RE46C425

Multicriteria Smoke Detector Companion IC with Dual Photoelectric and CO Sensing

Features

- Low Quiescent Current
- Operates Using 4.9V to 17V Supply
- 4V, 5.2V, 8.5V, 10V, 11.5V, or 17V Boost Converter
- Dual Independently-Controlled LED Drivers with Programmable Current up to 200 mA
- Dual-Input Programmable Gain Integrating Operational Amplifier with Effective Transimpedance > 20 MΩ at 100 µs
- Internal Operational Amplifier for Interfacing with a Two-Terminal CO or Toxic Gas Sensor:
  - Rail-to-Rail Inputs and Output
  - Unity Gain Stable
  - 10 kHz Gain Bandwidth Product
- Buffered Internal CO Reference
- Analog Buffer for Sensing Multiple Internal Voltages
- Watchdog Timer to Monitor Microcontroller Unit (MCU) Communication
- Serial Peripheral Interface (SPI) Controlled
- Packaging:
  - 4 mm × 4 mm 28-Lead VQFN

General Description

The Microchip RE46C425 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 RE46C425 can be powered from a constant current typically used in panel-based applications.

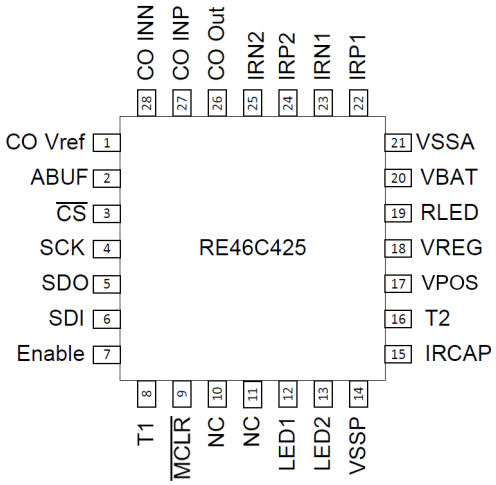
The product features a dual-input integrating photo amplifier to interface with a photoelectric smoke chamber, two independently controlled programmable LED drivers, an op amp with 10 kHz gain bandwidth product and rail-to-rail inputs and output to interface with a two terminal CO sensor, an ABUF for monitoring system voltages and a 3.3V regulator.

The RE46C425 allows the MCU to control all the parameters which set the operating conditions of the RE46C425, such as LED current, amplifier gain and integration time. All of these parameters, including the enabling of various functions, are managed via SPI.

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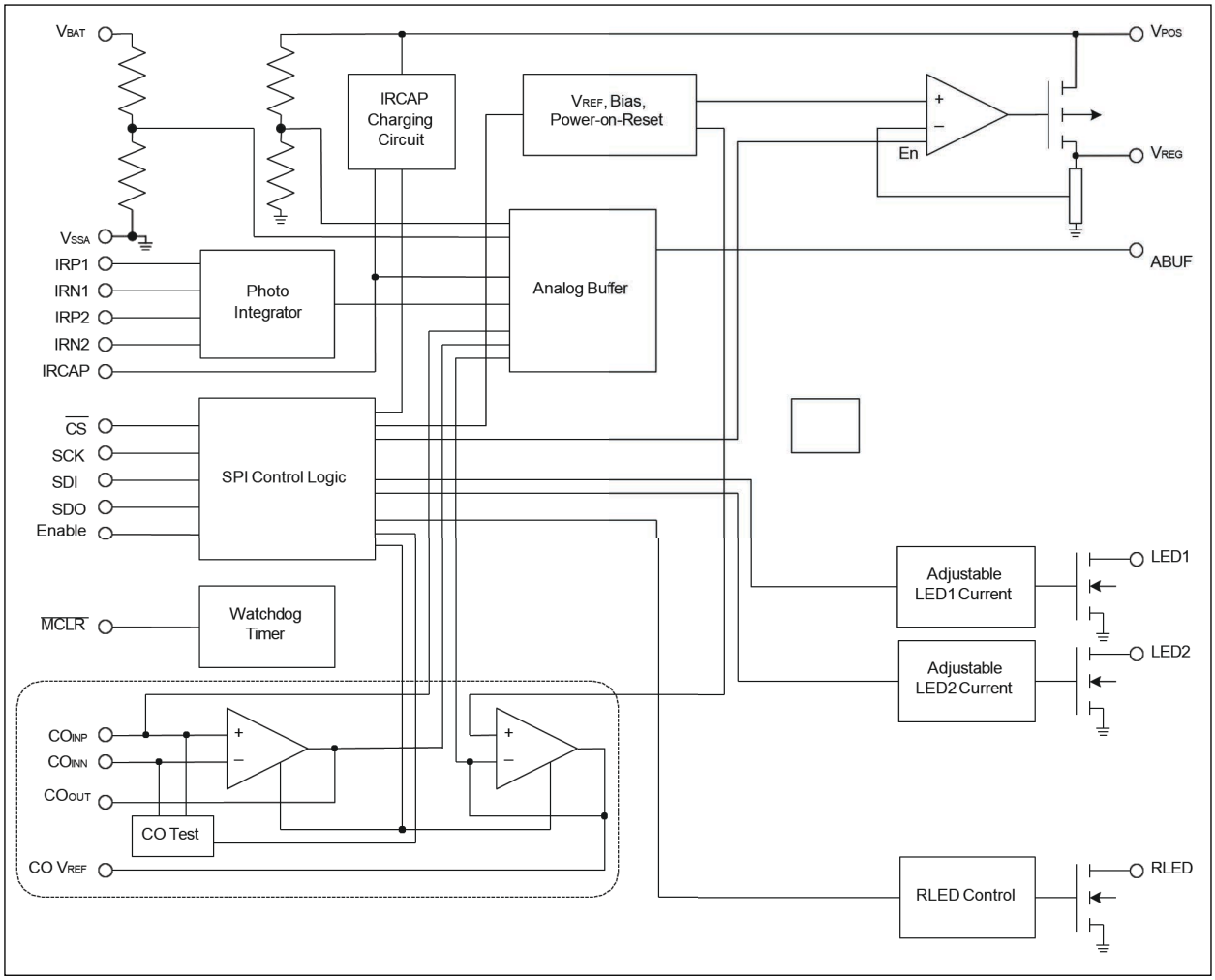
Package Type

RE46C425 (4 mm x 4 mm x 1 mm VQFN)

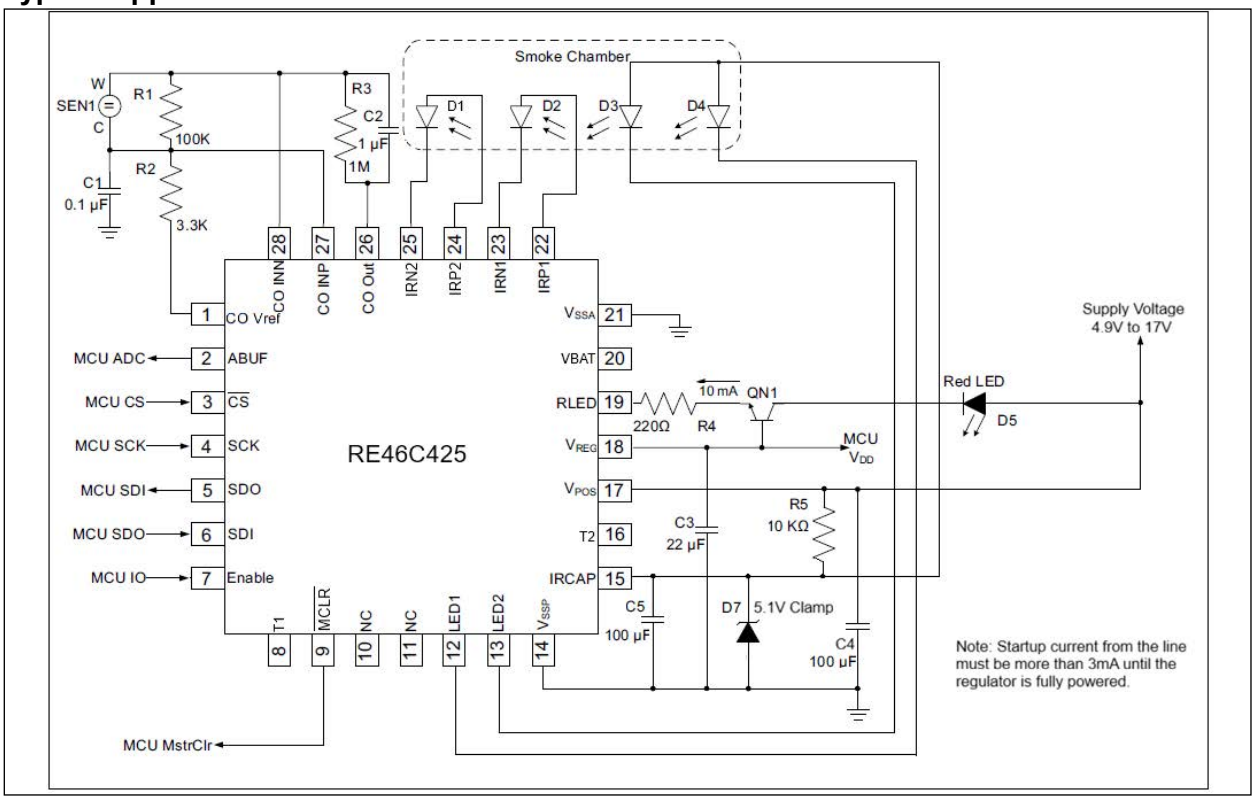


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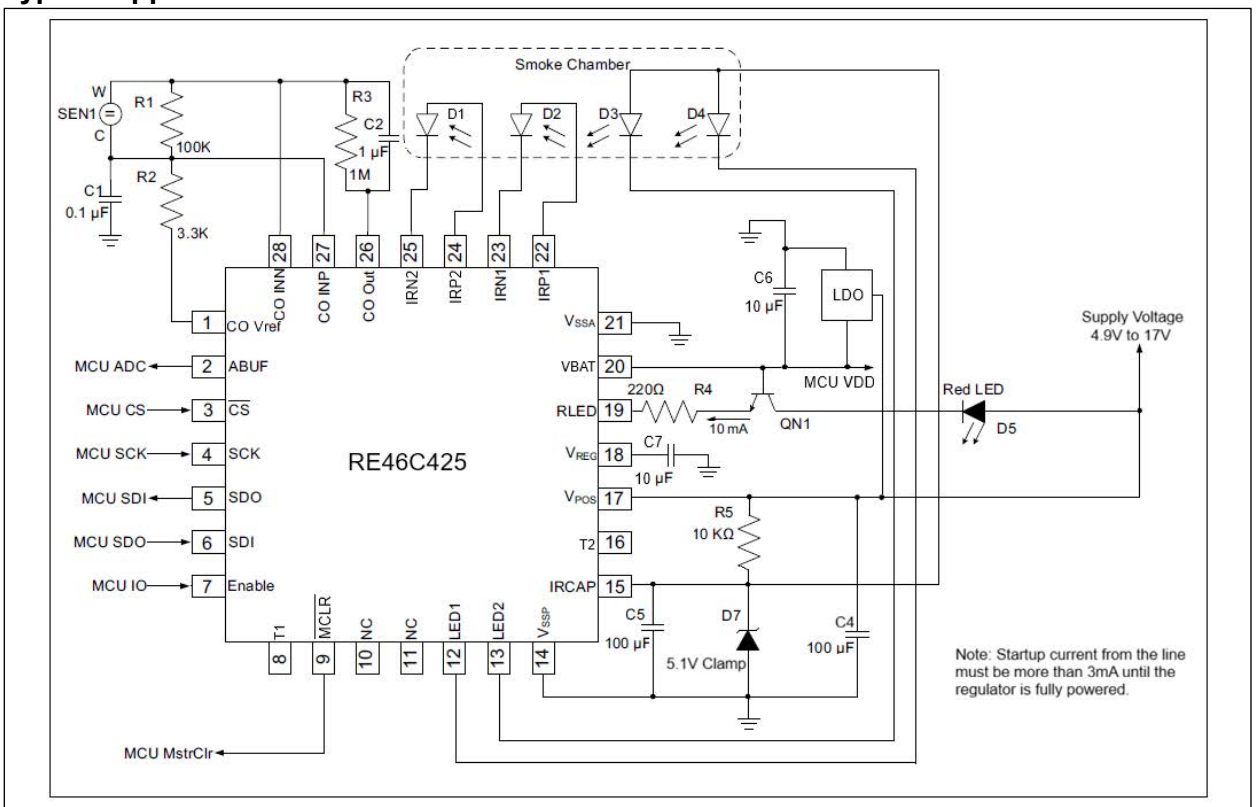
Functional Block Diagram



Typical Application – Panel Powered



Typical Application – Panel with 3V LDO



Note: RegEN=0 and MCU must be powered by external means.

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1.0 ELECTRICAL CHARACTERISTICS

1.1 Absolute Maximum Ratings(†)

V_{BAT} . . . . . +4.0V
V_{REG} . . . . . +3.5V
V_{POS} . . . . . +18V
IRCAP, LED1, LED2 . . . . . +5.5V
Input Voltage Range when BatSel = 1 (V_{IN}) . . . . . -0.3V to V_{BAT} + 0.3V
Input Voltage Range when RegSel = 1 (V_{IN}) . . . . . -0.3V to V_{REG} + 0.3V
Output Voltage Range when BatSel = 1 (V_{OUT}) . . . . . 0.3V to V_{BAT} + 0.3V
Output Voltage Range when RegSel = 1 (V_{OUT}) . . . . . 0.3V to V_{REG} + 0.3V
$\overline{\text{RLED}}$ Output Voltage Range . . . . . -0.3V to V_{POS}
$\overline{\text{MCLR}}$ Output Voltage Range . . . . . -0.3V to +12V
Input Current (I_{IN}) . . . . . +10 mA
Input Current (V_{BAT}) . . . . . +20 mA
Continuous Operating Current (V_{POS}, V_{REG}) . . . . . +40 mA
Continuous Operating Current (RLED) . . . . . +30 mA
Continuous Operating Current (ABUF, SDO, CO_{OUT}, $\overline{\text{MCLR}}$) . . . . . +10 mA
Continuous Operating Current (CO V_{REF}) . . . . . +1 mA
Continuous Operating Current (LED1, LED2) . . . . . +400 mA
HBM ESD . . . . . +1.5 kV
Storage Temperature (T_{STG}) . . . . . -55°C to +125°C
Operating Temperature Range (T_A) . . . . . -20°C to +70°C
Maximum Junction Temperature (T_J) . . . . . +150°C

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

1.2 ELECTRICAL SPECIFICATIONS

TABLE 1-1: ELECTRICAL CHARACTERISTICS

Electrical Characteristics: Unless otherwise indicated, all parameters apply at T_A = -10°C to +60°C, V_{BAT} = 3V, V_{SS} = 0V, V_{POS} = 9V, V_{IRCAP} = 5.5V, C_3 = 22 µF, C_4 = 10 µF, C_5 = 100 µF, BatSel = 1, RegEn = 0, RegSel = 0, IRCEn = 0 (Note 1), (Note 2), (Note 3), (Note 4)

Parameter	Symbol	Test Pin	Min.	Typical	Max.	Units	Conditions
System Supply							
Supply Voltage	V_{BAT}	V_{BAT}	2.1	—	3.6	V	—
	V_{POS}	V_{POS}	4.9	—	17	V	External Supply Powers V_{POS}
Reset Voltage	POR	V_{BAT}	1.2	1.7	2	V	Power-on reset, V_{BAT} rising, V_{POS} floating (Note 7)
		V_{POS}	2	2.4	3.7	V	Power-on reset, V_{BAT} floating, V_{POS} rising @0.5V/ms (Note 7)
		V_{BAT}	1.1	1.4	1.7	V	Brown-out reset, V_{BAT} falling, BatSel = 1 (Note 7)
I_{DD}	I_{DDSTBY}	V_{BAT}	—	300	600	nA	All circuits disabled
	I_{DDrev}	V_{BAT}	—	-20	-260	nA	(Note 5) V_{BAT} = 2V, V_{REG} = 3.5V, RegEn = 0, RegSel = 1, BatSel = 0
	$I_{DDrev25C}$	V_{BAT}	—	-20	-100	nA	T_A = +25°C V_{BAT} = 2V, V_{REG} = 3.5V, RegEn = 0, RegSel = 1, BatSel = 0
3.3V Regulator (V_{POS} = 5.2V, RegEn = 1, RegSel = 0) (Enable regulator, power internal circuits from V_{BAT}, boost regulator off)							
I_{POS}	I_{POSREG}	V_{POS}	—	3	6	µA	No load. BatSel = 0 All other circuits disabled (IRCEn = 0)
Startup Time	t_{REG}	V_{REG}	—	0.7	3	ms	No load, V_{REG} = 0.0V to 90% V_{REG}
Regulator Voltage	V_{REG1}	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 to 20 mA, RegSel = 1, BatSel = 0
Short Circuit Current	I_{REGSC}	—	—	52	—	mA	V_{REG} shorted to V_{SS}
Line Regulation	V_{REGLN}	V_{REG}	—	0.02	0.25	%/V	I_{LOAD} =1 mA, V_{POS} = 4.9V to 17V

Note 1: Wherever a specific V_{POS} value is listed under test conditions, V_{POS} is externally forced. IRCEn = 0.

2: Typical values are for design information only and apply at T_A = +25°C.

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

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

5: Not production-tested.

6: ΔmV = ABUF – 200 mV

7: POR threshold values are dependent on supply ramp rate and operating temperature. The specified POR limits apply only under the listed test conditions. Supply ramp rates outside the characterized condition may shift the effective POR release threshold, particularly at low temperature.

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TABLE 1-1: ELECTRICAL CHARACTERISTICS (CONTINUED)

Electrical Characteristics: Unless otherwise indicated, all parameters apply at T_A = -10°C to +60°C, V_{BAT} = 3V, V_{SS} = 0V, V_{POS} = 9V, V_{IRCAP} = 5.5V, C_3 = 22 µF, C_4 = 10 µF, C_5 = 100 µF, BatSel = 1, RegEn = 0, RegSel = 0, IRCEn = 0 (Note 1), (Note 2), (Note 3), (Note 4)

Parameter	Symbol	Test Pin	Min.	Typical	Max.	Units	Conditions
Photo Detection							
Photo Amplifier (PAEn = 1, ABUF[3:0] = 0000, EnBUF = 1, InSel = 0, ITCn = 0, EnCntl = 0, IT[5:4] = 00, Gain[2:0] = 000) (Photo amplifier and ABUF enabled, Inputs = IRN1 and IRP1, fixed integration time = 100 µs, Gain = 1, Status = Reset)							
I_{DD}	I_{DDPA}	V_{BAT}	—	50	120	µA	BatEn = 1
I_{POS}	I_{POSPA}	V_{POS}	—	60	130	µA	RegEn = 1, RegSel = 1
IRCAP Supply Current	$I_{IRCAPPA}$	IRCAP	—	340	410	µA	—
Startup Time	t_{SUPA}	ABUF	—	10	110	µs	IRCEn=1, PAEn = 0 to 1 transition
Input Bias Current	I_{BOP1}	IRN1, IRP1	-200	—	200	pA	InSel = 0, Gain[2:0] = 100, IT[5:4] = 01, Enable Pin = 1
	I_{BOP2}	IRN2, IRP2	-200	—	200	pA	InSel = 1, Gain[2:0] = 100, IT[5:4] = 01, Enable Pin = 1
Photo Amplifier Reference	PA_{Ref}	ABUF	—	200	—	mV	—
PAOut1	PA_{O01}	ABUF	620	830	1040	ΔmV(6)	G = 1, I_{PD} = 40 nA
	PA_{O02}		1290	1660	2050	ΔmV(6)	G = 2, Gain[2:0] = 001, I_{PD} = 40 nA
	PA_{O03}		—	830	—	ΔmV(6)	G = 4, Gain[2:0] = 010, I_{PD} = 10 nA
	PA_{O04}		—	1660	—	ΔmV(6)	G = 8, Gain[2:0] = 011, I_{PD} = 10 nA
	PA_{O05}		1200	1560	1920	ΔmV(6)	G = 16, Gain[2:0] = 100, I_{PD} = 5 nA
	PA_{O06}		1000	1400	1800	ΔmV(6)	G = 32, Gain[2:0] = 101, I_{PD} = 2.5 nA
PAOut2	PA_{O09}		620	830	1040	ΔmV(6)	Input2, InSel = 1, G = 1, Gain[2:0] = 000, I_{PD} = 40 nA
PAOut3	PA_{O10}		—	800	—	ΔmV(6)	t_i = 200 µs, IT[5:4] = 01, I_{PD} = 20 nA
	PA_{O11}		—	1200	—	ΔmV(6)	t_i = 300 µs, IT[5:4] = 10, I_{PD} = 20 nA
	PA_{O12}		—	1600	—	ΔmV(6)	t_i = 400 µs, IT[5:4] = 11, I_{PD} = 20 nA
	PA_{max}		2.6	—	—	V	t_i = 400 µs, IT[5:4] = 11, I_{PD} = 40 nA, V_{IRCAP} = 3.3V

Note 1: Wherever a specific V_{POS} value is listed under test conditions, V_{POS} is externally forced. IRCEn = 0.

2: Typical values are for design information only and apply at T_A = +25°C.

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

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

5: Not production-tested.

6: ΔmV = ABUF – 200 mV

7: POR threshold values are dependent on supply ramp rate and operating temperature. The specified POR limits apply only under the listed test conditions. Supply ramp rates outside the characterized condition may shift the effective POR release threshold, particularly at low temperature.

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TABLE 1-1: ELECTRICAL CHARACTERISTICS (CONTINUED)

Electrical Characteristics: Unless otherwise indicated, all parameters apply at T_A = -10°C to +60°C, V_{BAT} = 3V, V_{SS} = 0V, V_{POS} = 9V, V_{IRCAP} = 5.5V, C_3 = 22 µF, C_4 = 10 µF, C_5 = 100 µF, BatSel = 1, RegEn = 0, RegSel = 0, IRCEn = 0 (Note 1), (Note 2), (Note 3), (Note 4)

Parameter	Symbol	Test Pin	Min.	Typical	Max.	Units	Conditions
Integration Time (PAEn = 1, ABUF = 0000, EnBUF = 1, InSel = 0, ITCn = 0, EnCntl = 0, Gain[2:0] = 000) (Photo amplifier and ABUF enabled, Inputs IRN1 and IRP1, fixed integration time, Gain = 1)							
PAOut1 t_i = 100 µs	t_{i100}	ABUF	80	100	120	µs	IT[5:4] = 00
PAOut1 t_i = 200 µs	t_{i200}		160	200	240	µs	IT[5:4] = 01
PAOut1 t_i = 300 µs	t_{i300}		240	300	360	µs	IT[5:4] = 10
PAOut1 t_i = 400 µs	t_{i400}		320	400	480	µs	IT[5:4] = 11
IRCAP LED Supply (V_{POS} = 6V, IRCEn = 1, IRCV = 1)							
I_{RCAP}	I_{IRCAP1}	I_{RCAP}	—	4	7.2	µA	Not charging (V_{IRCAP} = 5.5V)
$I_{POSIRCAP}$	$I_{POSIRCPCHRG1}$	V_{POS}	—	60	—	µA	In excess of I_{IRCAP}
	$I_{POSIRCPCHRG2}$		—	70	—	µA	In excess of I_{IRCAP}
I_{DD}	$I_{DDIRCAP}$	V_{BAT}	—	6	10	µA	BatSel = 1, RegEn = 0
Startup Time	t_{IRCAP}	—	—	2	—	µs	R_{IRCAP} = 1 kΩ, V_{IRCAP} = 0V to 1V
IRCAP Voltage	V_{IRCAP}	IRCAP	3.3	—	5.5	V	LEDEn1 = 1 or LEDEn 2 = 1, PAEn = 1
Charging Current	I_{IRCAP}	IRCAP	—	18	—	mA	V_{IRCAP} = 3.5V, IRCV = 0,
Turn On Voltage	V_{TIR1}	IRCAP	3.6	4	4.4	V	Falling edge, I_{OUT} = 10 mA, IRCV = 0
	V_{TIR2}		4.6	4.85	5.1	V	Falling edge, I_{OUT} = 10 mA, IRCV = 1
Turn Off Voltage	V_{TIR3}	IRCAP	4	4.4	4.8	V	Rising edge, I_{OUT} = 1 mA, IRCV = 0
	V_{TIR4}		5	5.25	5.5	V	Rising edge, I_{OUT} = 1 mA, IRCV = 1

Note 1: Wherever a specific V_{POS} value is listed under test conditions, V_{POS} is externally forced. IRCEn = 0.

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

5: Not production-tested.

6: ΔmV = ABUF – 200 mV

7: POR threshold values are dependent on supply ramp rate and operating temperature. The specified POR limits apply only under the listed test conditions. Supply ramp rates outside the characterized condition may shift the effective POR release threshold, particularly at low temperature.

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TABLE 1-1: ELECTRICAL CHARACTERISTICS (CONTINUED)

Electrical Characteristics: Unless otherwise indicated, all parameters apply at T_A = -10°C to +60°C, V_{BAT} = 3V, V_{SS} = 0V, V_{POS} = 9V, V_{IRCAP} = 5.5V, C_3 = 22 µF, C_4 = 10 µF, C_5 = 100 µF, BatSel = 1, RegEn = 0, RegSel = 0, IRCEn = 0 (Note 1), (Note 2), (Note 3), (Note 4)

Parameter	Symbol	Test Pin	Min.	Typical	Max.	Units	Conditions
Photo LED Driver (X = 1 or 2) (V_{POS} = 5V, V_{IRCAP} = 4.5V, IRCEn = 0, LEDxEn = 1, PAEn = 1, ITCn = 1, Enable = 1) (IRCAP disabled, photo amplifier enabled)							
IRCAP LED Supply Current	$I_{IRCAPLED}$	IRCAP	—	1	—	mA	I_{LEDx} = 100 mA, LEDx[2:0] = 101
Startup Time (LEDx)	t_{SULED}	—	—	10	20	µs	PAEn = 1, LEDxEn = 1, Enable = 0 from LED select to LED ready to Enable
Turn On Time (LEDx)	t_{LED}	LEDx	—	0.4	—	µs	V_{LEDx} = 1V, LEDx[2:0] = 010, from rising edge of Enable to ILED at 70% (I_{LEDx} = 35 mA)
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; $I_{LEDXXXX}$ (**Note 5**)
	TC_{LED3}		—	0.3	—	%/°C	LEDxTC[2:0] = 001; $I_{LEDXXXX}$ (**Note 5**)
	TC_{LED4}		—	0.4	—	%/°C	LEDxTC[2:0] = 010; $I_{LEDXXXX}$ (**Note 5**)
	TC_{LED5}		—	0.5	—	%/°C	LEDxTC[2:0] = 011; $I_{LEDXXXX}$ (**Note 5**)
	TC_{LED6}		—	0.6	—	%/°C	LEDxTC[2:0] = 1XX; $I_{LEDXXXX}$ (**Note 5**)

Note 1: Wherever a specific V_{POS} value is listed under test conditions, V_{POS} is externally forced. IRCEn = 0.

2: Typical values are for design information only and apply at T_A = +25°C.

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

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

5: Not production-tested.

6: ΔmV = ABUF – 200 mV

7: POR threshold values are dependent on supply ramp rate and operating temperature. The specified POR limits apply only under the listed test conditions. Supply ramp rates outside the characterized condition may shift the effective POR release threshold, particularly at low temperature.

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TABLE 1-1: ELECTRICAL CHARACTERISTICS (CONTINUED)

Electrical Characteristics: Unless otherwise indicated, all parameters apply at T_A = -10°C to +60°C, V_{BAT} = 3V, V_{SS} = 0V, V_{POS} = 9V, V_{IRCAP} = 5.5V, C_3 = 22 µF, C_4 = 10 µF, C_5 = 100 µF, BatSel = 1, RegEn = 0, RegSel = 0, IRCEn = 0 (Note 1), (Note 2), (Note 3), (Note 4)

Parameter	Symbol	Test Pin	Min.	Typical	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_{BAT}	—	1.5	3	µA	No loads
	I_{DDCO}		—	1.1	2.2	µA	No loads, COREn = 0
	$I_{DDCOTst}$		—	7	12	µA	COTest = 1, COTRi = 1
I_{POS}	$I_{POSCOREF}$	V_{POS}	—	4.4	8	µA	No loads, RegEn = 1, RegSel = 1
Startup Time	t_{SUCO}	CO_{OUT}	—	900	—	µs	CO_{OUT} = 0.27V, CO_{INP} = 0.3V, Unity gain, C_{LOAD} = 50 pF, R_{LOAD} = 50 kΩ
Reference Voltage	CO V_{Ref}	CO V_{REF}	0.27	0.3	0.33	V	$I_{CO\ VREF}$ = ±10 µA, COREn = 1
Input Offset Voltage	V_{OSCO1}	CO_{INP}, CO_{INN}	-3	—	3	mV	V_{CM} = 0.3V
	V_{OSCO2}	CO_{INP}, CO_{INN}	-1	—	1	mV	V_{CM} = 0.3V, T_A = +25°C
Input Bias Current	I_{BOP1}	CO_{INN}	-200	—	200	pA	T_A = +25°C
	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 = 1 or 0
Common-Mode Input Range	V_{CMR}	CO_{INP}, CO_{INN}	0	—	V_{BAT}	V	—
Common-Mode rejection Ratio	CMRR	CO_{INP}, CO_{INN}	—	85	—	dB	V_{CM} = 0V to V_{BAT}
DC Open Loop Gain (large signal)	AOL	CO_{INP}, CO_{INN}	—	100	—	dB	R_{LOAD} = 50 kΩ to 0.5 * V_{BAT}
Maximum Output Voltage Swing	V_{OLCO}, V_{OHCO}	CO_{OUT}	Vss + 0.010	—	V_{BAT} - 0.020	V	R_{LOAD} = 50 kΩ to 0.5 * V_{BAT}, 0.5V input overdrive
Short Circuit Current	I_{OS}	CO_{OUT}	—	16	—	mA	—

Note 1: Wherever a specific V_{POS} value is listed under test conditions, V_{POS} is externally forced. IRCEn = 0.

2: Typical values are for design information only and apply at T_A = +25°C.

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

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

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TABLE 1-1: ELECTRICAL CHARACTERISTICS (CONTINUED)

Electrical Characteristics: Unless otherwise indicated, all parameters apply at T_A = -10°C to +60°C, V_{BAT} = 3V, V_{SS} = 0V, V_{POS} = 9V, V_{IRCAP} = 5.5V, C_3 = 22 µF, C_4 = 10 µF, C_5 = 100 µF, BatSel = 1, RegEn = 0, RegSel = 0, IRCEn = 0 (Note 1), (Note 2), (Note 3), (Note 4)

Parameter	Symbol	Test Pin	Min.	Typical	Max.	Units	Conditions
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 Operational Amplifier Noise							
Input Voltage Noise	eni	CO_{OUT}	—	5	—	μV_{PP}	—
Input Voltage Noise Density	eni	CO_{OUT}	—	170	—	nV/√Hz	—
Input Current Noise Density	ini	CO_{OUT}	—	0.6	—	fA/√Hz	—
ABUF Operational Amplifier (ABUF[3:0] = 1010) ABUF enabled, Input at pin CO_{INP}							
I_{DD}	I_{DDABUF}	V_{BAT}	—	50	120	µA	No load, ABUF[3:0] = 1010, CO_{INP} = 2.965V
Input Offset Voltage	V_{osABUF}	ABUF	-3	—	3	mV	—
Startup 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_{LOAD} = 50 kΩ, 0.5V input overdrive
	V_{OHABUF}	ABUF	—	—	V_{BAT} - 0.035	V	R_{LOAD} = 50 kΩ, 0.5V input overdrive
Short Circuit Current	I_{SC}	ABUF	—	12	—	mA	1.5V input, R_{LOAD} = 75 kΩ
Pull-Down Current Low	I_{OL_off}	ABUF	0.5	3	6	mA	ABUF[3:0] = 0000, V_{ABUF} = 3.0V

Note 1: Wherever a specific V_{POS} value is listed under test conditions, V_{POS} is externally forced. IRCEn = 0.

2: Typical values are for design information only and apply at T_A = +25°C.

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

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

5: Not production-tested.

6: ΔmV = ABUF – 200 mV

7: POR threshold values are dependent on supply ramp rate and operating temperature. The specified POR limits apply only under the listed test conditions. Supply ramp rates outside the characterized condition may shift the effective POR release threshold, particularly at low temperature.

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TABLE 1-1: ELECTRICAL CHARACTERISTICS (CONTINUED)

Electrical Characteristics: Unless otherwise indicated, all parameters apply at T_A = -10°C to +60°C, V_{BAT} = 3V, V_{SS} = 0V, V_{POS} = 9V, V_{IRCAP} = 5.5V, C_3 = 22 µF, C_4 = 10 µF, C_5 = 100 µF, BatSel = 1, RegEn = 0, RegSel = 0, IRCEn = 0 (Note 1), (Note 2), (Note 3), (Note 4)

Parameter	Symbol	Test Pin	Min.	Typical	Max.	Units	Conditions
ABUF Operational Amplifier (continued) (ABUF[3:0] = 1010) ABUF enabled, Input at pin CO_{INP}							
ABUF R Divider Ratio	ABUFVBAT	ABUF	0.475	0.5	0.525	—	ABUF[3:0] = 0111, BatSel = 1
	ABUFVREG	ABUF	0.475	0.5	0.525	—	V_{REG} = 3.3V, ABUF[3:0] = 1000, RegEn = 0
	ABUFIRCAP	ABUF	0.238	0.25	0.262	—	IRCAP = 5V, ABUF[3:0] = 0110, IRCEn = 0
	ABUFVPOS	ABUF	0.095	0.1	0.105	—	V_{POS} = 10V, ABUF[3:0] = 0101, LBEn = 0, HBEn = 0
	ABUFPHOTO	ABUF	—	1	—	—	ABUF[3:0] = 0010, PAEn = 1, INSEL = 0, EnBuf = 1, Status = 1
	ABUF200REF	ABUF	—	1	—	—	ABUF[3:0] = 0001, PAEn = 1
	ABUFCO	ABUF	0.95	1	1.05	—	CO_{OUT} = 1.5V, ABUF[3:0] = 0011, COAEn = 0
	ABUFCOREF	ABUF	0.95	1	1.05	—	CO V_{REF} = 0.3V, ABUF[3:0] = 0100, COREn = 0
	ABUFIOtr	ABUF	0.095	0.1	0.105	—	V_{IO} = 10V, ABUF[3:0] = 1001, IOEn = 0
	ABUFCOinp	ABUF	0.95	1	1.05	—	CO_{INP} = 0.3V, ABUF[3:0] = 1010, COAEn = 0
	ABUFCOinn	ABUF	0.95	1	1.05	—	CO_{INN} = 0.3V, ABUF[3:0] = 1011, COAEn = 0
	ABUFIRED1	ABUF	0.238	0.25	0.262	—	IRED1 = 2V, V_{IRCAP} = 5, ABUF[3:0] = 1100
	ABUFIRED2	ABUF	0.238	0.25	0.262	—	IRED2 = 2V, V_{IRCAP} = 5, 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	CO_{INP} = 0.3V to 1.3V, ABUF = 95% Final Value

Note 1: Wherever a specific V_{POS} value is listed under test conditions, V_{POS} is externally forced. IRCEn = 0.

2: Typical values are for design information only and apply at T_A = +25°C.

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

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

5: Not production-tested.

6: ΔmV = ABUF – 200 mV

7: POR threshold values are dependent on supply ramp rate and operating temperature. The specified POR limits apply only under the listed test conditions. Supply ramp rates outside the characterized condition may shift the effective POR release threshold, particularly at low temperature.

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TABLE 1-1: ELECTRICAL CHARACTERISTICS (CONTINUED)

Electrical Characteristics: Unless otherwise indicated, all parameters apply at T_A = -10°C to +60°C, V_{BAT} = 3V, V_{SS} = 0V, V_{POS} = 9V, V_{IRCAP} = 5.5V, C_3 = 22 µF, C_4 = 10 µF, C_5 = 100 µF, BatSel = 1, RegEn = 0, RegSel = 0, IRCEn = 0 (Note 1), (Note 2), (Note 3), (Note 4)

Parameter	Symbol	Test Pin	Min.	Typical	Max.	Units	Conditions
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}	—	—	360	—	nA	—
Watchdog Timer	t_{WD}	—	13	19	27	s	—
Watchdog Reset Pulse Width	t_{pw_WD}	—	14	20	27	ms	—
SPI and Digital I/O							
Input Leakage Low	I_{IL}	$\overline{CS}$, SCK, SDI, Enable	-100	—	—	nA	—
Input Leakage High	I_{IH}	$\overline{CS}$, SCK, SDI, Enable	—	—	100	nA	—
Input Voltage Low	V_{IL}	$\overline{CS}$, SCK, SDI,Enable	—	—	0.9	V	—
Input Voltage High	V_{IH}	$\overline{CS}$, SCK, SDI, Enable	2.1	—	—	V	—
Input Voltage Hysteresis	V_{HYS}	$\overline{CS}$, SCK, SDI, Enable	—	0.15	—	V	—
Output Voltage Low	V_{OL}	SDO,$\overline{MCLR}$	—	0.3	0.5	V	I_{LOAD} = 1 mA
Output Voltage High	V_{OH}	SDO, $\overline{MCLR}$	2.4	2.6	—	V	I_{LOAD} = -1 mA
Minimum Enable Pulse Width	EnPW	Enable	—	1	—	µs	ITCn = 0, EnCntl = 0

Note 1: Wherever a specific V_{POS} value is listed under test conditions, V_{POS} is externally forced. IRCEn = 0.

2: Typical values are for design information only and apply at T_A = +25°C.

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

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

5: Not production-tested.

6: ΔmV = ABUF – 200 mV

7: POR threshold values are dependent on supply ramp rate and operating temperature. The specified POR limits apply only under the listed test conditions. Supply ramp rates outside the characterized condition may shift the effective POR release threshold, particularly at low temperature.

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TABLE 1-1: ELECTRICAL CHARACTERISTICS (CONTINUED)

Electrical Characteristics: Unless otherwise indicated, all parameters apply at T_A = -10°C to +60°C, V_{BAT} = 3V, V_{SS} = 0V, V_{POS} = 9V, V_{IRCAP} = 5.5V, C_3 = 22 µF, C_4 = 10 µF, C_5 = 100 µF, BatSel = 1, RegEn = 0, RegSel = 0, IRCEn = 0 (Note 1), (Note 2), (Note 3), (Note 4)

Parameter	Symbol	Test Pin	Min.	Typical	Max.	Units	Conditions
SPI Timing (Figure 1-1)							
Digal Pin Capacitance	C_{IN}, C_{OUT}	—	—	10	—	pF	(All logic inputs/outputs)
Clock Frequency	FCLK	—	—	—	10	MHz	C_{LOAD} = 50 pF
Clock High Time	t_{HI}	—	—	50	—	ns	C_{LOAD} = 50 pF
Clock Low Time	t_{LO}	—	—	50	—	ns	C_{LOAD} = 50 pF
$\overline{CS}$ to First Rising Clock Edge	t_{CSSR}	—	50	—	—	ns	C_{LOAD} = 50 pF
Data Input Setup Time	t_{SU}	—	20	—	—	ns	C_{LOAD} = 50 pF
Data Input Hold Time	t_{HD}	—	40	—	—	ns	C_{LOAD} = 50 pF
SCK to $\overline{CS}$ Rise Hold Time	t_{CHS}	—	50	—	—	ns	C_{LOAD} = 50 pF
$\overline{CS}$ High Time	t_{CSH}	—	100	—	—	ns	C_{LOAD} = 50 pF

Note 1: Wherever a specific V_{POS} value is listed under test conditions, V_{POS} is externally forced. IRCEn = 0.

2: Typical values are for design information only and apply at T_A = +25°C.

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

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

5: Not production-tested.

6: ΔmV = ABUF – 200 mV

7: POR threshold values are dependent on supply ramp rate and operating temperature. The specified POR limits apply only under the listed test conditions. Supply ramp rates outside the characterized condition may shift the effective POR release threshold, particularly at low temperature.

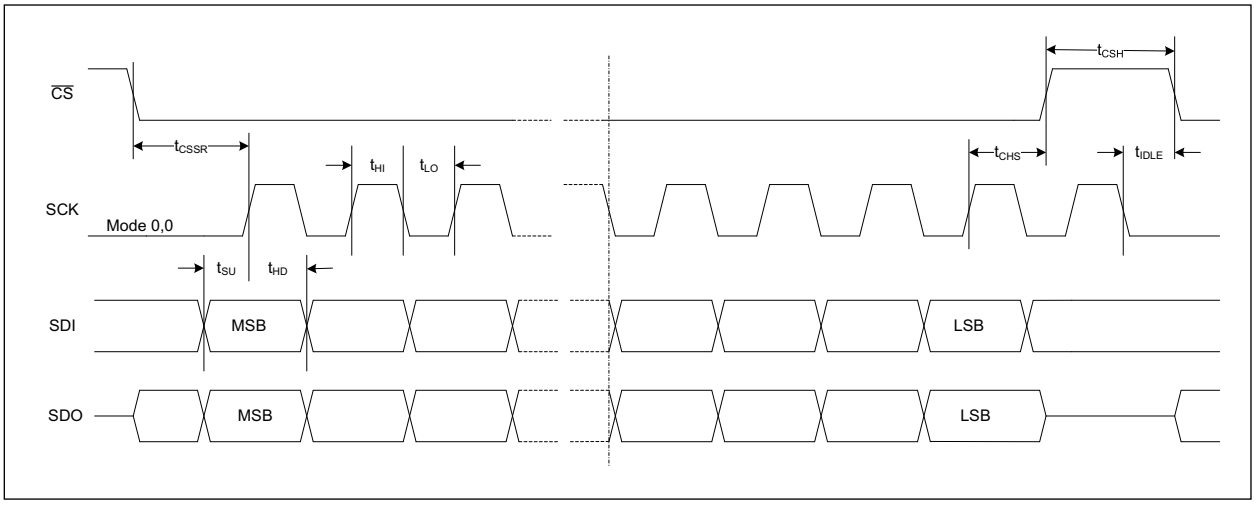


FIGURE 1-1: *SPI Timing Mode 0,0.*

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TEMPERATURE SPECIFICATIONS

Parameters	Symbol	Min.	Typical	Max.	Units	Conditions
Temperature Ranges						
Operating Temperature Range	T_A	-10	—	60	°C	—
Storage Temperature Range	T_{STG}	-55	—	125	°C	—
Thermal Package Resistances						
Thermal Resistance, 28-Lead VQFN	θ_{JA}	—	39.1	—	°C/W	—
Thermal Resistance, 32-Lead VQFN	θ_{JA}	—	36.1	—	°C/W	—

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2.0 PIN DESCRIPTION

TABLE 2-1: 28-LEAD VQFN (RE46C425) PIN FUNCTION TABLE

Pin Number	Symbol	Description
1	CO V_{REF}	CO Voltage Reference.
2	ABUF	Analog Buffer operational amplifier output. Used as the analog interface to the MCU.
3	$\overline{CS}$	Digital input for SPI chip select.
4	SCK	Digital input for SPI clock.
5	SDO	Digital output for SPI data.
6	SDI	Digital input for SPI data.
7	Enable	Digital input for photo integration signal.
8	T1	Reserved. Leave unconnected.
9	$\overline{MCLR}$	Watchdog Master Clear output.
10	NC	No connection.
11	NC	No connection.
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	IRCAP	Used to charge and monitor the LED capacitor.
16	T2	Reserved. Leave unconnected.
17	V_{POS}	Connect to the positive supply voltage.
18	V_{REG}	3.3V Regulator output.
19	RLED	Open drain NMOS output used to drive a red LED.
20	V_{BAT}	Connect to the positive supply voltage.
21	V_{SSA}	Connect to the negative supply voltage for analog circuits.
22	IRP1	Input for anode of the photodiode 1.
23	IRN1	Input for cathode of the photodiode 1.
24	IRP2	Input for anode of the photodiode 2.
25	IRN2	Input for cathode of the photodiode 2.
26	CO_{OUT}	Analog output of CO operational amplifier.
27	CO_{INP}	Noninverting input of the CO operational amplifier.
28	CO_{INN}	Inverting input of the CO operational amplifier.

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3.0 DEVICE OVERVIEW

3.1 Introduction

The RE46C425 provides the analog functions necessary to build a microcontroller-based multicriteria smoke detector. This includes a dual-input integrating amplifier for photoelectric current sensing, two independently controlled regulated current sink drivers for infrared and blue LED emitters, an operational amplifier and a reference for interfacing with a two-terminal CO sensor and a 3.3V regulator to power the microcontroller. The SPI allows the microcontroller unit to have full control over the RE46C425 operation.

3.2 Photoelectric Sensor Circuit

The RE46C425 device provides a dual photodiode input. The dual photodiode inputs are multiplexed via the SPI control. The photo amplifier block diagram is shown in Figure 3-1 along with the LED1 and LED2 driver circuits. The photo amplifier is configured as an integrating amplifier with gain. The photodiode is connected to IRPX and IRNX. The photodiode current is integrated by the photo amplifier to generate an output voltage. Equation 3-1 determines the operation of this amplifier.

EQUATION 3-1:

$$V_{OUT} = 0.2V + I_{PD} \times (t_i / C_I) \times Gain$$

Where:

I_{PD} = Photodiode Current (A)
t_i = Integration Time (S)
C_I = Integrating Capacitor (5 pF)
$Gain$ = Selectable Programmable 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 select one of four possible fixed integration times: 100 µs, 200 µs, 300 µs, and 400 µs. The integration process begins on the rising edge when the Enable pin is pulsed high. This mode of operation is designated Timer mode.

Second, the integration time can be controlled directly by the microprocessor using the Enable pin. When a logic high is applied to the Enable pin, integration begins. When a logic low is applied, integration stops and the photo amplifier circuit enters Hold mode. This mode of operation is designated Direct Control mode.

In Timer mode, the integrating capacitor and the timing capacitor are matched and the timing resistor is well controlled. Because the capacitor matching minimizes the effect of the capacitor tolerance, this mode of operation provides a more repeatable photo amplifier output voltage for a given photodiode current.

In the Direct Control mode, a fixed integration time produces a wider variation in the photo amplifier voltage. By adjusting the integration time to achieve a specific photo amplifier voltage, the effect can compensate for component tolerances, such as for the LED brightness. In the Hold mode, switches SW0 and SW5 are closed and switches SW1 and SW2 are open. Switches SW3 and SW4 can be open or closed. Switches SW3 and SW4 zero the integrating capacitors, which must be done before each measurement is made.

While in Integration mode, switches SW0 and SW5 are open and switches SW1 and SW2 are closed. Switches SW3 and SW4 are opened by the Integrate/Hold logic high. Switches SW3 and SW4 remain open when Hold mode is started. Switches SW3 and SW4 must be closed by an SPI command, before the start of the next integration. This ensures the integration capacitors are zeroed at the start of integration. Switch SW5 connects the photo amplifier output to the Analog Buffer (ABUF) input. The photo amplifier output can be monitored at the ABUF output.

IRCAP supplies the photo amplifier and its maximum output voltage is specified by PA_{MAX}. ABUF, however, is supplied from V_{REG}. Therefore, under conditions such as high gain, high-input current, or long integration time, the integrator output may be clipped at the PA_{MAX} level. Such clipping does not represent a valid measurement. The PA_{MAX} parameter defines the maximum integrator output that should be considered valid.

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

The photo amplifier can be powered on and off by the SPI register to save power. The photo amplifier powers up in the Hold mode, with switches SW3 and SW4 closed.

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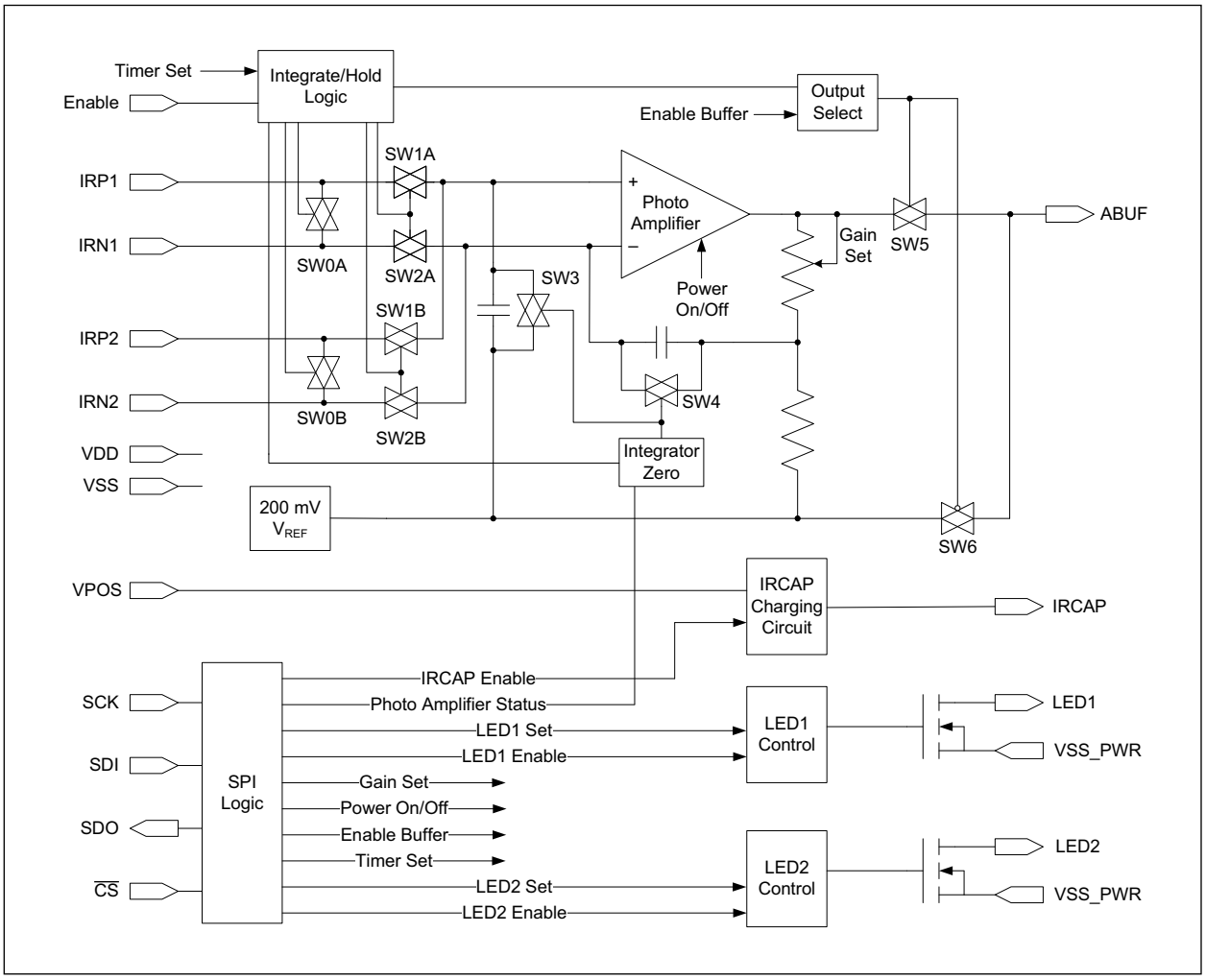


FIGURE 3-1: *Photoelectric Smoke Detection System.*

3.3 LED1 and LED2 Drivers and IRCAP

The LED1 and LED2 driver circuits provide a regulated and programmable current to the photo LEDs. Possible current settings are 20 mA, 40 mA, 50 mA, 60 mA, 80 mA, 100 mA, 150 mA, and 200 mA. The SPI also provides an enable function for the drive circuits. This enable function allows the programmed LED drivers to be turned on or off. The Integrate/Hold command turns on the LED1/LED2 current. The integration does not start until the current reaches 70% of the set value. This reduces the variability in the integrator output voltage.

The LED1 and LED2 diodes are biased from the IRCAP pin. The IRCAP charging circuit charges the IRCAP capacitor to 4.4V nominally when IRCV=0 and V_{POS} ≥5.2V.

The minimum IRCAP voltage for proper operation is 3.3V, which needs to be maintained during the duration of the integration. This ensures there is adequate headroom for diode operation and preserves the regulated current operation. The IRCAP charging circuit is enabled by through SPI. This helps reduce power consumption. The IRCAP charging circuit is powered from the V_{POS} pin.

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3.4 CO Sensor Circuit

The RE46C425 provides a low-offset operational amplifier and a voltage reference, CO V_{REF}, for a two-terminal CO or toxic gas sensor. The unity gain stable operational amplifier provides rail-to-rail inputs and output. The operational amplifier output is monitored by the microcontroller to determine the CO concentration. The operational amplifier 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 operational amplifier 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/sink operation is controlled by individual bits in the SPI register, COCurSel (register 3, bit 6), and COCurPol (register 4, bit 6). In the case of testing the CO_{INN} pin, the CO operational amplifier output is disabled by tristating the CO amplifier output with the SPI bit COTri (register 3, bit 7).

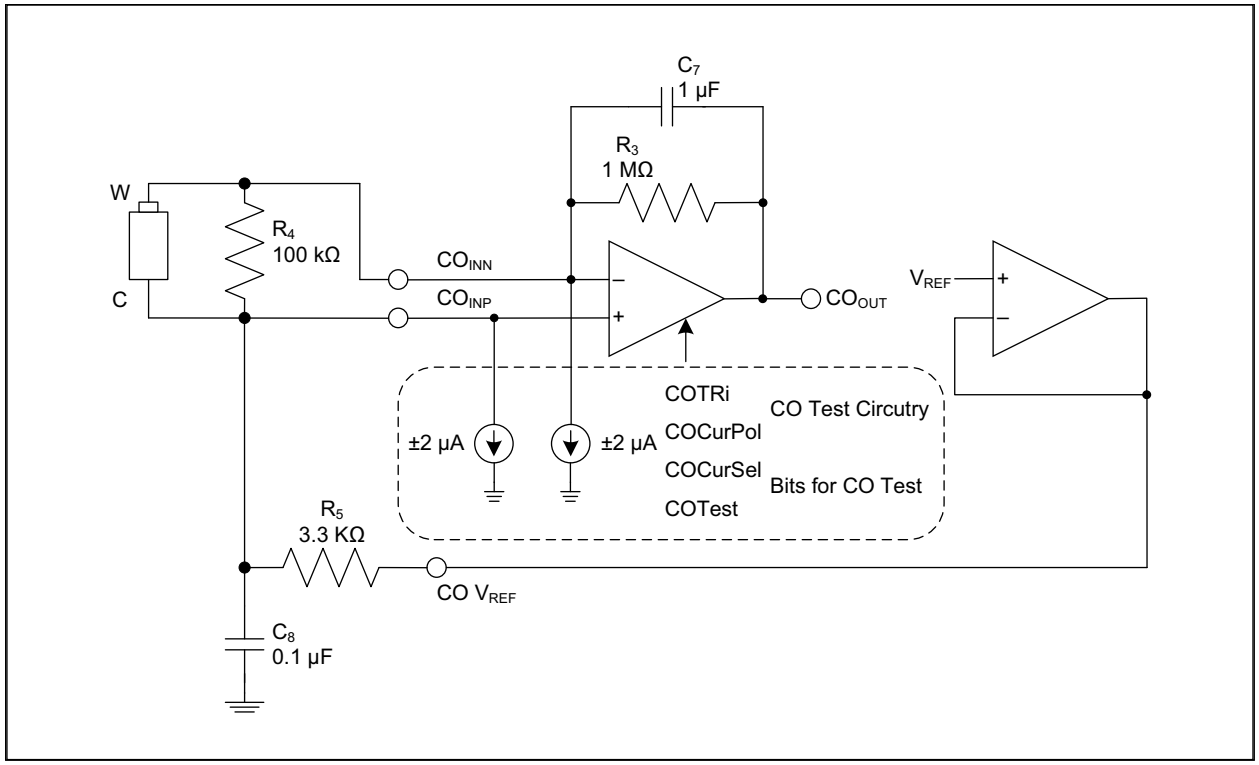


FIGURE 3-2: *CO Test Circuit.*

3.5 Analog Buffer

The analog buffer amplifier provides the means to monitor a number of signals under SPI control. The signals are listed in Table 3-1. The analog buffer can be turned off until needed, which reduces the I_{DD} requirements of the system.

TABLE 3-1: ABUF AVAILABLE SIGNALS

Address	Output Signal
0	ABUF Off output low
1	Photo Amplifier 0.2V Reference
2	Photo Amplifier Output
3	CO_{OUT}
4	CO V_{REF} pin voltage
5	Scaled V_{POS} Monitor
6	Scaled IRCAP Monitor
7	Scaled V_{BAT} Monitor
8	Scaled V_{REG} Monitor
9	Not used
10	CO_{INP} pin voltage
11	CO_{INN} pin voltage
12	Scaled IRED1 pin voltage
13	Scaled IRED2 pin voltage
14	ABUF Off output low
15	ABUF Off output low

3.6 Power Control System

The power control system allows the RE46C425 to be powered by a panel-based system with input voltages ranging from 4.9V to 17V.

In a panel-based system, as shown in the Panel Powered Typical Application drawing, the MCU is powered from the V_{REG} pin, as is most of the internal circuitry of the RE46C425.

3.7 Voltage Regulator

The voltage regulator provides a nominal 3.3V output at the V_{REG} pin and is intended to power a microcontroller. The regulator voltage is turned on through SPI. In normal operation, the regulator can 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.

3.8 RLED Driver

The RLED driver provides a means to drive a red LED from the V_{POS} supply. The RLED driver can be enabled or disabled via the SPI with the RLEn bit (register 3, bit 3).

3.9 Watchdog Timer

When the Watchdog Timer is enabled, the RE46C425 will expect the CS pin to be asserted low and an MCU initiated SPI SCK pulse sent every 20 seconds to prevent a Watchdog Timer alert. If an alert occurs, the MCLR pin will be pulled low for 20 ms to reset the MCU in an attempt to reestablish SPI communication.

3.10 SPI Control

The RE46C425 devices are designed to interface directly with the SPI port available on many microcontrollers and Support mode 0,0. All the digital input pins are Schmitt-Triggered to avoid system noise perturbations during the communications.

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

Refer to Figure 1-1 and the **SPI and Digital I/O** section of the Electrical Characteristics table for detailed input and output timing. The SPI provides complete control of the RE46C425 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.

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3.11 SPI Registers

The RE46C425 SPI interface uses a simple command structure. Each command is either a register write operation or a register read operation. Read commands are primarily intended to verify the results of write operations.

Each register command consists of two bytes: an upper byte and a lower byte. The upper byte contains the register address bits [AD5:AD0], the read/write control bit, and an unused bit (bit 0), which is not part of the address. The lower byte contains the register data.

The SPI RdNow bit enables register data to be returned immediately after the address byte is received. Alternatively, the data can be read after completion of a second 16.bit clock cycle.

The RE46C425 includes nine registers, as defined in Register 3-1. Unused data bits and reads from undefined register addresses return '0'.

REGISTER 3-1: CONFIGURATION SETTINGS AND CALIBRATION SETTINGS

Register 9:0 Address 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		IR Charging Control					
U	U	U	U	U	R/W-0	U	U
—	—	—	—	—	IRCEn	—	—
bit 7							bit 0

Register 2 Data Byte		Photo Amplifier Control					
U	U	R/W-0	R/W-0	R/W-0	U	R/W-1	R/W-0
—	—	InSel	LED2En	LED1En	—	Status	PAEn
bit 7							bit 0

Register 3 Data Byte		CO Control					
R/W-0	R/W-0	R/W-0	U	R/W-0	U	U	U
COTri	COCurSel	COTest	—	RLEn	—	—	—
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	—	BatSel	RegSel	RegEn
bit 7							bit 0

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REGISTER 3-1: CONFIGURATION SETTINGS AND CALIBRATION SETTINGS (CONTINUED)

Register 5 Data Byte		IRCAP/SPI/WD Setup					
U	R/W-1	U	R/W-1	U	U	U	R/W-1
—	WDEn	—	RdNow	—	—	—	IRCV
bit 7							bit 0

Register 6 Data Byte		Photo Amplifier 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		Unused					
U	U	U	U	R/W-0	U	U	U
—	—	—	—	EnCntl	—	—	—
bit 7							bit 0

Register 9 Data Byte		Photo LED TC Selection					
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#	Bit#	POR Value	Description
9:0	8	—	Not Used
	14:9	—	**AD[5:0]:** Address Select 00000 = Register 0; ABUF Select 00001 = Register 1; IRCAP Enable 00010 = Register 2; Photo Amplifier Control 00011 = Register 3; RLED/CO Control 00100 = Register 4; Regulator, CO, SPI Control 00101 = Register 5; IRCAP Voltage, SPI Hold, Watch Dog 00110 = Register 6; Photo Amplifier Setup 00111 = Register 7; LED1/LED2 Setup 01000 = Register 8; Reserved 01001 = Register 9; LED1/LED2 TC Setup X1XXX = Don't Care (Except 01000 and 01001)
	15	—	**RW:** Read/Write Select 1 = Read contents of the specified register 0 = Write data to the specified register

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REGISTER 3-1: CONFIGURATION SETTINGS AND CALIBRATION SETTINGS (CONTINUED)

0	3:0	0	**ABUF[3:0]:** ABUF Channel Select 0000 = ABUF off; output low 0001 = 0.2V Photo Amplifier Reference Output 0010 = Photo Amplifier Output 0011 = CO Amplifier Output 0100 = CO 0.3V Reference Output 0101 = Scaled V_{POS} Voltage Output 0110 = Scaled IRCAP Voltage Output 0111 = Scaled V_{BAT} Voltage Output 1000 = Scaled V_{REG} Voltage Output 1001 = Unused 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	0	Set to 0 at least 10 mS after POR
1	1	0	Not Used, should be set to 0
1	2	0	**IRCEn**: IRCAP Power On/Off 1 = IRCAP Enable 0 = IRCAP Disable
1	7:3	—	Not Used

2	0	0	**PAEn**: Photo Amplifier Power On/Off 1 = Photo Amplifier On Enable 0 = Photo Amplifier On Disable
2	1	0	**Status**: Photo Integrator Status 1 = Ready 0 = Reset
2	2	0	Not Used
2	3	0	**LED1En**: LED1 Driver Power On 1 = LED1 Driver Power On Enable 0 = LED1 Driver Power On Disable
2	4	0	**LED2En**: LED2 Driver Power On 1 = LED2 Driver Power On Enable 0 = LED2 Driver Power On Disable
2	5	0	**InSel**: Photo Amplifier Input Select 1 = IRN2, IRP2 0 = IRN1, IRP1
2	7:6	—	Not Used

3	0	0	Not Used
3	1	0	Not Used
3	2	0	Not Used
3	3	0	**RLEn**: RLED Enable/Disable 1 = RLED Power On Enable 0 = RLED Power On Disable
3	4	0	Not Used

REGISTER 3-1: CONFIGURATION SETTINGS AND CALIBRATION SETTINGS (CONTINUED)

3	5	0	**COTest**: CO Test On/Off 1 = Current Test On 0 = Current Test Off
3	6	0	**COCurSel**: CO Current sink Source Select 1 = CO Source at Noninverting Input 0 = CO Sink at Inverting Input
3	7	0	**COTri**: CO Operational amplifier Output Tristate Enable 1 = Enable CO Operational Amplifier Output Tristate 0 = Disable CO Operational Amplifier Output Tristate

4	0	1	**RegEn**: Regulator Power On 1 = Regulator Power On Enable 0 = Regulator Power On Disable
4	1	0	**RegSel** 1 = Regulator powers internal circuitry 0 = Regulator not used to power internal circuitry
4	2	0	**BatSel** 1 = V_{BAT} powers internal circuitry 0 = V_{BAT} not used to power internal circuitry
4	3	0	Not Used
4	4	0	**COAEn**: CO Amplifier Power On 1 = Enable CO Operational Amplifier 0 = Disable CO Operational Amplifier
4	5	0	**COREn**: CO Reference Power On 1 = Enable CO Reference 0 = Disable CO Reference
4	6	0	**COCurPol**: CO Current sink source polarity 1 = INN source/INP sink 0 = INN sink/INP source
4	7	0	Not Used

5	0	1	**IRCV**: IRCAP Voltage Setting 1 = IRCAP Voltage = 5.2V 0 = IRCAP Voltage = 4.0V
5	2:1	0	Not used, should be set to 0
5	3	0	Not Used
5	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	5	0	Not Used
5	6	1	**WDEn**: Watchdog Timer Power On 1 = Enable Watchdog Timer 0 = Disable Watchdog Timer
5	7	1	Not used, should be set to 0

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REGISTER 3-1: CONFIGURATION SETTINGS AND CALIBRATION SETTINGS (CONTINUED)

6	2:0	0	**Gain[2:0]**: Photo Amplifier 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
6	3	0	**ITCn**: Integration Time Control Method 1 = Integration Time Control is Enable Pin 0 = Integration Time Control is Internal Timer
6	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	6	0	Not Used
6	7	0	**EnBuf**: Photo Amplifier Output to ABUF Control 1 = ABUF Output is the Photo Amplifier Output for the full integration cycle (Full Mode) 0 = ABUF Output is the Photo Amplifier Hold Voltage or 0.2V Reference Voltage (Blind Mode). Should be set to 1 after POR.

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
7	3	0	Not Used
7	6:4	0	**LED2[2:0]**: LED1 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	7	0	Not Used

8	0	0	Not Used
8	1	0	Not Used
8	2	0	Not Used

REGISTER 3-1: CONFIGURATION SETTINGS AND CALIBRATION SETTINGS (CONTINUED)

8	3	0	**EnCntl**: Defines Function that Enable controls Must be 0
8	4	0	Not Used
8	5	0	Not Used
8	6	0	Not Used
8	7	0	Not Used

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

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4.0 APPLICATIONS INFORMATION

4.1 Power Management

4.1.1 POWER UP

The RE46C425 device is powered from the V_{POS} pin. At power up, the internal logic is powered through resistive switches connected to V_{BAT} and V_{REG}. V_{REG} is powered via V_{POS}. The first MCU SPI instructions, after power up, must turn certain registers off for proper device operation. These registers turn off unused functions, properly define the power system, and operate the MCU voltage regulator. Table 4-1 shows the bit settings that are required.

System designs should ensure adequate supply margin during power-up across the full operating temperature range. If the V_{BAT} or V_{POS} ramp profile differs significantly from the Electrical Characteristics test condition, firmware should verify that the supply has reached a valid operating level after reset before enabling normal operation.

TABLE 4-1: REQUIRED DEVICE POWER-UP SETTINGS

Register Number	Register Name	Bit Number	Required Bit Value
Register 1	IR Charging Control	Bit 0	0 (10 ms after power-up)
		Bit 1	0
Register 3	CO Control	Bit 0	0
		Bit 1	0
		Bit 2	0
Register 4	Regulator, CO Control	See Table 4-2 and Table 4-3 below	
Register 5	IRCAP/SPI/WD Setup	Bit 1	0
		Bit 2	0
		Bit 7	0
Register 6	Photo Amplifier Setup	Bit 7	1
Register 8	Unused	Bit 0	0
		Bit 1	0
		Bit 2	0
		Bit 3	0
		Bit 4	0
		Bit 5	0
		Bit 6	0
		Bit 7	0

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4.1.2 OPERATING MODES

Panel-based Systems

A panel-based system relies on the diode-connected power sources to power the RE46C425 at the V_{POS} pin. When powered by V_{POS} and with the appropriate register settings, V_{REG} can then be used to power the MCU. Table 4-2 shows the power-up flow chart for panel-based systems.

When the MCU is powered by an external regulator instead of the internal regulator, the external regulator output must be connected to the V_{BAT} pin. In this configuration, a 10 µF capacitor to ground is still required on the V_{REG} pin. It is recommended to have a 10 µF capacitor at V_{BAT}. Table 4-3 shows the power-up flow chart and register settings for this system configuration.

TABLE 4-2: V_{REG} ENABLED POWER-UP FLOW CHART

	SPI Hex Code	SPI Register/Comment
1	**Apply power to V_{POS} pin. After the MCU is powered on, send the following SPI commands:**	
2	0x0803	**Register 4**: RegSel = 1, RegEn = 1, BatSel = 0, COAEn = 0. COREn = 0, COCurPol = 0 Set the regulator as the internal power source with regulator enabled.
3	**Precharge the IRCAP (capacitor C5), then begin the setup of the smoke and CO detector operation.**	
4	0x0A51	**Register 5**: Bit 7 = 0, WDEn = 1, RdNow = 1, Bits [2:1] = [00], IRCV = 1 (5.2V) Enable Watchdog Timer with watchdog horn disabled; set SPI read-now to immediate.
5	0x0204	**Register 1**: IRCEn = 1 Turn on the IRCAP charging.
6	0x0200	**Register 1**: IRCEn = 0 Turn off the IRCAP charging after approximately 25 ms (delay determined by the size of C5).
7	0x0833	**Register 4**: RegSel = 1, RegEn = 1, BatSel = 0, COAEn = 1. COREn = 1, COCurPol = 0 Turn on CO operational amplifier and CO reference voltage.
8	**Continue with additional setup commands:**	
9	0x0C93	**Register 6**: Gain[2:0] = [011] (8), ITCn = 0, IT[5:4] = [01] (200 µs), EnBuf = 1 Set photo amplifier gain, integration time, integration control, ABUF control for photo amplifier output.
10	0x0E64	**Register 7**: LED1[2:0] = [100] (80 mA), LED2[6:4] = [110] (150 mA) Set LED currents.
11	0x4000	**Register 8**: EnCtl = 0 Set Enable to control integration.
12	0x1233	**Register 9**: LED1 TC[2:0] = [011] (0.5%), LED2 TC[6:4] = [011] (0.5%) Set LED current TC.
13	**Continue with normal operation.**	

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TABLE 4-3: EXTERNAL LDO POWER-UP FLOW CHART

SPI Hex Code		SPI Register/Comment
1	**Apply power to V_{POS} pin. After the MCU is powered on, send the following SPI commands:**	
2	0x0804	**Register 4**: RegSel = 0, RegEn = 0, BatSel = 1, COAEn = 0. COREn = 0, COCurPol = 0 Disable the internal regulator and set the V_{BAT} pin to power the internal circuitry.
3	**Precharge the IRCAP (capacitor C5), then begin the setup of the smoke and CO detector operation.**	
4	0x0A51	**Register 5**: Bit 7 = 0, WDEn = 1, RdNow = 1, Bits [2:1] = [00], IRCV = 1 (5.2V) Enable Watchdog Timer with watchdog horn disabled; set SPI read-now to immediate.
5	0x0204	**Register 1**: IRCEn = 1 Turn on the IRCAP charging.
6	0x0200	**Register 1**: IRCEn = 0 Turn off the IRCAP charging after approximately 25 ms (delay determined by the size of C5).
7	0x0833	**Register 4**: RegSel = 1, RegEn = 1, BatSel = 0, COAEn = 1, COREn = 1, COCurPol = 0 Turn on CO operational amplifier and CO reference voltage.
8	**Continue with additional setup commands:**	
9	0x0C93	**Register 6**: Gain[2:0] = [011] (8), ITCn = 0, IT[5:4] = [01] (200 µs), EnBuf = 1 Set photo amplifier gain, integration time, integration control, ABUF control for photo amplifier output.
10	0x0E64	**Register 7**: LED1[2:0] = [100] (80 mA), LED2[6:4] = [110] (150 mA) Set LED currents.
11	0x4000	**Register 8**: EnCntl = 0 Set Enable to control integration.
12	0x1233	**Register 9**: LED1 TC[2:0] = [011] (0.5%), LED2 TC[6:4] = [011] (0.5%) Set LED current TC.
13	**Continue with normal operation.**	

4.1.3 IRCAP

The IRCAP is the bias supply for the smoke chamber LEDs and the photo amplifier. The IRCAP voltage needs to be large enough to maintain a 1V drop across the LED drivers for LED driver currents ≥80 mA and a 0.8V drop across the LED drivers, when the LED driver current is <80 mA. For a blue LED, the maximum forward voltage drop is about 4V. The minimum high-voltage for IRCAP is 5V, which provides a 1V drop across the LED driver when using a blue LED. For an infrared diode-only system, the worst-case forward voltage drop is about 2V. In this case, the lower IRCAP voltage can be used, which is 4V. The IRCAP is powered on with SPI bit IRCEn (register 1, bit 2), which charges the IRCAP capacitor, C_5, using a 21 mA current source. The IRCAP must be fully charged after power-up prior to integration.

Each smoke check discharges capacitor C_5 by an amount equal to the LED driver current multiplied by the integration time and divided by the value of C_5, as shown in Equation 4-1.

EQUATION 4-1: IRCAP DISCHARGING CALCULATION

$$\Delta V_{IRCAP} = \frac{I_{LED} \times t_i}{C_5}$$

Where:

ΔV_{IRCAP} = IRCAP Voltage Change (V)
I_{LED} = LED Driver Current (A)
t_i = Integration Time (S)
C_5 = Capacitance C_5 (100 µF)

The IRCAP should be turned on prior to integration to charge the capacitor and then turned off after PAEn = 1, before the start of integration to prevent possible switching noise, which could cause measurement errors.

4.2 Operation Overview

After the initial power up is complete, the remaining setup registers must be set. The setup registers are Register 5 through Register 9. The setup registers set operating parameters for the various analog and interface functions. The setup registers can be changed at any time during smoke detector operation. Register 0 through Register 4 are control registers and are used to turn on and off the various analog and interface functions. Practice care with the register addresses, since the LSB of the address byte is a don't care. Effectively, the Register number is multiplied by 2, and then applied, along with the R/W bit, to the upper byte in the 16 bit SPI command code. For example, to turn on the RLED by using Register 3, the hex SPI code is 0x0608.

To reduce current draw and conserve energy, the analog and interface functions can be powered off when not in use. Depending on local regulatory requirements, systems with CO monitoring may require continuous sampling. In such cases, the CO operational amplifier and its reference may be left enabled continuously, independent of other analog or interface blocks.

4.3 Smoke Check

A typical smoke check process consists of two MCU initiated measurements made measuring the analog output of the photo amplifier on the ABUF pin. The first measurement is made with the LED off, a dark measurement, and the second measurement is made with the LED on, a lit measurement. The MCU should subtract the result of the dark measurement from the result of the lit measurement to determine the smoke check result. The dark measurement includes the 200 mV offset from ground, offset voltage effects, leakage current effects and any smoke chamber light leakage effects. These are all sources of error that are also included in the lit measurement result and are removed by the dark measurement subtraction to produce an accurate smoke check measurement.

A smoke measurement is performed by first ensuring the IRCAP capacitor is fully charged. The correct IRCAP voltage must be selected using IRCV (register 5, bit 0) to ensure the correct IRCAP voltage is used. The IRCAP capacitor is the source of current for the LEDs. Then, the LED driver must be enabled, LED1En (register 2, bit 3) or LED2En (register 2, bit 4), unless a dark measurement is being made. The LED driver current is not turned on by this operation. Then, the integrating photo amplifier must be turned on, PAEn (register 2, bit 0), and ABUF must be turned on, ABUF[3:0]. The integrating capacitors must be zeroed before an integration is started by setting SPI register 2, bit 1 = `0` and then setting SPI register 2, bit 1 = `1`. The startup time specifications for the LED driver, the photo amplifier and ABUF set the stabilization time for these circuits. The Enable pin being driven high starts the integration by turning on the LED.

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In Figure 3-1 there is a switch, SW5, between the photo amplifier output and the ABUF input. If the switch is closed, the ABUF output follows the photo amplifier output.

SPI write or read operations must not be performed during an integration. While the photo integration is in process, only photo outputs may be monitored on ABUF.

4.3.1 INTEGRATOR TIMING

The smoke check integration timing setup has two operating modes: Timer mode and Direct Control mode. In either operating mode, a dark measurement must be subtracted from a lit measurement.

In Timer mode, there are four fixed integration times selectable by SPI register 6, bit [5:4]: 100 µs, 200 µs, 300 µs, and 400 µs. Timer mode compensates for internal chip tolerances. After charging the IRCAP capacitor, enabling the LED driver, enabling the photo amplifier, and disabling the IRCAP charging circuit, a smoke measurement is made by pulsing the Enable pin high for a minimum of 1 µs. This turns on the LED Driver, if enabled, and starts the integration timer, which runs to completion for the selected timing. To ensure the integration completes properly, wait for the maximum specified time for the selected integration time and complete the A/D conversion.

In Direct Control mode, the width of the Enable pin pulse is the integration time. After powering on IRCAP, the LED driver, photo amplifier and ABUF, a smoke measurement is made by pulsing the Enable pin high for the length of the desired integration time. The minimum pulse width is 50 µs. The rising edge of the Enable pin pulse turns on the LED Driver, if it is enabled. The manufacturing tolerances for photodiode current, integrating capacitor value and photo amplifier gain all affect the photo amplifier output voltage for each detector. Adjusting the integration time to produce a consistent result for given smoke check condition, such as clean air, simplifies detector calibration. Table 4-4 shows the smoke check flow chart.

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TABLE 4-4: SMOKE CHECK SAMPLE CODE

	SPI Hex Code	SPI Register/Comment
1	**Photo amplifier setup after power up.**	
2	0x0A51	**Register 5**: Bit 7 = 0, WDEn = 1, RdNow = 1, Bits [2:1] = [00], IRCV = 1 (5.2V) Set the IRCAP voltage.
3	0x0C83	**Register 6**: Gain[2:0] = [011] (8), ITCn = 0, IT[5:4] = [01] (100 µs), EnBuf = 1 Set photo amplifier gain, integration time, integration control and ABUF control.
4	0x0E25	**Register 7**: ILED1[2:0] = [101] 100 mA, ILED2[6:4] = [010] 50 mA Set LED currents.
5	0x1000	**Register 8**: EnCtl = 0 Enable pin controls integration on time or start.
6	0x1203	**Register 9**: TCLED1[2:0] = [011] 0.5%/°C, TCLED2[6:4] = [000] 0%/°C Set LED current TC.
7	**Normal operation (Sleep).**	
8	**Photo amplifier operation (Wake Up):**	
9	0x0204	**Register 1**: IRCEn = 1 Turn on IRCAP charging; use Equation 4-1 to calculate charging time.
10	0x0006	**Register 0**: ABUF[3:0] = [0110] Check IRCAP voltage via ABUF pin to make sure it is sufficiently charged (≥ 5V for blue LED and ≥ 3.4V for infrared LED).
11	**ADC ABUF voltage measurement conversion after waiting for IRCAP to charge.**	
12	0x0200	**Register 1**: IRCEn = 0 Turn off the IRCAP charging.It is recommended to turn off IRCAP after enabling the photo amplifier.
13	**Dark measurement LED2; photo amplifier is on.**	
14	0x0C82	**Register 6**: EnBuf = 1, IT[5:4] = [00] (100us), ITCn = 0, and Gain[2:0] = [010] (Gain = 4) Setup photo amplifier for LED2 measurement.
15	0x0401	**Register 2**: PAEn = 1, Status = 0, InSel = 0, LED1En = 0, LED2En = 0 Zero integrating capacitors.
16	**Photo amplifier biases up and stabilizes; wait 110 µs.**	
17	0x0403	**Register 2**: PAEn = 1, Status = 1, InSel = 0, LED1En = 0, LED2En = 0 Ready, LED2 disabled
18	**Enable pin pulsed high to start fixed time integration of 100 µs**.	
19	**Wait 125 µs.**	
20	**ADC makes dark photo measurement conversion.**	
21	**Lit measurement LED2:**	
22	0x0411	**Register 2**: PAEn = 1, Status = 0, InSel = 0, LED1En = 0, LED2En = 1 Zero integrating capacitors. Enable LED2 bias circuitry.
23	0x0413	**Register 2**: PAEn = 1, Status = 1, InSel = 0, LED1En = 0, LED2En = 1 Ready, LED2 enabled.
24	**Enable pin pulsed high to start fixed time integration of 100 µs:**	
25	**Wait 125 µs.**	
26	**ADC makes lit photo measurement conversion.** **Subtract dark ADC value from lit ADC value to get LED2 smoke check value.**	
27	**Smoke check measurement LED1:** (IRCAP ≥3.7V with these Register settings)**.**	
28	0x0204	**Register 1**: IRCEn = 1 Turn on the IRCAP charging, briefly (optional).
29	**Adjust photo amplifier gain and integration time for LED1**.	

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TABLE 4-4: SMOKE CHECK SAMPLE CODE (CONTINUED)

SPI Hex Code		SPI Register/Comment
30	0x0C92	**Register 6**: EnBuf = 1, IT[5:4] = [01] (200 us), ITCn = 0, Gain[2:0] = [010] (Gain = 4) Photo amplifier setup for LED1 measurement.
31	0x0200	**Register 1**: IRCEn = 0 Turn off IRCAP charging.
32	**Dark measurement for LED1:**	
33	0x0401	**Register 2**: PAEn = 1, Status = 0, InSel = 0, LED1En = 0, LED2En = 0 Zero integrating capacitors.
34	0x0403	**Register 2**: PAEn = 1, Status = 1, InSel = 0, LED1En = 0, LED2En = 0 Ready, LED1 disabled.
35	**Enable pin pulsed high to start fixed time integration of 200 µs.**	
36	**Wait 250 µs.**	
37	**ADC makes dark photo measurement conversion.**	
38	**Lit measurement LED1:**	
39	0x0401	**Register 2**: PAEn = 1, Status = 0, InSel = 0, LED1En = 0, LED2En = 0 Zero integrating capacitors.
40	0x040B	**Register 2**: PAEn = 1, Status = 1, InSel = 0, LED1En = 1, LED2En = 0 Ready, LED1 enabled.
41	**Enable pin pulsed high to start fixed time integration of 200 µs.**	
42	**Wait 250 µs.**	
43	**ADC makes lit photo measurement conversion.** **Subtract dark ADC value from lit ADC value to get LED1 smoke check value.**	
44	0x0400	**Register 2**: PAEn = 0, Status = 0, InSel = 0, LED1En = 0, LED2En = 0 Turn off the photo amplifier and the LEDs.

4.4 CO Detection and Sensor Test

The CO operational amplifier is a high performance low current operational amplifier that is configured as a transimpedance amplifier. The 300 mV CO reference ensures the operational amplifier output operates above ground. The CO operational amplifier is powered on by SPI register 4, bit 4 (COAEn) and the CO reference is powered on by SPI register 4, bit 5 (COREn). Each operational amplifier input is connected to a 2 µA current source/sink. Only one current source/sink on one pin can be turned on at a time. The current source/sink is powered on by COTest (register 3, bit 5). Register 3, bit 6, COCurSel, controls which input is used for the CO test. The current source/sink polarity is controlled by COCurPol (register 4, bit 6). SPI register 3, bit 7 (COTri) tristates the CO operational amplifier output, which prevents the CO operational amplifier output from correcting for the test charge injection.

To test the CO sensor, use the following procedure:

The CO operational amplifier and reference are assumed to be running with a stable CO operational amplifier output. The CO test pin must be selected with COCurSel (register 3, bit 6) and the current source polarity must be set with COCurPol (register 4, bit 6).

First, turn off the operational amplifier output with register 3, bit 7, COTri, so the operational amplifier output does not override the test current injection. Then, turn on the current source with register 3, bit 5, COTest, for 2s to 5s. About 50 µs after the current source is turned off, turn on the operational amplifier output using register 3, bit 7, COTri. About 5s after operational amplifier output turns on, check the operational amplifier output voltage. Refer to the CO manufacturers documentation for information regarding testing the CO sensor. For typical responses, see the RE46C425 Demonstration Board User's Guide.

TABLE 4-5: POWER-UP AND CO TEST

SPI Hex Code		SPI Register/Comment
1	**Apply power to V_{POS} pin. After the MCU is powered on, send the following SPI commands:**	
2	**Use setup commands found in** Table 4-2**.** (COAEn=1, COREn=1, COCurPol=0)	
3	**Begin CO Test.** Steps 3 through 9 are optional depending on intended application.	
4	0x0203	**Register 0**: ABUF[3:0] = [0011] (3) Monitor the CO operational amplifier output.
5	0x0680	**Register 3**: RLEn = 0, COTest = 0, COCurSel = 0, COTri = 1 Tristate the CO amplifier output.
6	0x06A0	**Register 3**: RLEn = 0, COTest = 1, COCurSel = 0, COTri = 1 Turn on the test current source. For settings COCurSel=0, COCurPol=0: test current sinks 2 µA on pin CO_{INN}.
7	**Wait from 2s to 5s, then turn off the current source.**	
8	0x0680	**Register 3**: RLEn = 0, COTest = 0, COCurSel = 0, COTri = 1 Turn off the current source.
9	**Wait 50 µs then turn on the operational amplifier output.**	
10	0x0600	**Register 3**: RLEn = 0, COTest = 0, COCurSel = 0, COTri = 0 Enable the CO operational amplifier output.
11	**Make ADC measurement at ABUF pin per CO manufacturers recommendations.**	
12	0x0000	**Register 0:** Turn off the ABUF.

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4.5 Enable Pin

The Enable pin is a digital input connected to the Integrate/Hold logic for the photo amplifier and used to control the photo amplifier integration timing. As part of the normal device startup procedure, EnCntl must be set to 0 in Register 8.

The photo amplifier supports two integration timing modes, selected by ITCn in Register 6:

- Timer Mode: When ITCn = 0, the internal integration timer controls the integration interval. The Enable pin starts the integration cycle. A logic high pulse on the Enable pin starts the selected fixed integration time of 100 µs, 200 µs, 300 µs or 400 µs, as programmed by IT[5:4] in Register 6 [1]. The Enable pulse must meet the minimum Enable pulse width specification.
- Direct Control Mode: When ITCn = 1, the Enable pin directly controls the integration interval. Driving the Enable pin high starts integration, and driving it low stops integration and places the photo amplifier into Hold mode. In this mode, the width of the Enable pulse determines the integration time.

When an LED driver is enabled for a lit smoke measurement, the Enable pin also initiates LED current turn-on. Integration begins after the LED current reaches the required operating level, helping reduce variation in the photo amplifier output caused by LED turn-on settling.

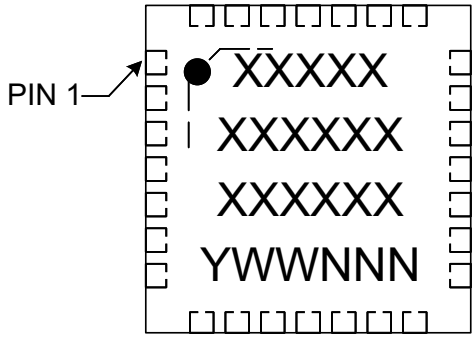
For smoke-check operation, the MCU typically uses the Enable pin to initiate both dark and lit measurements. In Timer mode, the MCU pulses Enable high to start the selected fixed integration time. In Direct Control mode, the MCU sets the integration time by controlling the duration of the Enable high pulse.

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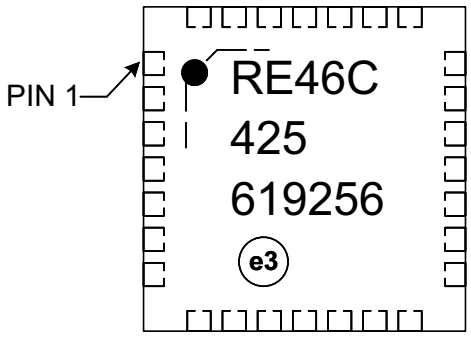
5.0 PACKAGING INFORMATION

5.1 Package Marking Information

28-Lead VQFN, 4 x 4 x 1 mm



Example:



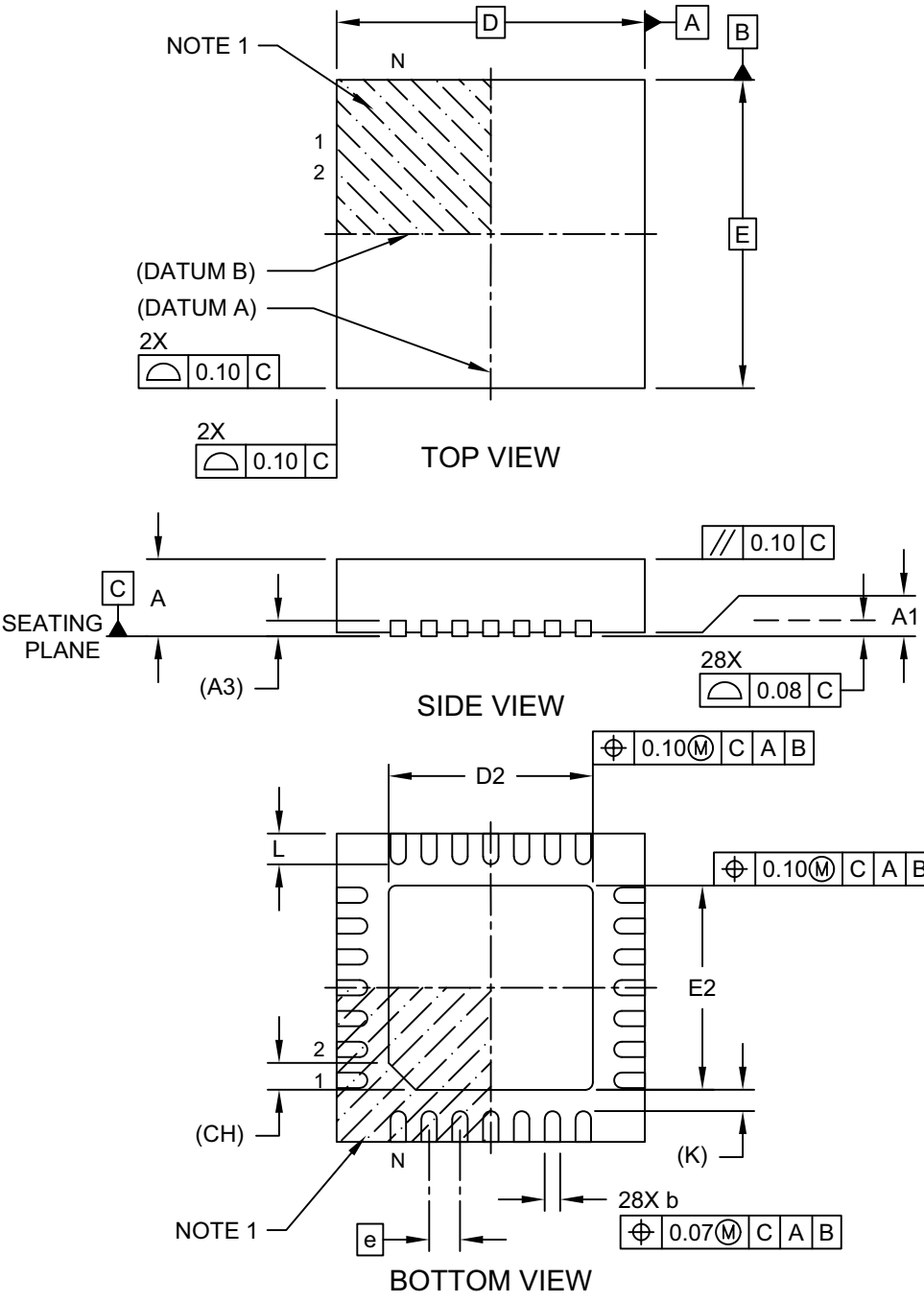
Legend:	XX...X	Customer-specific information
	Y	Year code (last digit of calendar year)
	YY	Year code (last 2 digits of calendar year)
	WW	Week code (week of January 1 is week ‘01’)
	NNN	Alphanumeric traceability code
	(e3)*	Pb-free JEDEC designator for Matte Tin (Sn)
		This package is Pb-free. The Pb-free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

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

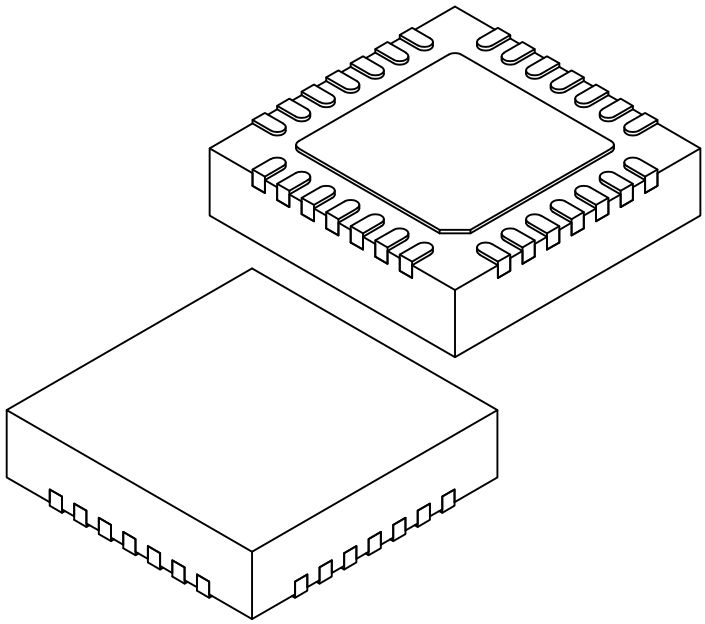
Note:	For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging



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.

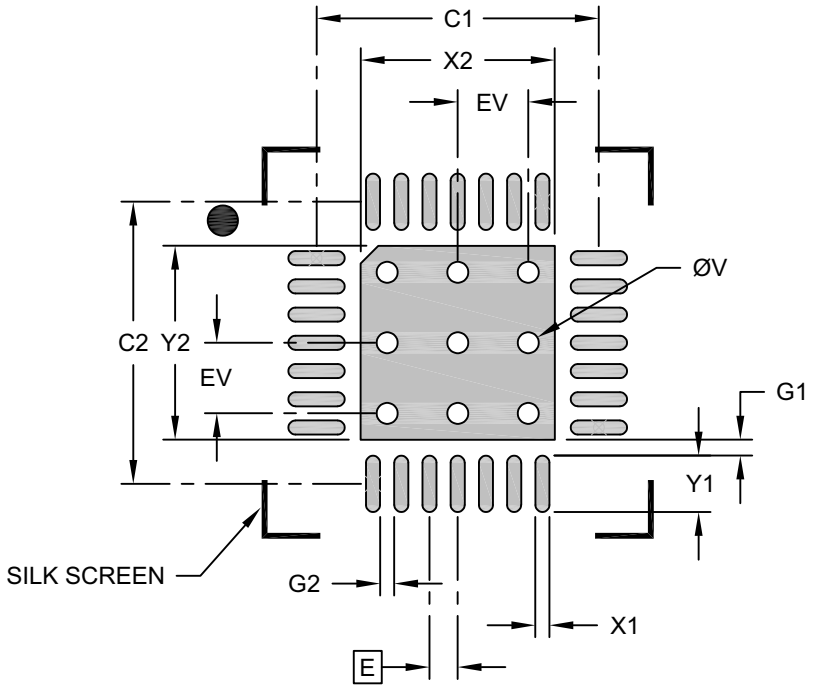
   REF: Reference Dimension, usually without tolerance, for information purposes only.

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

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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

NOTES:

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APPENDIX A: REVISION HISTORY

Revision A (June 2026)

- Initial release of this document.

NOTES:

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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.	VXX	[X](1)
Device	Package	Tape and Reel Option

Device:	RE46C425:	Photoelectric Smoke Detector Companion IC
Package:	V28 =	Very Thin Plastic Quad Flat, No Lead (STX), 4 x 4 mm body, 28-Lead VQFN
Tape and Reel Option:	T =	Tape and Reel(1)

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.

Examples:

a) RE46C425V28 = Photoelectric Smoke Detector Companion IC, 28-Lead VQFN

b) RE46C425V28T = Photoelectric Smoke Detector Companion IC, 28-Lead QFN, Tape and Reel

NOTES:

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- 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.