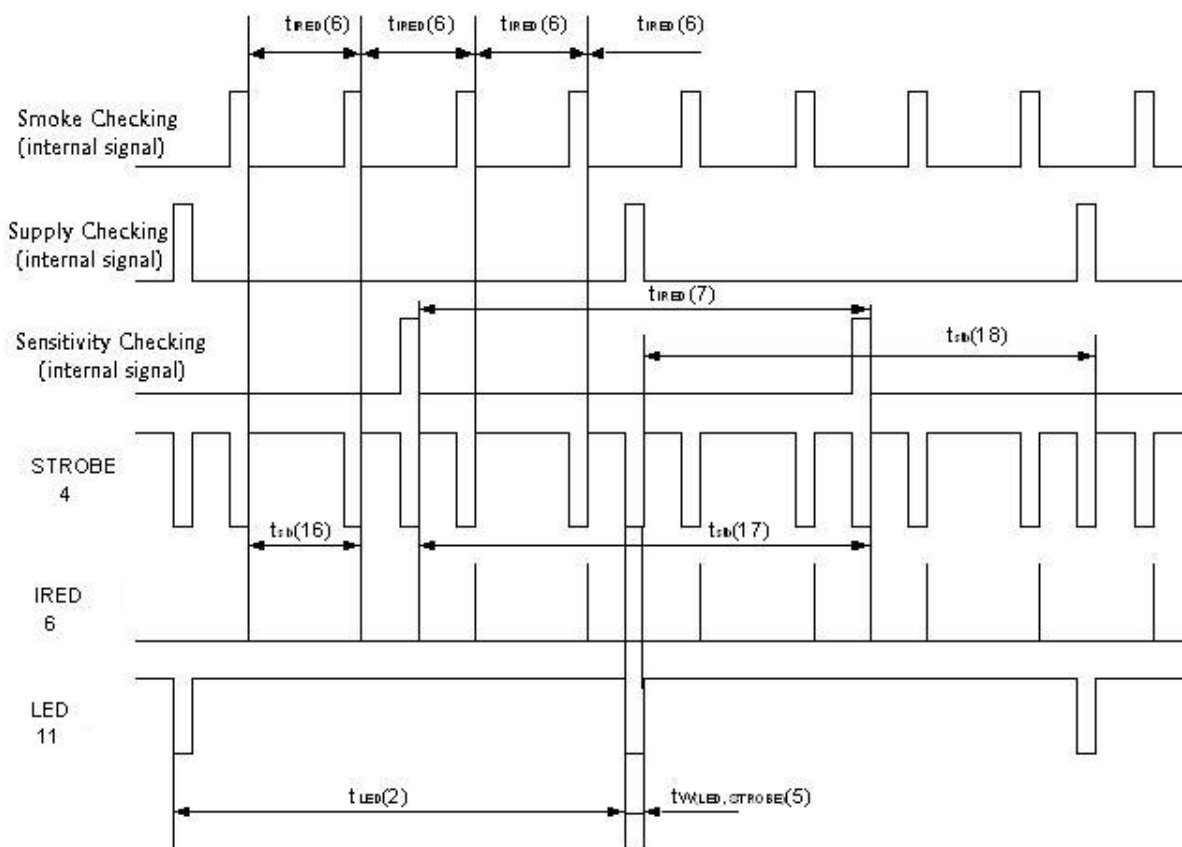


Figure 3. Typical Standby Timing (No local smoke, normal supply and normal sensitivity)

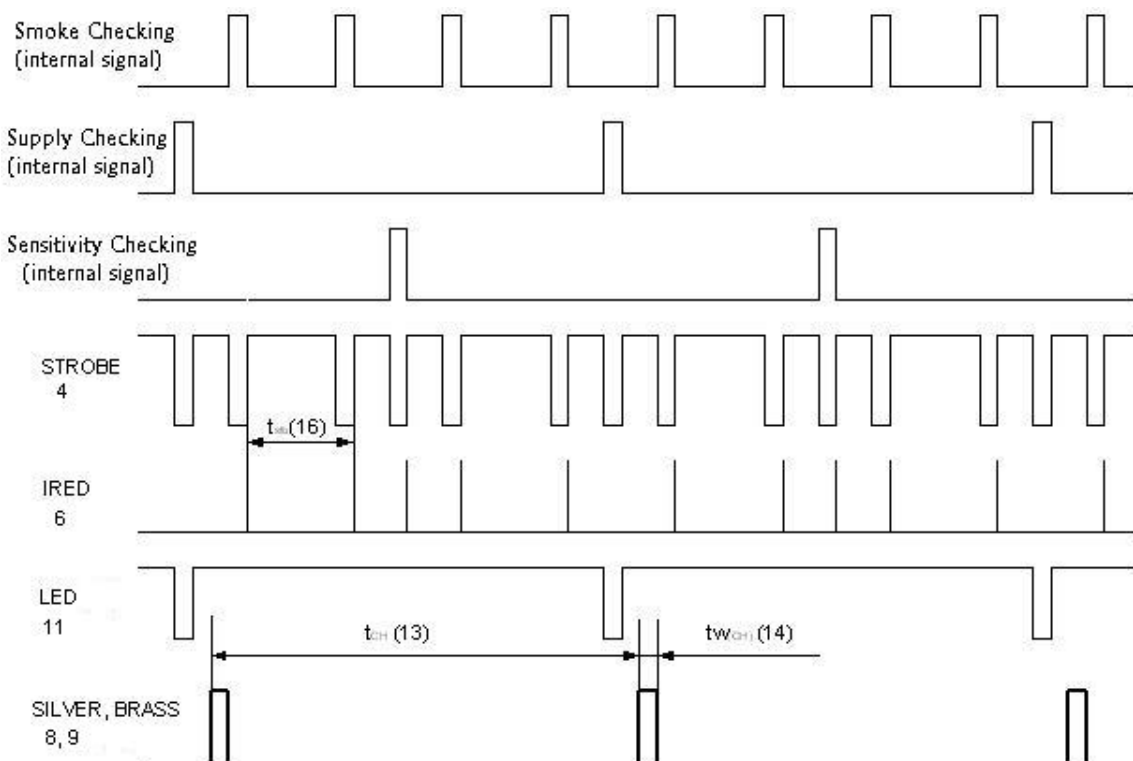


Figure 4 Typical Standby Timing (No local smoke, normal sensitivity but low supply)

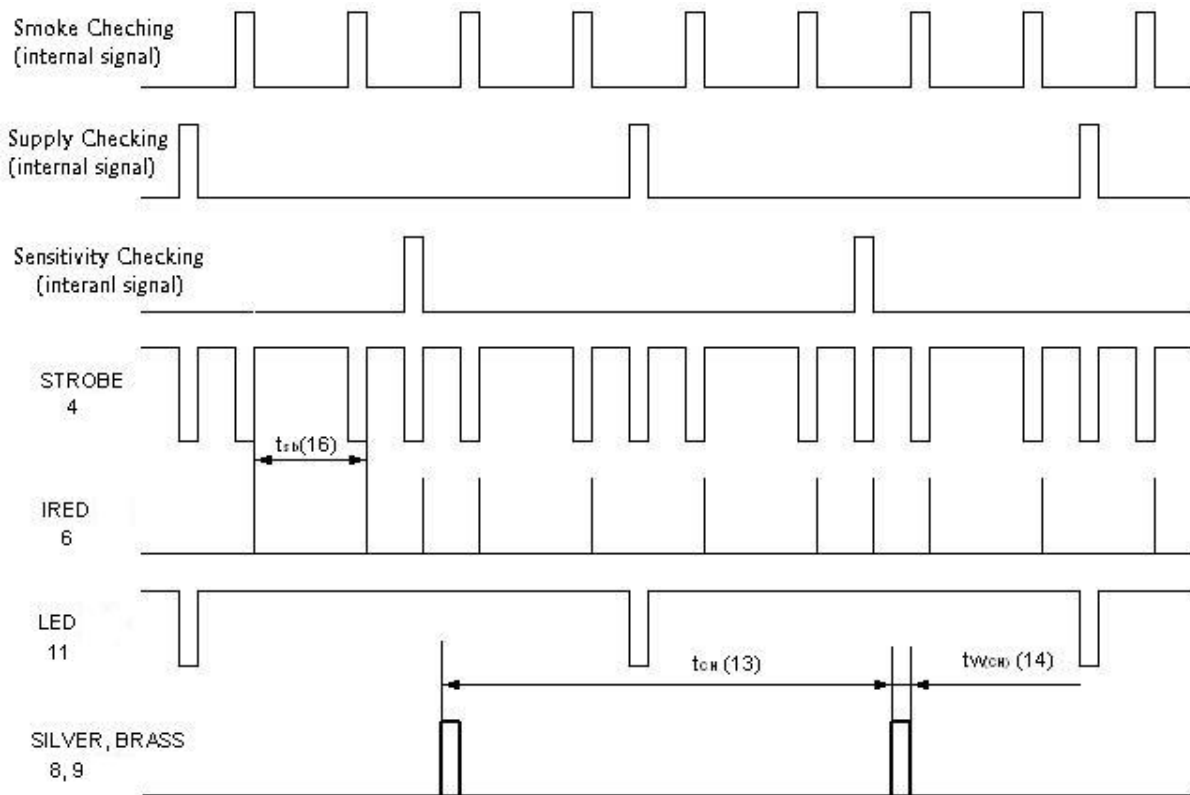


Figure 5. Typical Standby Timing (No local smoke, normal supply but low sensitivity)

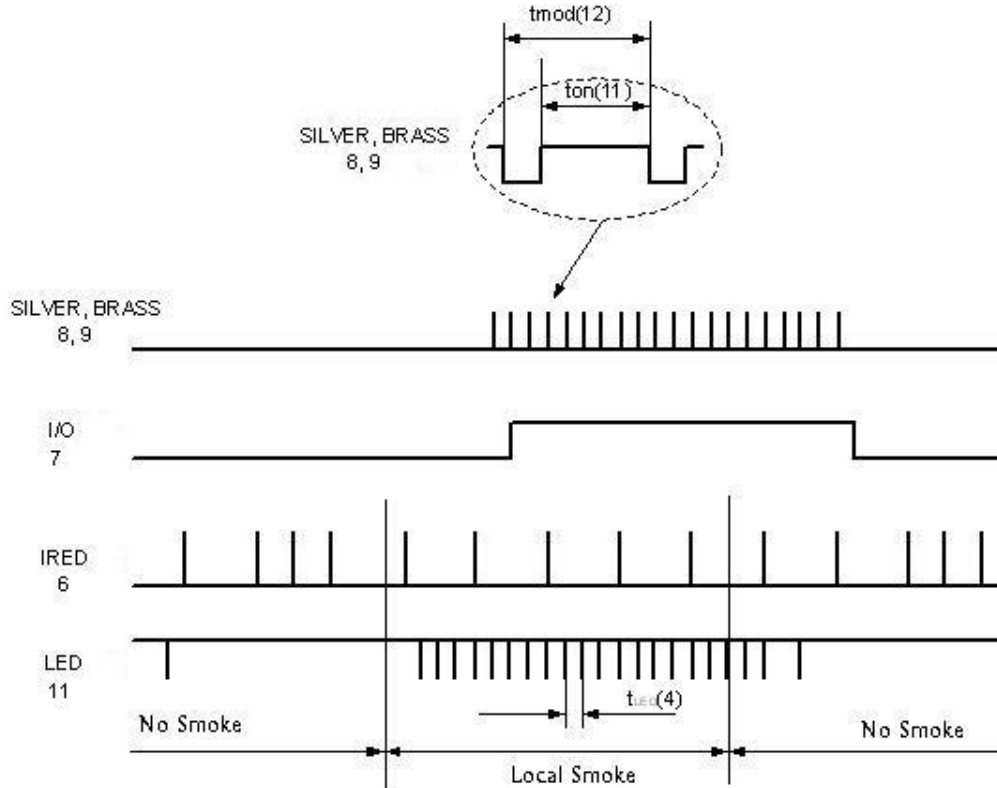


Figure 6. Typical Local Smoke Timing

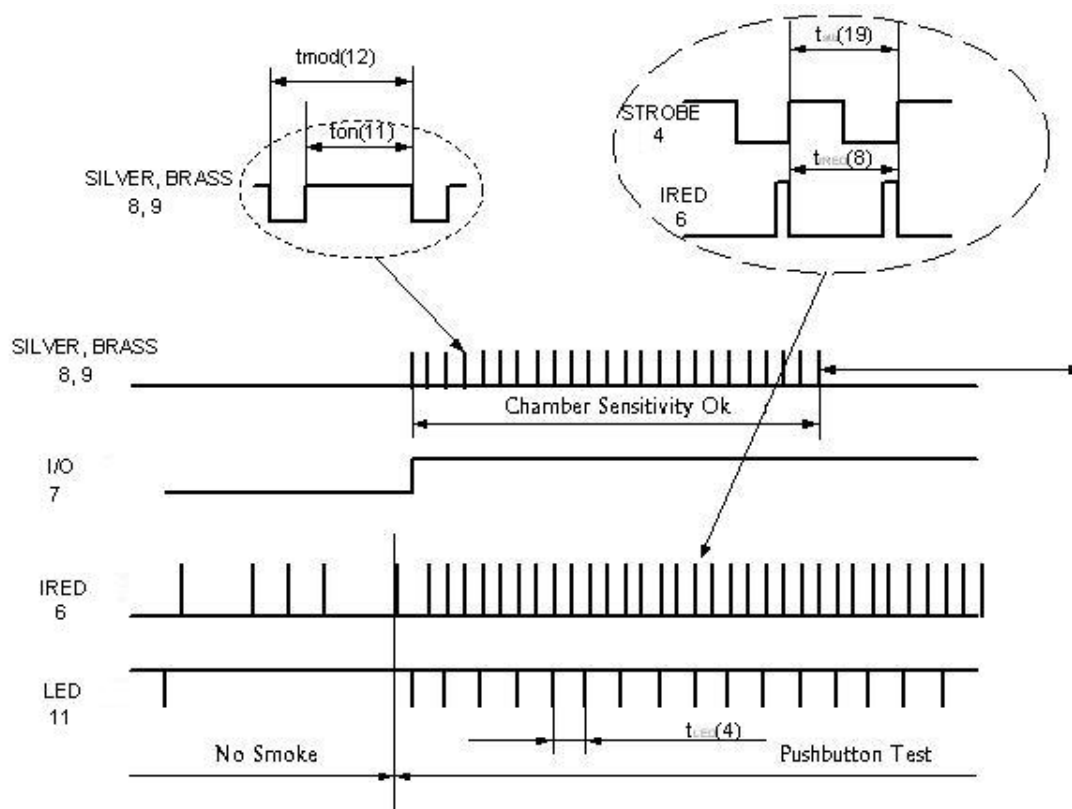


Figure 7. Pushbutton Test Timing

APPLICATION CIRCUIT

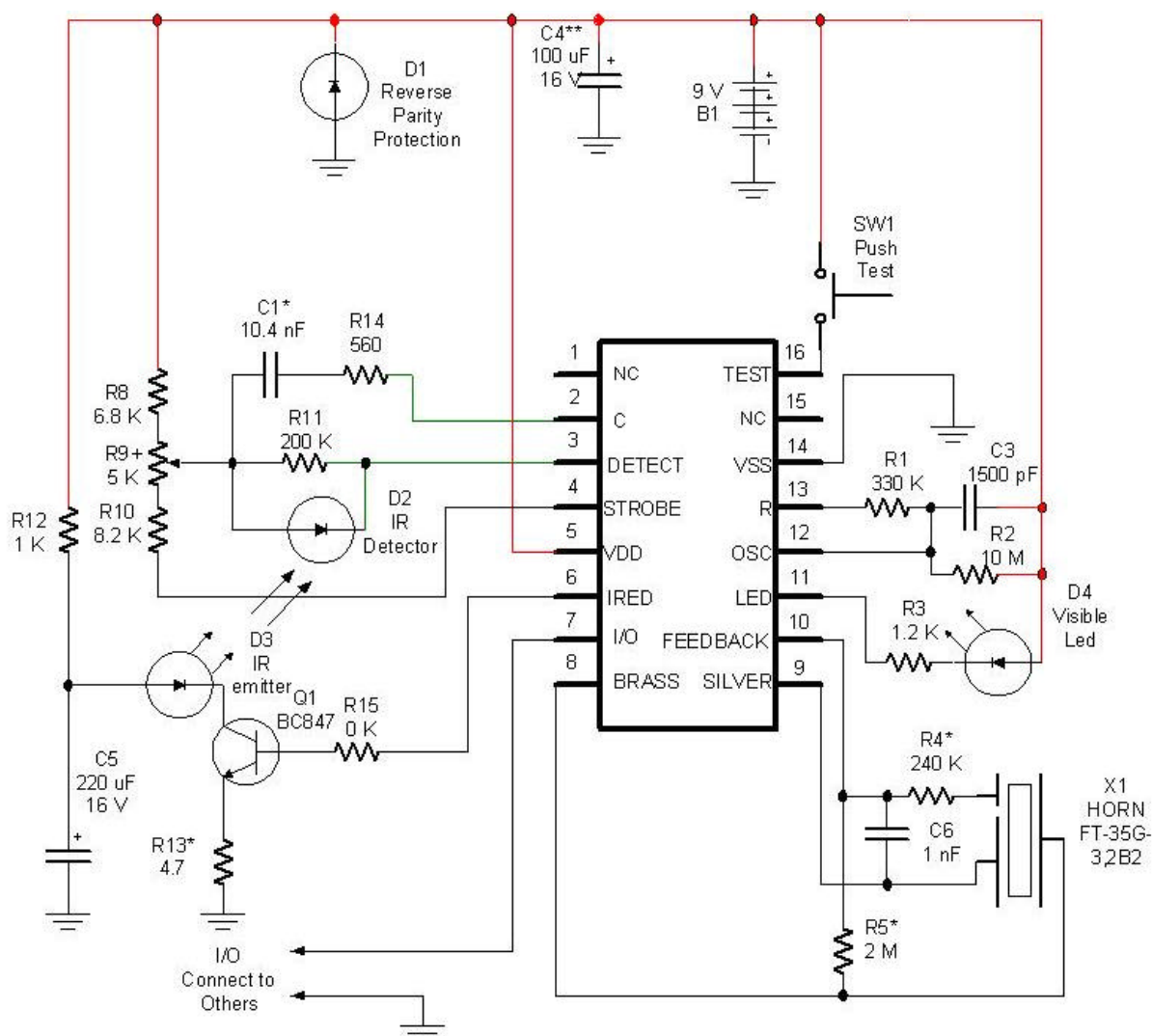


Figure 8. Typical Battery-Powered Application

- Values for R4, R5, and C6 may differ depending on type of piezoelectric horn used.
- R13 are used for coarse sensitivity adjustment. Typical value is shown.
- *C1 connected to this pin determines the gain of the on-chip photo amplifier
- †R9 is for fine sensitivity adjustment (optional). If fixed resistors are used, R8 = 12K, R10 = 5.6... 10K, and R9 is eliminated. When R9 is used, noise pickup is increased due to antenna effects. Shielding may be required.
- **C4 should be 22 μ F if B1 is a carbon battery. C4 could be reduced to 1 μ F when an alkaline battery is used.
- Leads 1, 2, and 3 and their associated traces must be kept as short as possible. Lead 2 must be as short as possible and shielded. In ideal case R9 is eliminated.

Table 4

EXTERNAL COMPONENTS INFORMATION

Marking	Quantity	Value	Unit measure
Resistors	13		
R1		330	KO (1e+3)
R2		10	MO (1e+6)
R3		1.2	KO (1e+3)
R4		240	KO (1e+3)
R5		2	MO (1e+6)
R8		6.8	KO (1e+3)
R9		5	KO (1e+3)
R10		8.2	KO (1e+3)
R11		200	KO (1e+3)
R12		1	KO (1e+3)
R13		4.7	O
R14		560	O
R15		0	KO (1e+3)
Capacitors	5		
C1		10.4	nF (1e-9)
C3		1.5	nF (1e-9)
C4		100	uF (1e-6)
C5		220	uF (1e-6)
C6		1	nF (1e-9)
Diodes	4		
D1			
D2			
D3			
D4			
Transistors	1		
Q1		BC847	
Piezoceramics Sound Elements	1		
X1		FT-35G-3,2B2	
Switch	1		
SW1			

PIN DESCRIPTIONS

(NC) – No Connection (Pin 1)

C (Pin 2)

A capacitor connected to this pin as shown in Figure 8 determines the gain of the on-chip photo amplifier during pushbutton test and chamber sensitivity test (high gain). The capacitor value is chosen such that the alarm is tripped from background reflections in the chamber during pushbutton test. $A_v = 1 + (C1/2)$ where C1 is in pF.

CAUTION: The value of the closed-loop gain should not exceed 10,000.

Gain in a stand by mode - $A_v2 = 1 + C1/34$, where C1 is in pF.

Resistor R14 must be installed in series with C1. $R14 \sim [1/(12vC1)] - 680$ where R14 is in ohms and C1 is in farads. This gain increases about 10% during the IRED pulse, after two consecutive local smoke detections.

DETECT (Pin 3)

The Detect input must be ac/dc decoupled from all other signals, V_{DD}, and V_{SS}. Lead length and/or foil traces to this pin must be minimized, also. See Figure 8.

STROBE (Pin 4)

This output provides a strobed, regulated voltage referenced to V_{DD}. The temperature coefficient of this voltage is $\pm 0.2\%/^{\circ}\text{C}$ maximum from -10° to 60°C . The supply-voltage coefficient (line regulation) is $\pm 0.2\%/V$ maximum from 6 to 12 V. Strobe is tied to external resistor string R8, R9, and R10.

V_{DD} (Pin 5)

This pin is connected to the positive supply potential and may range from + 6 to + 12 V with respect to V_{SS}.

CAUTION: In battery-powered applications, reverse-polarity protection must be provided externally.

IRED (Pin 6)

This output provides pulsed base current for external NPN transistor Q1 used as the infrared emitter driver. Q1 must have $\beta > 100$

At 10 mA, the temperature coefficient of the output voltage is typically $+ 0.5\%/^{\circ}\text{C}$ from -10° to 60°C . The supply-voltage coefficient (line regulation) is $\pm 0.2\%/V$ maximum from 6 to 12 V. The IRED pulse width (active-high) is determined by external components R1 and C3 (with a 330 k Ω /1500 pF combination, the nominal width is 330 μs). To minimize noise impact, IRED is not active when the visible LED and horn outputs are active.

IRED is active near the end of strobe pulses for smoke tests, chamber sensitivity test, and pushbutton test.

I/O (Pin 7)

This pin can be used to connect up to 40 units together in a wired-OR configuration for common signaling. V_{SS} is used as the return.

An on-chip current sink minimizes noise pick up during non-smoke conditions and eliminates the need for an external pull-down resistor to complete the wired-OR.

Remote units at lower supply voltages do not draw excessive current from a sending unit at a higher supply voltage.

I/O can also be used to activate escape lights, auxiliary alarms, remote alarms, and/or auto-dialers. As an input, this pin feeds a positive-edge-triggered flip-flop whose output is sampled nominally every 625ms during standby (using the recommended component values).

A local-smoke condition or the pushbutton-test mode forces this current-limited output to source current. All input signals are ignored when I/O is sourcing current.

I/O is disabled by the on-chip power-on reset to eliminate nuisance signaling during battery changes or system power-up. If unused, I/O must be left unconnected.

BRASS (Pin 8)

This half of the push-pull driver output is connected to the metal support electrode of a piezoelectric audio transducer and to the horn-starting resistor. A continuous modulated tone from the transducer is a smoke alarm indicating either local or remote smoke. A short beep or chirp is a trouble alarm indicating a low supply or degraded chamber sensitivity.

SILVER (Pin 9)

This half of the push-pull driver output is connected to the ceramic electrode of a piezoelectric transducer and to the horn-starting capacitor.

FEEDBACK (Pin 10)

This input is connected to both the feedback electrode self-resonating piezoelectric transducer and the horn-starting resistor and capacitor through current-limiting resistor R4. If unused, this pin must be tied to V_{SS} or V_{DD}.

LED (Pin 11)

This active-low open-drain output directly drives an external visible LED at the pulse rates indicated below. The pulse width is equal to the OSC period. The load for the low -supply test is applied by this output. This low -supply test is non-coincident with the smoke tests, chamber sensitivity test, pushbutton test, or any alarm signals. The LED also provides a visual indication of the detector status as follows, assuming the component values shown in [Figure 8](#).

Standby (includes low -supply and chamber sensitivity tests) — Pulses every 43 seconds (typical)

Local Smoke — Pulses every 0.67 seconds (typical)

Remote Smoke — No pulses

Pushbutton Test — Pulses every 0.67 seconds (typical)

OSC (Pin 12)

This pin is used in conjunction with external resistor R2 (7.5 M Ω) to V_{DD} and external capacitor C3 (1500 pF) to V_{DD} to form an oscillator with a nominal period of 7.9 ms (typical).

R1 (Pin 13)

This pin is used in conjunction with resistor R1 (330 k Ω) to Pin 12 and C3 (1500 pF, see Pin 11 description) to determine the IRED pulse width. With this RC combination, the nominal pulse width is 330 μ s.

V_{SS} (Pin 14)

This pin is the negative supply potential and the return for the I/O pin. Pin 13 is usually tied to ground.

(NC) – No Connection (Pin 16)**TEST (Pin 16)**

This input has an on-chip pull-down device and is used to manually invoke a test mode. The Pushbutton Test mode is initiated by a high level at Pin 14 (usually depression of a S.P.S.T. normally-open pushbutton switch to V_{DD}). After one oscillator cycle, IRED pulses approximately every 336 ms, regardless of the presence of smoke. Additionally, the amplifier gain is increased by automatic selection of C1. Therefore, the background reflections in the smoke chamber may be interpreted as smoke, generating a simulated-smoke condition. After the second IRED pulse, a successful test activates the horn-driver and I/O circuits. The active I/O allows remote signaling for system testing.

When the Pushbutton Test switch is released, the Test input returns to V_{SS} due to the on-chip pull-down device. After one oscillator cycle, the amplifier gain returns to normal, thereby removing the simulated-smoke condition. After two additional IRED pulses, less than 1 second, the IC exits the alarm mode and returns to standby timing.