RE46C400/1

Photoelectric Smoke Detector MCU Companion IC with CO Sensing for Panel-Based Detectors

Features

- Low Quiescent Current
- 3.3V Regulator
- Dual Independently Controlled LED Drivers with Programmable Current up to 200 mA
- Single Programmable Gain Integrating Op Amp with Effective Transimpedance >20 MΩ at 100 µs
- Internal Op Amp for Use with CO or Toxic Gas Sensor
  - Rail-to-Rail Inputs and Output
  - Unity Gain Stable
  - 10 kHz Gain Bandwidth Product
- Buffered Internal CO Reference
- Voltage Monitoring Circuit (an Analog Buffer Circuit [ABUF])
- Watchdog Timer
- SPI Controlled
- Powered from a Current Source

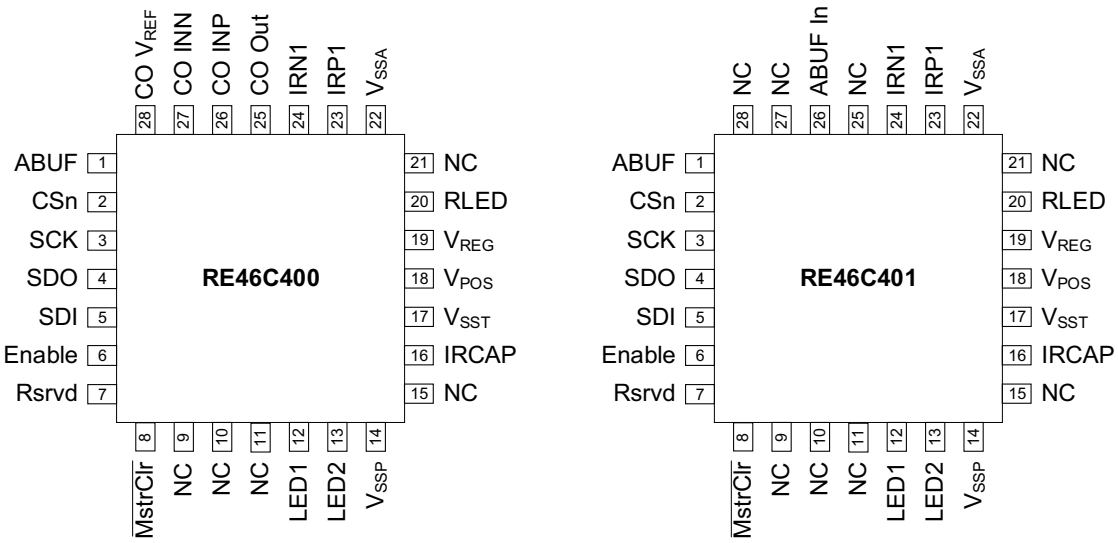
Description

The Microchip RE46C400/1 is a low-power smoke detector MCU companion IC intended for panel-based applications. It provides all of the analog, interface and power regulation functions for a microcontroller (MCU)-based multicriteria smoke detector. The RE46C400/1 can be powered from a constant current typically used in panel-based applications. The product features an integrating photo amplifier to interface with a photoelectric smoke chamber, two independently controlled programmable LED drivers, an op amp with 10 kHz Gain Bandwidth Product and rail-to-rail inputs and output to interface with a two terminal CO sensor, an ABUF for monitoring system voltages and a 3.3V regulator. The RE46C401 does not include the CO circuitry.

The RE46C400/1 allows the MCU to control all the parameters which set the operating conditions of the RE46C400/1, such as LED current, amplifier gain and integration time. All of these parameters including the enabling of various functions will be set via the SPI port.

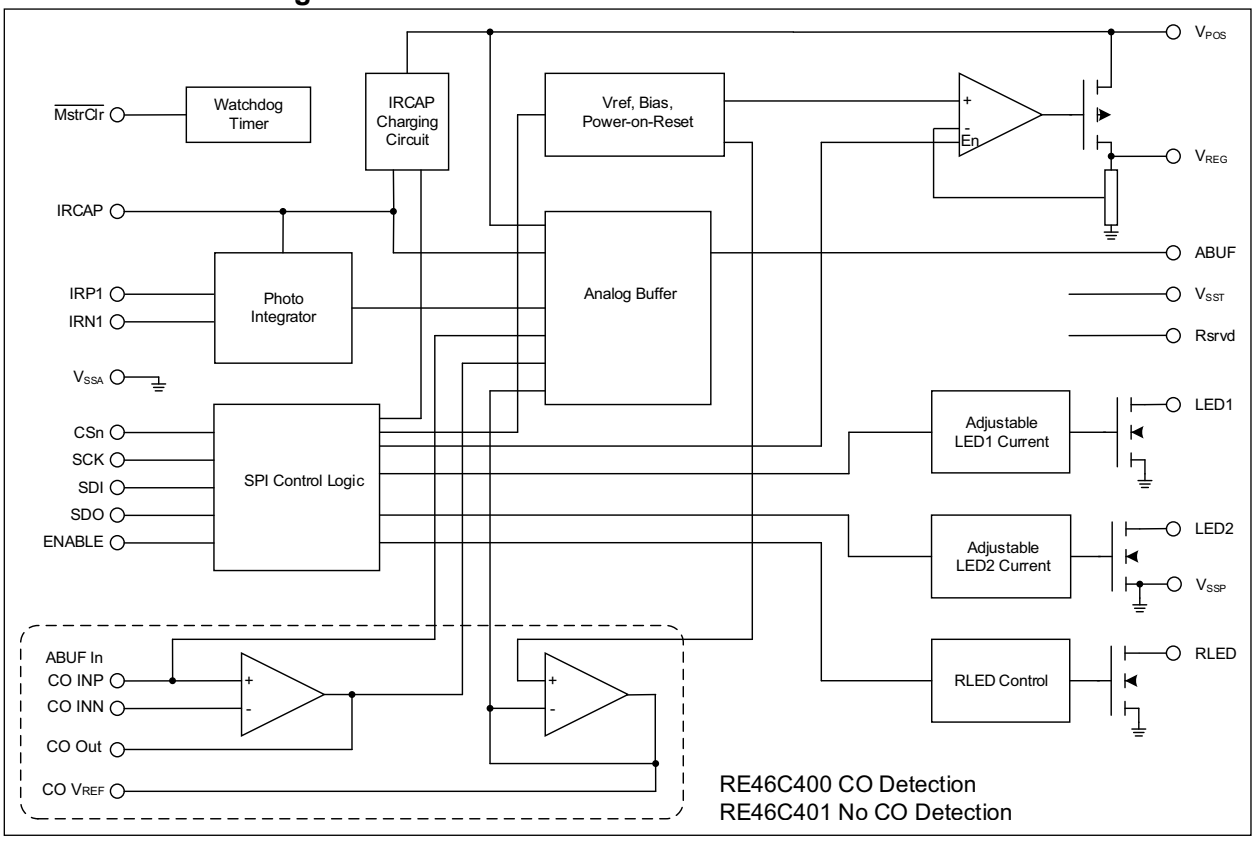
Package Types and Pin Configuration

28-Lead VQFN



Note: For more information see the Pin Function Table.

Functional Block Diagram



Typical Applications

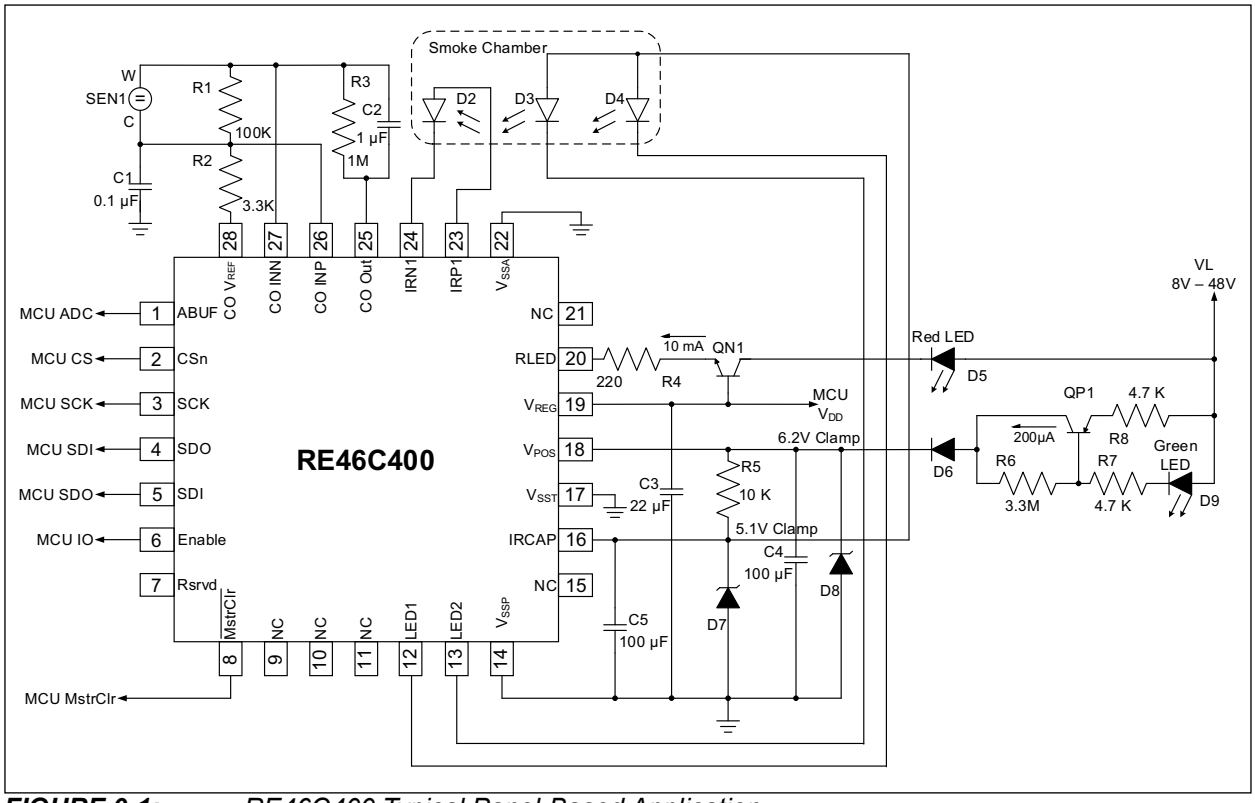


FIGURE 0-1: *RE46C400 Typical Panel-Based Application.*

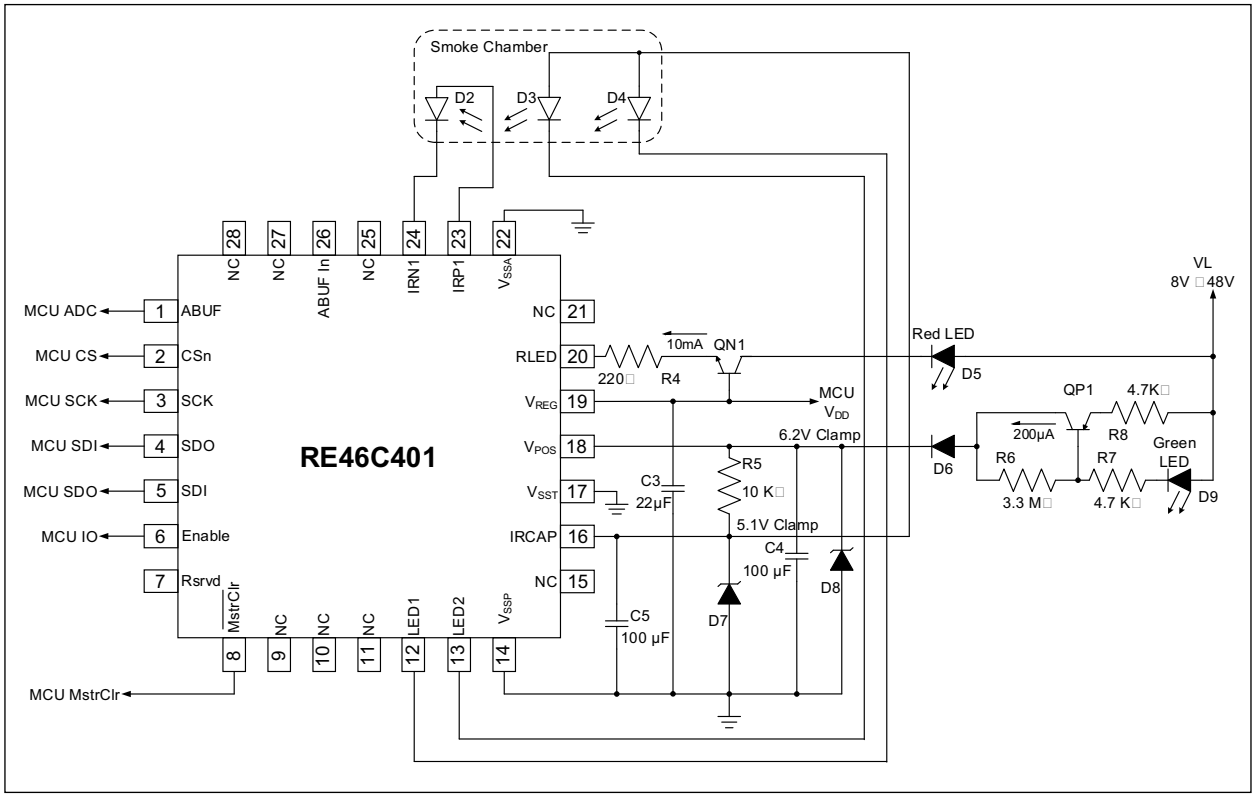


FIGURE 0-2: *RE46C401 Typical Panel-Based Application.*

Pin Descriptions

TABLE 0-1: PIN FUNCTION TABLE

28-Lead VQFN	Pin Name	Pin Description
1	ABUF	Analog Buffer op amp output. Used as the analog interface to the MCU
2	CSn	Digital input for SPI chip select
3	SCK	Digital input for SPI clock
4	SDO	Digital output for SPI data
5	SDI	Digital input for SPI data
6	Enable	Digital input to enable photo amp integration
7	Rsrvd	Reserved
8	$\overline{\text{MstrClr}}$	Watchdog Master Clear output
9	NC	No Connect
10	NC	No Connect
11	NC	No Connect
12	LED1	Provides regulated sink current for infrared LED or blue LED
13	LED2	Provides regulated sink current for infrared LED or blue LED
14	V_{SSP}	Connect to the negative supply voltage
15	NC	No Connect
16	IRCAP	Used to charge and monitor the LED capacitor
17	V_{SST}	Connect to the negative supply voltage
18	V_{POS}	Positive supply input
19	V_{REG}	3.3V Regulator output
20	RLED	Open-drain NMOS output used to drive a red LED
21	NC	No Connect
22	V_{SSA}	Connect to the negative supply voltage for analog circuits
23	IRP1	Input for anode of the photodiode 1
24	IRN1	Input for cathode of the photodiode 1
25	CO Out	Analog output of CO op amp (**RE46C400**)
	NC	No Connect (**RE46C401**)
26	CO INP	Non-inverting input of the CO op amp (**RE46C400**)
	ABUF In	Analog Buffer input (**RE46C401**)
27	CO INN	Inverting input of the CO op amp (**RE46C400**)
	NC	No Connect (**RE46C401**)
28	CO V_{REF}	CO voltage reference (**RE46C400**)
	NC	Analog Buffer input (**RE46C401**)

1.0 ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings

V_{POS} 14V
IRCAP, LED1, LED2 ..... 7.0V
Input Voltage Range (V_{IN1}) ..... –0.3V to 3.6V
Output Voltage Range (V_{OUT}) ..... –0.3V to 3.6V
RLED Output Voltage Range ..... –0.3V to VPOS
$\overline{\text{MstrClr}}$ Output Voltage Range ..... –0.3V to 12V
Input Current (I_{IN}) ..... 10 mA
V_{REG} Continuous Operating Current (I_{O1}) ..... 40 mA
RLED Continuous Operating Current (I_{RL}) ..... 30 mA
ABUF, SDO, CO Out Continuous Operating Current (I_{O2}) ..... 10 mA
CO V_{REF} Continuous Operating Current (I_{reg}) ..... 1 mA
LED1, LED2 Continuous Operating Current (I_{OLED}) ..... 400 mA
Storage Temperature (T_{STG}) ..... –55°C to +125°C
Maximum Junction Temperature (T_J) ..... +150°C

† Notice: Stresses above those listed under “Absolute Maximum Ratings” may cause permanent damage to the device. This is a stress rating only and functional operation of the device at those or any other conditions above those indicated in the operational listings of this specification is not implied. Exposure to maximum rating conditions for extended periods may affect device reliability.

Electrical Characteristics

Electrical Characteristics: Unless otherwise indicated, all parameters apply at T_A = -40°C to +90°C, V_{SS} = 0V, V_{POS} = 6.2V, V_{IRCAP} = 5.5V, V_{REG} = 3.3V, C5 = 100 µF, C4 = 100 µF, C3 = 22 µF, BatSel=0, RegEn=0, BGstartup=1, LBEn=0, HBEn=0. (**Note 1**) (**Note 2**) (**Note 3**)

Parameters	Symbol	Test Pin	Min.	Typ.	Max.	Units	Conditions
System Supply							
Supply Voltage	V_{POS}	V_{POS}	4.9	—	12.0	V	External Supply Powers V_{POS}
Reset Voltage	POR	V_{POS}	1.2	2.4	3.7	V	Power-on Reset, V_{REG}, V_{POS} = V_{REG}
Reset Voltage	POR	V_{REG}	1.2	1.7	2.0	V	Power-on Reset, V_{REG}, V_{POS} = V_{REG}
Brown Out	BOR	V_{REG}	1.1	1.4	1.7	V	Brown out V_{REG} falling
IDD	IDDSTBY	V_{REG}	—	450	1300	nA	All circuits disabled (**Note 7**)
3.3V Regulator (V_{POS} = 5.2V, RegEn=1, BGstartup=1, LBEn=0, HBEn=0) (Enable regulator. Power internal circuitry from the regulator.)							
I_{POS}	$I_{POSREG1}$	V_{POS}	—	5	8	µA	No load
Start-Up Time	t_{rREG}	V_{REG}	—	1.3	2.8	ms	V_{REG} = 0.0V to 90%V_{REG}
Regulator Voltage	V_{REG}	V_{REG}	3.1	3.3	3.5	V	I_{LOAD} = 20 mA
Load Regulation	V_{REGLD}	V_{REG}	—	10	50	mV	I_{LOAD} = 0 mA to 20 mA
Line Regulation	V_{REGLN}	V_{REG}	—	0.02	0.25	%/V	I_{LOAD} = 1 mA, V_{POS} = 4.9V to 12V
Photo Detection **Photo Amplifier** (PAEn=1, ABUF[3:0]=0010, InSel=0, ITCn=0, EnCntl=0, IT[5:4]=00, Gain[2:0]=000) (Photo Amp & ABUF Enabled, Inputs = IRN1, IRP1, Fixed Integration Time = 100 µs, Gain = 1, Status = Reset)							
I_{DD}	I_{DDPA}	V_{REG}	—	50	100	µA	**Note 7**
IRCAP Supply Current	$I_{IRCAPPA}$	IRCAP	—	330	410	µA	—
Start-Up Time	T_{suPA}	ABUF	—	7	20	µs	PAEn=0 to 1 transition

Note 1: Typical values are for design information only and apply at +25°C.

2: The limits shown are 100% tested at +25°C only. Test limits are guard-banded based on temperature characterization to warrant compliance at temperature extremes.

3: All analog functions are off unless otherwise noted (ABUF[3:0]=0000, PAEn=0, LED2En=0, LED1En=0, RLEn=0, RegEn=0, COAEn=0, COREn=0, COTest=0, WDEn=0).

4: Not production tested.

5: Warranted by functional tests.

6: Subtract measurement with Ipd=0 from measurement with given Ipd input to get the specified result, which is 200 mV.

7: I_{DD} measurements are made at the VREG pin with the regulator off.

Electrical Characteristics (Continued)

Electrical Characteristics: Unless otherwise indicated, all parameters apply at T_A = -40°C to +90°C, V_{SS} = 0V, V_{POS} = 6.2V, V_{IRCAP} = 5.5V, V_{REG} = 3.3V, C5 = 100 µF, C4 = 100 µF, C3 = 22 µF, BatSel=0, RegEn=0, BGstartup=1, LBEn=0, HBEn=0. (**Note 1**) (**Note 2**) (**Note 3**)

Parameters	Symbol	Test Pin	Min.	Typ.	Max.	Units	Conditions
Input Bias Current	I_{BOP1}	IRN1, IRP1	200	—	200	µA	InSel=0, Gain[2:0]=101, IT[5:4]=11, Enable Pin=1
PAOut1 Voltage	PAO01	ABUF	620	830	1040	ΔmV	G = 1, I_{PD} = 40 nA (**Note 6**)
	PAO02		1290	1660	2030	ΔmV	G = 2, Gain[2:0]=001, I_{PD} = 40 nA (**Note 6**)
	PAO03		—	830	—	ΔmV	G = 4, Gain[2:0]=010, I_{PD} = 10 nA (**Note 6**)
	PAO04		—	1660	—	ΔmV	G = 8, Gain[2:0]=011, I_{PD} = 10 nA (**Note 6**)
	PAO05		1200	1560	1920	ΔmV	G = 16, Gain[2:0]=100, I_{PD} = 5 nA (**Note 6**)
	PAO06		1000	1400	1800	ΔmV	G = 32, Gain[2:0]=101, I_{PD} = 2.5 nA (**Note 6**)
	PAO10		—	800	—	ΔmV	T_I = 200 µs, IT[5:4]=01, I_{PD} = 20 nA (**Note 6**)
	PAO11		—	1200	—	ΔmV	T_I = 300 µs, IT[5:4]=10, I_{PD} = 20 nA (**Note 6**)
	PAO12		—	1600	—	ΔmV	T_I = 400 µs, IT[5:4]=11, I_{PD} = 20 nA (**Note 6**)
	PAO13		—	2900	—	mV	T_I = 400 µs, IT[5:4]=11, I_{PD} = 40 nA, High-Side Test (**Note 6**)
Integration Time (PAEn=1, ABUF=0010, InSel=0, ITCn=0, EnCntl=0, Gain[2:0]=001) (Photo Amp and ABUF Enabled, Input = Input1 (= IRN1, IRP1), Fixed Integration Time, Gain = 2)							
PAOut1 Integration Time	T_{I100}	ABUF	80	100	120	µs	T_I = 100 µs, IT[5:4]=00, I_{PD} = 10 nA
	T_{I200}		160	200	240	µs	T_I = 200 µs, IT[5:4]=01, I_{PD} = 10 nA
	T_{I300}		240	300	360	µs	T_I = 300 µs, IT[5:4]=10, I_{PD} = 10 nA
	T_{I400}		320	400	480	µs	T_I = 400 µs, IT[5:4]=11, I_{PD} = 10 nA
IRCAP LED Supply (V_{POS} = 6V; IRCEn=1, LBEn=0, LBV=1)							
IRCAP Supply Voltage	V_{IRCAP}	IRCAP	3.2	—	5.5	V	—
Photo LED Driver (x =1 or 2) (V_{POS} = 5V, V_{IRCAP} = 5V, IRCEn=0, LEDxEn=1, PAEn=1, ITCn=1, Enable=1) (IRCAP disabled, Photo Amp enabled, Enable pin controls LED on/off)							
LED Supply Current	$I_{IRCAPLED}$	IRCAP	—	1	3	mA	LEDx[2:0]=XXX
Start-Up Time (LEDx)	T_{suLED}	—	—	6	20	µs	LEDxEn=1; from LED select to LED ready to enable
Turn-On Time	t_{rLED}	LEDx	—	0.37	—	µs	V_{LEDx} = 1V, LEDx[2:0]=100, from LED enable to I_{LED} @70% (I_{LEDx} = 35 mA)
LEDx Leakage	I_{OZ}	LEDx	-1000	0	-1000	nA	IRCAP = 5V/0V
LED1 and LED2 Output Current	I_{LEDx20}	LEDx	18	20	22	mA	V_{LEDx} = 0.8V, T_A = +25°C, LEDx[2:0]=000
	I_{LEDx40}		36	40	44	mA	V_{LEDx} = 0.8V, T_A = +25°C, LEDx[2:0]=001
	I_{LEDx50}		45	50	55	mA	V_{LEDx} = 0.8V, T_A = +25°C, LEDx[2:0]=010
	I_{LEDx60}		54	60	66	mA	V_{LEDx} = 0.8V, T_A = +25°C, LEDx[2:0]=011
	I_{LEDx80}		72	80	88	mA	V_{LEDx} = 1V, T_A = +25°C, LEDx[2:0]=100
	$I_{LEDx100}$		90	100	110	mA	V_{LEDx} = 1V, T_A = +25°C, LEDx[2:0]=101
	$I_{LEDx150}$		135	150	165	mA	V_{LEDx} = 1V, T_A = +25°C, LEDx[2:0]=110
	$I_{LEDx200}$		180	200	220	mA	V_{LEDx} = 1V, T_A = +25°C, LEDx[2:0]=111
LED Current Temperature Coefficient	TC_{LED0}	LEDx	—	0	—	%/°C	LEDxTC[2:0]=000; ILEDXXXX (**Note 4**)
	TC_{LED3}		—	0.3	—	%/°C	LEDxTC[2:0]=001; ILEDXXXX (**Note 4**)
	TC_{LED0}		—	0.4	—	%/°C	LEDxTC[2:0]=010; ILEDXXXX (**Note 4**)
	TC_{LED0}		—	0.5	—	%/°C	LEDxTC[2:0]=011; ILEDXXXX (**Note 4**)
	TC_{LED0}		—	0.6	—	%/°C	LEDxTC[2:0]=1XX; ILEDXXXX (**Note 4**)

Note 1: Typical values are for design information only and apply at +25°C.

2: The limits shown are 100% tested at +25°C only. Test limits are guard-banded based on temperature characterization to warrant compliance at temperature extremes.

3: All analog functions are off unless otherwise noted (ABUF[3:0]=0000, PAEn=0, LED2En=0, LED1En=0, RLEn=0, RegEn=0, COAEn=0, COREn=0, COTest=0, WDEn=0).

4: Not production tested.

5: Warranted by functional tests.

6: Subtract measurement with Ipd=0 from measurement with given Ipd input to get the specified result, which is 200 mV.

7: I_{DD} measurements are made at the VREG pin with the regulator off.

Electrical Characteristics (Continued)

Electrical Characteristics: Unless otherwise indicated, all parameters apply at T_A = -40°C to +90°C, V_{SS} = 0V, V_{POS} = 6.2V, V_{IRCAP} = 5.5V, V_{REG} = 3.3V, C5 = 100 µF, C4 = 100 µF, C3 = 22 µF, BatSel=0, RegEn=0, BGstartup=1, LBEn=0, HBEn=0. (**Note 1**) (**Note 2**) (**Note 3**)

Parameters	Symbol	Test Pin	Min.	Typ.	Max.	Units	Conditions
CO Detection (COAEn=1, COREn=1, COTest=0, COTRi=0) (CO amplifier and reference enabled, CO test functions disabled.)							
I_{DD}	$I_{DDCOREF}$	V_{REG}	—	1.5	3	µA	No loads (**Note 7**)
	I_{DDCO}		—	1.1	2.2	µA	No loads, COREn=0 (**Note 7**)
	$I_{DDCOTst}$		—	7	12	µA	COTest=1, COTRi=1 (**Note 7**)
Start-Up Time	T_{suCO}	CO Out	—	8	—	ms	—
Reference Voltage	CORef	CO V_{REF}	0.27	0.3	0.33	V	I_{COVref} = ±10 µA, COREn=1
Input Offset Voltage	V_{osco1}	CO INP, CO INN	-3	—	3	mV	V_{CM} = 0.3V
	V_{osco2}		-1	—	1	mV	V_{CM} = 0.3V, T_A = 25°C
Input Bias Current	I_{BOP1}	CO INN	-200	—	200	pA	—
	I_{BOP2}	CO INP	-100	—	100	nA	—
Test Source Current	I_{COTst1}	CO INP, CO INN	-2.5	-2	-1.6	µA	V_{CM} = 0.3V, COTri=1, COTest=1, COCurSel=0 or 1, COCurPol=0 or 1
Test Sink Current	I_{COTst2}	CO INP, CO INN	1.6	2	2.5	µA	V_{CM} = 0.3V, COTri=1, COTest=1, COCurSel=0 or 1, COCurPol=0 or 1
Common-Mode Input Range	V_{CMR}	CO INP, CO INN	0	—	V_{REG}	V	—
Common-Mode Rejection Ratio	CMRR	CO INP, CO INN	—	80	—	dB	V_{CM} = 0V to V_{REG}
DC Open Loop Gain (large signal)	AOL	CO INP, CO INN	—	100	—		R_L = 50 kΩ, V_L = 0.5 x V_{REG} V_{OUT} = 0.3V to V_{REG} - 0.3V
Maximum Output Voltage Swing	V_{OLCO}, V_{OHCO}	CO Out	V_{SS} + 0.010	—	V_{REG} - 0.02	V	R_L = 50 kΩ, V_L = 0.5 x V_{REG}, 0.5V input overdrive
Output Leakage	I_{OZ}	CO Out	-100	—	100	nA	—
Short Circuit Current	I_{SC}	CO Out	—	16	—	mA	—
CO AC Response (COAEn=1, COREn=1)							
CO GBW	GBWCO	CO Out	—	10	—	kHz	Gain = 1, C_{LOAD} = 50 pF
Phase Margin	PM	CO Out	—	65	—	°	Gain = 1, C_{LOAD} = 50 pF
Slew Rate	SRCO	CO Out	—	3	—	V/ms	Gain = 1, C_{LOAD} = 50 pF
CO Op Amp Noise							
Input Voltage Noise	Eni	CO Out	—	5	—	µVPP	—
Input Voltage Noise Density	eni		—	170	—	nV/√Hz	—
Input Current Noise Density	ini		—	0.6	—	fa/√Hz	—
ABUF Op Amp (ABUF[3:0]=1010) ABUF enabled, Input at pin CO INP							
I_{DD}	I_{DDABUF}	V_{REG}	—	50	120	µA	No load, ABUF[3:0]=0111 (**Note 7**)
Input Offset Voltage	V_{osABUF}	ABUF	-3	—	3	mV	—
Start-Up Time	t_{suABUF}	ABUF	—	10	—	µs	From ABUF[3:0]=0000 to 95% ABUF[3:0]=0101, V_{POS} = 10V
Maximum Output Voltage Swing	V_{OLABUF}	ABUF	V_{SS} + 0.035	—	—	V	R_L = 50 kΩ, 0.5V input overdrive
	V_{OHABUF}		—	—	V_{REG} - 0.035	V	R_L = 50 kΩ, 0.5V input overdrive
Pull-Down Current	I_{OL}	ABUF	0.2	3.5	6	mA	ABUF off, ABUF[3:0] = 0000

Note 1: Typical values are for design information only and apply at +25°C.

2: The limits shown are 100% tested at +25°C only. Test limits are guard-banded based on temperature characterization to warrant compliance at temperature extremes.

3: All analog functions are off unless otherwise noted (ABUF[3:0]=0000, PAEn=0, LED2En=0, LED1En=0, RLEn=0, RegEn=0, COAEn=0, COREn=0, COTest=0, WDEn=0).

4: Not production tested.

5: Warranted by functional tests.

6: Subtract measurement with Ipd=0 from measurement with given Ipd input to get the specified result, which is 200 mV.

7: I_{DD} measurements are made at the VREG pin with the regulator off.

Electrical Characteristics (Continued)

Electrical Characteristics: Unless otherwise indicated, all parameters apply at T_A = -40°C to +90°C, V_{SS} = 0V, V_{POS} = 6.2V, V_{IRCAP} = 5.5V, V_{REG} = 3.3V, C5 = 100 µF, C4 = 100 µF, C3 = 22 µF, BatSel=0, RegEn=0, BGstartup=1, LBEn=0, HBEn=0. (**Note 1**) (**Note 2**) (**Note 3**)

Parameters	Symbol	Test Pin	Min.	Typ.	Max.	Units	Conditions
Short Circuit Current	I_{SC}	ABUF	—	12	—	mA	1.5V input, R_L = 75 kΩ
Output Source Impedance	Z_{OUT}	ABUF	—	0.4	—	Ω	V_{OUT} = 1.5V, I_{LOAD} = +/-30 µA, Characterization Only
ABUF Attenuation Factors	ABUFVREG	ABUF	0.475	0.5	0.525	—	V_{REG} = 3.3V, ABUF[3:0]=1000, RegEn=0
	ABUFIRCAP		0.238	0.25	0.262	—	IRCAP = 5V, ABUF[3:0]=0110, IRCEn=0
	ABUFVPOS		0.095	0.1	0.105	—	V_{POS} = 10V, ABUF[3:0]=0101, LBEn=0, HBEn=0
	ABUFPHOTO		—	1	—	—	ABUF[3:0]=0010, PAEn=1, INSEL=0, EnBuf=1, Status=1
	ABUF200REF		—	1	—	—	ABUF[3:0]=0001, PAEn=1
	ABUFCO		0.95	1	1.05	—	CO Out = 1.5V, ABUF[3:0]=0011, COAEn=0
	ABUFCOREF		0.95	1	1.05	—	CO V_{REF} = 0.3V, ABUF[3:0]=0100, COAEn=0
	ABUFCOinp		0.95	1	1.05	—	CO INP = 0.3V, ABUF[3:0]=1010, COAEn=0
	ABUFCOinn		0.95	1	1.05	—	CO INP = 0.3V, ABUF[3:0]=1011, COAEn=0
	ABUFIRED1		0.238	0.25	0.262	—	IRED1 = 2V, V_{IRCAP} = 5V, ABUF[3:0]=1100
	ABUFIRED2		0.238	0.25	0.262	—	IRED1 = 2V, V_{IRCAP} = 5V, ABUF[3:0]=1101
ABUF AC Response							
ABUF GBW	GBWABUF	ABUF	—	1.24	—	MHz	C_{LOAD} = 50 pF
Phase Margin	PM	ABUF	—	65	—	—	C_{LOAD} = 50 pF
ABUF Slew Rate	SRABUF	ABUF	—	400	—	V/ms	C_{LOAD} = 50 pF
ABUF Settle Time	STABUF	ABUF	—	3	—	µs	C_{LOAD} = 50 pF, CO INP = 0.3V to 1.3V, ABUF = 95% Final Value
Red LED							
Output Voltage Low	V_{RLED}	RLED	—	0.15	0.5	V	I_{LOAD} = 10 mA, RLEn=1
RLED Turn-On Time	t_{rLED}	RLED	—	0.6	1	µs	I_{RLED} = 10 mA, RLEn=0 to 1
Watchdog Timer (WDEn=1)							
I_{DD}	I_{DDWD}	—	—	500	—	nA	**Note 7**
Leakage Current	I_{HOZMC}	—	3	8	20	µA	$V_{MstrClr}$ = 12V
Watchdog Timer	t_{dWD}	—	13	19	27	s	WDEn=1 (**Note 5**)
Watchdog Reset	t_{pwWD}	—	14	20	27	ms	**Note 5**
Pulse Width SPI and Digital I/O							
Input Leakage Low	I_{IL}	CSn, SCK, SDI, Enable	—	—	-100	nA	—
Input Leakage High	I_{IH1}	CSn, SCK, SDI, Enable	—	—	100	nA	—
Input Voltage Low	V_{IL1A}	CSn, SCK, SDI	—	—	0.9	V	—
	V_{IL1B}	Enable	—	—	0.9	V	—
Input Voltage High	V_{IH1}	CSn, SCK, SDI	2.1	—	—	V	—
	V_{IH1}	Enable	2.1	—	—	V	—

Note 1: Typical values are for design information only and apply at +25°C.

2: The limits shown are 100% tested at +25°C only. Test limits are guard-banded based on temperature characterization to warrant compliance at temperature extremes.

3: All analog functions are off unless otherwise noted (ABUF[3:0]=0000, PAEn=0, LED2En=0, LED1En=0, RLEn=0, RegEn=0, COAEn=0, COREn=0, COTest=0, WDEn=0).

4: Not production tested.

5: Warranted by functional tests.

6: Subtract measurement with Ipd=0 from measurement with given Ipd input to get the specified result, which is 200 mV.

7: I_{DD} measurements are made at the VREG pin with the regulator off.

Electrical Characteristics (Continued)

Electrical Characteristics: Unless otherwise indicated, all parameters apply at T_A = -40°C to +90°C, V_{SS} = 0V, V_{POS} = 6.2V, V_{IRCAP} = 5.5V, V_{REG} = 3.3V, C5 = 100 µF, C4 = 100 µF, C3 = 22 µF, BatSel=0, RegEn=0, BGstartup=1, LBEn=0, HBEn=0. (**Note 1**) (**Note 2**) (**Note 3**)

Parameters	Symbol	Test Pin	Min.	Typ.	Max.	Units	Conditions
Input Voltage Hysteresis	V_{HYS}	CSn, SCK, SDI, Enable	—	0.15	—	V	—
Output Voltage Low	V_{OLL}	SDO	—	200	500	mV	I_{LOAD} = 1 mA
Output Voltage High	V_{OHH}	SDO	2.4	2.6	—	V	I_{LOAD} = -1 mA
SPI Timing (Figure 1-1)							
Digital Pin Capacitance	C_{IN}, C_{OUT}	—	—	10	—	pF	All logic inputs/outputs
Clock Frequency	F_{CLK}	—	—	—	10	MHz	C_{LOAD} = 50 pF (**Note 5**)
Clock High Time	t_{HI}	—	—	50	—	ns	C_{LOAD} = 50 pF (**Note 5**)
Clock Low Time	t_{LO}	—	—	50	—	ns	C_{LOAD} = 50 pF (**Note 5**)
CSn to First Rising Clock Edge	t_{CSSR}	—	50	—	—	ns	C_{LOAD} = 50 pF (**Note 5**)
Data Input Setup Time	t_{SU}	—	20	—	—	ns	C_{LOAD} = 50 pF (**Note 5**)
Data Input Hold Time	t_{HD}	—	40	—	—	ns	C_{LOAD} = 50 pF (**Note 5**)
SCK to CSn Rise Hold Time	t_{CHS}	—	50	—	—	ns	C_{LOAD} = 50 pF (**Note 5**)
CSn High Time	t_{CSH}	—	100	—	—	ns	C_{LOAD} = 50 pF (**Note 5**)

Note 1: Typical values are for design information only and apply at +25°C.

2: The limits shown are 100% tested at +25°C only. Test limits are guard-banded based on temperature characterization to warrant compliance at temperature extremes.

3: All analog functions are off unless otherwise noted (ABUF[3:0]=0000, PAEn=0, LED2En=0, LED1En=0, RLEn=0, RegEn=0, COAEn=0, COREn=0, COTest=0, WDEn=0).

4: Not production tested.

5: Warranted by functional tests.

6: Subtract measurement with Ipd=0 from measurement with given Ipd input to get the specified result, which is 200 mV.

7: I_{DD} measurements are made at the VREG pin with the regulator off.

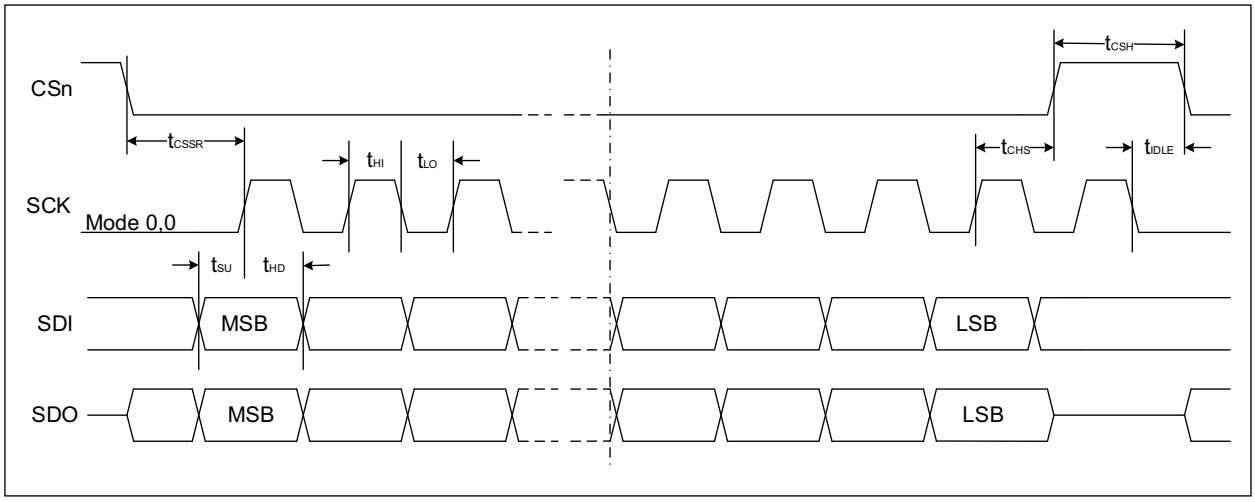


FIGURE 1-1: *SPI Timing Mode 0,0.*

Temperature Characteristics

Electrical Characteristics						
Parameters	**Symbol**	**Min.**	**Typ.**	**Max.**	**Units**	**Conditions**
Temperature Ranges						
Operating Temperature Range	T_A	-40	—	+90	°C	—
Storage Temperature Range	T_{STG}	-55	—	+125	°C	—
Thermal Package Resistances						
Thermal Resistance, 28L-VQFN	θ_{JA}	—	39.1	—	°C/W	—

2.0 DEVICE DESCRIPTION

2.1 Introduction

The RE46C400/1 provides the necessary analog functions to build an MCU-based multicriteria smoke detector. This includes an integrating amplifier for photodiode current sensing, two independently controlled regulated sink drivers for IR and Blue LED emitters, and a 3.3V regulator to power the MCU. The RE46C400 also features an op amp and reference for interfacing with a two-terminal CO sensor. The SPI allows the MCU to have full control over the RE46C400/1 operation.

2.2 Photoelectric Sensor Circuit

The RE46C400/1 provides a single photodiode input. The photo amplifier block diagram is shown in Figure 2-1 along with the LED1 and LED2 driver circuits. The photo amplifier is configured as an integrating amplifier with gain. The photodiode is connected to the IRP1 and IRN1 pins. The photodiode current is integrated by the photo amp to generate an output voltage. Equation 2-1 governs the operation of this amplifier.

EQUATION 2-1:

$$V_{OUT} = 0.2V + 2 \times I_{PD} \times \frac{t_i}{C_i} \times Gain$$

The integrator timing is controlled by the Integrate/Hold logic. The Integrate/Hold logic provides two methods of controlling the integration time. First, an internal timer can be programmed to set one of four possible fixed integration times. The fixed integration times are 100 µs, 200 µs, 300 µs and 400 µs. Integration begins when the Enable pin of the IC is pulsed high. This mode of operation is designated Fixed Timer mode. The integration time can be controlled directly by the microprocessor using the Enable pin. When a logic high is applied to the Enable pin, an integration begins. When a logic low is applied to the Enable pin the integration stops and the photo amplifier circuit is placed in Hold mode. This mode of operation is designated Direct Control mode ITCn, register 6 bit 3, controls the integration method.

In Timer mode, the integrating capacitor and the timing capacitor are matched, and the timing resistor is trimmed to a tight tolerance. The capacitor matching reduces the effect of internal capacitor tolerance on the photo amp output voltage. In the Direct Control mode, there is no compensation for the internal capacitance tolerance. By adjusting the integration time to achieve a specific photo amp output voltage the effect of component tolerances such as LED brightness can be compensated for.

Table 2-1 below shows the operating states for the integrating photo amplifier shown in Figure 2-1. At photo amplifier power-up, the photo amplifier is in the Reset state. In the Reset state, the photo diode is not connected to the photo amplifier input and the integrating capacitors are shorted, held in a Zero state. Setting the Photo Integrator Status bit to '1' sets the integrating photo amplifier state to the Ready state. The Ready state connects the photo diode to the photo amp inputs while the integrating capacitors are held in the Zero state. The photo amp enters the Integrate state when the Enable pin is driven high. In Timer mode, when the timer period ends the photo amplifier enters the Hold state. In Direct Control mode, the Hold state begins when the Enable pin is driven low. Setting the Photo Integrator Status bit to '0' sets the integrating photo amplifier to the Reset state which zeroes the integrating capacitors.

TABLE 2-1: PHOTO AMPLIFIER SWITCH TRUTH TABLE

State	SW0	SW1 SW2	SW3 SW4	SW5	SW6
Reset	Closed	Open	Closed	Open	Closed
Ready	Open	Closed	Closed	Open	Closed
Integrate	Open	Closed	Open	Open	Closed
Hold	Closed	Open	Open	Closed	Open

Switch SW5 connects the photo amp output to the ABUF input. SW5 should remain open during an integration operation.

Note: The EnBuf bit can force the switch SW5 to remain closed during the integration operation. This is the recommend method for using the integrator.

The photo amp output can be monitored at the ABUF output. Switch SW6 connects the 0.2V reference to ABUF when switch SW5 is open.

IRCAP provides the positive supply for the photo amp while V_{REG} provides the positive supply for ABUF. Clipping of the photo amp signal can occur if the integration time or photo amp gain is not selected properly.

The photo amp gain is set by the SPI. The available gain settings are 1, 2, 4, 8, 16 and 32.

2.3 LED1 and LED2 Driver

The LED1 and LED2 driver circuit provides a regulated and programmable current to LED1 or LED2 via the SPI. Possible current values are 20 mA, 40 mA, 50 mA, 60 mA, 80 mA, 100 mA, 150 mA and 200 mA. The SPI provides an enable function for the drive circuits. This enable function turns on the bias to the LED drive circuit. The Integ/Hold command turns on the LED current. The photo amp integration will not be enabled until the current reaches 70% of the set value.

2.4 IRCAP

The LEDs are biased from the capacitor connected to the IRCAP pin. For panel-based smoke detectors powered from a fixed current source, the IRCAP capacitor should be charged using an external resistor. The IRCAP voltage is also used to power the photo amp and the minimum IRCAP voltage required for proper operation of the photo amp is 3.2V.

The internal IRCAP charging circuit must be disabled. The IRCAP charging circuit can draw 21 mA from the V_{POS} pin and may cause an unacceptable voltage sag at the V_{POS} pin while charging. The IRCAP charging circuit can be enabled or disabled by the SPI.

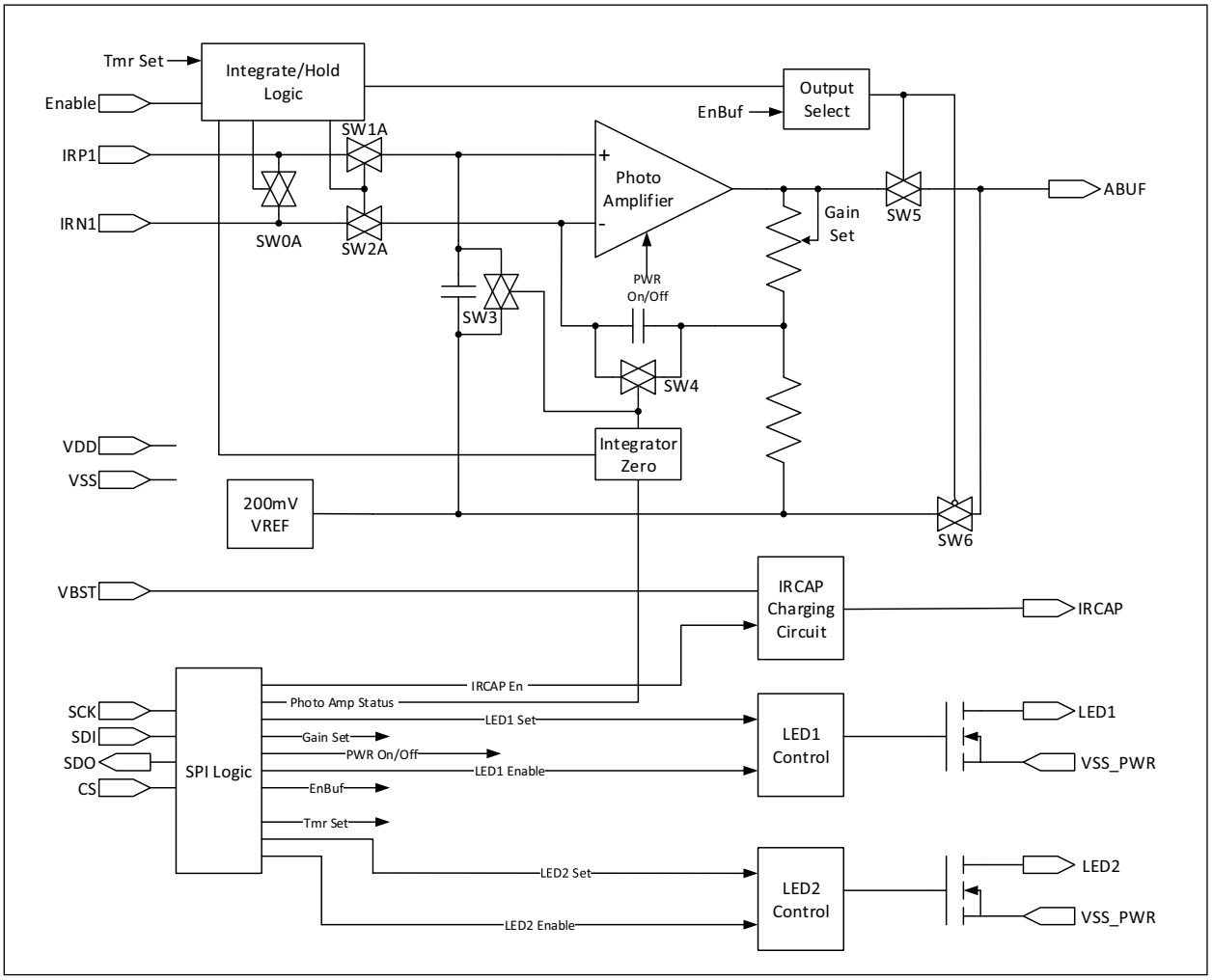


FIGURE 2-1: *Photoelectric Smoke Detection System.*

2.5 CO Sensor Circuit

The RE46C400 provides a low-offset op amp and a voltage reference (CO V_{REF}) for a two-terminal CO or toxic gas sensor. The unity gain stable op amp provides rail-to-rail inputs and output. The op amp output is monitored by the MCU to determine the CO concentration. The op amp output can be monitored directly or via the ABUF output. The CO amplifier and reference can be turned on and off independently by the SPI. The uncommitted CO op amp can be used for other purposes.

In order to test the CO sensor, the CO INP pin and the CO INN pin are each connected to a 2 µA current source/sink. The current source and current sink operation is controlled by individual bits in the SPI register, COCurSel and COCurPol. In the case of testing the CO INN pin, the CO op amp output is disabled by tri-stating the CO amp output with the SPI bit COTri.

2.6 Analog Buffer

The analog buffer amplifier (ABUF) provides the means to monitor a number of signals under SPI control. The signals are listed in Table 2-2. The analog buffer can be turned off until needed which will reduce the IDD requirements of the system.

TABLE 2-2: ABUF AVAILABLE SIGNALS

Address	Output Signal
0	ABUF Off Output Low
1	Photo Amp 0.2V Reference
2	Photo Amp Output
3	CO Out
4	CO 0.3V Reference
5	Scaled V_{POS} Monitor
6	Scaled IRCAP Monitor
7	Not Used
8	Scaled V_{REG} Monitor
9	Not Used
10	CO INP Pin Voltage/ABUF In
11	CO INN Pin Voltage (**RE46C400** only)
12	Scaled IRED1 Pin Voltage
13	Scaled IRED2 Pin Voltage
14	ABUF Off Output Low
15	ABUF Off Output Low

2.7 System Power

The RE46C400/1 is intended for panel-based smoke detectors that are powered from a constant current source. The current is supplied at the V_{POS} pin, as shown in the Typical Applications schematic in Figure 0-1. Energy is stored on capacitors C4 and C5, which should be sized according the chosen operating conditions for the RE46C400.

V_{POS} powers the IRCAP via an external resistor and should be set high enough to ensure the proper operation of the type of LED used in the smoke chamber.

V_{POS} also powers the 3.3V regulator. At power-up, the 3.3V regulator is enabled without an SPI write. To aid the regulator startup Register 4 bit 1 BGstartup is defaulted to 0 which provides additional current to the bandgap (Startup Mode). This should be switched to 1 (Normal Mode) after the MCU is active.

The analog buffer amp (ABUF) can be used to monitor the voltage at the V_{POS}, V_{REG} and IRCAP pins.

2.8 Voltage Regulator

The voltage regulator provides a nominal 3.3V output at the V_{REG} pin and is intended to power an MCU. In normal operation, the regulator will source current up to 20 mA, but the current sinking capability is typically under 1 µA. The voltage regulator is powered from the V_{POS} pin. An overvoltage clamp is intended to limit the voltage at V_{REG} if it is pulled up by an external source to greater than 4V.

2.9 RLED Driver

The RLED driver provides the means to drive a red LED to provide a visual signal or other signal to the panel. A voltage buffer will be needed for system voltages greater than 18V. The RLED driver can be enabled or disabled via the SPI with the RLEn bit.

2.10 Watchdog Timer

The RE46C400/1 includes a watchdog timer which monitors the SCK input. An SPI clock must occur every 20 seconds to prevent a watchdog timer alert. The alert will pulse the $\overline{\text{MstrClr}}$ pin low for 20 ms. The watchdog timer can be disabled via the SPI to reduce current consumption.

2.11 SPI Control

The RE46C400/1 is designed to interface directly with the Serial Peripheral Interface (SPI) port, available on many microcontrollers, and supports Mode 0,0. All the digital input pins are Schmitt Trigger inputs to avoid system noise perturbations during the communications.

Each SPI communication starts with a CS falling edge and stops with the CS rising edge. Each SPI communication is independent. When CS is logic high, SDO is in a high-impedance state, and transitions on SCK and SDI have no effect. Any CS rising edge clears the communication and resets the SPI digital interface. If CS is at a logic low at power-up, then CS must be driven high and then low before communications can start.

Refer to Figure 1-1 and SPI Timing Specifications for detailed input and output timing.

The SPI provides complete control of the RE46C400/1 operation. SPI Registers can be programmed with setup information for each of the functions. The SPI Registers also control the operation of certain functions as well as power each function on or off with an enable bit.

2.12 SPI Register

The RE46C400/1 interface has a simple command structure. Every command is either a write command to a register or a read command from a register. The read command is intended to verify the write command's results. Each register command consists of two bytes. The upper byte is the register address which includes the read/write bit. The lower byte is the register data. The SPI RdNow bit allows the SPI to immediately read out data after the byte address has been read in. Alternatively, the data for a byte address can be read out when a second 16-bit clock cycle is completed. The RE46C400/1 device includes nine registers defined in the Register 2-1 register map. Unused data bits read back as '0'. Data bits for nonexistent registers read back as all '1'.

2.13 Critical SPI Register Bits

Power-on Reset initializes the bits in the SPI Register. Some of the "Set to 0" bits are initialized to '1' at POR. These bits must be set to '0' as indicated in the table.

Bits designated as "Set to 0" insure low I_{DD} and I_{POS} and no unintended device operation.

When using the internal regulator, RegEn must be set to '1'. After startup BGstartup should be set to '1' to remove the high current startup state.

REGISTER 2-1: CONFIGURATION SETTINGS AND CALIBRATION SETTINGS

Register 9:0 Adress Byte							
R/W	R/W	R/W	R/W	R/W	R/W	R/W	U
RW	AD5	AD4	AD3	AD2	AD1	AD0	—
bit 15							bit 8

Register 0 Data Byte				ABUF Control			
U	U	U	U	R/W-0	R/W-0	R/W-0	R/W-0
—	—	—	—	AB3	AB2	AB1	AB0
bit 7							bit 0

Register 1 Data Byte				Not Used			
U	U	U	U	U	R/W-0	R/W-0	R/W-1
—	—	—	—	—	Set to '0'	Set to '0'	Set to '0'
bit 7							bit 0

Register 2 Data Byte				Photo Amp Control			
U	U	R/W-0	R/W-0	R/W-0	U	R/W-1	R/W-0
—	—	Set to '0'	LED2En	LED1En	—	Status	PAEn
bit 7							bit 0

REGISTER 2-1: CONFIGURATION SETTINGS AND CALIBRATION SETTINGS (CONTINUED)

Register 3 Data Byte		Red LED/CO Control					
R/W-0	R/W-0	R/W-0	U	R/W-0	R/W-0	R/W-0	R/W-0
COTri	COCurSel	COTest	—	RLEn	Set to '0'	Set to '0'	Set to '0'
bit 7							bit 0

Register 4 Data Byte		Regulator, CO Control					
U	R/W-0	R/W-0	R/W-0	U	R/W-0	R/W-0	R/W-1
—	COCurPol	COREn	COAEn	—	Set to '0'	BGstartup	RegEn
bit 7							bit 0

Register 5 Data Byte		SPI/WD Setup					
R/W-1	R/W-1	U	R/W-1	U	R/W-0	R/W-0	R/W-1
Set to 0	WDEn	—	RdNow	—	Set to '0'	Set to '0'	Set to '0'
bit 7							bit 0

Register 6 Data Byte		Photo Amp Setup					
R/W-0	U	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0
EnBuf	—	IT1	IT0	ITCn	Gain2	Gain1	Gain0
bit 7							bit 0

Register 7 Data Byte		LED Setup					
U	R/W-0	R/W-0	R/W-0	U	R/W-0	R/W-0	R/W-0
—	LED2 2	LED2 1	LED2 0	—	LED1 2	LED1 1	LED1 0
bit 7							bit 0

Register 8 Data Byte		Not Used					
U	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0
—	Set to '0'	Set to '0'	Set to '0'	Set to '0'	Set to '0'	Set to '0'	Set to '0'
bit 7							bit 0

Register 9 Data Byte		Photo LED TC					
U	R/W-0	R/W-1	R/W-1	U	R/W-0	R/W-1	R/W-1
—	LED2 TC 2	LED2 TC 1	LED2 TC 0	—	LED1 TC 2	LED1 TC 1	LED1 TC 0
bit 7							bit 0

Legend:			
R = Readable bit	W = Writable bit	U = Unimplemented bit, read as '0'	
-n = Value at POR	'1' = Bit is set	'0' = Bit is cleared	x = Bit is unknown

REGISTER 2-1: CONFIGURATION SETTINGS AND CALIBRATION SETTINGS (CONTINUED)

Register#	Bit#	POR Value	Description
9:0	8	—	Not Used
	14:9	—	**AD[5:0]:** Address Select 00000 = Register 0; ABUF Select 00001 = Register 1; Not Used 00010 = Register 2; Photo Amp Control 00011 = Register 3; Red LED, CO Control 00100 = Register 4; Regulator, CO 00101 = Register 5; SPI, Watchdog Setup 00110 = Register 6; Photo Amp Setup 00111 = Register 7; LED1/LED2 Setup 01000 = Register 8; Not Used 01001 = Register 9; LED1/LED2 TC Setup XXX1X = Don't Care (Except 0100X)
	15	—	**RW:** Read/Write Select 1 = Read contents of the specified register 0 = Write data to the specified register
0	3:0	0	**ABUF[3:0]:** ABUF Channel Select 0000 = ABUF off; output low 0001 = 0.2V Photo Amp reference output 0010 = Photo Amp output 0011 = CO amp output 0100 = CO 0.3V reference output 0101 = Scaled V_{POS} voltage output 0110 = Scaled IRCAP voltage output 0111 = Not used 1000 = Scaled V_{REG} voltage output 1001 = Not Used 1010 = CO INP pin voltage 1011 = CO INN pin voltage 1100 = Scaled IRED1 pin voltage 1101 = Scaled IRED2 pin voltage 1110 = ABUF off; output low 1111 = ABUF off; output low
	7:4	—	Not Used
1	0	1	Must be set to '0'. POR initializes to '1'.
	1	0	Must be set to '0'.
	2	0	Must be set to '0'.
	7:3	—	Not Used

REGISTER 2-1: CONFIGURATION SETTINGS AND CALIBRATION SETTINGS (CONTINUED)

2	0	0	**PAEn:** Photo Amp Power On/Off 1 = Photo Amp On Enable 0 = Photo Amp On Disable
	1	0	**Status:** Photo Integrator Status 1 = Ready 0 = Reset
	2	0	Not Used
	3	0	**LED1En:** LED1 Driver Power On 1 = LED1 Driver Power-on Enable 0 = LED1 Driver Power-on Disable
	4	0	**LED2En:** LED2 Driver Power On 1 = LED2 Driver Power-on Enable 0 = LED2 Driver Power-on Disable
	5	0	Must be set to '0'.
	7:6	—	Not Used

3	0	0	Must be set to '0'.
	1	0	Must be set to '0'.
	2	0	Must be set to '0'.
	3	0	**RLEn:** RLED Enable/Disable 1 = RLED Power-on Enable 0 = RLED Power-on Disable
	4	0	Not Used
	5	0	**COTest:** CO Test On/Off. Set to '0' for **RE46C401**. 1 = Current Test On 0 = Current Test Off
	6	0	**COCurSel:** CO Current Sink Source Select. Set to '0' for **RE46C401**. 1 = CO source at non-inverting input 0 = CO sink at inverting input
	7	0	**COTri:** CO Op Amp Output Tristate Enable. Set to '0' for **RE46C401**. 1 = Enable CO Op Amp Output Tristate 0 = Disable CO Op Amp Output Tristate

REGISTER 2-1: CONFIGURATION SETTINGS AND CALIBRATION SETTINGS (CONTINUED)

4	0	1	**RegEn:** Regulator Power On 1 = Regulator powered on (enable) 0 = Regulator powered off (disable)
	1	0	**BGstartup:** Must be set to '1'. 1 = Normal operation 0 = Startup Mode
	2	0	Must be set to '0'.
	3	0	Not Used
	4	0	**COAEn:** CO Amp Power On. Set to '0' for **RE46C401**. 1 = Enable CO op amp 0 = Disable CO op amp
	5	0	**COREn:** CO Reference Power On. Set to '0' for **RE46C401**. 1 = Enable CO reference 0 = Disable CO reference
	6	0	**COCurPol:** CO Current Sink Source Polarity 1 = INN source/INP sink 0 = INN sink/INP source
	7	0	Not Used

5	0	1	Must be set to '0'.
	1	0	Must be set to '0'.
	2	0	Must be set to '0'.
	3	0	Not Used
	4	1	**RdNow:** SPI Read Output Delay 1 = SPI read output immediately ready 0 = SPI read output normal mode, data ready 1 (16 bit) word after requested
	5	0	Not Used
	6	1	**WDEn:** Watchdog Timer Power On 1 = Enable Watchdog timer 0 = Disable Watchdog timer
	7	1	Must be set to '0'.

REGISTER 2-1: CONFIGURATION SETTINGS AND CALIBRATION SETTINGS (CONTINUED)

6	2:0	0	**Gain[2:0]:** Photo Amp Gain Setting 000 = Photo Gain = 1 001 = Photo Gain = 2 010 = Photo Gain = 4 011 = Photo Gain = 8 100 = Photo Gain = 16 101 = Photo Gain = 32 110 = Photo Gain = 16 111 = Photo Gain = 32
	3	0	**ITCn:** Integration Time Control Method 1 = Integration Time Control is Enable Pin 0 = Integration Time Control is Internal Timer
	5:4	0	**IT[5:4]:** Integration Internal Timer Setting 00 = Integration Time = 100 µs 01 = Integration Time = 200 µs 10 = Integration Time = 300 µs 11 = Integration Time = 400 µs
	6	0	Not Used
	7	0	**EnBuf:** Photo Amp Output to ABUF Control 1 = ABUF Output is the Photo Amp Output for the full-integration cycle 0 = ABUF Output is the Photo Amp Hold Voltage or 0.2V Reference Voltage

7	2:0	0	**LED1[2:0]:** LED1 Driver Current Setting 000 = LED1 Current = 20 mA 001 = LED1 Current = 40 mA 010 = LED1 Current = 50 mA 011 = LED1 Current = 60 mA 100 = LED1 Current = 80 mA 101 = LED1 Current = 100 mA 110 = LED1 Current = 150 mA 111 = LED1 Current = 200 mA
	3	0	Not Used
	6:4	0	**LED2[2:0]:** LED2 Driver Current Setting 000 = LED2 Current = 20 mA 001 = LED2 Current = 40 mA 010 = LED2 Current = 50 mA 011 = LED2 Current = 60 mA 100 = LED2 Current = 80 mA 101 = LED2 Current = 100 mA 110 = LED2 Current = 150 mA 111 = LED2 Current = 200 mA
	7	0	Not Used

REGISTER 2-1: CONFIGURATION SETTINGS AND CALIBRATION SETTINGS (CONTINUED)

8	0	0	Must be set to '0'.
	1	0	Must be set to '0'.
	2	0	Must be set to '0'.
	3	0	Must be set to '0'.
	4	0	Must be set to '0'.
	5	0	Must be set to '0'.
	6	0	Must be set to '0'.
	7	0	Not Used

9	2:0	011	**LED1 TC[2:0]:** 000 = 0.0%/C 001 = 0.3%/C 010 = 0.4%/C 011 = 0.5%/C 1XX = 0.6%/C
	3	0	Not Used
	6:4	011	**LED2 TC[2:0]:** 000 = 0.0%/C 001 = 0.3%/C 010 = 0.4%/C 011 = 0.5%/C 1XX = 0.6%/C
	7	0	Not Used

3.0 APPLICATION NOTES

3.1 Biasing the RE46C400/1

The RE46C400/1 is powered from the V_{POS} pin. V_{REG} is powered from the V_{POS} pin. V_{REG} powers most of the internal circuitry of the RE46C400/1 as well as the MCU.

Note:	For component references, please refer to Figure 0-1 or Figure 0-2.

Power for LED1 and LED2 is supplied by the capacitor, C5, and connected to the IRCAP pin. The capacitor, C5, also powers the photo amp of the RE46C400/1.

The V_{POS} can be biased by a low-current voltage regulator or by a constant current source. In the application drawings, the RE46C400/1 is biased with a constant current source. The voltage at the V_{POS} pin is clamped to 6.2V by diode D8 which allows the line voltage, V_L, to operate down to 8V. The diode D6 protects the RE46C400/1 for the case where V_L pulses below ground. The capacitor C4 powers the RE46C400/1, when V_L is pulsed below 8V. The capacitor C4 should be sized to maintain V_{POS} during a worst-case pulsing condition. The minimum V_{POS} voltage is 4.9V. Below 4.9V the regulator performance can be affected which can affect analog circuit performance.

The voltage on capacitor C5, V_{IRCAP}, should be maintained between 3.2V and 5.5V. The voltage drop across the LED drivers should be 0.8V to 1V depending on the LED driver current selected to maintain a constantly regulated current. Allowing for a voltage drop of 2V across an infrared LED, V_{IRCAP} should be a minimum of 3.2V. Allowing for a voltage drop of 4V across a blue LED, V_{IRCAP} should be a minimum of 5V. Using a slightly higher voltage will allow for C5 discharge during a smoke measurement. In the application drawings, V_{IRCAP} is clamped at 5.1V which will accommodate a blue LED. Resistor R5 sets the charging current for C5 and depends on the smoke measurement duty cycle.

3.2 Power-Up

When the RE46C400/1 is powered on with a current source, capacitors C4 and C5 must charge up to the clamp voltages before normal operation can begin. At POR most of the bits of Register 2-1 are set to '0' which turns off most of the analog circuitry. Only the regulator, RdNow, Photo LED TC and watchdog circuit are turned on. Table 3-1 lists other unused bits that must be set to '0' after the MCU is powered on. When the regulator turns on at power-up, any capacitance associated with the regulator output and the MCU must be charged which will affect the overall detector turn on time.

TABLE 3-1: POWER-UP SAMPLE CODE

Register or Function	Purpose
Power-Up RE46C400/1	Apply power to V_{POS} pin and internal POR is asserted.
SPI(0x08, 0x03)	SPI(0x08, 0x03) RegEn (1) on & BGstartup (2) normal(2+1 =3). To initialize the regulator BGstartup (Register 4, bit1) should be set to normal operation. This turns off the high start-up current for the internal reference.
If the CO function is to be used, then the following command can be used:	
SPI(0x08, 0x33)	Register 4: CO reference (COREn=0x20) & CO op-amp(COAEn=0x10) enabled (0x20+0x10=0x30), RegEn (1) on & BGstartup (2) normal (1+2=3)
SPI(0x0A, 0x90)	Register 5: Enable SPI watchdog, RdNow SPI format.
SPI(0x02, 0x00) SPI(0x06, 0x00)	Must be set to zero.

SPI(0x08, 0x03) refers to the SPI Register and Bits which are set to logic High. In this example, write to Register 4 Bits 1:0.

3.3 Smoke Check Setup

Register 6 (Photo Amp Setup), Register 7 (LED1/LED2 Current Setup) and Register 9 (LED1/LED2 TC Setup) set the operating parameters for the smoke detector (see Register 2-1). While these registers should be set initially, they can be changed during normal operation of the smoke detector.

Register 6 sets the operating parameters for the photo amp as defined by Equation 3-1. Bits [2:0] set the Gain.

EQUATION 3-1:

$$V_{OUT} = 0.2V + 2 \times I_{PD} \times \frac{t_I}{C_I} \times Gain$$

The integration time has two modes of operation: Direct Control mode or Fixed Timer mode. The Integration mode of operation is set by bit [3]. In Direct Control mode the integration time, t_I, is set by driving the Enable pin high for the desired integration time and then driving the Enable pin low. The integration time can be adjusted as necessary to accommodate variations in I_{PD} and C_I in volume production. The minimum integration time in Direct Control mode should be greater than 50 µs.

In Fixed Timer mode, one of four fixed integration times can be selected. In this case, t_I is proportional to R_t x C_t, where R_t is a trimmed timing resistor, and C_t is the timing capacitor which matches C_I. This will yield a smaller spread in photo amp output voltages for a given photo diode current, I_{PD}. In the Fixed Timer mode, the Enable pin only needs to be pulsed high briefly such as 5 µs.

Measurement accuracy can be improved by subtracting a dark (LED off) photo amp measurement from a lit (LED on) measurement. The subtraction removes any photo amp offset voltage, and the 200 mV reference voltage from the result. In addition, any PCB leakage or smoke chamber light leakage effects that contribute to the photo diode current are removed from the result.

In Figure 2-1, switch SW5 connects the photo amp output to the ABUF input. SW5 and SW6 are controlled by Bit 7 of Register 6. When Bit 7 is high, the photo amp output is connected to the ABUF input for the whole integration period. This is the recommended mode of operation for running the integrator.

Register 7 sets the magnitude of the regulated constant current source for LED1, Bit [2:0] and LED2, Bit [6:4]. In order to maintain current regulation for currents between 80 mA and 200 mA, the voltage drop across LED1 and LED2 must be greater than 1V. For regulated currents between 20 mA and 60 mA, the voltage drop across LED1 and LED2 must be greater than 0.8V. These voltages, in combination with the worst-case forward diode voltage drops for the LED, set the minimum IRCAP voltage. Allowing 2V worst-case diode drop for an infrared LED, IRED, the calculated IRCAP voltage is 3V, but the minimum IRCAP voltage must be 3.2V, since the IRCAP voltage powers the photo amp. For a 200 mA IRED current, a 400 µs integration time and a C5 value of 100 µF, an additional 0.8V must be added to the minimum IRCAP voltage which results in a 4V minimum IRCAP voltage. Register 9 sets the temperature coefficient, TC for each LED current. The increase in LED current over temperature needs to be accounted for when calculating the IRCAP voltage.

3.4 Smoke Check Measurement

After Registers 6, 7 and 9 have been set up, Register 2 is used to power-up the photo amp, Bit 0, and the LED Driver, Bit 3 or Bit 4, being used for the measurement. The power-up sequence does not start the measurement. It only applies the necessary bias to the photo amp and LED driver. This power-up sequence allows the photo amp and LED driver to stabilize before the measurement cycle begins. Bit 1 of Register 2 disconnects the photodiode from the photo amp input and zeroes the integrating capacitor with a logic 0. A logic 1 connects the photodiode to the photo amp input and zeroes the integrating capacitor. This function is useful when two successive measurements are being made since delays associated with power-up of the photo amp and LED driver are eliminated.

Driving the Enable pin high starts the integration measurement cycle. For Fixed Timer mode, the Enable pin only needs to be pulsed high to start the integration. For the Direct Control mode, the integration time is set by how long the Enable pin is held high. At the end of the integration time, the photo amp enters a Hold state.

TABLE 3-2: SMOKE CHECK SAMPLE CODING

Register or Function	Purpose
Photo Setup	
SPI(0x0E, 0x25)	Register 7: set LED1=100 mA (0x5), LED2=50 mA (0x20)
SPI(0x12, 0x03)	Register 9: set LED1 TC=0.5%/C(0x3), LED2 TC=0%/C(0x0)
SPI(0x0C, 0x92)	Register 6: Gain=4(0x2) Timing source(ITCn)=internal timing (0x0) Integration Time(IT)=200us(0x10) ABUF(EnBuf)= full integration(0x80)

Note: For normal photo detection, it is recommended that EnBuf = 0x1.

Photo Operation	
SPI(0x00, 0x06)	Register 0: check V(IRCAP) ÷ 4 on ABUF pin to make sure it is sufficiently charged (≥ 5V for blue LED). This check may be useful after first powering-up but is optional (not needed) as long as IRCAP is sufficiently charged.
A2D	V(IRCAP) ÷ 4 voltage measurement
SPI(0x00, 0x00)	Register 0: turn off ABUF, unload IRCAP
SPI(0x04, 0x03)	Register 2: Photo on, PAEn=0x1 ready for dark measurement, Status=0x2,
{wait 100 µs}	Photo-amp biases up and stabilizes.
Dark Measurement	
Enable=Pulsed High 5 µs	Integration starts and, because internal timing is set, completes automatically in ≈100 µs.
{wait 120 µs}	
A2D	Dark photo measurement
Lit Measurement LED2	
SPI(0x04, 0x01)	Register 2: Keep Photo on, PAEn=0x1, Status=0x0, photo integrator reset
SPI(0x04, 0x13)	Register 2: Photo ready for LED2 lit integration Keep Photo on, PAEn=0x1, Status=0x02 photo integrator ready LED2 Power on=0x10
Enable=Pulsed High 5us	Integration starts and, because internal timing is set, completes automatically.
{wait 120 µs}	
A2D	Lit LED2 photo measurement, Subtract dark measurement from lit measurement

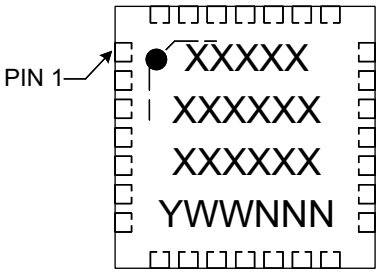
TABLE 3-2: SMOKE CHECK SAMPLE CODING (CONTINUED)

Register or Function	Purpose
Lit Measurement LED1	
SPI(0x04, 0x01)	Register 2: Keep Photo Amp on, PAEn=0x1, Status=0x0, photo integrator reset
SPI(0x04, 0x0B)	Register 2: Photo ready for LED1 lit integration Keep Photo Amp on, PAEn=0x1, Status=0x02 photo integrator ready LED1 Power on=0x10
Enable=Pulsed High 5 µs	Integration starts and, because internal timing is set, completes automatically.
{wait 120 µs}	
A2D	Lit LED1 photo detection Subtract dark measurement from lit measurement
SPI(0x04, 0x00)	Register 2: Photo off, integrator reset

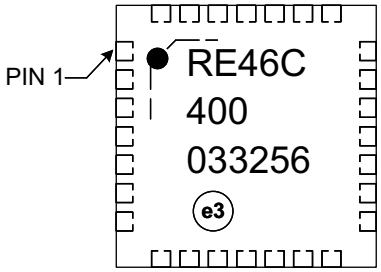
4.0 PACKAGING INFORMATION

4.1 Package Marking Information

28-Lead VQFN



Example

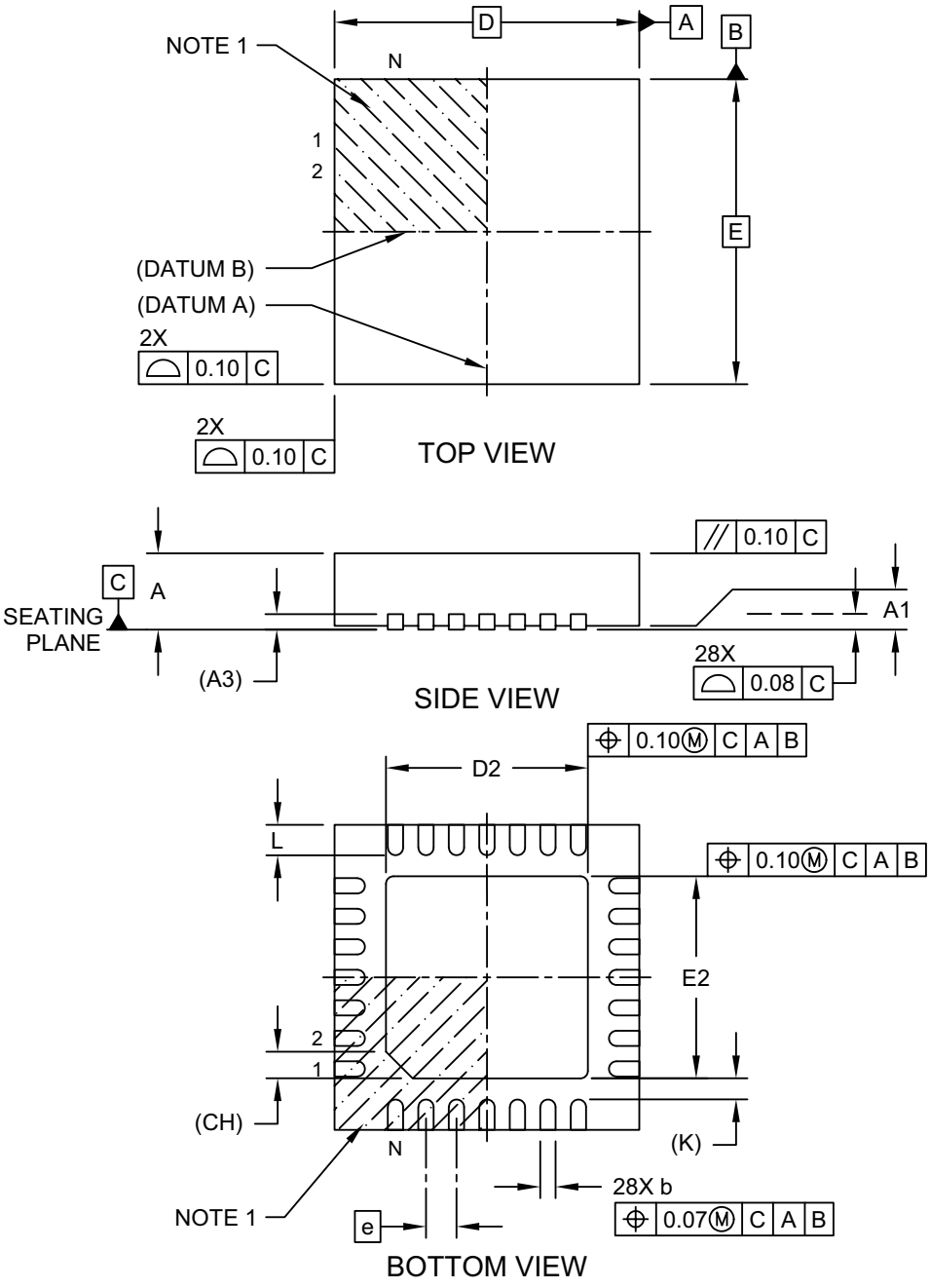


Legend:	XX...X	Customer-specific information
	Y	Year code (last digit of calendar year)
	YY	Year code (last 2 digits of calendar year)
	WW	Week code (week of January 1 is week ‘01’)
	NNN	Alphanumeric traceability code
	(e3)	Pb-free JEDEC® designator for Matte Tin (Sn)
	*	This package is Pb-free. The Pb-free JEDEC designator ((e3)) can be found on the outer packaging for this package.

Note: In the event the full Microchip part number cannot be marked on one line, it will be carried over to the next line, thus limiting the number of available characters for customer-specific information.

28-Lead Very Thin Plastic Quad Flat, No Lead (STX) - 4x4x1.0 mm Body [VQFN]
With 2.65x2.65 mm Exposed Pad

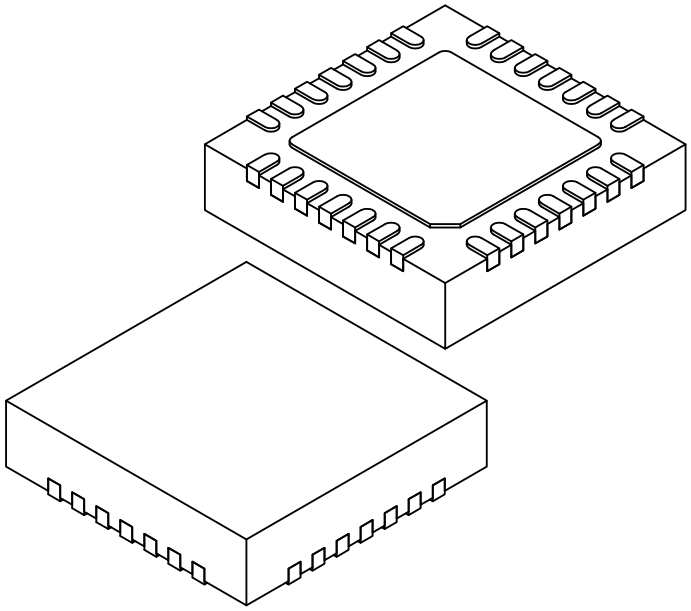
Note:	For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging



Microchip Technology Drawing C04-456 Rev C Sheet 1 of 2

28-Lead Very Thin Plastic Quad Flat, No Lead (STX) - 4x4x1.0 mm Body [VQFN] With 2.65x2.65 mm Exposed Pad

Note: For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging



Units		MILLIMETERS		
Dimension Limits		MIN	NOM	MAX
Number of Terminals	N		28	
Pitch	e		0.40 BSC	
Overall Height	A	0.80	0.90	1.00
Standoff	A1	0.00	0.02	0.05
Terminal Thickness	A3		0.203 REF	
Overall Length	D		4.00 BSC	
Exposed Pad Length	D2	2.55	2.65	2.75
Overall Width	E		4.00 BSC	
Exposed Pad Width	E2	2.55	2.65	2.75
Exposed Pad Corner Chamfer	CH		0.35 REF	
Terminal Width	b	0.15	0.20	0.25
Terminal Length	L	0.30	0.40	0.50
Terminal-to-Exposed-Pad	K		0.275 REF	

Notes:

1. Pin 1 visual index feature may vary, but must be located within the hatched area.
2. Package is saw singulated
3. Dimensioning and tolerancing per ASME Y14.5M

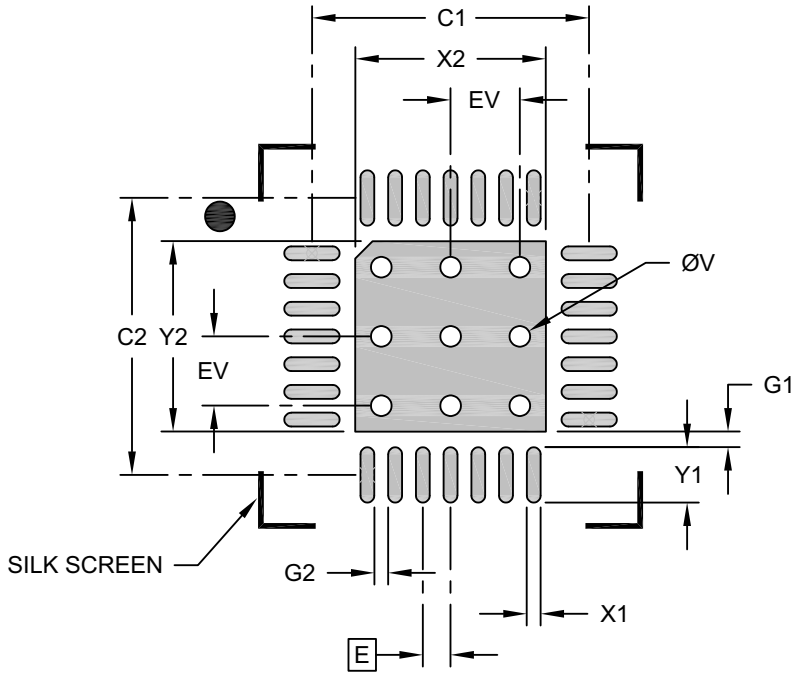
   BSC: Basic Dimension. Theoretically exact value shown without tolerances.

   REF: Reference Dimension, usually without tolerance, for information purposes only.

Microchip Technology Drawing C04-456 Rev C Sheet 2 of 2

28-Lead Very Thin Plastic Quad Flat, No Lead (STX) - 4x4x1.0 mm Body [VQFN] With 2.65x2.65 mm Exposed Pad

Note: For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging



RECOMMENDED LAND PATTERN

Units		MILLIMETERS		
Dimension Limits		MIN	NOM	MAX
Contact Pitch	E	0.40 BSC		
Optional Center Pad Width	X2			2.75
Optional Center Pad Length	Y2			2.75
Contact Pad Spacing	C1		4.00	
Contact Pad Spacing	C2		4.00	
Contact Pad Width (X28)	X1			0.20
Contact Pad Length (X28)	Y1			0.80
Contact Pad to Center Pad (X28)	G1	0.23		
Contact Pad to Contact Pad (X24)	G2	0.20		
Thermal Via Diameter	V		0.30	
Thermal Via Pitch	EV		1.00	

Notes:

1. Dimensioning and tolerancing per ASME Y14.5M

   BSC: Basic Dimension. Theoretically exact value shown without tolerances.

2. For best soldering results, thermal vias, if used, should be filled or tented to avoid solder loss during reflow process

Microchip Technology Drawing C04-2456 Rev C

APPENDIX A: REVISION HISTORY

Revision D (July 2025)

- Updated the **Section 4.0 "Packaging Information"**.
- Register 4 bit 1 was renamed to BGstartup to better reflect its operation. This was previously named RegSel.
- **Section 2.2 "Photoelectric Sensor Circuit"** was updated to better explain photo integration operation
- **Section 2.7 "System Power"** and **Section 2.13 "Critical SPI Register Bits"** was updated to clarify the Register 4 bit 1 name change and its operation.
- Updated Table 3-1.

Revision C (August 2024)

- Updated Figure 0-1 and Figure 0-2.
- Updated Table 0-1.

Revision B (June 2021)

- Updated **Product Identification System** section.

Revision A (September 2020)

- Original release of this document.

PRODUCT IDENTIFICATION SYSTEM

To order or obtain information, e.g., on pricing or delivery, refer to the factory or the listed sales office.

PART NO.	XXX	X(1)
Device	Package	Tape and Reel Option

Device:	RE46C400/1:	Photoelectric Smoke Detector MCU Companion IC
	RE46C400/1T:	Photoelectric Smoke Detector MCU Companion IC (Tape and Reel)
Tape and Reel Option:	Blank =	Standard packaging (tube or tray)
	T =	Tape and Reel(1)
Package:	V28 =	Very Thin Plastic Quad Flat, No Lead, 28-Lead, 4 x 4 mm Body (VQFN)

Examples:

a) RE46C400V28: 28-Lead VQFN package

b) RE46C400V28T: 28-Lead VQFN package, Tape and Reel

c) RE46C401V28 28-Lead VQFN package Tape and Reel

d) RE46C401V28T 28-Lead VQFN package, Tape and Reel

Note 1: Tape and Reel identifier only appears in the catalog part number description. This identifier is used for ordering purposes and is not printed on the device package. Check with your Microchip Sales Office for package availability with the Tape and Reel option.

Microchip Information

Trademarks

The “Microchip” name and logo, the “M” logo, and other names, logos, and brands are registered and unregistered trademarks of Microchip Technology Incorporated or its affiliates and/or subsidiaries in the United States and/or other countries (“Microchip Trademarks”). Information regarding Microchip Trademarks can be found at https://www.microchip.com/en-us/about/legal-information/microchip-trademarks.

ISBN: 979-8-3371-1509-2

Legal Notice

This publication and the information herein may be used only with Microchip products, including to design, test, and integrate Microchip products with your application. Use of this information in any other manner violates these terms. Information regarding device applications is provided only for your convenience and may be superseded by updates. It is your responsibility to ensure that your application meets with your specifications. Contact your local Microchip sales office for additional support or, obtain additional support at www.microchip.com/en-us/support/design-help/client-support-services.

THIS INFORMATION IS PROVIDED BY MICROCHIP "AS IS". MICROCHIP MAKES NO REPRESENTATIONS OR WARRANTIES OF ANY KIND WHETHER EXPRESS OR IMPLIED, WRITTEN OR ORAL, STATUTORY OR OTHERWISE, RELATED TO THE INFORMATION INCLUDING BUT NOT LIMITED TO ANY IMPLIED WARRANTIES OF NON-INFRINGEMENT, MERCHANTABILITY, AND FITNESS FOR A PARTICULAR PURPOSE, OR WARRANTIES RELATED TO ITS CONDITION, QUALITY, OR PERFORMANCE.

IN NO EVENT WILL MICROCHIP BE LIABLE FOR ANY INDIRECT, SPECIAL, PUNITIVE, INCIDENTAL, OR CONSEQUENTIAL LOSS, DAMAGE, COST, OR EXPENSE OF ANY KIND WHATSOEVER RELATED TO THE INFORMATION OR ITS USE, HOWEVER CAUSED, EVEN IF MICROCHIP HAS BEEN ADVISED OF THE POSSIBILITY OR THE DAMAGES ARE FORESEEABLE. TO THE FULLEST EXTENT ALLOWED BY LAW, MICROCHIP'S TOTAL LIABILITY ON ALL CLAIMS IN ANY WAY RELATED TO THE INFORMATION OR ITS USE WILL NOT EXCEED THE AMOUNT OF FEES, IF ANY, THAT YOU HAVE PAID DIRECTLY TO MICROCHIP FOR THE INFORMATION.

Use of Microchip devices in life support and/or safety applications is entirely at the buyer's risk, and the buyer agrees to defend, indemnify and hold harmless Microchip from any and all damages, claims, suits, or expenses resulting from such use. No licenses are conveyed, implicitly or otherwise, under any Microchip intellectual property rights unless otherwise stated.

Microchip Devices Code Protection Feature

Note the following details of the code protection feature on Microchip products:

- Microchip products meet the specifications contained in their particular Microchip Data Sheet.
- Microchip believes that its family of products is secure when used in the intended manner, within operating specifications, and under normal conditions.
- Microchip values and aggressively protects its intellectual property rights. Attempts to breach the code protection features of Microchip product is strictly prohibited and may violate the Digital Millennium Copyright Act.
- Neither Microchip nor any other semiconductor manufacturer can guarantee the security of its code. Code protection does not mean that we are guaranteeing the product is “unbreakable”. Code protection is constantly evolving. Microchip is committed to continuously improving the code protection features of our products.