
Multicriteria Smoke Detector Companion IC with Dual Photoelectric and CO Sensing

Features

- Low Quiescent Current
- Operation from Two AA Batteries or a Single Lithium Battery
- 4V, 5.2V, 8.5V, 10V, 11.5V, 17V Boost Converter
- Piezoelectric Horn Driver
- 3.3V Regulator
- Dual Independently-Controlled LED Drivers with Programmable Current up to 200 mA
- Dual-Input Programmable Gain Integrating Operational Amplifier with Effective Transimpedance higher than 20 MΩ at 100 μs
- Internal Operational Amplifier 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
- Analog Buffer for Sensing Multiple Internal Voltages
- Alarm Interconnect
- Serial Peripheral Interface (SPI) Controlled
- Packaging: 4 x 4 mm, 28-Lead VQFN (RE46C420 and RE46C421), 5 x 5 mm, 32-Lead VQFN (RE46C422 only)

General Description

The RE46C420/1/2 device is a low-power smoke detector companion IC. It provides all of the analog, interface and power regulation functions for a microcontroller-based multicriteria smoke detector. It is intended for use in 3V and 9V battery applications. It features an integrating photo amplifier to interface with a photoelectric smoke chamber, two independently controlled programmable LED drivers, an operational amplifier with 10 kHz gain-bandwidth product and rail-to-rail inputs and output, to interface with a two-terminal CO sensor, a boost converter and driver circuit suitable for driving a piezoelectric horn, an interconnect output with a 5 mA current source for signaling an alarm condition to interconnected units, a low battery detection circuit and a 3.3V regulator.

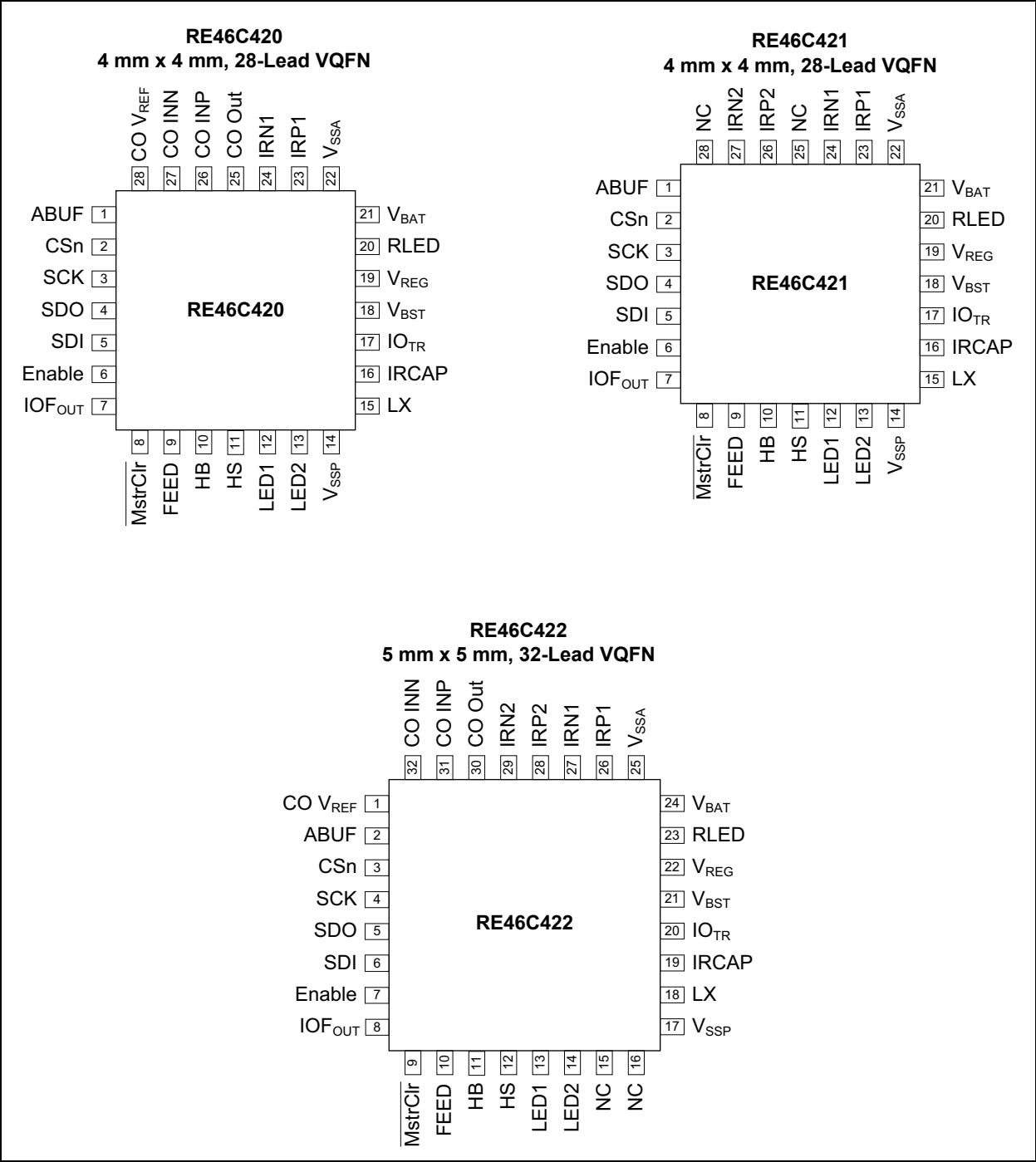
Differences between the devices:

- RE46C420:
 - One integrating photo amplifier
 - CO circuitry
- RE46C421:
 - Dual integrating photo amplifiers
 - No CO circuitry
- RE46C422:
 - Dual integrating photo amplifiers
 - CO circuitry

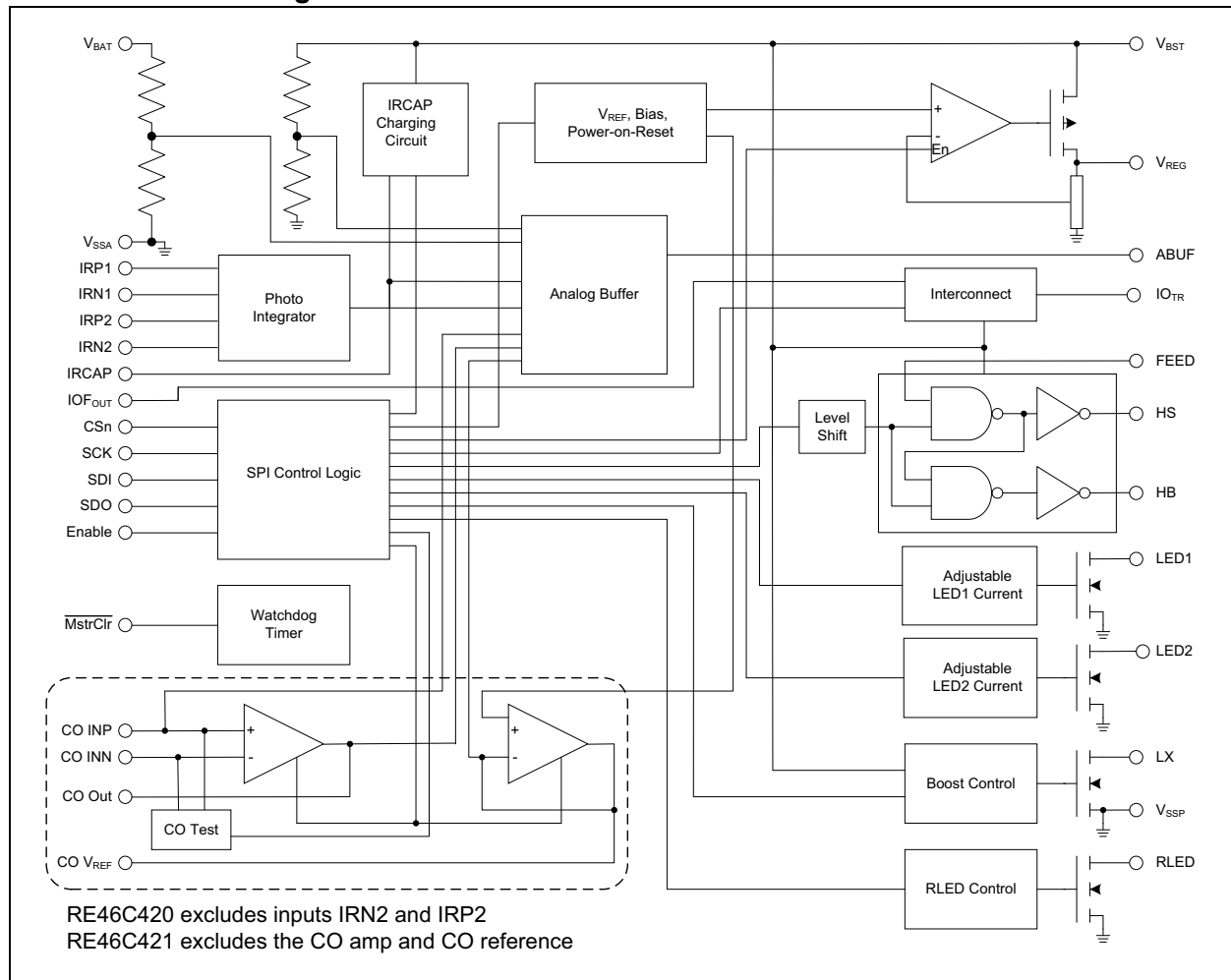
The RE46C420/1/2 allows the microcontroller unit to access and manage all of the parameters which set the output voltage signal levels of the RE46C420/1/2 device, such as the LED current, amplifier gain and the integration time. All of these parameters, including the enabling of various functions, can be set through the SPI port.

RE46C420/1/2

Package Types

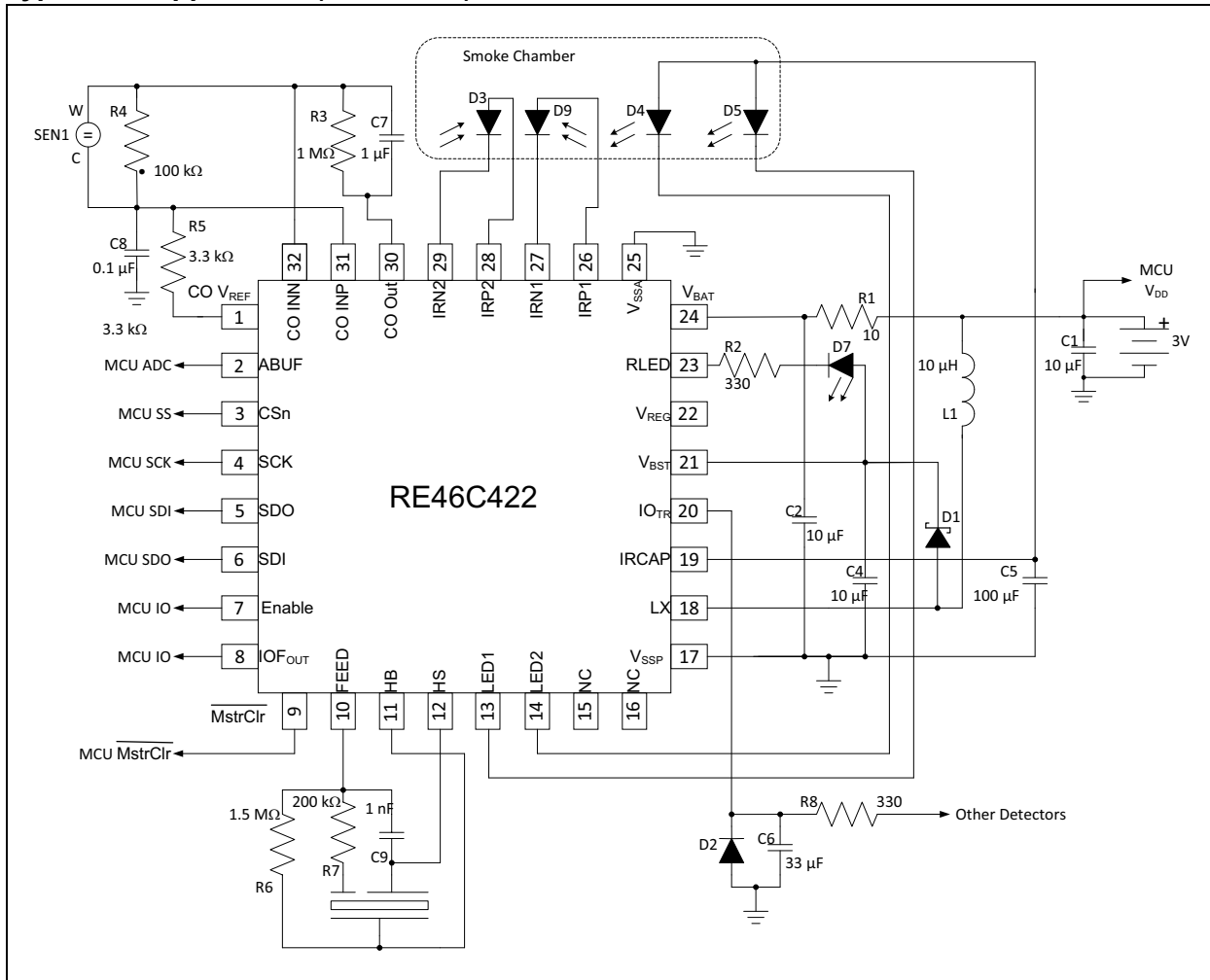


Functional Block Diagram



RE46C420/1/2

Typical 3V Application (RE46C422)



1.0 ELECTRICAL CHARACTERISTICS

1.1 Absolute Maximum Ratings†

V_{BAT}	+4.0V
V_{REG}	+3.5V
V_{BST}	+18V
LX	$V_{BST} + 0.6V$
IRCAP, LED1, LED2	+5.5V
Input Voltage Range Except FEED, when BatSel = 1, (V_{IN1})	-0.3V to $V_{BAT} + 0.3V$
Input Voltage Range Except FEED, when RegSel = 1, (V_{IN1})	-0.3V to $V_{REG} + 0.3V$
FEED Input Voltage Range (V_{INFD})	-15V to +35V
Output Voltage Range, except as noted below (V_{OUT})	-0.3 to +3.6V
HB, HS, RLED Output Voltage Range	-0.3V to V_{BST}
$\overline{MstrClr}$ Output Voltage Range	-0.3V to +12V
IO_{TR}	-0.3V to +18V
Input Current Except FEED (I_{IN})	+10 mA
Input Current (V_{BAT})	$I_{BAT} = +20$ mA
Continuous Operating Current (HS, HB, V_{BST} , V_{REG})	$I_{O1} = +40$ mA
Continuous Operating Current (RLED)	$I_{RL} = +30$ mA
Continuous Operating Current (ABUF, SDO, IO_{FOUT} , CO_{OUT} , $\overline{MstrClr}$)	$I_{O2} = +10$ mA
Continuous Operating Current (CO V_{REF})	$I_{BAT} = +1$ mA
Continuous Operating Current (LED1, LED2)	$I_{OIR} = +400$ mA
HBM ESD	+1500V
Storage Temperature (T_{STG})	-55°C to +125°C
Operating Temperature Range	-20°C to +70°C
Maximum Junction Temperature (T_J)	+150°C

† **Notice:** Stresses above those listed under “Absolute Maximum Ratings” can 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 can affect device reliability.

RE46C420/1/2

1.2 ELECTRICAL SPECIFICATIONS

ELECTRICAL CHARACTERISTICS

Electrical Characteristics: Unless otherwise indicated, all parameters apply at $T_A = -10^{\circ}\text{C}$ to $+60^{\circ}\text{C}$, $V_{BAT} = 3\text{V}$, $V_{SS} = 0\text{V}$, $V_{BST} = 9\text{V}$, $V_{IRCAP} = 5.5\text{V}$, $C_5 = 100\text{ }\mu\text{F}$, $C_4 = 10\text{ }\mu\text{F}$, $C_3 = 22\text{ }\mu\text{F}$, $\text{BatSel} = 1$, $\text{RegEn} = 0$, $\text{RegSel} = 0$, $\text{LBE}n = 0$, $\text{HBE}n = 0$ (Note 1), (Note 2), (Note 3), (Note 4)

Parameter	Symbol	Test Pin	Min.	Typ.	Max.	Units	Conditions
System Supply							
Supply Voltage	V_{BAT}	V_{BAT}	2.1	—	3.6	V	
	V_{BST}	V_{BST}	4.9	—	17	V	External Supply Powers V_{BST}
Reset Voltage	POR	V_{BAT}	1.2	1.7	2	V	Power-on reset, V_{BAT} rising, V_{BST} floating
		V_{BST}	2	2.4	3.7	V	Power-on reset, V_{BAT} floating, V_{BST} rising
		V_{BAT}	1.1	1.4	1.7	V	Brown-out reset, V_{BAT} falling, $\text{BatSel} = 1$
I_{DD}	I_{DDSTBY}	V_{BAT}	180	300	600	nA	All circuits disabled
	I_{DDrev}	V_{BAT}	—	-20	-175	nA	Reverse I_{DD} leakage, $V_{BAT} = 2\text{V}$, $V_{REG} = 3.5\text{V}$, $\text{RegEn} = 0$, $\text{RegSel} = 1$, $\text{BatSel} = 0$
Boost Regulator ($\text{LBE}n = 1$, $\text{LBV} = 1$, $\text{HBE}n = 0$, $\text{HBV}[2:1] = 00$) (Low-boost enabled, high-boost disabled, low-boost voltage set to 5.2V)							
I_{DD}	I_{DDBST}	V_{BAT}	—	18	—	μA	No load, $\text{LBV} = 1$
I_{POS}	I_{POSBST}	V_{BST}	—	9	—	μA	No load, $\text{LBV} = 1$
V_{BST} Output Voltage	V_{BST1}	V_{BST}	3.74	4	4.26	V	$I_{LOAD} = 10\text{ mA}$, $\text{LBV} = 0$
	V_{BST2}		4.9	5.2	5.5	V	$I_{LOAD} = 10\text{ mA}$, $\text{LBV} = 1$
	V_{BST3}		8	8.5	9	V	$I_{LOAD} = 10\text{ mA}$, $\text{HBE}n = 1$, $\text{HBV}[2:1] = 00$
	V_{BST4}		9.4	10	10.6	V	$I_{LOAD} = 10\text{ mA}$, $\text{HBE}n = 1$, $\text{HBV}[2:1] = 0$
	V_{BST5}		10.8	11.5	12.2	V	$I_{LOAD} = 10\text{ mA}$, $\text{HBE}n = 1$, $\text{HBV}[2:1] = 10$
	V_{BST6}		15	16	17	V	$I_{LOAD} = 10\text{ mA}$, $\text{HBE}n = 1$, $\text{HBV}[2:1] = 11$
Soft-Start Time	tr_{BST0}	V_{BST}	—	15	—	ms	Initial Startup, $V_{BAT} = 0\text{V}$ to 3V
	tr_{BST1}		—	2.5	—	ms	$\text{HBE}n = 0$ to 1 , $\text{HBV}[2:1] = 00$
	tr_{BST2}		—	3.7	—	ms	$\text{HBE}n = 0$ to 1 , $\text{HBV}[2:1] = 01$
	tr_{BST3}		—	7	—	ms	$\text{HBE}n = 0$ to 1 , $\text{HBV}[2:1] = 11$
	tr_{BST4}		—	4	—	ms	$\text{LBE}n = 0$ to 1 , $\text{LBV} = 1$, $\text{RegEn} = 1$
	tr_{BST5}		—	5.5	—	ms	$\text{LBE}n = 0$, $\text{HBE}n = 0$ to 1 , $\text{HBV}[2:1] = 01$, $\text{RegEn} = 1$
	tr_{BST6}		—	11	—	ms	$\text{LBE}n = 0$, $\text{HBE}n = 0$ to 1 , $\text{HBV}[2:1] = 10$, $\text{RegEn} = 1$
V_{BST} Efficiency	V_{EFF}	V_{BST} , V_{BAT}	—	76	—	%	$I_{LOAD} = 10\text{ mA}$, $\text{LBV} = 1$
Output Off Leakage High	I_{IHOZ}	LX	—	—	1	μA	$\text{LX} = V_{BST} = 18\text{V}$, $\text{LBE}n = 0$, $\text{HBE}n = 0$

- Note**
- Wherever a specific V_{BST} value is listed under test conditions, the V_{BST} is forced externally with the inductor disconnected and the Boost converter is NOT running, $\text{LBE}n = 0$, $\text{HBE}n = 0$.
 - Typical values are for design information only and apply at $+25^{\circ}\text{C}$.
 - The limits shown are 100% tested at $+25^{\circ}\text{C}$ only. Test limits are guard-banded based on temperature characterization to warrant compliance at temperature extremes.
 - All analog functions are off, unless otherwise noted. ($\text{ABUF} 3:0 = 0000$, $\text{LBE}n = 0$, $\text{HBE}n = 0$, $\text{IRCE}n = 0$, $\text{PAEn} = 0$, $\text{LED2En} = 0$, $\text{LED1En} = 0$, $\text{HrnEn} = 0$, $\text{IOEn} = 0$, $\text{RLE}n = 0$, $\text{RegEn} = 0$, $\text{COAE}n = 0$, $\text{CORE}n = 0$, $\text{COTest} = 0$, $\text{WDE}n = 0$).
 - Not production-tested.
 - $\Delta\text{mV} = \text{ABUF} - 200\text{ mV}$

ELECTRICAL CHARACTERISTICS

Electrical Characteristics: Unless otherwise indicated, all parameters apply at $T_A = -10^{\circ}\text{C}$ to $+60^{\circ}\text{C}$, $V_{BAT} = 3\text{V}$, $V_{SS} = 0\text{V}$, $V_{BST} = 9\text{V}$, $V_{IRCAP} = 5.5\text{V}$, $C5 = 100\text{ }\mu\text{F}$, $C4 = 10\text{ }\mu\text{F}$, $C3 = 22\text{ }\mu\text{F}$, $\text{BatSel} = 1$, $\text{RegEn} = 0$, $\text{RegSel} = 0$, $\text{LBEn} = 0$, $\text{HBEn} = 0$ (Note 1), (Note 2), (Note 3), (Note 4)

Parameter	Symbol	Test Pin	Min.	Typ.	Max.	Units	Conditions
3.3V Regulator ($V_{BST} = 5.2\text{V}$, $\text{RegEn} = 1$, $\text{RegSel} = 0$, $\text{LBEn} = 0$, $\text{HBEn} = 0$) (Enable regulator, power internal circuits from V_{BAT} , boost regulator off)							
I_{POS}	I_{POSREG}	V_{BST}	—	3	6	μA	No load
Startup Time	t_{rREG}	V_{REG}	—	0.7	3	ms	No load, $V_{REG} = 0.0\text{V}$ to 90% V_{REG}
Regulator Voltage	V_{REG1}	V_{REG}	3.1	3.3	3.5	V	$I_{LOAD} = 20\text{ mA}$,
Load Regulation	V_{REGLD}	V_{REG}	—	10	50	mV	$I_{LOAD} = 0$ to 20 mA, $\text{RegSel} = 1$, $\text{BatSel} = 0$
Short Circuit Current	I_{regSC}	—	—	52	—	mA	V_{REG} shorted to V_{SS}
Line Regulation	V_{REGLN}	V_{REG}	—	0.02	0.25	%/V	$I_{LOAD} = 1\text{mA}$, $V_{BST} = 4.9\text{V}$ to 17V
Photo Detection							
Photo Amplifier ($\text{PAEn} = 1$, $\text{ABUF}[3:0] = 0000$, $\text{EnBUF} = 1$, $\text{InSel} = 0$, $\text{ITCn} = 0$, $\text{EnCntl} = 0$, $\text{IT}[5:4] = 00$, $\text{Gain}[2:0] = 000$) (Photo amp and ABUF enabled, Inputs = IRN1 and IRP1 , fixed integration time = 100 μs , $\text{Gain} = 1$, $\text{Status} = \text{Reset}$)							
I_{DD}	I_{DDPA}	V_{BAT}	—	50	120	μA	I_{DD} due to ABUF powering on when photo amp powered on
IRCAP Supply Current	I_{IRCAPP}	IRCAP	—	340	410	μA	
Startup Time	T_{suPA}	ABUF	—	10	110	μs	$\text{IRCEn} = 1$, $\text{PAEn} = 0$ to 1 transition
Input Bias Current	I_{BOP1}	IRN1 , IRP1	-200	—	200	pA	$\text{InSel} = 0$, $\text{Gain}[2:0] = 100$, $\text{IT}[5:4] = 01$, $\text{Enable Pin} = 1$
	I_{BOP2}	IRN2 , IRP2	-200	—	200	pA	$\text{InSel} = 1$, $\text{Gain}[2:0] = 100$, $\text{IT}[5:4] = 01$, $\text{Enable Pin} = 1$
Photo Amp Reference	PARef	ABUF	—	200	—	mV	
PAOut1	PAO01	ABUF	620	830	1040	$\Delta\text{mV}^{(6)}$	$G = 1$, $I_{PD} = 40\text{ nA}$
	PAO02		1290	1660	2050	$\Delta\text{mV}^{(6)}$	$G = 2$, $\text{Gain}[2:0] = 001$, $I_{PD} = 40\text{ nA}$
	PAO03		—	830	—	$\Delta\text{mV}^{(6)}$	$G = 4$, $\text{Gain}[2:0] = 010$, $I_{PD} = 10\text{ nA}$
	PAO04		—	1660	—	$\Delta\text{mV}^{(6)}$	$G = 8$, $\text{Gain}[2:0] = 011$, $I_{PD} = 10\text{ nA}$
	PAO05		1200	1560	1920	$\Delta\text{mV}^{(6)}$	$G = 16$, $\text{Gain}[2:0] = 100$, $I_{PD} = 5\text{ nA}$
	PAO06		1000	1400	1800	$\Delta\text{mV}^{(6)}$	$G = 32$, $\text{Gain}[2:0] = 101$, $I_{PD} = 2.5\text{ nA}$
PAOut2	PAO09	ABUF	620	830	1040	$\Delta\text{mV}^{(6)}$	Input2 , $\text{InSel} = 1$, $G = 1$, $\text{Gain}[2:0] = 000$, $I_{PD} = 40\text{ nA}$
PAOut1	PAO10		—	800	—	$\Delta\text{mV}^{(6)}$	$T_i = 200\text{ }\mu\text{s}$, $\text{IT}[5:4] = 01$, $I_{PD} = 20\text{ nA}$
	PAO11		—	1200	—	$\Delta\text{mV}^{(6)}$	$T_i = 300\text{ }\mu\text{s}$, $\text{IT}[5:4] = 10$, $I_{PD} = 20\text{ nA}$
	PAO12		—	1600	—	$\Delta\text{mV}^{(6)}$	$T_i = 400\text{ }\mu\text{s}$, $\text{IT}[5:4] = 11$, $I_{PD} = 20\text{ nA}$
	PAO13		—	2800	—	mV	$T_i = 400\text{ }\mu\text{s}$, $\text{IT}[5:4] = 11$, $I_{PD} = 40\text{ nA}$, Highside Test, $V_{IRCAP} = 3.3\text{V}$

- Note**
- Wherever a specific V_{BST} value is listed under test conditions, the V_{BST} is forced externally with the inductor disconnected and the Boost converter is NOT running, $\text{LBEn} = 0$, $\text{HBEn} = 0$.
 - Typical values are for design information only and apply at $+25^{\circ}\text{C}$.
 - The limits shown are 100% tested at $+25^{\circ}\text{C}$ only. Test limits are guard-banded based on temperature characterization to warrant compliance at temperature extremes.
 - All analog functions are off, unless otherwise noted. ($\text{ABUF}[3:0] = 0000$, $\text{LBEn} = 0$, $\text{HBEn} = 0$, $\text{IRCEn} = 0$, $\text{PAEn} = 0$, $\text{LED2En} = 0$, $\text{LED1En} = 0$, $\text{HrnEn} = 0$, $\text{IOEn} = 0$, $\text{RLEn} = 0$, $\text{RegEn} = 0$, $\text{COAEn} = 0$, $\text{COREn} = 0$, $\text{COTest} = 0$, $\text{WDEn} = 0$).
 - Not production-tested.
 - $\Delta\text{mV} = \text{ABUF} - 200\text{ mV}$

ELECTRICAL CHARACTERISTICS

Electrical Characteristics: Unless otherwise indicated, all parameters apply at $T_A = -10^{\circ}\text{C}$ to $+60^{\circ}\text{C}$, $V_{BAT} = 3\text{V}$, $V_{SS} = 0\text{V}$, $V_{BST} = 9\text{V}$, $V_{IRCAP} = 5.5\text{V}$, $C5 = 100\text{ }\mu\text{F}$, $C4 = 10\text{ }\mu\text{F}$, $C3 = 22\text{ }\mu\text{F}$, $\text{BatSel} = 1$, $\text{RegEn} = 0$, $\text{RegSel} = 0$, $\text{LBEn} = 0$, $\text{HBEn} = 0$ (Note 1), (Note 2), (Note 3), (Note 4)

Parameter	Symbol	Test Pin	Min.	Typ.	Max.	Units	Conditions
Integration Time (PAEn = 1, ABUF = 0000, EnBUF = 1, InSel = 0, ITCn = 0, EnCntl = 0, Gain[2:0] = 000) (Photo amp and ABUF enabled, Inputs IRN1 and IRP1, fixed integration time, Gain = 1)							
PAOut1 Ti = 100 μs	TI100	ABUF	80	100	120	μs	IT[5:4] = 00, I _{PD} = 20 nA
PAOut1 Ti = 200 μs	TI200		160	200	240	μs	IT[5:4] = 01, I _{PD} = 20 nA
PAOut1 Ti = 300 μs	TI300		240	300	360	μs	IT[5:4] = 10, I _{PD} = 20 nA
PAOut1 Ti = 400 μs	TI400		320	400	480	μs	IT[5:4] = 11, I _{PD} = 20 nA
IRCAP LED Supply (V _{BST} = 6V; IRCEn = 1, LBEn = 1, LBV = 1)							
I _{POS}	I _{POSIRCAP1}	V _{BST}	—	4	7.2	μA	Not charging (V _{IRCAP} = 5.5V)
	I _{POSIRCP-CHRG}		—	60	100	μA	Charging (V _{IRCAP} = 3.5V)
I _{DD}	I _{DDIRCAP}	V _{BAT}	—	6	10	μA	
Startup Time	t _{rIRCAP}	—	—	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, LBV = 0,
Turn On Voltage	V _{TIR1}	IRCAP	3.6	4	4.4	V	Falling edge; I _{OUT} = 10 mA; LBV = 0
	V _{TIR2}		4.6	4.85	5.1	V	Falling edge; I _{OUT} =10 mA; LBV = 1
Turn Off Voltage	V _{TIR3}	IRCAP	4	4.4	4.8	V	Rising edge; I _{OUT} =1mA; LBV = 0
	V _{TIR4}		5	5.25	5.5	V	Rising edge; I _{OUT} = 1mA; LBV = 1
Photo LED Driver (X = 1 or 2) (V _{BST} = 5V, V _{IRCAP} = 4.5V, IRCEn = 0, LEDxEn = 1, PAEn = 1, ITCn = 1, Enable = 1) (IRCAP disabled, photo amp enabled, Enable pin controls LED on/off)							
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; from LED select to LED ready to enable
Turn On Time (LEDx)	t _{rLED}	LEDx	—	0.4	—	μs	V _{LEDx} = 1V, LEDx[2:0] = 010, from LED enable to ILED at 70% (I _{LEDx} = 35 mA)

- Note**
- 1: Wherever a specific V_{BST} value is listed under test conditions, the V_{BST} is forced externally with the inductor disconnected and the Boost converter is NOT running, $\text{LBEn} = 0$, $\text{HBEn} = 0$.
 - 2: Typical values are for design information only and apply at $+25^{\circ}\text{C}$.
 - 3: The limits shown are 100% tested at $+25^{\circ}\text{C}$ 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. ($\text{ABUF} 3:0 = 0000$, $\text{LBEn} = 0$, $\text{HBEn} = 0$, $\text{IRCEn} = 0$, $\text{PAEn} = 0$, $\text{LED2En} = 0$, $\text{LED1En} = 0$, $\text{HrnEn} = 0$, $\text{IOEn} = 0$, $\text{RLEn} = 0$, $\text{RegEn} = 0$, $\text{COAEn} = 0$, $\text{COREn} = 0$, $\text{COTest} = 0$, $\text{WDEn} = 0$).
 - 5: Not production-tested.
 - 6: $\Delta\text{mV} = \text{ABUF} - 200\text{ mV}$

ELECTRICAL CHARACTERISTICS

Electrical Characteristics: Unless otherwise indicated, all parameters apply at $T_A = -10^{\circ}\text{C}$ to $+60^{\circ}\text{C}$, $V_{BAT} = 3\text{V}$, $V_{SS} = 0\text{V}$, $V_{BST} = 9\text{V}$, $V_{IRCAP} = 5.5\text{V}$, $C5 = 100\text{ }\mu\text{F}$, $C4 = 10\text{ }\mu\text{F}$, $C3 = 22\text{ }\mu\text{F}$, $\text{BatSel} = 1$, $\text{RegEn} = 0$, $\text{RegSel} = 0$, $\text{LBEn} = 0$, $\text{HBEn} = 0$ (Note 1), (Note 2), (Note 3), (Note 4)

Parameter	Symbol	Test Pin	Min.	Typ.	Max.	Units	Conditions
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)
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
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 Ref	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}	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

- Note**
- 1: Wherever a specific V_{BST} value is listed under test conditions, the V_{BST} is forced externally with the inductor disconnected and the Boost converter is NOT running, $\text{LBEn} = 0$, $\text{HBEn} = 0$.
 - 2: Typical values are for design information only and apply at $+25^{\circ}\text{C}$.
 - 3: The limits shown are 100% tested at $+25^{\circ}\text{C}$ 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. ($\text{ABUF} 3:0 = 0000$, $\text{LBEn} = 0$, $\text{HBEn} = 0$, $\text{IRCEn} = 0$, $\text{PAEn} = 0$, $\text{LED2En} = 0$, $\text{LED1En} = 0$, $\text{HrnEn} = 0$, $\text{IOEn} = 0$, $\text{RLEn} = 0$, $\text{RegEn} = 0$, $\text{COAEn} = 0$, $\text{COREn} = 0$, $\text{COTest} = 0$, $\text{WDEn} = 0$).
 - 5: Not production-tested.
 - 6: $\Delta\text{mV} = \text{ABUF} - 200\text{ mV}$

ELECTRICAL CHARACTERISTICS

Electrical Characteristics: Unless otherwise indicated, all parameters apply at $T_A = -10^{\circ}\text{C}$ to $+60^{\circ}\text{C}$, $V_{BAT} = 3\text{V}$, $V_{SS} = 0\text{V}$, $V_{BST} = 9\text{V}$, $V_{IRCAP} = 5.5\text{V}$, $C5 = 100\text{ }\mu\text{F}$, $C4 = 10\text{ }\mu\text{F}$, $C3 = 22\text{ }\mu\text{F}$, $\text{BatSel} = 1$, $\text{RegEn} = 0$, $\text{RegSel} = 0$, $\text{LBEn} = 0$, $\text{HBEn} = 0$ (Note 1), (Note 2), (Note 3), (Note 4)

Parameter	Symbol	Test Pin	Min.	Typ.	Max.	Units	Conditions
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	$V_{CM} = 0\text{V}$ to V_{BAT}
DC Open Loop Gain (large signal)	AOL	CO INP, CO INN	—	100	—	dB	$R_L = 50\text{ k}\Omega$ to $0.5 * V_{BAT}$
Maximum Output Voltage Swing	V_{OLCO} , V_{OHCO}	CO Out	$V_{SS} + 0.010$	—	$V_{BAT} - 0.020$	V	$R_L = 50\text{ k}\Omega$ to $0.5 * V_{BAT}$, 0.5V input overdrive
Short Circuit Current	I_{OS}	CO Out	—	16	—	mA	
CO AC Response ($\text{COAEn} = 1$, $\text{COREn} = 1$)							
CO GBW	GBWCO	CO Out	—	10	—	kHz	Gain = 1, $C_{LOAD} = 50\text{ pF}$
Phase margin	PM	CO Out	—	65	—	°	Gain = 1, $C_{LOAD} = 50\text{ pF}$
Slew Rate	SRCO	CO Out	—	3	—	V/ms	Gain = 1, $C_{LOAD} = 50\text{ pF}$
CO Op Amp Noise							
Input Voltage Noise	eni	CO Out	—	5	—	μV_{PP}	
Input Voltage Noise Density	eni	CO Out	—	170	—	$\text{nV}/\sqrt{\text{Hz}}$	
Input Current Noise Density	ini	CO Out	—	0.6	—	$\text{fA}/\sqrt{\text{Hz}}$	
ABUF Op Amp ($\text{ABUF}[3:0] = 1010$) ABUF enabled, Input at pin CO INP							
I_{DD}	I_{DDABUF}	V_{BAT}	—	50	120	μA	No load, $\text{ABUF}[3:0] = 1010$ $\text{CO Inp} = 2.965\text{V}$
Input Offset Voltage	V_{osABUF}	ABUF	-3	—	3	mV	
Startup Time	T_{suABUF}	ABUF	—	10	—	μs	From $\text{ABUF}[3:0] = 0000$ to 95% $\text{ABUF}[3:0] = 0101$, $V_{BST} = 10\text{V}$
Maximum Output Voltage Swing	V_{OLABUF}	ABUF	$V_{SS} + 0.035$	—	—	V	$R_L = 50\text{ k}\Omega$, 0.5V input overdrive
	V_{OHABUF}	ABUF	—	—	$V_{BAT} - 0.035$	V	$R_L = 50\text{ k}\Omega$, 0.5V input overdrive
Short Circuit Current	I_{SC}	ABUF	—	12	—	mA	1.5V input, $R_L = 75$
Pull-Down Current Low	I_{OL_off}	ABUF	0.5	3	6	mA	$\text{ABUF}[3:0] = 0000$, $V_{ABUF} = 3.0\text{V}$

- Note**
- Wherever a specific V_{BST} value is listed under test conditions, the V_{BST} is forced externally with the inductor disconnected and the Boost converter is NOT running, $\text{LBEn} = 0$, $\text{HBEn} = 0$.
 - Typical values are for design information only and apply at $+25^{\circ}\text{C}$.
 - The limits shown are 100% tested at $+25^{\circ}\text{C}$ only. Test limits are guard-banded based on temperature characterization to warrant compliance at temperature extremes.
 - All analog functions are off, unless otherwise noted. ($\text{ABUF } 3:0 = 0000$, $\text{LBEn} = 0$, $\text{HBEn} = 0$, $\text{IRCEn} = 0$, $\text{PAEn} = 0$, $\text{LED2En} = 0$, $\text{LED1En} = 0$, $\text{HrnEn} = 0$, $\text{IOEn} = 0$, $\text{RLEn} = 0$, $\text{RegEn} = 0$, $\text{COAEn} = 0$, $\text{COREn} = 0$, $\text{COTest} = 0$, $\text{WDEn} = 0$).
 - Not production-tested.
 - $\Delta\text{mV} = \text{ABUF} - 200\text{ mV}$

ELECTRICAL CHARACTERISTICS

Electrical Characteristics: Unless otherwise indicated, all parameters apply at $T_A = -10^{\circ}\text{C}$ to $+60^{\circ}\text{C}$, $V_{BAT} = 3\text{V}$, $V_{SS} = 0\text{V}$, $V_{BST} = 9\text{V}$, $V_{IRCAP} = 5.5\text{V}$, $C_5 = 100\text{ }\mu\text{F}$, $C_4 = 10\text{ }\mu\text{F}$, $C_3 = 22\text{ }\mu\text{F}$, $\text{BatSel} = 1$, $\text{RegEn} = 0$, $\text{RegSel} = 0$, $\text{LBEn} = 0$, $\text{HBEn} = 0$ (Note 1), (Note 2), (Note 3), (Note 4)

Parameter	Symbol	Test Pin	Min.	Typ.	Max.	Units	Conditions
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	—	$V_{REG} = 3.3\text{V}$, ABUF[3:0] = 1000, RegEn = 0
	ABUFIRCAP	ABUF	0.238	0.25	0.262	—	IRCAP = 5V ABUF[3:0] = 0110, IRCEn = 0
	ABUFVBST	ABUF	0.095	0.1	0.105	—	$V_{BST} = 10\text{V}$, 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 $V_{REF} = 0.3\text{V}$, ABUF[3:0] = 0100, COREn = 0
	ABUFIOtr	ABUF	0.095	0.1	0.105	—	$V_{IO} = 10\text{V}$, 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
	ABUFIRE1	ABUF	0.238	0.25	0.262	—	IRE1 = 2V, $V_{IRCAP} = 5$, ABUF[3:0] = 1100
	ABUFIRE2	ABUF	0.238	0.25	0.262	—	IRE2 = 2V, $V_{IRCAP} = 5$, ABUF[3:0] = 1101
ABUF AC Response							
ABUF GBW	GBWABUF	ABUF	—	1.24	—	MHz	$C_{LOAD} = 50\text{ pF}$
Phase Margin	PM	ABUF	—	65	—	°	$C_{LOAD} = 50\text{ pF}$
ABUF Slew Rate	SRABUF	ABUF	—	400	—	V/ms	$C_{LOAD} = 50\text{ pF}$
ABUF Settle Time	STABUF	ABUF	—	3	—	μs	CO INP 0.3V to 1.3V, ABUF = 95% Final Value
IO Function (IOEn = 0, IOThrsh = 0, IRCEn = 0, IOout = 0, HiIO = 0, HiDmp = 0) (IO Receive mode, low threshold voltages, IRCAP off, IO out set to 0, high-source current disabled, high-sink current disabled)							
I_{DD}	I_{DDIO}	V_{BAT}	5	9	13	μA	$I_{LOAD} = 200\text{ }\mu\text{A}$, IOEn = 1, IOout = 1, HiIO = 0
	I_{DDIOHI}	V_{BAT}	—	400	—	nA	No load, $IO_{TR} = 4\text{V}$
I_{POS}	I_{POSIO}	V_{BST}	—	700	850	μA	$I_{LOAD} = 200\text{ }\mu\text{A}$, IOEn = 1, IOout = 1
IRCAP Supply Current	$I_{IRCAPIO}$	IRCAP	—	200	600	μA	$I_{LOAD} = 200\text{ }\mu\text{A}$, IRCEn = 1, IOEn = 1, IOout = 1, HiIO = 1
	$I_{IRCAPIODMP}$		—	1	—	μA	No load, IRCEn = 1, IOEn = 1, IOout = 0, HiDmp = 1
Startup Time	tr_{IO}	IO_{TR}	—	5	—	μs	Transmit, IOEn = 1, IOout = 1, HiIO = 0, COAEn = 1, (Band-gap and current reference already enabled)

- Note**
- 1: Wherever a specific V_{BST} value is listed under test conditions, the V_{BST} is forced externally with the inductor disconnected and the Boost converter is NOT running, LBEn = 0, HBEn = 0.
 - 2: Typical values are for design information only and apply at $+25^{\circ}\text{C}$.
 - 3: The limits shown are 100% tested at $+25^{\circ}\text{C}$ 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, LBEn = 0, HBEn = 0, IRCEn = 0, PAEn = 0, LED2En = 0, LED1En = 0, HrnEn = 0, IOEn = 0, RLEn = 0, RegEn = 0, COAEn = 0, COREn = 0, COTest = 0, WDEn = 0).
 - 5: Not production-tested.
 - 6: $\Delta\text{mV} = \text{ABUF} - 200\text{ mV}$

ELECTRICAL CHARACTERISTICS

Electrical Characteristics: Unless otherwise indicated, all parameters apply at $T_A = -10^{\circ}\text{C}$ to $+60^{\circ}\text{C}$, $V_{BAT} = 3\text{V}$, $V_{SS} = 0\text{V}$, $V_{BST} = 9\text{V}$, $V_{IRCAP} = 5.5\text{V}$, $C5 = 100\text{ }\mu\text{F}$, $C4 = 10\text{ }\mu\text{F}$, $C3 = 22\text{ }\mu\text{F}$, $\text{BatSel} = 1$, $\text{RegEn} = 0$, $\text{RegSel} = 0$, $\text{LBE} = 0$, $\text{HBE} = 0$ (Note 1), (Note 2), (Note 3), (Note 4)

Parameter	Symbol	Test Pin	Min.	Typ.	Max.	Units	Conditions
Input Voltage Low	V_{IL3}	IO_{TR}	—	—	1.16	V	$V_{BAT} = 3\text{V}$
	V_{IL3B}	IO_{TR}	—	—	1.25	V	$V_{BAT} = 3.3\text{V}$
	V_{IL4}	IO_{TR}	—	—	2.3	V	$V_{BAT} = 3\text{V}$, $\text{IO}_{THRSH} = 1$
	V_{IL4B}	IO_{TR}	—	—	2.5	V	$V_{BAT} = 3.3\text{V}$, $\text{IO}_{THRSH} = 1$
Input Voltage High	V_{IH3}	IO_{TR}	1.95	—	—	V	$V_{BAT} = 3\text{V}$
	V_{IH3B}	IO_{TR}	2.05	—	—	V	$V_{BAT} = 3.3\text{V}$
	V_{IH4}	IO_{TR}	3.8	—	—	V	$V_{BAT} = 3\text{V}$, $\text{IO}_{THRSH} = 1$
	V_{IH4B}	IO_{TR}	4	—	—	V	$V_{BAT} = 3.3\text{V}$, $\text{IO}_{THRSH} = 1$
Input Voltage Hysteresis	V_{HYS3}	IO_{TR}	—	0.3	—	V	$V_{BAT} = 3\text{V}$
	V_{HYS3B}	IO_{TR}	—	0.3	—	V	$V_{BAT} = 3.3\text{V}$
	V_{HYS4}	IO_{TR}	—	0.55	—	V	$V_{BAT} = 3\text{V}$, $\text{IO}_{THRSH} = 1$
	V_{HYS4B}	IO_{TR}	—	0.56	—	V	$V_{BAT} = 3.3\text{V}$, $\text{IO}_{THRSH} = 1$
IO Filter Delay	t_{dIO}	IO_{TR} , IO_{FOUT}	20	30	41	ms	$\text{IO}_{TR} = 0\text{V}$ to 4V
Output Voltage Low	V_{OLIO}	IO_{TR}	—	0.3	0.5	V	$I_{LOAD} = 4\text{ mA}$, $\text{IOEn} = 1$, $\text{IOout} = 0$, $\text{HiDmp} = 0$
Output Voltage High	V_{OHIO}	IO_{TR}	6.6	7.3	—	V	$I_{OUT} = -4\text{ mA}$, $\text{IOEn} = 1$, $\text{IOout} = 1$, $\text{HiIO} = 0$
IO Output Current	I_{OIH1}	IO_{TR}	25	35	60	μA	$\text{IO}_{TR} = 1\text{V}$
	I_{OIH2}	IO_{TR}	—	—	150	μA	$\text{IO}_{TR} = 15\text{V}$
	I_{OIOH1}	IO_{TR}	-4	-5	-6	mA	$\text{IO}_{TR} = 4\text{V}$; $\text{IOEn} = 1$, $\text{IOout} = 1$, $\text{HiIO} = 0$
	I_{OIOH2}	IO_{TR}	-4	-5	-6.5	mA	$\text{IO}_{TR} = 0\text{V}$; $\text{IOEn} = 1$, $\text{IOout} = 1$, $\text{HiIO} = 0$
	I_{OIOH3}	IO_{TR}	-30	-40	-55	mA	$\text{IO}_{TR} = 4\text{V}$, $\text{IRCAP} = 5.2\text{V}$; $\text{IOEn} = 1$, $\text{IOout} = 1$, $\text{HiIO} = 1$
	I_{OIOH4}	IO_{TR}	-60	-74	-90	mA	$\text{IO}_{TR} = 0\text{V}$, $\text{IRCAP} = 5.2\text{V}$; $\text{IOEn} = 1$, $\text{IOout} = 1$, $\text{HiIO} = 1$
	I_{O1IOL1}	IO_{TR}	8	14	22	mA	$\text{IO}_{TR} = 1\text{V}$; $\text{IOEn} = 1$, $\text{IOout} = 0$, $\text{HiDMP} = 0$
	I_{O1IOL2}	IO_{TR}	25	35	60	mA	$\text{IO}_{TR} = 1\text{V}$, $\text{IRCAP} = 5.2\text{V}$; $\text{IOEn} = 1$, $\text{IOout} = 0$, $\text{HiDMP} = 1$
Red LED							
Output Voltage Low	V_{RLED}	RLED	—	0.15	0.5	V	$I_{LOAD} = 10\text{ mA}$, $\text{RLEn} = 1$
RLED Turn On time	t_{rRLED}	RLED	—	0.6	1	μs	$I_{RLED} = 10\text{ mA}$, $\text{RLEn} = 0$ to 1
Horn ($T_A = -10^{\circ}\text{C}$ to $+60^{\circ}\text{C}$) ($\text{HrnEn} = 1$, $\text{HEnCn} = 0$, $\text{HrnBrdg} = 0$, $\text{FEED} = 0$) (Horn enabled, horn controlled by Enable pin or HrnEn bit, HrnBridge disabled)							
Output Voltage Low	V_{OL}	HS, HB	—	0.3	0.5	V	$I_{OUT} = 16\text{ mA}$, $V_{BST} = 10\text{V}$
Output Voltage High	V_{OH}	HS, HB	9.5	9.6	—	V	$I_{OUT} = -16\text{ mA}$, $V_{BST} = 10\text{V}$

- Note**
- 1: Wherever a specific V_{BST} value is listed under test conditions, the V_{BST} is forced externally with the inductor disconnected and the Boost converter is NOT running, $\text{LBE} = 0$, $\text{HBE} = 0$.
 - 2: Typical values are for design information only and apply at $+25^{\circ}\text{C}$.
 - 3: The limits shown are 100% tested at $+25^{\circ}\text{C}$ 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. ($\text{ABUF} 3:0 = 0000$, $\text{LBE} = 0$, $\text{HBE} = 0$, $\text{IRCEn} = 0$, $\text{PAEn} = 0$, $\text{LED2En} = 0$, $\text{LED1En} = 0$, $\text{HrnEn} = 0$, $\text{IOEn} = 0$, $\text{RLEn} = 0$, $\text{RegEn} = 0$, $\text{COAEn} = 0$, $\text{COREn} = 0$, $\text{COTest} = 0$, $\text{WDEn} = 0$).
 - 5: Not production-tested.
 - 6: $\Delta\text{mV} = \text{ABUF} - 200\text{ mV}$

ELECTRICAL CHARACTERISTICS

Electrical Characteristics: Unless otherwise indicated, all parameters apply at $T_A = -10^{\circ}\text{C}$ to $+60^{\circ}\text{C}$, $V_{BAT} = 3\text{V}$, $V_{SS} = 0\text{V}$, $V_{BST} = 9\text{V}$, $V_{IRCAP} = 5.5\text{V}$, $C5 = 100\text{ }\mu\text{F}$, $C4 = 10\text{ }\mu\text{F}$, $C3 = 22\text{ }\mu\text{F}$, $\text{BatSel} = 1$, $\text{RegEn} = 0$, $\text{RegSel} = 0$, $\text{LBEn} = 0$, $\text{HBEn} = 0$ (Note 1), (Note 2), (Note 3), (Note 4)

Parameter	Symbol	Test Pin	Min.	Typ.	Max.	Units	Conditions
Startup Delay	t_{HRN}	HS, HB	—	—	1	μs	HS, HB = 10 mA, $\text{HrnEn} = 1$,
Input Leakage Low	I_{ILF}	FEED	-50	-15	—	μA	FEED (pin) = -10V
Input Leakage High	I_{IHF}	FEED	—	20	50	μA	FEED (pin) = 22V
Input Voltage Low	V_{IL1}	FEED	—	—	0.9	V	$V_{\text{BAT}} = 3\text{V}$, $\text{HrnBrdg} = 1$
	V_{IL2}	FEED	—	—	3	V	$V_{\text{BST}} = 10\text{V}$
Input Voltage High	V_{IH1}	FEED	2.1	—	—	V	$V_{\text{BAT}} = 3\text{V}$, $\text{HrnBrdg} = 1$
	V_{IH2}	FEED	7	—	—	V	$V_{\text{BST}} = 10\text{V}$
Watchdog Timer ($\text{WDEn} = 1$)							
I_{DD}	I_{DDWD}	—	—	360	—	nA	
Watchdog Timer	t_{dWD}	—	13	19	27	s	$\text{WDHrn} = 1$
Watchdog Reset Pulse Width	t_{pwWD}	—	14	20	27	ms	
Watchdog Osc Period (800Hz)	t_{pOsc}	—	0.85	1.25	1.71	ms	Internal Use Only
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	$\text{HrnEn} = 1$, $\text{HrnBrdg} = 0$, Monitor HB
Input Voltage High	V_{IH1}	CSn, SCK, SDI	2.1	—	—	V	
	V_{IH1}	Enable	2.1	—	—	V	$\text{HrnEn} = 1$, $\text{HrnBrdg} = 0$, Monitor HB
Input Voltage Hysteresis	V_{HYS}	CSn, SCK, SDI, Enable	—	0.15	—	V	
Output Voltage Low	V_{OLL}	SDO, IOF _{OUT}	—	0.3	0.5	V	$I_{\text{LOAD}} = 1\text{ mA}$
Output Voltage High	V_{OHH}	SDO, IOF _{OUT}	2.4	2.6	—	V	$I_{\text{LOAD}} = -1\text{ mA}$
Minimum Enable Pulse Width	EnPW	Enable	—	1	—	μs	$\text{ITCn} = 0$, $\text{EnCntl} = 0$

- Note**
- 1: Wherever a specific V_{BST} value is listed under test conditions, the V_{BST} is forced externally with the inductor disconnected and the Boost converter is NOT running, $\text{LBEn} = 0$, $\text{HBEn} = 0$.
 - 2: Typical values are for design information only and apply at $+25^{\circ}\text{C}$.
 - 3: The limits shown are 100% tested at $+25^{\circ}\text{C}$ 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. ($\text{ABUF} 3:0 = 0000$, $\text{LBEn} = 0$, $\text{HBEn} = 0$, $\text{IRCEn} = 0$, $\text{PAEn} = 0$, $\text{LED2En} = 0$, $\text{LED1En} = 0$, $\text{HrnEn} = 0$, $\text{IOEn} = 0$, $\text{RLEn} = 0$, $\text{RegEn} = 0$, $\text{COAEn} = 0$, $\text{COREn} = 0$, $\text{COTest} = 0$, $\text{WDEn} = 0$).
 - 5: Not production-tested.
 - 6: $\Delta\text{mV} = \text{ABUF} - 200\text{ mV}$

ELECTRICAL CHARACTERISTICS

Electrical Characteristics: Unless otherwise indicated, all parameters apply at $T_A = -10^{\circ}\text{C}$ to $+60^{\circ}\text{C}$, $V_{BAT} = 3\text{V}$, $V_{SS} = 0\text{V}$, $V_{BST} = 9\text{V}$, $V_{IRCAP} = 5.5\text{V}$, $C5 = 100\text{ }\mu\text{F}$, $C4 = 10\text{ }\mu\text{F}$, $C3 = 22\text{ }\mu\text{F}$, $\text{BatSel} = 1$, $\text{RegEn} = 0$, $\text{RegSel} = 0$, $\text{LBEn} = 0$, $\text{HBEn} = 0$ (Note 1), (Note 2), (Note 3), (Note 4)

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

- Note**
- 1: Wherever a specific V_{BST} value is listed under test conditions, the V_{BST} is forced externally with the inductor disconnected and the Boost converter is NOT running, $\text{LBEn} = 0$, $\text{HBEn} = 0$.
 - 2: Typical values are for design information only and apply at $+25^{\circ}\text{C}$.
 - 3: The limits shown are 100% tested at $+25^{\circ}\text{C}$ 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. ($\text{ABUF} 3:0 = 0000$, $\text{LBEn} = 0$, $\text{HBEn} = 0$, $\text{IRCEn} = 0$, $\text{PAEn} = 0$, $\text{LED2En} = 0$, $\text{LED1En} = 0$, $\text{HrnEn} = 0$, $\text{IOEn} = 0$, $\text{RLEn} = 0$, $\text{RegEn} = 0$, $\text{COAEn} = 0$, $\text{COREn} = 0$, $\text{COTest} = 0$, $\text{WDEn} = 0$).
 - 5: Not production-tested.
 - 6: $\Delta mV = \text{ABUF} - 200\text{ mV}$

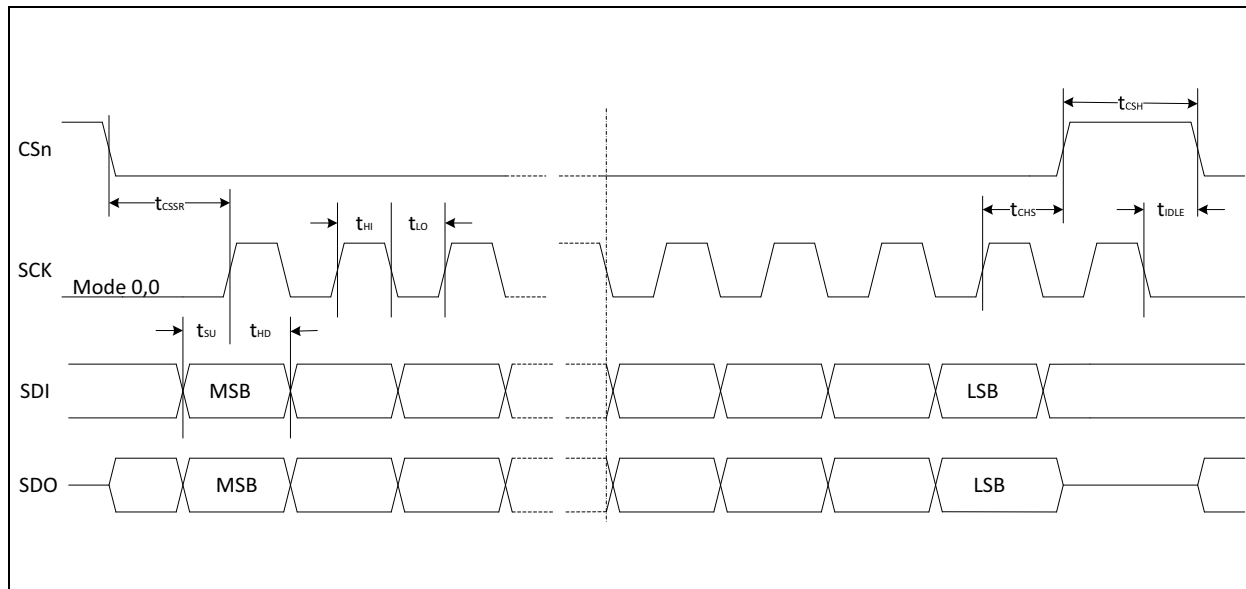


FIGURE 1-1: SPI Timing Mode 0,0.

TEMPERATURE SPECIFICATION

Electrical Characteristics: Unless otherwise indicated.						
Parameters	Sym.	Min.	Typ.	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	

RE46C420/1/2

2.0 PIN DESCRIPTION

TABLE 2-1: VQFN-28 (RE46C420, RE46C421) PIN FUNCTION TABLE

Pin Number	Symbol	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	Multiplexed digital input to provide enable signal for various functions
7	IOF _{OUT}	Filtered and level shifted IO signal
8	MstrClr	Watchdog Master Clear output
9	FEED	Usually connected to the feedback electrode of the piezoelectric horn through a resistor. If not used, this pin must be connected to V _{SS} .
10	HB	This pin is connected to the metal electrode (G) of a piezoelectric transducer
11	HS	HS is a complementary output to HB and connects to the ceramic electrode (M) of the piezoelectric transducer
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	LX	Open drain NMOS to drive the boost converter inductor
16	IRCAP	Used to charge and monitor the LED capacitor
17	IO _{TR}	Pin for bidirectional communication with remote units. This pin has an internal pull-down device. High level is V _{BST} .
18	V _{BST}	Regulated boost converter output voltage
19	V _{REG}	3.3V Regulator output
20	RLED	Open drain NMOS output used to drive a red LED
21	V _{BAT}	Connect to the positive supply voltage
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 (RE46C420)
	NC	No Connection (RE46C421)
26	CO INP	Noninverting input of the CO op amp. (RE46C420)
	IRP2	Input for anode of the photodiode 2 (RE46C421)
27	CO INN	Inverting input of the CO op amp. (RE46C420)
	IRN2	Input for cathode of the photodiode 2 (RE46C421)
28	CO V _{REF}	CO Voltage Reference (RE46C420)
	NC	No Connect. (RE46C421)

TABLE 2-2: VQFN-32 (RE46C422) PIN FUNCTION TABLE

Pin Number	Symbol	Description
1	CO V_{REF}	CO Voltage Reference
2	ABUF	Analog Buffer op amp output. Used as the analog interface to the MCU.
3	CSn	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	Multiplexed digital input to provide enable signal for various functions
8	IOF _{OUT}	Filtered and level shifted IO signal
9	MstrClr	Watchdog Master Clear output
10	FEED	Usually connected to the feedback electrode of the piezoelectric horn through a resistor. If not used, this pin must be connected to V_{SS} .
11	HB	This pin is connected to the metal electrode (G) of a piezoelectric transducer
12	HS	HS is a complementary output to HB and connects to the ceramic electrode (M) of the piezoelectric transducer.
13	LED1	Provides regulated sink current for infrared LED or blue LED
14	LED2	Provides regulated sink current for infrared LED or blue LED
15	NC	No Connection
16	NC	No Connection
17	V_{SSP}	Connect to the negative supply voltage
18	LX	Open drain NMOS output used to drive the boost converter inductor
19	IRCAP	Used to charge and monitor the LED capacitor
20	IO _{TR}	Pin for bidirectional communication with remote units. This pin has an internal pull-down device. High level is V_{BST} .
21	V_{BST}	Regulated boost converter output voltage
22	V_{REG}	3.3V Regulator output
23	RLED	Open drain NMOS output used to drive a red LED
24	V_{BAT}	Connect to the positive supply voltage
25	V_{SSA}	Connect to the negative supply voltage for analog circuits
26	IRP1	Input for anode of the photodiode 1
27	IRN1	Input for cathode of the photodiode 1
28	IRP2	Input for anode of the photodiode 2
29	IRN2	Input for cathode of the photodiode 2
30	CO OUT	Analog output of CO op amp
31	CO INP	Noninverting input of the CO op amp
32	CO INN	Inverting input of the CO op amp

3.0 DEVICE OVERVIEW

3.1 Introduction

The RE46C420/1/2 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 op amp and a reference for interfacing with a two-terminal CO sensor, a horn driver, a detector interconnect function, a boost regulator for low voltage operation and a 3.3V regulator to power the microcontroller. The SPI allows the microcontroller unit to have full control over the RE46C420/1/2 operation.

3.2 Photoelectric Sensor Circuit

The RE46C420 device provides a single photodiode input, while the RE46C421/RE46C422 provide 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 amp 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
T_I	=	Integration Time
C_I	=	5 pF (Integrating Capacitor Value)
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 set one of four possible fixed integration times. The fixed integration times are: 100 μ s, 200 μ s, 300 μ s and 400 μ s. Integration begins when the Integrate/Hold input is pulsed high. The Integrate/Hold input is connected to the Enable pin. This mode of operation is designated Timer mode.

Second, the integration time can be controlled directly by the microprocessor by using the Enable (Integrate/Hold) input. When a logic high is applied to

the Enable (Integrate/Hold) input, an integration begins and when a logic low is applied to the Enable (Integrate/Hold) input, the integration stops and the photo amplifier circuit is placed in 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 trimmed. This mode of operation provides a more repeatable photo amp output voltage for a given photodiode current, since the capacitor matching minimizes the effect of the capacitor tolerance.

In the Direct Control mode, a fixed integration time produces a wider variation in the photo amp voltage. By adjusting the integration time to achieve a specific photo amp 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 amp output to the Analog Buffer (ABUF) input. The EnBuf bit in the SPI register forces the SW5 switch to remain closed during the integration operation. 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 the 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 register. The available gain settings are 1, 2, 4, 8, 16 and 32.

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

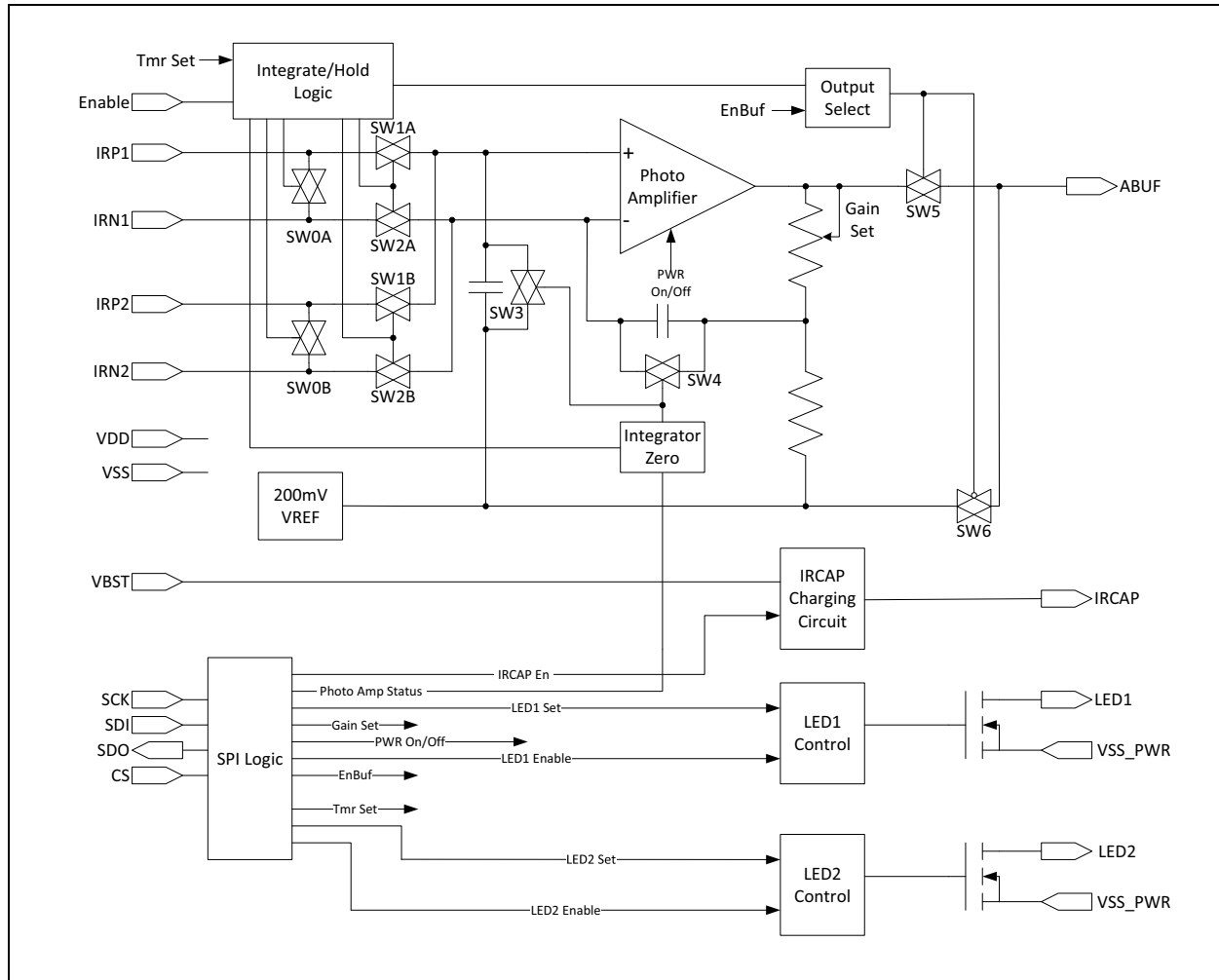


FIGURE 3-1: Photoelectric Smoke Detection System

3.3 LED1 and LED2 Drivers and IRCAP

The LED1 and LED2 driver circuits provide a regulated and programmable current to the LED1 and LED2. Possible current values 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 current to be turned on or off by the Integrate/Hold command. The Integrate/Hold command turns on the LED1/LED2 current. The integration does not start until the current reaches 70% of the set value. If the LED1/LED2 is not fully on when integration starts, variability in the integrator output voltage can occur.

The LED1 and LED2 diodes are biased from the IRCAP pin. The IRCAP charging circuit charges the IRCAP capacitor to 4.4V nominally with V_{BST} nominally set to 5.2V. This ensures there is adequate headroom for diode operation and preserves the regulated current operation. The IRCAP charging circuit can be enabled by the SPI. This helps reduce power consumption. The IRCAP charging circuit is powered from the V_{BST} pin in Low-Boost mode, unless a high-boost voltage has been commanded. The IRCAP voltage can be clamped by the V_{BST} voltage.

RE46C420/1/2

3.4 CO Sensor Circuit

The RE46C420/1/2 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 microcontroller 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 $2\mu A$ 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 I_{NN} pin, the CO op amp output is disabled by tristating the CO amp output with the SPI bit COTri (register 3, bit 7).

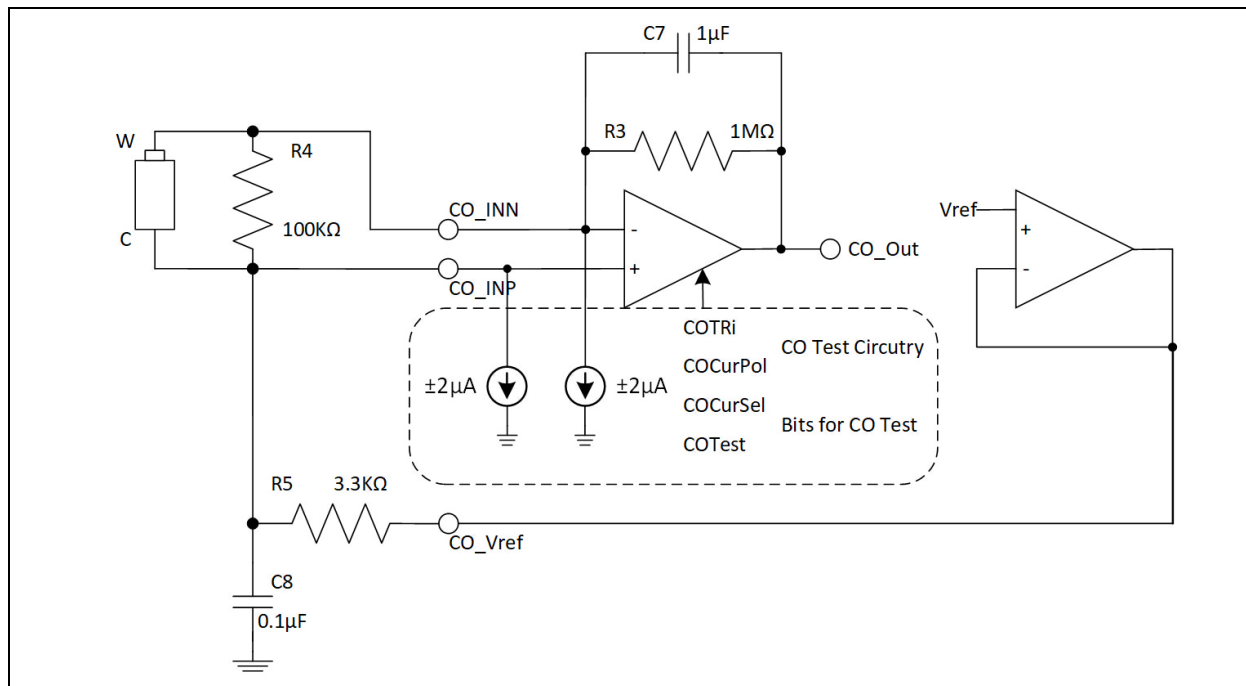


FIGURE 3-2: CO Test Circuit

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 Amp 0.2V Reference
2	Photo Amp Output
3	CO Out
4	CO 0.3V Reference
5	Scaled V_{BST} Monitor
6	Scaled IRCAP Monitor
7	Scaled V_{BAT} Monitor
8	Scaled V_{REG} Monitor
9	Scaled IO_{TR} Input
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 RE46C420/1/2 to be powered by a 3V or 9V battery or by AC power with battery backup. AC power is supplied as a DC voltage derived from an AC power supply. The AC power supply must include an AC on/off logic input for battery test.

In a 9V-battery-only system, the 9V battery connects directly to the V_{BST} pin. In this configuration, the MCU is powered from the V_{REG} pin, as is most of the internal circuitry of the RE46C420/1/2. The boost regulator is not used in this configuration and is disabled by the MCU.

In an AC system with 9V battery backup, the AC-derived voltage and the 9V battery must be diode-connected to the V_{BST} pin, as shown in [Figure 4-11](#). In this configuration, the MCU is powered from the V_{REG} pin, as is most of the internal circuitry of the RE46C420/1/2. The boost regulator is not used in this configuration and is disabled by the MCU. The diodes can be replaced with switches controlled by the MCU.

In a 3V-battery-only system, the 3V battery connects to the V_{BAT} pin through the RC filter shown in [Figure 4-10](#). The filter is intended to minimize any boost regulator switching noise that can be coupled on to the V_{BAT} pin.

In this configuration, the MCU is powered directly from the battery, as is most of the internal circuitry of the RE46C420/1/2. The 3.3V regulator is not used in this configuration and is disabled by the MCU.

In an AC powered system with 3V battery backup, the AC derived power must be diode-connected to the V_{BST} pin, as shown in [Figure 4-9](#). The boost regulator must be enabled. The voltage of the AC-derived power must be greater than the maximum high-boost voltage to hold off the boost regulator. The 3V battery is connected to the V_{BAT} pin through the RC filter shown in [Figure 4-9](#). In this configuration, the microcontroller is powered from V_{REG} , as is most of the internal circuitry of the RE46C420/1/2. When AC power is lost, the boost regulator turns on to power the 3.3V regulator. The boost regulator must be configured to operate in Low-Boost mode. The analog buffer amp can be used to monitor V_{BST} and V_{BAT} .

3.7 Boost Regulator

The boost regulator is an adjustable off-time boost converter with peak current limiting. In low-boost operation, the peak current is nominally 0.6A and for high-boost operation it is 1.5A. The boost regulator provides power to the voltage regulator, IRCAP charging circuit, horn driver and interconnect circuit. The boost regulator is enabled by the SPI.

The boost regulator is intended only for 3V battery applications (3.6V absolute maximum). The boost regulator has two operating modes: Low-Boost voltage and High-Boost voltage. The boost regulator normally operates in the Low-Boost mode when enabled by the SPI bit LBEn or by the IRCAP Enable bit, IRCEn.

In Low-Boost mode, the boost voltage can be programmed to 4.0V or 5.2V. The boost regulator switches to high-boost operation via the SPI HBEn bit. The high-boost operating mode always overrides the low-boost operating mode. The high-boost voltage can be programmed to 8.5V, 10V, 11.5V or 16.9V. High-boost operation is used when the horn driver or IO is enabled.

The boost regulator includes a soft-start circuit for power up and for switching from low-boost to high-boost operation. In the case of short duration high-boost operation, such as a horn chirp, the soft-start time must be accounted for in the firmware controlling this operation.

Equation 3-2 defines the battery current draw, based on the boost converter load current, I_{BST} .

EQUATION 3-2:

$$I_{DD} = \frac{V_{BST}}{V_{DD} \times \text{Eff}} \times I_{BST}$$

Where:

'Eff' is the boost regulator efficiency. Choosing the lower boost voltage for a particular operating mode, when practical, helps minimize the battery drain.

3.8 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 the SPI. In normal operation, the regulator sources current up to 20 mA, but the current sinking capability is typically under 1 μ A. The voltage regulator is powered from the V_{BST} pin. In low-voltage applications, the regulator is powered by the boost regulator and the regulator load current is part of the boost regulator load current. An over-voltage clamp is intended to limit the voltage at V_{REG} if it is pulled up by an external source to greater than 4 V. When the regulator is used in a 3V system, the low-boost regulator voltage is forced to be 5.2V to ensure adequate headroom for proper regulator operation and overrides the low-boost voltage setting in SPI register.

3.9 Interconnect Operation

The interconnect circuit provides the means for the smoke detector to communicate with other smoke detectors. The IO_{TR} pin is a bidirectional pin that provides both receive and transmit capabilities. The received IO signal is digitally filtered, level shifted and made available to the MCU on the IOF_{OUT} pin. The received signal has two selectable input thresholds controlled by the IO_{THRS} bit (register 8, bit 7). The higher input thresholds are intended to improve noise immunity while the lower thresholds provide compatibility with older smoke detectors.

The IO_{TR} pin normally operates as an input and monitors the IO line for a logic high when the bit IO_{EN} (register 3, bit 1) is set low. A 30 ms digital filter prevents pulse widths less than 30 ms from asserting a

logic high at the IOF_{OUT} pin. As a result of the filter action, the actual pulse width is shortened by 30 ms at IOF_{OUT} , e.g. a 40 ms pulse width appears as a 10 ms pulse width at IOF_{OUT} .

The microcontroller can set the IO_{EN} (register 3, bit 1) enable bit via the SPI, which causes the IO transmit circuit to turn on. The IO output acts as a current source that is biased from V_{BST} . In low-voltage applications, when IO_{EN} (register 3, bit 1), is asserted high, the boost regulator needs to enable high-boost operation. This ensures there is adequate IO drive capability. The IO state bit, IO_{OUT} (register 3, bit 2) controls the logic level at the IO_{TR} pin. When the IO_{OUT} bit is set high, the IO_{TR} pin sources 5 mA. A higher current can be sourced if the $HiIO$ bit (register 8, bit 4) is set high. When the IO_{OUT} (register 3, bit 2) is set to a logic low, the IO_{TR} pin sinks 13 mA. This helps discharge the interconnect line. A higher sink current can be set by setting the $HiDmp$ bit (register 8, bit 5) high. The IO_{TR} output voltage can be monitored via ABUF.

The high current operation of the interconnect circuit is powered by the IRCAP circuit, as well as boost regulator operating in High-Boost mode. This requires the capacitor used with the IRCAP function to be much larger than the capacitor shown in the applications drawings.

3.10 Horn Driver

The horn driver operates a standard three terminal piezoelectric horn connected to the pins HB, HS and FEED. The alarm is sounded by having the microcontroller set and reset the $HRNEN$ bit (register 3, bit 0) with required horn modulation pattern. Alternatively, the horn modulation pattern can be controlled by the Enable pin, when the Enable pin is programmed to control the horn. In low-voltage applications, before $HRNEN$ is asserted high, the SPI enables the high-boost operation. This ensures there is adequate horn drive capability to achieve the necessary sound pressure levels. The horn can begin to sound before the boost regulator reaches the high-boost level.

For two-terminal horns the Enable pin can be used to toggle the HB and HS pins at the desired operating frequency of the horn.

3.11 RLED Driver

The RLED driver provides the means to drive a red LED from a nominal 10V supplied by V_{BST} . This provides a means to perform a low-battery test or provide a visual signal. The RLED driver current must be set to match the horn driver load current, by using the external resistor. The RLED driver can be enabled or disabled via the SPI with the $RLEn$ bit (register 3, bit 3).

3.12 Watchdog Timer

The RE46C420/1/2 includes a Watchdog Timer, which monitors the SCK input pin. An SPI clock must occur every 20 seconds to prevent a Watchdog Timer alert. The alert pulses the `MstrClr` pin low for 20 ms. In addition, the SPI can be programmed to sound the horn continuously when a Watchdog Timer alert occurs. The Watchdog Timer can be disabled via the SPI to reduce current consumption.

3.13 SPI Control

The RE46C420/1/2 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 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, 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 the **SPI and Digital I/O** section of the [Electrical Specifications](#) table for detailed input and output timing. The SPI provides complete control of the RE46C420/1/2 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.

RE46C420/1/2

3.14 SPI Registers

The RE46C420/1/2 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 results. Each register command consists of 2 bytes. The upper byte is the register address, which includes the read/write bit and 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 readout when a second 16-bit clock cycle is completed. The RE46C420/1/2 device includes 9 registers defined in [Register 3-1](#). Unused data bits read back as 0. Data bits for nonexistent registers read back as 1.

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							
Boost Control							
U	U	U	U	U	R/W-0	R/W-0	R/W-1
—	—	—	—	—	IRCEn	HBEn	LBEn
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
—	—	InSel	LED2En	LED1En	—	Status	PAEn
bit 7							bit 0

Register 3 Data Byte							
IO/HORN/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	IOout	IOEn	HrnEn
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

Register 5 Data Byte							
Boost/IRCAP/SPI/WD Setup							
R/W-1	R/W-1	U	R/W-1	U	R/W-0	R/W-0	R/W-1
WDHrn	WDEn	—	RdNow	—	HBV1	HBV0	LBV
bit 7							bit 0

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

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		IO Setup					
U	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0
—	IOThrsh	HiDmp	HiIO	EnCntl	HrnBrdg	HEnCn	FEED
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; Boost Control 00010 = Register 2; Photo Amp Control 00011 = Register 3; IO/Horn Control 00100 = Register 4; Regulator, CO, SPI Control 00101 = Register 5; Boost Setup 00110 = Register 6; Photo Amp Setup 00111 = Register 7; LED1/LED2 Setup 01000 = Register 8; IO/Horn Setup 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

RE46C420/1/2

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 Amp Reference Output 0010 = Photo Amp Output 0011 = CO Amp Output 0100 = CO 0.3V Reference Output 0101 = Scaled V_{BST} Voltage Output 0110 = Scaled IRCAP Voltage Output 0111 = Scaled V_{BAT} Voltage Output 1000 = Scaled V_{REG} Voltage Output 1001 = Scaled IO_{TR} 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	LBEn: Low-Boost Operation Enabled 1 = Low-Boost Enable 0 = Low-Boost Disable Disabled at power up, after 10 ms, if $V_{BAT} > V_{REG}$, then low-boost is enabled.
1	1	0	HBEn: High-Boost Operation Enabled 1 = High-Boost Enable/Overrides Low-Boost Enable 0 = High-Boost Disable
1	2	0	IRCEn: IRCAP Power On/Off 1 = IRCAP Enable 0 = IRCAP Disable
1	7:3	—	Not Used

2	0	0	PAEn: Photo Amp Power On/Off 1 = Photo Amp On Enable 0 = Photo Amp 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 Amp Input Select (Not Applicable RE46C420) 1 = IRN2, IRP2 0 = IRN1, IRP1
2	7:6	—	Not Used

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

3	0	0	HrnEn: Horn Enable 1 = Horn Enable 0 = Horn Disable
3	1	0	IOEn: IO Transmit On 1 = IO Transmit Output 0 = IO Read Input
3	2	0	IOOut: Set IO Output State 1 = IO Out State Logic High 0 = IO Out State Logic Low
3	3	0	RLEn: RLED Enable/Disable 1 = RLED Power On Enable 0 = RLED Power On Disable
3	4	0	Not Used
3	5	0	COTest: CO Test On/Off (Not Applicable RE46C421) 1 = Current Test On 0 = Current Test Off
3	6	0	COCurSel: CO Current sink Source Select (Not Applicable RE46C421) 1 = CO Source at Noninverting Input 0 = CO Sink at Inverting Input
3	7	0	COTri: CO Op amp Output Tristate Enable (Not Applicable RE46C421) 1 = Enable CO Op Amp Output Tristate 0 = Disable CO Op Amp 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 Regulator powers boost comparators 0 = Regulator not used to power internal circuitry V _{BAT} powers boost comparators
4	2	0	BatSel 1 = V _{BAT} (3V Battery) powers internal circuitry 0 = V _{BAT} not used to power internal circuitry
4	3	0	Not Used
4	4	0	COAEn: CO Amp Power On (Not Applicable RE46C421) 1 = Enable CO Op Amp 0 = Disable CO Op Amp
4	5	0	COREn: CO Reference Power On (Not Applicable RE46C421) 1 = Enable CO Reference 0 = Disable CO Reference
4	6	0	COCurPol: CO Current sink source polarity (Not Applicable RE46C421) 1 = INN source/INP sink 0 = INN sink/INP source
4	7	0	Not Used

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

5	0	1	LBV : Low-Boost Voltage Setting 1 = Low-Boost Voltage = 5.2V 0 = Low-Boost Voltage = 4.0V
5	2:1	0	HBV[2:1] : High-Boost Voltage Setting 11 = High-Boost Voltage = 17.0V 10 = High-Boost Voltage = 11.5V 01 = High-Boost Voltage = 10.0V 00 = High-Boost Voltage = 8.5V
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	WDHrn : Watchdog Enable Horn on Continuously 1 = Enable Horn on continuously 0 = Disable Watchdog Horn

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
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 μ s 01 = Integration Time = 200 μ s 10 = Integration Time = 300 μ s 11 = Integration Time = 400 μ s
6	6	0	Not Used
6	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

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

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]: 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	7	0	Not Used

8	0	0	FEED: Horn Control for 2 pin and 3 pin horns 1 = Enable pin is used to toggle HB and HS with Horn FEED pin not connected 0 = IC FEED pin uses Horn FEED pin connection
8	1	0	HEnCntrl: Horn Enable Control Selection 0 = Horn controlled by bit 0 in register 3 only 1 = Horn controlled by Enable pin AND bit 0, register 3
8	2	0	HrnBrdg: Horn Bridge Enable Control Selection 0 = Horn in normal configuration 1 = Horn in bridge configuration (FEED pin drives HS, Enable pin drives HB)
8	3	0	EnCntrl: Defines Function that Enable controls 1 = Enable controls Horn on time 0 = Enable controls Photo Integration on time or start
8	4	0	HiIO: Select high or low-current operation for IO out at logic high 1 = High-current operation 0 = Low-current operation
8	5	0	HiDmp: Select high or low-current operation for IO out at a logic low 1 = High-current operation 0 = Low-current operation
8	6	0	IOThrsh: IO Input Switching Thresholds 1 = High-voltage switching threshold 0 = Nominal voltage switching threshold
8	7	0	Not Used

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

9	2:0	3	LED1 TC [2:0] 000 = 0.0%/°C 001 = 0.2%/°C 010 = 0.3%/°C 011 = 0.4%/°C 1XX = 0.5%/°C
9	3	0	Not Used
9	6:4	3	LED2 TC [2:0] 000 = 0.0%/°C 001 = 0.2%/°C 010 = 0.3%/°C 011 = 0.4%/°C 1XX = 0.5%/°C
9	7	0	Not Used

4.0 APPLICATIONS INFORMATION

4.1 Power Management

4.1.1 POWER UP

The RE46C420/1/2 devices can be powered from the V_{BAT} pin or the V_{BST} 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_{BST} . The first MCU SPI instruction, after power up, must select the power source for detector operation. Register 4, bit[2:0] controls the power source selection and regulator enable. [Table 4-1](#) shows the bit settings for register 4 for the different power source configurations.

TABLE 4-1: REGISTER 4 POWER MANAGEMENT BIT SETTINGS

Operating Modes	RegEn (r4b0)	RegSel (r4b1)	BatSel (r4b2)	Application Figures
9V Battery Only	1	1	0	Figure 4-4 , Figure 4-8 , Figure 4-12
AC/9V Battery Backup	1	1	0	Figure 4-3 , Figure 4-7 , Figure 4-11
3V Battery Only	0	0	1	Figure 4-2 , Figure 4-6 , Figure 4-10
AC/3V Battery Backup	1	1	0	Figure 4-1 , Figure 4-5 , Figure 4-9

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4.1.2 OPERATING MODES

9V Battery Only

For 9V-battery-only operation, the battery is connected to the V_{BST} pin and the 3.3V regulator is used to power the MCU and the internal circuitry of the RE46C420/1/2. The boost regulator is disabled.

AC with 9V Battery Backup

AC with 9V battery backup relies on the diode-connected power sources to power the RE46C420/1/2 at the V_{BST} pin. The voltage of the AC-derived power must be set to a voltage higher than the voltage of a new battery. The AC-derived power needs to include an on/off function for the MCU to perform a battery test by loading the V_{BST} pin with the RLED current. Table 4-2 shows the power-up flow chart for 9V or AC-powered systems.

TABLE 4-2: POWER-UP FLOW CHART FOR 9V BATTERY OR AC POWERED SYSTEM

SPI Hex Code		SPI Register/Comment
1	Apply power to V_{BST} 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 and turn on the regulator.
3	Precharge the IRCAP (capacitor C5), then begin the setup of the smoke and CO detector operation.	
4	0x0A53	Register 5: WDHrn = 0, WDEn = 1, RdNow = 1, LBV = 1 (5.2V), HBV[2:1] = [01] (10V) Enable Watchdog Timer with no watchdog horn alert; set SPI read-now to immediate; set high and low-boost voltages. Low-boost voltage also sets IRCAP voltage.
5	0x0204	Register 1: LBEn = 0, HBEn = 0, IRCEn = 1 Turn on the IRCAP charging.
6	0x0200	Register 1: LBEn = 0, HBEn = 0, 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 op amp 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 μ s), EnBuf = 1 Set photo amp gain, integration time, integration control, ABUF control for photo amp output.
10	0x0E64	Register 7: LED1[2:0] = [100] (80 mA), LED2[6:4] = [110] (150 mA) Set LED currents.
11	0x1030	Register 8: FEED = 0, HEnCntl = 0, HrnBrdg = 0, EnCntl = 0, HiIO = 1, HiDmp = 1, IO _{THRS} H = 0 Setup horn control, high or low-current IO operation and high or low-input threshold voltage.
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.	

3V Battery Only

For 3V-battery-only operation, the battery is connected to the V_{BAT} pin and is used to power the MCU along with the internal circuitry of the RE46C420/1/2. The boost regulator is enabled when needed and the 3.3V regulator is disabled. The boost regulator must be turned on only when specific functions need it.

TABLE 4-3: POWER-UP FLOW CHART FOR 3V BATTERY SYSTEM

SPI Hex Code		SPI Register/Comment
1	Apply power to V_{BAT} 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 Set the battery as the internal power source and leave regulator off.
3	Precharge IRCAP (capacitor C5) and begin the setup of the smoke and CO detector operation:	
4	0x0A53	Register 5: WDHrn = 0, WDEn = 1, RdNow = 1, LBV = 1(5.2V), HBV[2:1] = [01] (10V) Enable Watchdog Timer with no watchdog horn alert; set SPI read-now to immediate; set high and low-boost voltages.
5	0x0201	Register 1: LBEn = 1, HBEn = 0, IRCEn = 0 Turn on low-boost and wait for soft startup time to finish.
6	0x0205	Register 1: LBEn = 1, HBEn = 0, IRCEn = 1 Turn on the IRCAP charging.
7	0x0200	Register 1: LBEn = 0, HBEn = 0, IRCEn = 0 Turn off low-boost and IRCAP charging after ~ 25 ms (delay determined by the size of C5).
8	0x0834	Register 4: RegSel = 0, RegEn = 0, BatSel = 1, COAEn = 1. COREn = 1, COCurPol = 0 Turn on CO op amp and CO reference voltage.
9	Continue with additional setup commands, as shown in Table 4-2, then begin normal operation.	

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AC with 3V Battery Backup

AC with 3V battery backup uses the 3.3V regulator to power the system. AC power is diode-connected to the V_{BST} pin and is greater than the selected high-boost voltage plus a diode drop. The boost regulator must be enabled. This allows the boost regulator to turn on when the AC derived voltage drops below the high-boost voltage or low-boost voltage, whichever is selected. [Table 4-4](#) assumes AC power is turned on first at power up.

TABLE 4-4: POWER-UP FLOW CHART FOR AC POWER WITH 3V BATTERY BACKUP SYSTEM

SPI Hex Code		SPI Register/Comment
1	Apply AC power to V_{BST} 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 and turn on the regulator.
3	0x0A55	Register 5: WDHrn = 0, WDEn = 1, RdNow = 1, LBV = 1 (5.2V), HBV[2:1] = [10] (11.5V) Enable Watchdog Timer with no watchdog horn alert; set SPI read-now to immediate; set high and low-boost voltages.
4	0x0201	Register 1: LBEn = 1, HBEn = 0, IRCEn = 0 Turn on low-boost; AC power has precharged C4.
5	0x0205	Register 1: LBEn = 1, HBEn = 0, IRCEn = 1; Turn on the IRCAP charging.
6	0x0201	Register 1: LBEn = 1, HBEn = 0, IRCEn = 0; Turn off the IRCAP charging after approximately 25 ms; leave low-boost on.
7	Begin setup of smoke and CO detector operation:	
8	0x0833	Register 4: RegSel = 1, RegEn = 1, BatSel = 0, COAEn = 1. COREn = 1, COCurPol = 0; Turn on CO op amp and CO reference voltage.
9	Continue with additional setup commands, as shown in Table 4-2, then begin normal operation.	

AC Power Failure

Table 4-5 exemplifies the response to an AC power failure.

Scenario:

The AC power is normally supplied at startup. If the AC power is removed after startup for a long-enough period of time, the AC power supply shuts down. The AC power is restored afterwards.

Response:

In a 3V-battery system, the boost regulator is left on continuously, but held off by the AC power with a voltage greater than the boost voltage. When the AC power fails and its voltage output decays, the boost regulator turns on to maintain the voltage until the AC power is restored.

TABLE 4-5: POWER FAIL FLOW CHART FOR AC POWER WITH 3V BATTERY BACKUP SYSTEM

SPI Hex Code	SPI Register/Comment
1	Apply AC power to V_{BST} 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 regulator as internal power source and turn on regulator.
3	0x0A55 Register 5: WDHrn = 0, WDEn = 1, RdNow = 1, LBV = 1 (5.2V), HBV[2:1] = [10] (11.5V) Enable Watchdog Timer with no watchdog horn alert; set SPI read-now to immediate; set high and low-boost voltages.
4	0x0201 Register 1: LBEn = 1, HBEn = 0, IRCEn = 0 Turn on low-boost; AC power has precharged C4.
5	0x0205 Register 1: LBEn = 1, HBEn = 0, IRCEn = 1 Turn on the IRCAP charging.
6	0x0201 Register 1: LBEn = 1, HBEn = 0, IRCEn = 0 Turn off the IRCAP charging after approximately 25 ms; leave low-boost on.
7	0x0833 Register 4: RegSel = 1, RegEn = 1, BatSel = 0, COAEn = 1. COREn = 1, COCurPol = 0 Turn on CO op amp and CO reference voltage.
8	Continue with additional setup commands, as shown in Table 4-2, then begin normal operation.
9	AC power fails. Boost regulator begins operation as necessary.
10	Continue normal operation.
11	AC power restored. AC power holds off the boost regulator.
12	Continue normal operation.

4.1.3 BOOST REGULATOR

Boost converter in Active mode can draw current pulses greater than 0.6A in low-boost operation and 1.5A in high-boost operation and is, therefore, very sensitive to series resistance. Critical components of this resistance are the inductor DC resistance, the internal resistance of the battery and the resistance in the connections from the inductor to the battery, from the inductor to the LX pin, from the inductor through the boost capacitor and from the V_{SS} pin to the battery. In order to function properly under full load at V_{BAT} = 2V, the total of the inductor and interconnect resistances must not exceed 0.3Ω. The internal battery resistance must not exceed 0.5Ω and a low-ESR capacitor of 10 μF or more must be connected in parallel with the battery to average the current draw over the boost converter switching cycle. The Schottky diode and inductor must have a maximum operating current of 1.5A or higher. The Schottky diode must be low-leakage to prevent unwanted battery charging current under reverse bias. The boost capacitor must have a low ESR.

The boost regulator is used to power the 3.3V regulator, the horn driver, the interconnect circuit and the IRCAP circuit. The 3.3V regulator and the IRCAP circuit are powered by boost regulator when it is operating in either Low-Boost or High-Boost mode. The horn driver requires a high-boost voltage, so the piezo horn can achieve the necessary sound pressure levels. The interconnect function needs a high-boost voltage to provide proper interconnect operation with interconnected alarms. The boost regulator can supply a nominal maximum current shown in Table 4-6. These data apply for a temperature of +60°C.

TABLE 4-6: V_{BST} NOMINAL MAXIMUM I_{LOAD}

V _{BAT}	V _{BST}	I _{LOAD} (mA)
2	4	38
2	5.2	32
2	8.5	40
2.1	10	40
2.1	11.5	40
2.1	16	30

In order to conserve battery current, the boost voltage must be set to the lowest value that produces the desired operating result.

EQUATION 4-1: BATTERY CURRENT CALCULATION

$$I_{BAT} = I_{LOAD} \times \frac{V_{BST}}{V_{BAT}}$$

4.1.4 LOW BATTERY TEST

During smoke alarm operation, the horn driver current is typically the largest sustained current that the battery must supply. The red LED and resistor R2 shown in Section 4.7 “Applications Drawings” provide a visual signal and a battery load current when RLED is enabled, RLEn (register 3, bit 3). The resistor R2 must be selected to draw the equivalent RMS current the horn draws. Current draw from the IO_{TR} pin must also be accounted for if it is used.

For systems using AC-derived power, the AC power supply must include a disable input. The voltage of AC-derived power must be reduced below the battery voltage in 9V systems or reduced below the minimum high-boost voltage in 3V systems. This ensures that only the battery is powering the system. Alternatively, the AC supply input can turn off the AC supply, but power-up timing must be accounted for.

For 3V systems, the high-boost operating mode must be used to perform the battery test, just as it is used when sounding a smoke alarm. The boost regulator soft start timing needs to be accounted for when making the measurement of V_{BAT} . The ABUF is used to monitor the voltage at V_{BAT} or V_{BST} , depending on the detector operating mode.

TABLE 4-7: LOW-BATTERY TEST 3V

SPI Hex Code	SPI Register/Comment	
1	Normal operation – start low-battery test.	
2	0x0202	Register 1: LBEn = 0, HBEn = 1, IRCEn = 0 Turn on high-boost.
3	Wait for boost soft start to complete and enable red LED.	
4	0x0608	Register 3: HrnEn = 0, IOEn = 0, IOout = 0, RLEn = 1, COTest = 0, COCurSel = 0, COTri = 0 Turn on the red LED.
5	Wait ~ 10 ms to allow the system to stabilize.	
6	0x0007	Register 0: ABUF[3:0] = [0111] Measure V_{BAT} via ABUF
7	Make ADC conversion and compare to limit.	
8	0x0000	Register 0: ABUF[3:0] = [0000] Turn off the ABUF.
9	0x0600	Register 3: HrnEn = 0, IOEn = 0, IOout = 0, RLEn = 0, COTest = 0, COCurSel = 0, COTri = 0 Turn off the red LED.
10	0x0200	Register 1: LBEn = 1, HBEn = 0, IRCEn = 0 Turn off high-boost and turn on low-boost.
11	Continue normal operation. Sound the low-battery chirp warning as necessary.	

TABLE 4-8: LOW BATTERY TEST AC WITH 9V BATTERY BACKUP

SPI Hex Code	SPI Register/Comment	
1	Normal operation – start low-battery test.	
2	The MCU disables the AC supply, then enables the red LED.	
3	0x0608	Register 3: HrnEn = 0, IOEn = 0, IOout = 0, RLEn = 1, COTest = 0, COCurSel = 0, COTri = 0 Turn on the red LED.
4	Wait ~ 10 ms to allow the system to stabilize.	
5	0x0005	Register 0: ABUF[3:0] = [0101] Connect V_{BST} to ADC via ABUF.
6	Make the ADC conversion and compare to limit.	
7	0x0000	Register 0: ABUF[3:0] = [0000] Turn off the ABUF.
8	0x0600	Register 3: HrnEn = 0, IOEn = 0, IOout = 0, RLEn = 0, COTest = 0, COCurSel = 0, COTri = 0 Turn off the red LED.
9	MCU enables the AC supply.	
10	Continue normal operation. Sound the low-battery chirp warning as necessary.	

4.1.5 IRCAP

The IRCAP is the bias supply for the smoke chamber LEDs and the photo amp. 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 low-boost voltage can be used, which also selects the lower IRCAP voltage of 4V. The IRCAP is powered on with SPI bit IRCEn (register 1, bit 2), which charges the IRCAP capacitor, C5, using a 21 mA current source. The IRCAP must be one of the first functions powered on at system power up.

Each smoke check discharges C5 by an amount equal to the LED driver current, multiplied by the integration time and divided by the C5 value, as shown in [Equation 4-2](#).

EQUATION 4-2: IRCAP DISCHARGING CALCULATION

$$\Delta V_{IRCAP} = \frac{I_{LED} \times t_i}{C5}$$

The IRCAP is turned on at the beginning of the smoke check cycle. The IRCAP is turned off before the smoke check photo amp integrations start 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 decimal value for the register is multiplied by 2 when the full hex value is used for the address byte. For example, to turn on the RLED by using Register 3, the hex SPI code is 0x0608.

To reduce battery current draw and conserve battery energy, all analog and interface functions can be turned off until needed. For AC and 9V operations, the boost regulator can be powered off as well. In a 3V system, the boost regulator must be pulsed on only when it is needed. The boost capacitor, C4, must be a low-leakage ceramic capacitor, since any energy loss due to a leakage current must be recovered when the boost converter is turned on. For CO detection, the CO op amp and reference can be turned on continuously. High-boost operation is intended to power the horn driver and interconnect circuits. The IRCAP circuit operates properly independent of boost regulator operating mode.

4.3 Smoke Check

The recommended smoke check makes two measurements. 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 result of the dark measurement is subtracted 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 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 turning on the boost regulator in 3V systems, LBEn (register 1, bit 0), in low-boost operation and then ensuring the IRCAP capacitor is fully charged. High-boost operation (register 0, bit 1) can also be used. High-boost operation overrides low-boost operation. The correct low-boost voltage must be selected using LBV (register 5, bit 0) to insure 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), to turn on the necessary internal bias circuitry, unless a dark measurement is being made. The LED driver current is not turned on by this operation. Then, the integrating photo amp 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 amp, and ABUF set the stabilization time for these circuits. The Enable pin being driven high starts the integration by turning on the LED.

In [Figure 3-1](#) there is a switch, SW5, between the photo amp output and the ABUF input. If the switch is closed, the ABUF output follows the photo amp output. Monitoring the photo amp output during an integration can be a useful diagnostic tool, but stray capacitive coupling between ABUF out and the photo amp inputs can cause an output error. To eliminate possible errors, set EnBuf (register 6, bit 7) to 0 and set ABUF to monitor a scaled LED voltage, ABUF[3:0] = 0xC or 0xD, during the integration period. When the integration is complete, set ABUF to the photo amp output ABUF[3:0] = 0x2 (register 0, bit [3:0]) and make the ADC conversion after the ABUF output has settled.

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 μ s, 200 μ s, 300 μ s and 400 μ s. Timer mode compensates for internal chip tolerances. After powering on IRCAP, the LED driver, photo amp and ABUF, a smoke measurement is made by pulsing the Enable pin high for a minimum of 1 μ s. 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. Then, select the photo amp output for ABUF out 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 amp and ABUF, a smoke measurement is made by pulsing the Enable pin high for the length of the desired integration time. The minimum length must be 50 μ s or higher. 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 amp gain affects the photo amp 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 4-9](#) shows the smoke check flow chart for a 9V system.

TABLE 4-9: SMOKE CHECK 9V SYSTEM SAMPLE CODE

SPI Hex Code		SPI Register/Comment
1	Photo amp setup after power up.	
2	0x0A55	Register 5: LBV = 1 (5.2V), HBV[2:1] = [10] (11.5V), RdNow = 1, WDEn = 1, WDHrn = 0 Set low and high-boost voltages; low-boost voltage sets the IRCAP voltage.
3	0x0C93	Register 6: Gain[2:0] = [011] (8), ITCn = 0, IT[5:4] = [01] (200 μ s), EnBuf = 1 Set photo amp 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: FEED = 0, HEnCtl = 0, HrnBrdg = 0, EnCtl = 0, HiIO = 0, HiDmp = 0, IOThrsh = 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 amp operation (Wake Up):	
9	0x0204	Register 1: LBEn = 0, HBEn = 0, IRCEn = 1 Turn on IRCAP charging; boost regulator not needed; use Equation 4-2 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 (≥ 5 V for blue LED and ≥ 3 V for infrared LED).
11	ADC ABUF voltage measurement conversion after waiting for IRCAP to charge.	
12	0x0200	Register 1: LBEn = 0, HBEn = 0, IRCEn = 0 Turn off the IRCAP charging.
13	Dark measurement LED2; photo amp is on.	
14	0x000D	Register 0: ABUF[3:0] = [1101] Set the ABUF to measure the LED2 voltage; keep the ABUF on, but disconnected from the photo amp output.
15	0x0C82	Register 6: EnBuf = 1, IT[5:4] = [00] (100 μ s), ITCn = 0, and Gain[2:0] = [010] (4) Setup photo amp for LED2 measurement.
16	0x0401	Register 2: PAEn = 1, Status = 0, InSel = 0, LED1En = 0, LED2En = 0 Zero integrating capacitors.
17	Photo-amp biases up and stabilizes; wait 110 μs.	
18	0x0403	Register 2: PAEn = 1, Status = 1, InSel = 0, LED1En = 0, LED2En = 0 Ready, LED2 disabled
19	Enable pin pulsed high to start fixed time integration of 100 μs.	
20	Wait 125 μs.	
21	0x0002	Register 0: ABUF[3:0] = [0010] Set the ABUF to measure LED2 photo amp voltage.
22	ADC makes dark photo measurement conversion.	
23	0x000D	Register 0: ABUF[3:0] = [1101]; Keep the ABUF on, but disconnected from the photo amp output.
24	Lit measurement LED2:	
25	0x0401	Register 2: PAEn = 1, Status = 0, InSel = 0, LED1En = 0, LED2En = 0 Zero integrating capacitors.
26	0x0413	Register 2: PAEn = 1, Status = 1, InSel = 0, LED1En = 0, LED2En = 1 Ready, LED2 enabled.
27	Enable pin pulsed high to start fixed time integration of 100 μs.	
28	Wait 125 μs.	

RE46C420/1/2

TABLE 4-9: SMOKE CHECK 9V SYSTEM SAMPLE CODE (CONTINUED)

SPI Hex Code		SPI Register/Comment
29	0x0002	Register 0: ABUF[3:0] = [0010] Set the ABUF to measure the LED2 photo amp voltage.
30	ADC makes lit photo measurement conversion. Subtract dark ADC value from lit ADC value to get LED2 smoke check value.	
31	Smoke check measurement LED1:	
32	0x0204	Register 1: LBEn = 0, HBEn = 0, IRCEn = 1 Turn on the IRCAP charging, briefly (optional).
33	Adjust photo amp gain and integration time for LED1.	
34	0x0C92	Register 6: EnBuf = 1, IT[5:4] = [01] (200 us), ITCn = 0, Gain[2:0] = [011] (8) Photo amp setup for LED1 measurement.
35	0x0200	Register 1: LBEn = 0, HBEn = 0, IRCEn = 0 Turn off IRCAP charging.
36	Dark measurement for LED1:	
37	0x0401	Register 2: PAEn = 1, Status = 0, InSel = 0, LED1En = 0, LED2En = 0 Zero integrating capacitors
38	0x0403	Register 2: PAEn = 1, Status = 1, InSel = 0, LED1En = 0, LED2En = 0 Ready, LED1 disabled.
39	Enable pin pulsed high to start fixed time integration of 200 μs.	
40	Wait 250 μs.	
41	ADC makes dark photo measurement conversion.	
42	Lit measurement LED1:	
43	0x0401	Register 2: PAEn = 1, Status = 0, InSel = 0, LED1En = 0, LED2En = 0 Zero integrating capacitors.
44	0x040B	Register 2: PAEn = 1, Status = 1, InSel = 0, LED1En = 1, LED2En = 0 Ready, LED1 enabled.
45	Enable pin pulsed high to start fixed time integration of 200 μs.	
46	Wait 250 μs.	
47	ADC makes lit photo measurement conversion. Subtract dark ADC value from lit ADC value to get LED1 smoke check value.	
48	0x0400	Register 2: PAEn = 0, Status = 0, InSel = 0, LED1En = 0, LED2En = 0 Turn off the photo amp and the LEDs.

4.4 CO Detection and Sensor Test

The CO op amp is a high performance low current op amp that is configured as a transimpedance amplifier. The 300 mV CO reference ensures the op amp output operates above ground. The CO op amp 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 op amp input is connected to a 2 μ A 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 op amp output, which prevents the CO op amp output from correcting for the test charge injection.

To test the CO sensor, use the following procedure:

The CO op amp and reference are assumed to be running with a stable CO op amp 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 op amp output with register 3, bit 7, COTri, so the op amp 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 μ s after the current source is turned off, turn on the op amp output using register 3, bit 7, COTri. About 5s after op amp output turns on, check the op amp output voltage. Refer to the CO manufacturers documentation for information regarding testing the CO sensor.

TABLE 4-10: 9V POWER-UP AND CO TEST

SPI Hex Code		SPI Register/Comment
1	Apply power to V_{BST} pin. After the MCU is powered on, send the following SPI commands:	
2	0x0833	Register 4: RegSel = 1, RegEn = 1, BatSel = 0, COAEn = 1. COREn = 1, COCurPol = 0
3	Continue with additional setup commands, as shown in Table 4-2, then begin normal operation.	
4	Begin CO Test.	
5	0x0203	Register 1: ABuf[3:0] = [0011] (3) Monitor the CO op amp output.
6	0x0680	Register 3: HrnEn = 0, IOEn = 0, IOout = 0, RLEn = 0, COTest = 0, COCurSel = 0, COTri = 1 Tristate the CO amp output.
7	0x06A0	Register 3: HrnEn = 0, IOEn = 0, IOout = 0, RLEn = 0, COTest = 1, COCurSel = 0, COTri = 1 Turn on the test current source.
8	Wait from 2s to 5s, then turn off the current source.	
9	0x0680	Register 3: HrnEn = 0, IOEn = 0, IOout = 0, RLEn = 0, COTest = 0, COCurSel = 0, COTri = 1 Turn off the current source.
10	Wait 50 μs then turn on the op amp output.	
11	0x0600	Register 3: HrnEn = 0, IOEn = 0, IOout = 0, RLEn = 0, COTest = 0, COCurSel = 0, COTri = 0 Turn the CO op amp output.
12	Make ADC measurement at ABUF pin per CO manufacturers recommendations.	
13	0x0000	Register 0: Turn off the ABUF.

4.5 Interconnect Circuit

The interconnect circuit, IO, is a bidirectional communication interface between smoke detectors in a home. All the detectors in the home operate in Listen mode and assert a logic high during a smoke alarm event. During a CO event, the line is pulsed on and off. The communication line is subject to noise pickup, especially in AC-powered systems, where the communication line is the third wire in a three wire cable. A digital filter prevents noise pulses less than 30 ms wide from asserting a logic high at IOF_{OUT}. This simplifies any external filtering that may be required.

The interconnect circuit operation as a receiver or transmitter is controlled via SPI register 3, bit 1, IOEn. The receive operation is set by register 3, bit 1 = 0. The receive circuit logic thresholds and hysteresis are set

via SPI register 8, bit 6, IO_{THRS}H. The transmit operation is set by register 3, bit 1 = 1. The transmit logic high or low is set by register 3, bit 2. A transmit logic high, register 3, bit 2 = 1, is implemented with a current source that supplies -4 mA and pulls up to 6.6V minimum. A logic low (register 3, bit 2 = 0) is implemented with a current sink of 13 mA.

In the case of CO signaling, the interconnect line can be pulsed. A high-current mode is available when the external detectors present a high capacitance to the system. The high-current source operation is implemented by register 8, bit 4, HiIO. The high-current sink operation is implemented by register 8, bit 5, HiDmp. The duration of these current sink and source events is controlled by the MCU firmware.

TABLE 4-11: 3V BATTERY HORN AND IO OPERATION FOR SMOKE ALARM

SPI Hex Code		SPI Register/Comment
1		Horn uses T3 temporal pattern; on 0.5s, off 0.5s, on 0.5s, off 0.5s, on 0.5s, off 1.5s.
2		Horn and low-current IO setup; use register 3, bit 0 (HrnEn), to modulate horn pattern.
3	0x1000	Register 8: FEED = 0, HEnCtl = 0, HrnBrdg = 0, EnCtl = 0, HiIO = 0, HiDmp = 0, IOThrsH = 0; Horn modulation controlled by register 3, bit 0 (HrnEn).
4		Normal operation detects smoke after smoke check completes; Leave photo amp and LEDs off. Turn on high voltage boost regulator operation.
5	0x0202	Register 1: LBEEn = 0, HBEEn = 1, IRCEEn = 0. Turn on high-boost operation.
6		Turn on IO.
7	0x0606	Register 3: HrnEn = 0, IOEn = 1, IOout = 1, RLEn = 0, COTest = 0, COCurSel = 0, COTri = 0 Enable IOout and set IOout to logic high.
8		MCU sounds horn using SPI register 3, bit 0 (HrnEn),
9	0x0607	Register 3: HrnEn = 1, IOEn = 1, IOout = 1, RLEn = 0, COTest = 0, COCurSel = 0, COTri = 0 Turn horn on for 0.5s.
10	0x0606	Register 3: HrnEn = 0, IOEn = 1, IOout = 1, RLEn = 0, COTest = 0, COCurSel = 0, COTri = 0 Turn horn off for 0.5s.
11		System continues with smoke check measurements when horn is off.
12	0x0607	Register 3: HrnEn = 1, IOEn = 1, IOout = 1, RLEn = 0, COTest = 0, COCurSel = 0, COTri = 0 Turn horn on for 0.5s.
13	0x0606	Register 3: HrnEn = 0, IOEn = 1, IOout = 1, RLEn = 0, COTest = 0, COCurSel = 0, COTri = 0 Turn horn off for 0.5s.
14		System continues with smoke check measurements when horn is off.
15	0x0607	Register 3: HrnEn = 1, IOEn = 1, IOout = 1, RLEn = 0, COTest = 0, COCurSel = 0, COTri = 0 Turn horn on for 0.5s.
16	0x0606	Register 3: HrnEn = 0, IOEn = 1, IOout = 1, RLEn = 0, COTest = 0, COCurSel = 0, COTri = 0 Turn horn off for 1.5s.
17		System continues with smoke check measurements when horn is off.
18		Smoke alarm condition ends; MCU stops sounding the horn. Turn on IO dump (sink) to discharge IO line for ~ 1s.
19	0x0602	Register 3: HrnEn = 0, IOEn = 1, IOout = 0, RLEn = 0, COTest = 0, COCurSel = 0, COTri = 0 Turn horn off, set IOout to logic low.
20	0x0600	Register 3: HrnEn = 0, IOEn = 0, IOout = 0, RLEn = 0, COTest = 0, COCurSel = 0, COTri = 0 Turn off IOout dump after ~ 1s.
21		Continue with normal operation.

4.6 Enable Pin

The Enable pin can control both the photo amp integration time and the horn modulation. Register 8, bit 3 = 0 selects the photo amp integration control by the Enable pin and register 8, bit 3 = 1 allows horn on time to be controlled by the Enable pin or by the HrnEn (register 3, bit 0). Register 8, bit 1 determines how the horn is controlled. For register 8, bit 1 = 0, the horn modulation is only controlled by bit HrnEn (register 3, bit 0) and for register 8, bit 1 = 1, the horn is controlled by the register 3, bit 0 = 1 and by the Enable pin. If register 3, bit 0 = 0, then the Enable pin does not modulate the horn output. To reduce the impact of horn related noise, perform smoke check measurements with the horn off. In general, it is recommended to let only the Enable pin control the photo amp integration time and to use the HrnEn bit to modulate the horn.

RE46C420/1/2

4.7 Applications Drawings

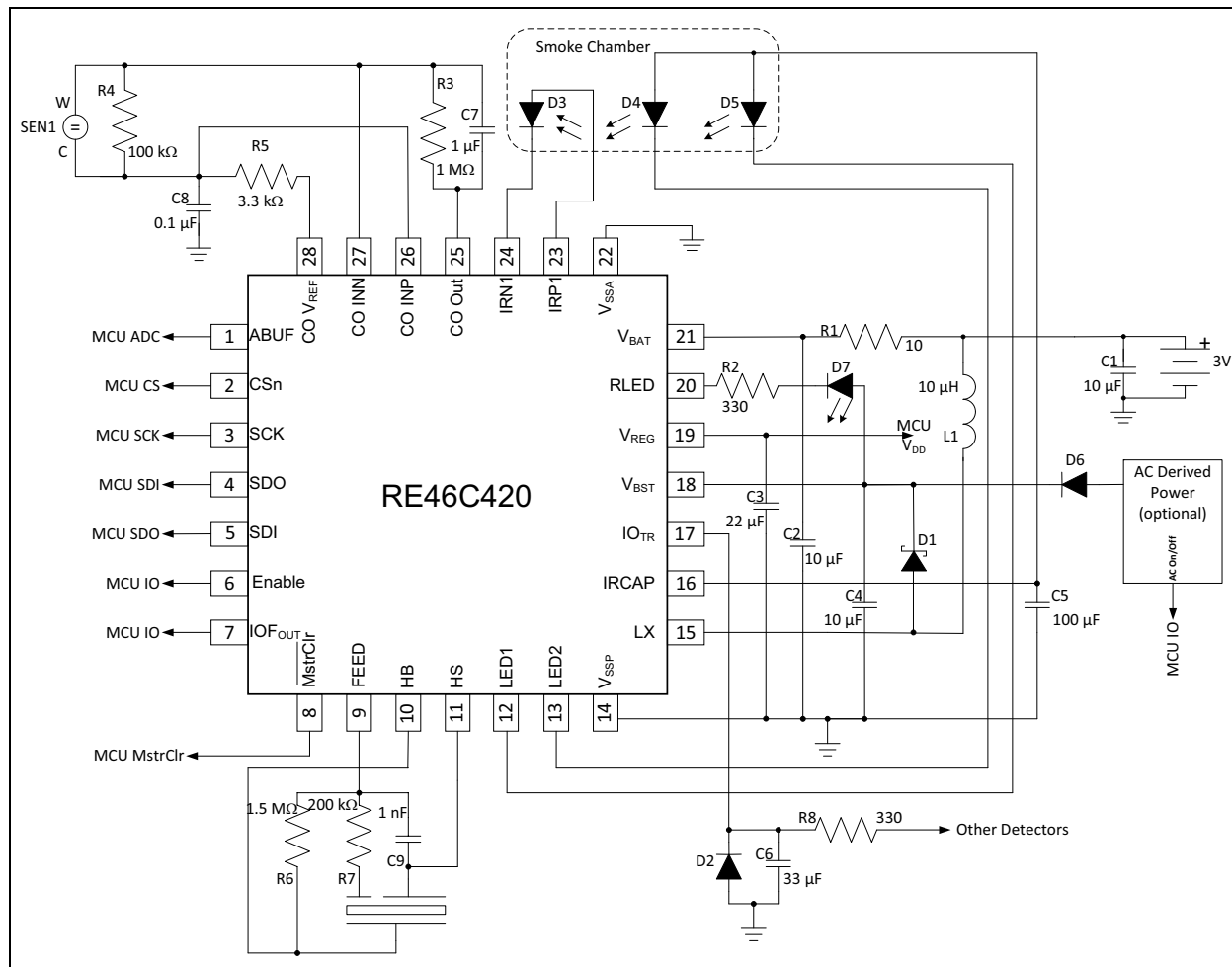


FIGURE 4-1: RE46C420 Typical 3V AC Application

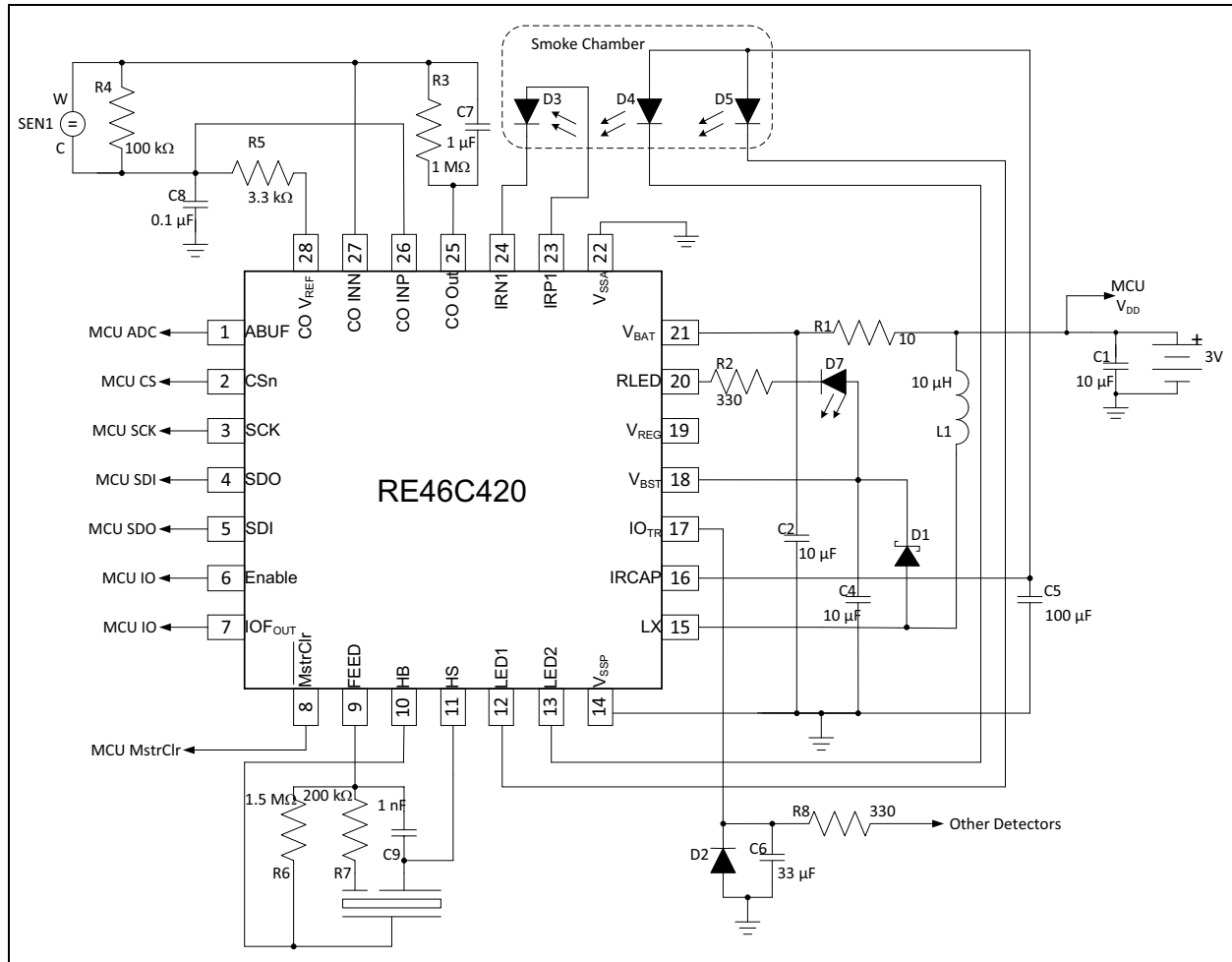
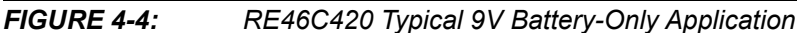


FIGURE 4-2: RE46C420 Typical 3V Battery-Only Application





RE46C420/1/2

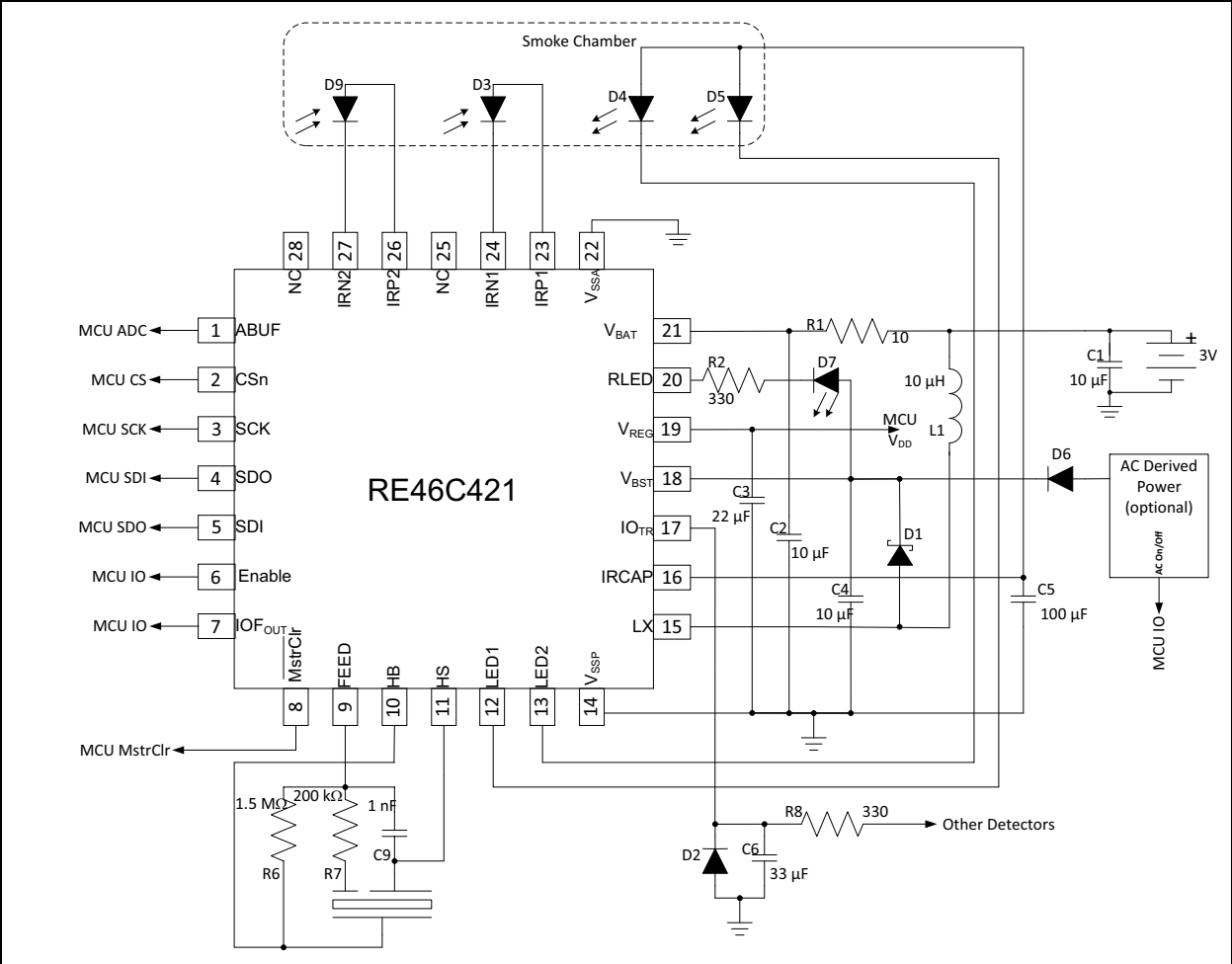


FIGURE 4-5: RE46C421 Typical 3V AC Application

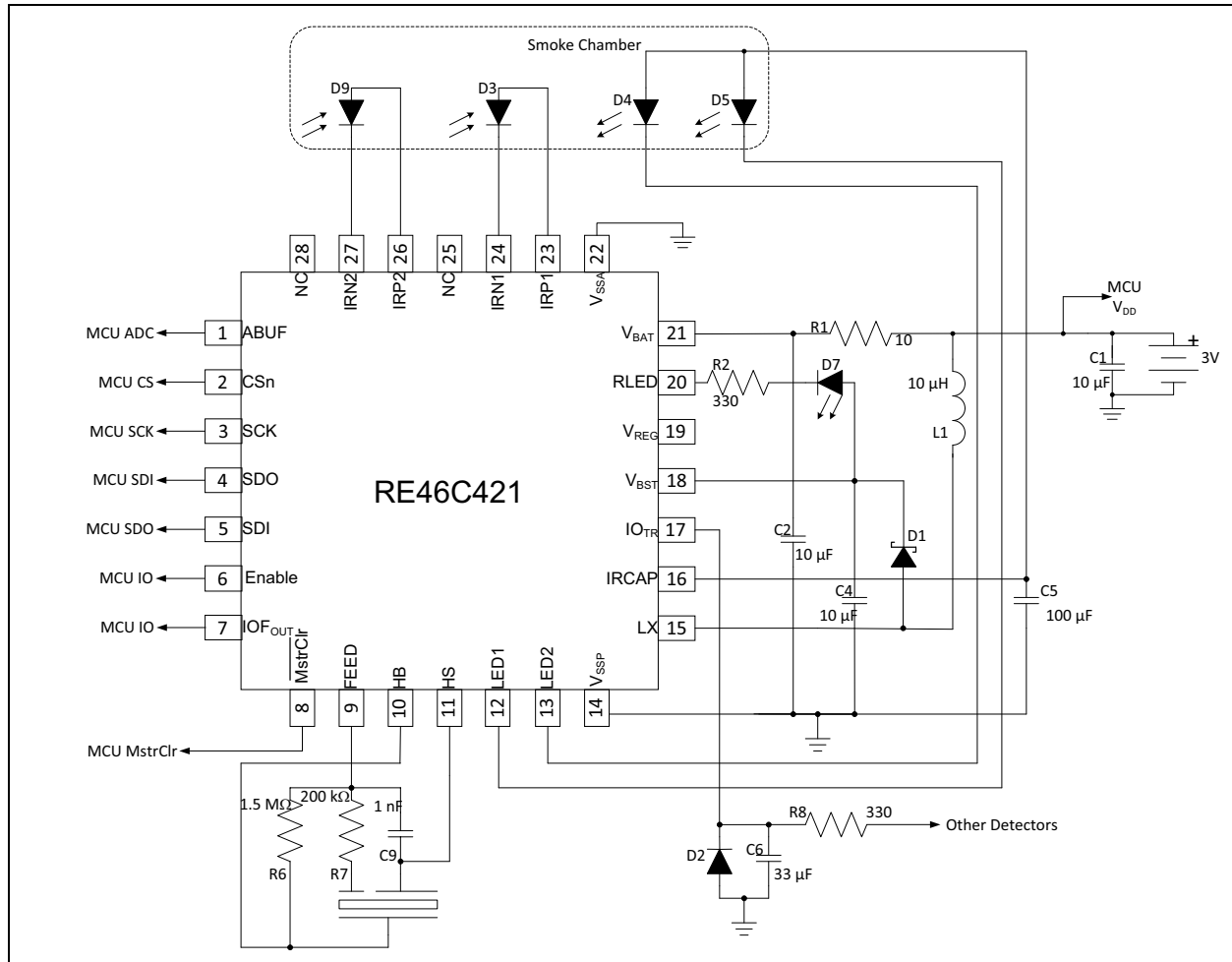


FIGURE 4-6: RE46C421 Typical 3V Battery-Only Application

RE46C420/1/2

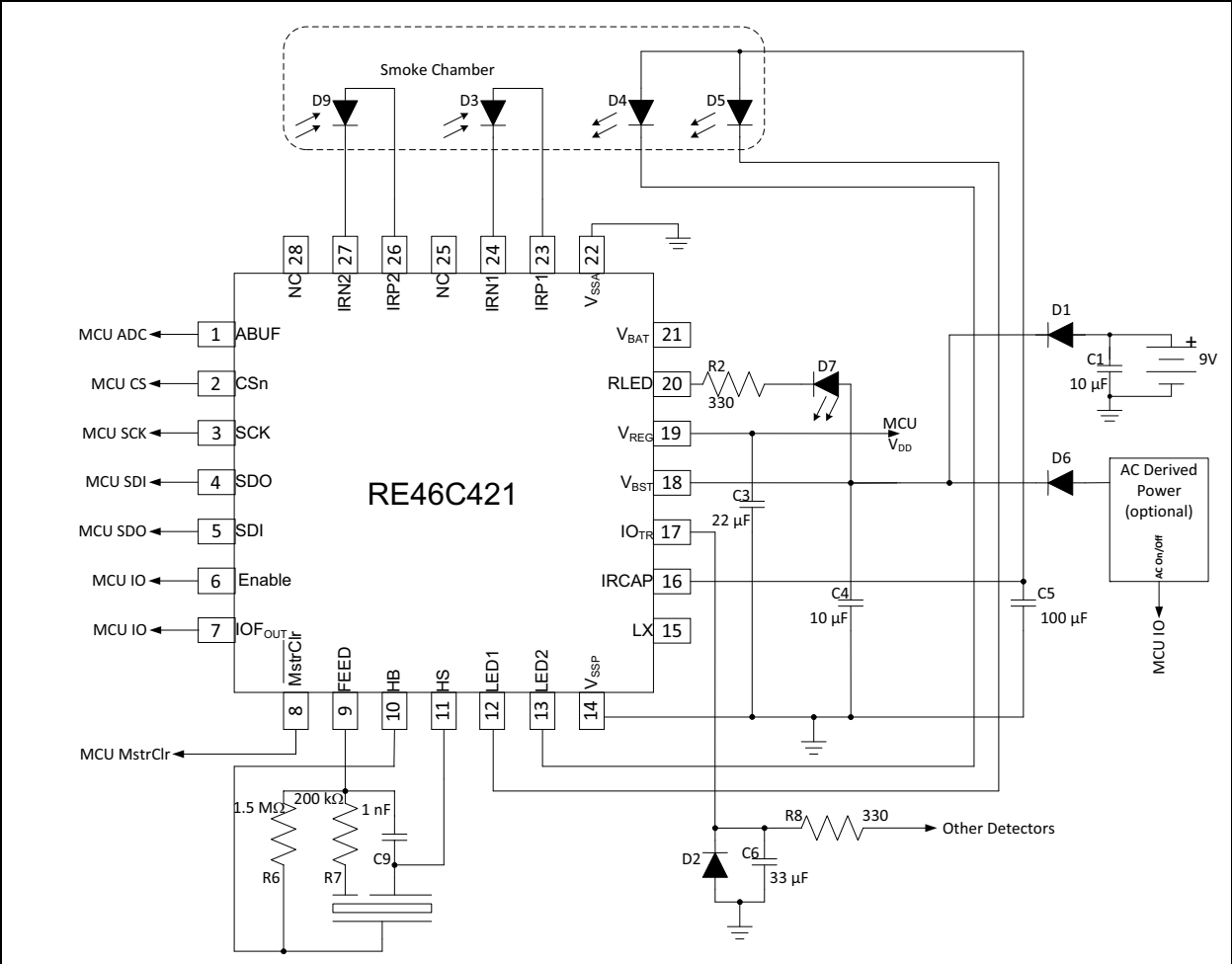


FIGURE 4-7: RE46C421 Typical 9V AC Application

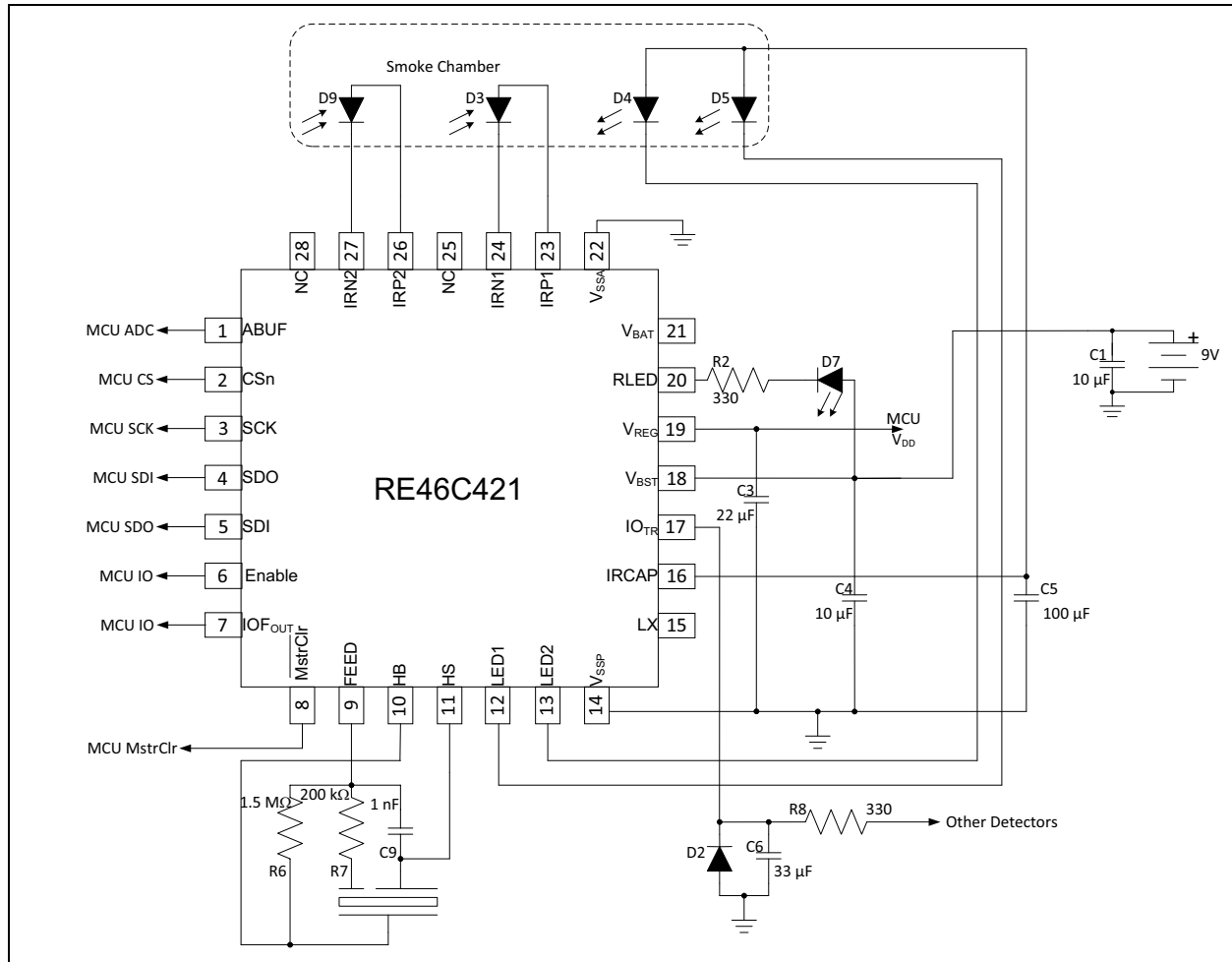


FIGURE 4-8: RE46C421 Typical 9V Application

RE46C420/1/2

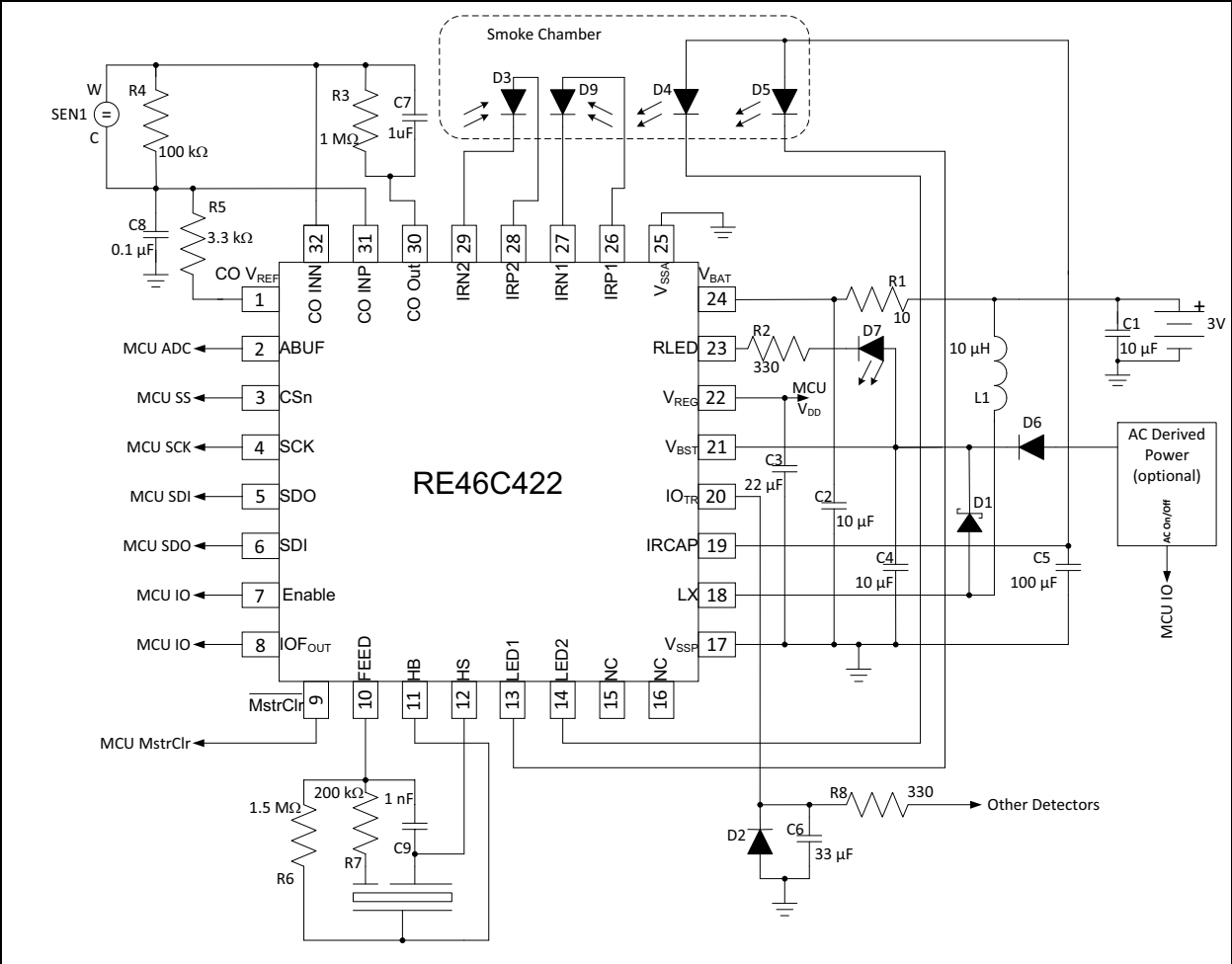


FIGURE 4-9: RE46C422 Typical 3V AC Application

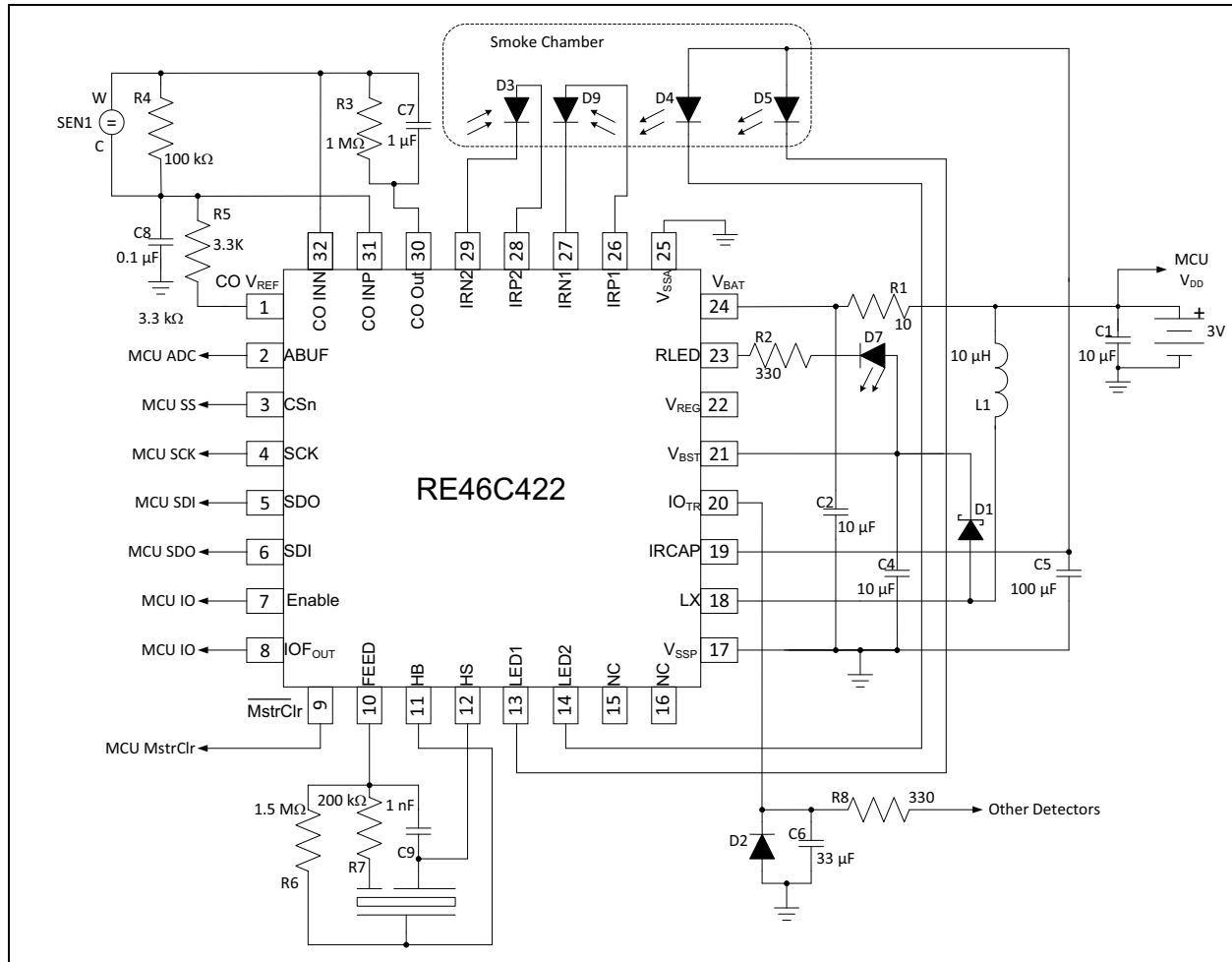


FIGURE 4-10: RE46C422 Typical 3V Battery-Only Application

RE46C420/1/2

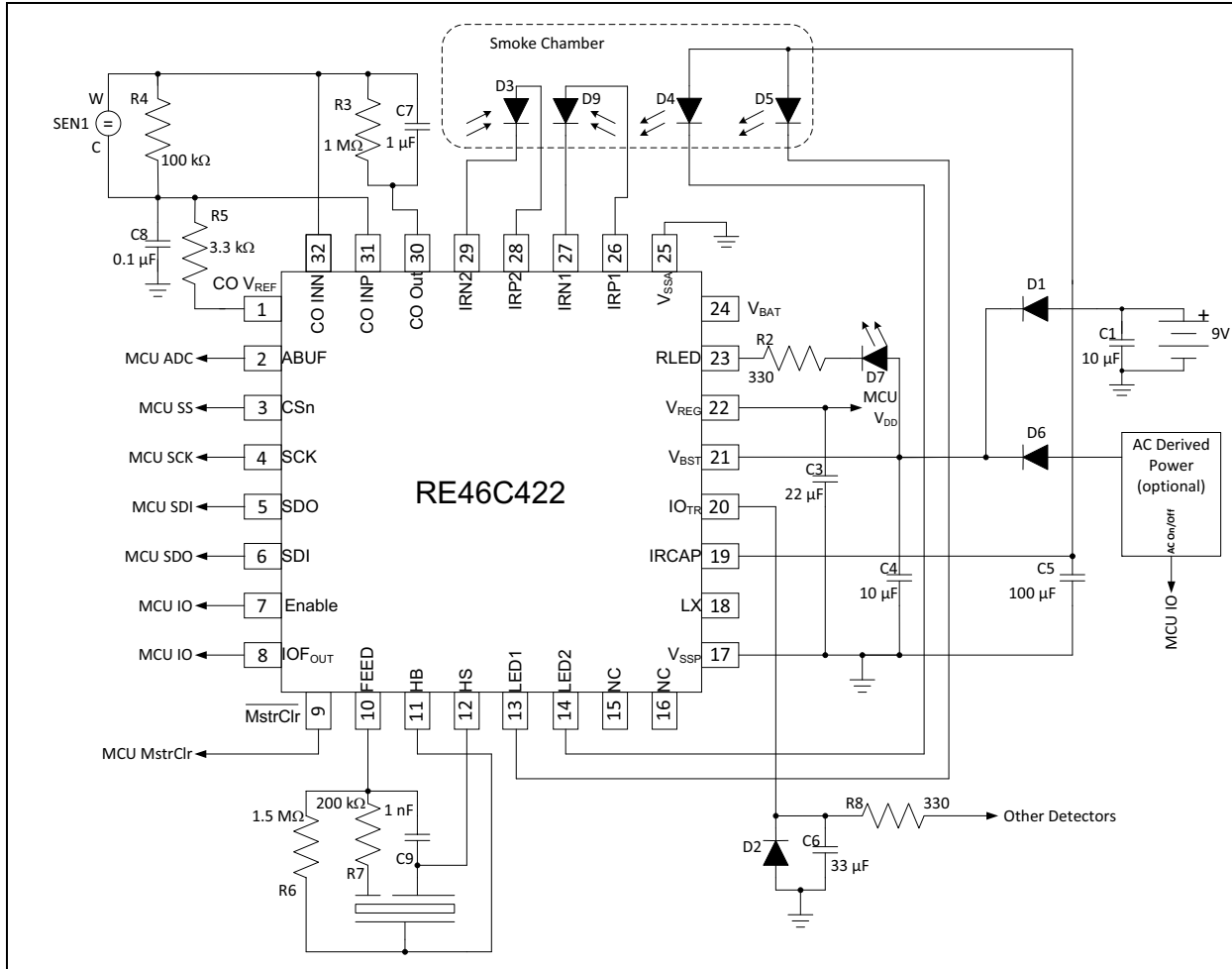


FIGURE 4-11: RE46C422 Typical 9V AC Application

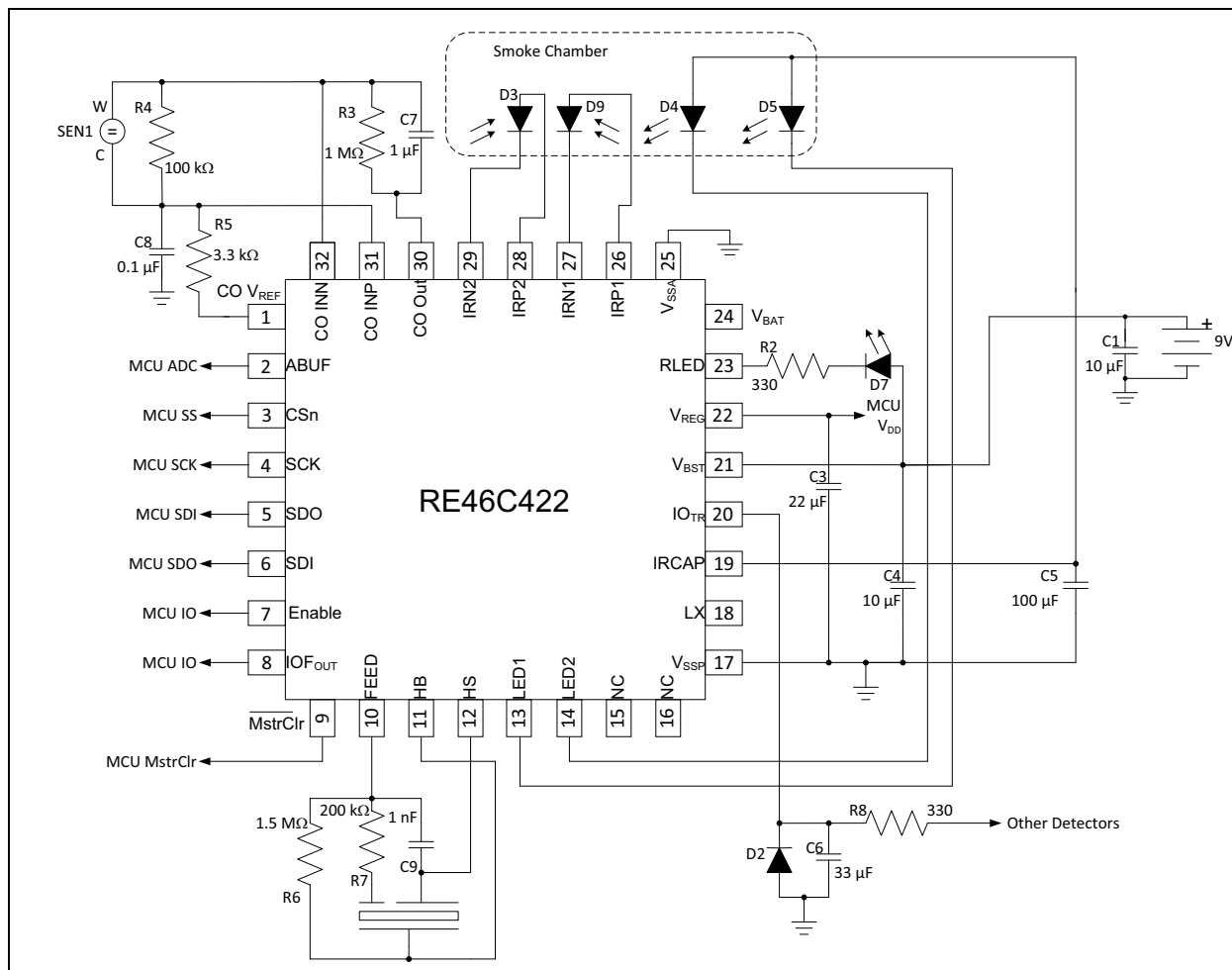


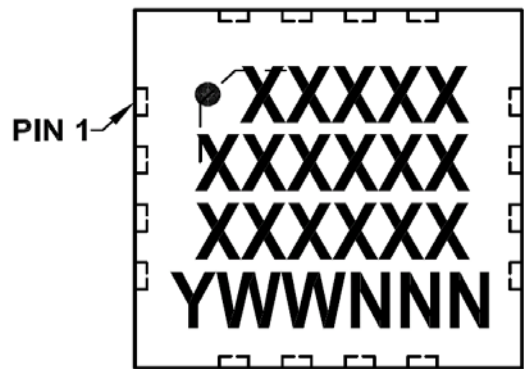
FIGURE 4-12: RE46C422 Typical 9V Battery-Only Application

RE46C420/1/2

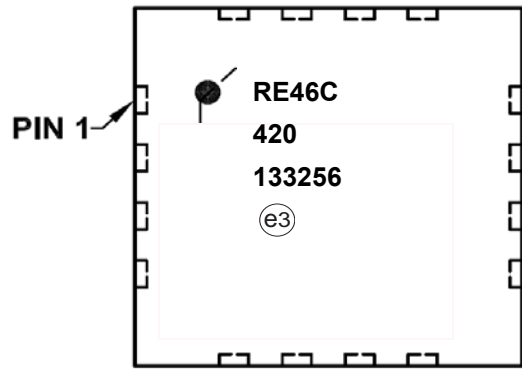
5.0 PACKAGING INFORMATION

5.1 Package Marking Information

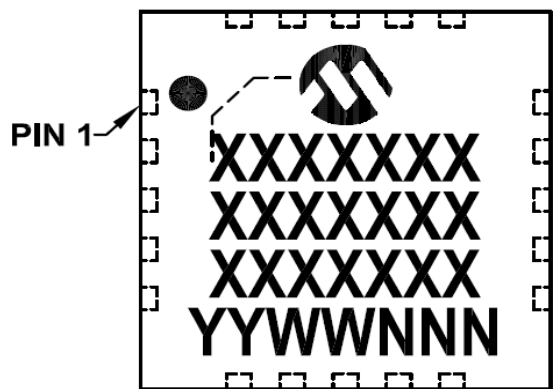
28-Lead VQFN
4 x 4 x 1 mm



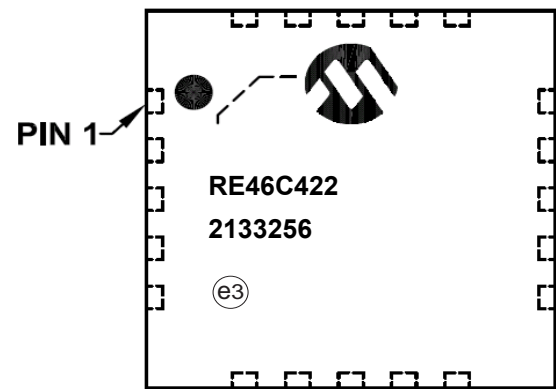
Example:



32-Lead VQFN
5 x 5 x 1 mm



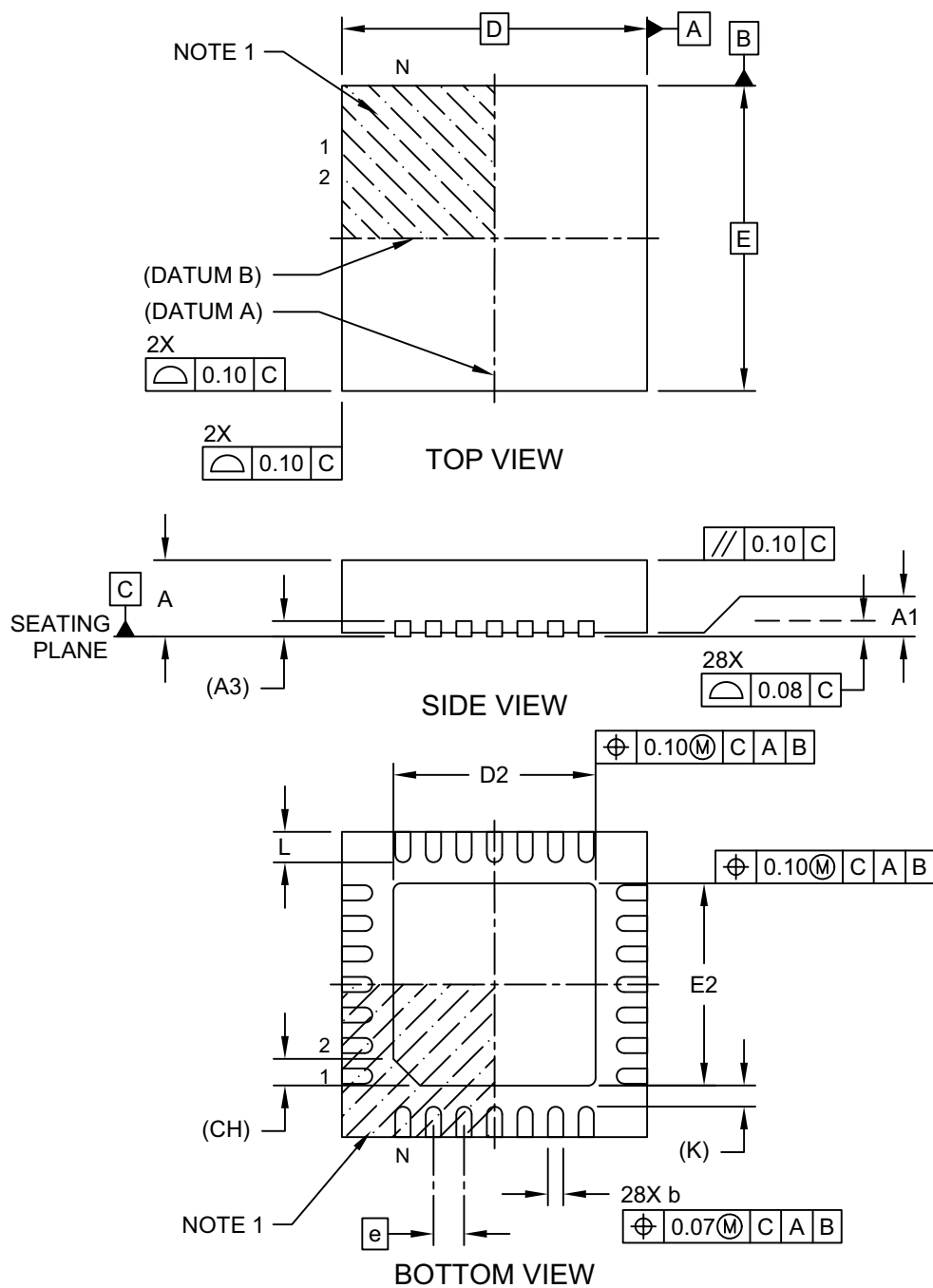
Example:



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.		

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>

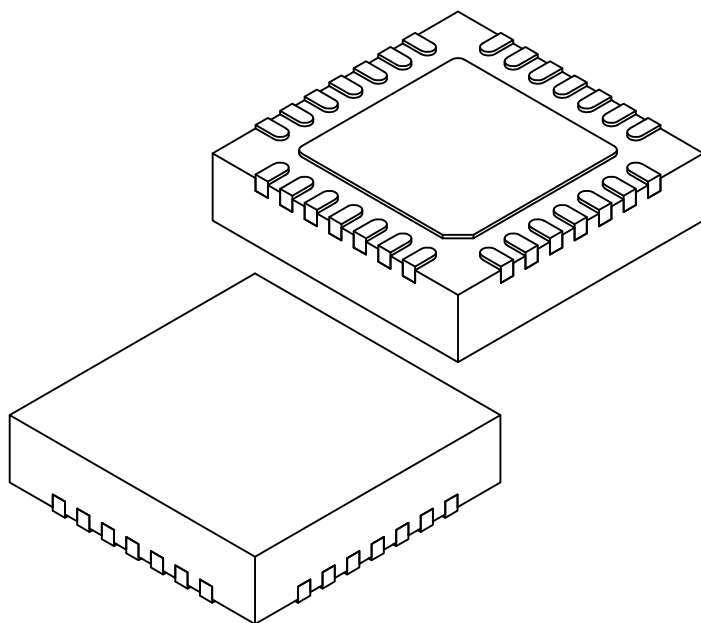


Microchip Technology Drawing C04-456 Rev C Sheet 1 of 2

RE46C420/1/2

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		

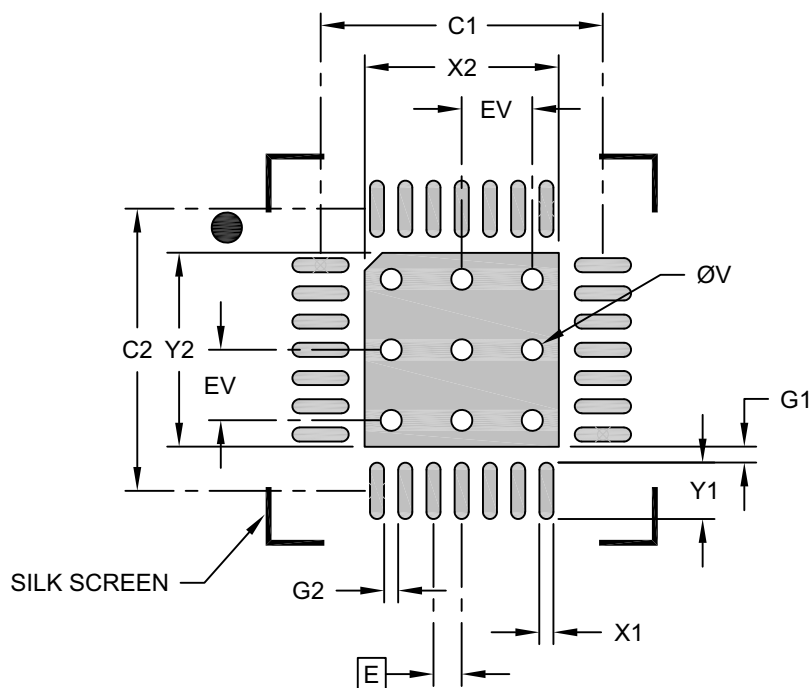
Notes:

- Pin 1 visual index feature may vary, but must be located within the hatched area.
- Package is saw singulated
- 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:

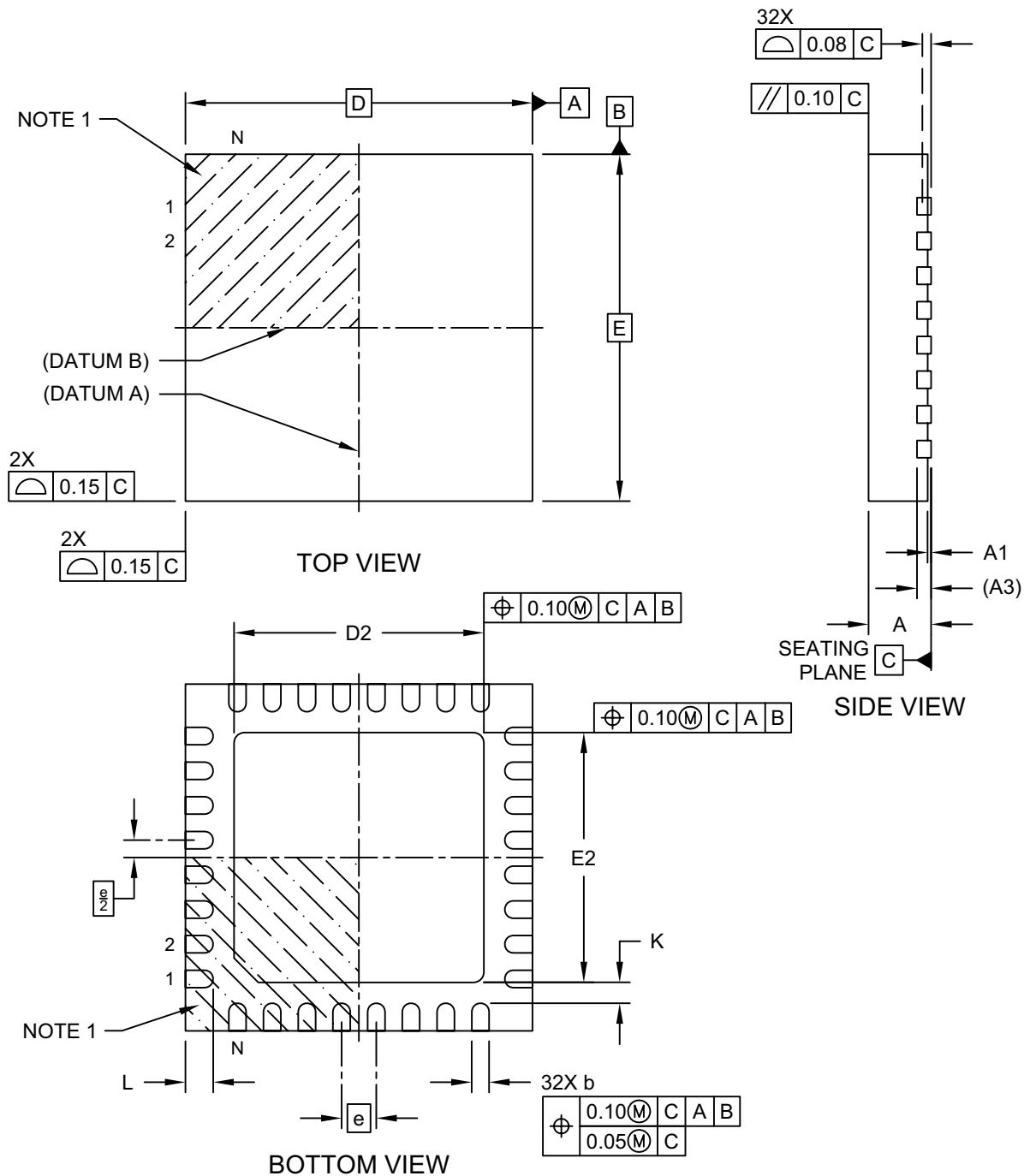
- Dimensioning and tolerancing per ASME Y14.5M
BSC: Basic Dimension. Theoretically exact value shown without tolerances.
- For best soldering results, thermal vias, if used, should be filled or tented to avoid solder loss during reflow process

Microchip Technology Drawing C04-2456 Rev C

RE46C420/1/2

32-Lead Very Thin Plastic Quad Flat, No Lead Package (S8B) - 5x5 mm Body [VQFN] With 3.60 mm Exposed Pad; Atmel Legacy Global Package Code ZKV

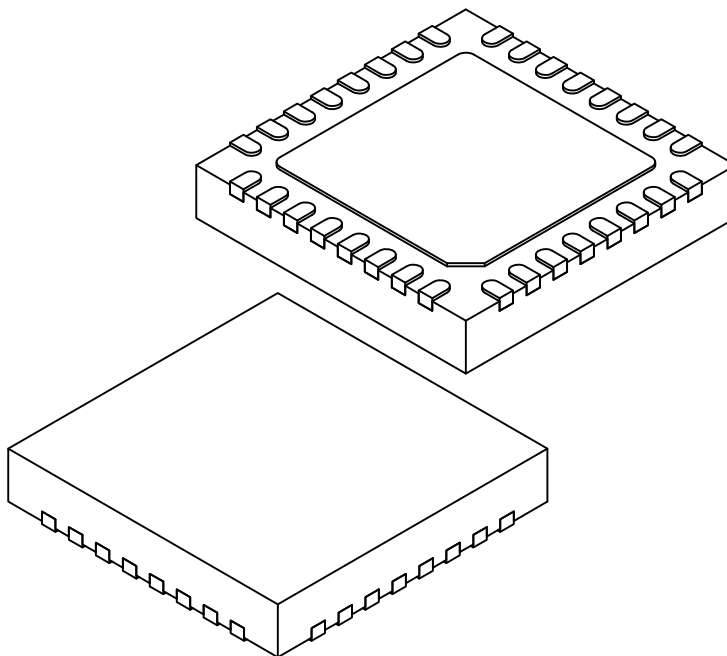
Note: For the most current package drawings, please see the Microchip Packaging Specification located at <http://www.microchip.com/packaging>



Microchip Technology Drawing C04-21402 Rev A Sheet 1 of 2

32-Lead Very Thin Plastic Quad Flat, No Lead Package (S8B) - 5x5 mm Body [VQFN] With 3.60 mm Exposed Pad; Atmel Legacy Global Package Code ZKV

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	32		
Pitch	e	0.50 BSC		
Overall Height	A	0.80	0.90	1.00
Standoff	A1	0.00	0.02	0.05
Terminal Thickness	A3	0.20 REF		
Overall Length	D	5.00 BSC		
Exposed Pad Length	D2	3.50	3.60	3.70
Overall Width	E	5.00 BSC		
Exposed Pad Width	E2	3.50	3.60	3.70
Terminal Width	b	0.18	0.25	0.30
Terminal Length	L	0.30	0.40	0.50
Terminal-to-Exposed-Pad	K	0.20	-	-

Notes:

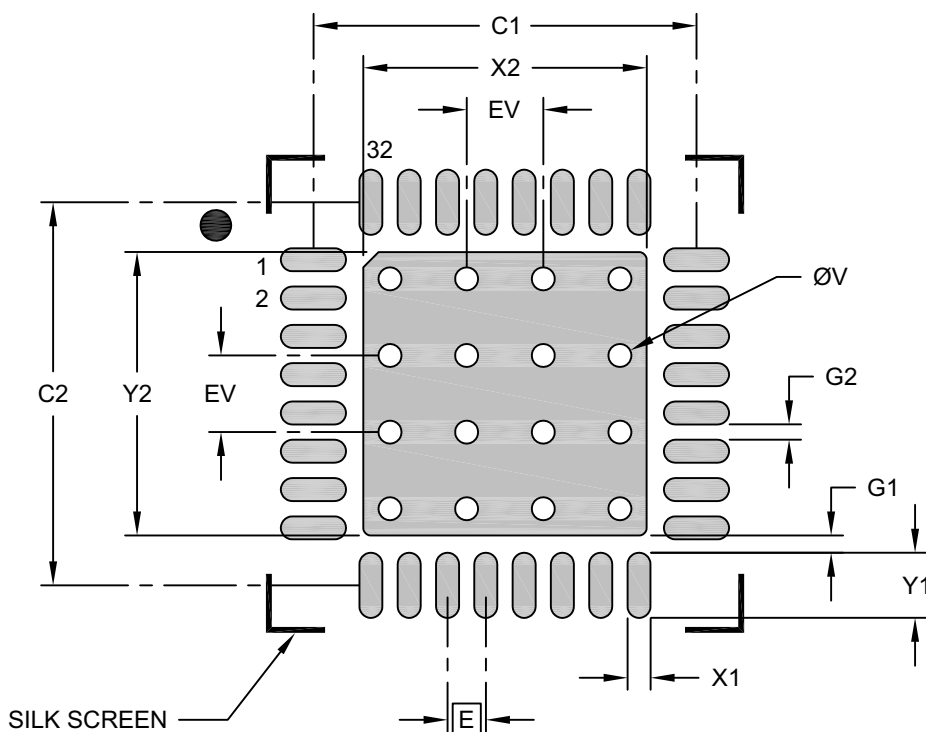
- Pin 1 visual index feature may vary, but must be located within the hatched area.
- Package is saw singulated
- Dimensioning and tolerancing per ASME Y14.5M
 - BSC: Basic Dimension. Theoretically exact value shown without tolerances.
 - REF: Reference Dimension, usually without tolerance, for information purposes only.

Microchip Technology Drawing C04-21402 Rev A Sheet 1 of 2

RE46C420/1/2

32-Lead Very Thin Plastic Quad Flat, No Lead Package (S8B) - 5x5 mm Body [VQFN] With 3.60 mm Exposed Pad; Atmel Legacy Global Package Code ZKV

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	0.50 BSC		
Optional Center Pad Width	X2			3.70
Optional Center Pad Length	Y2			3.70
Contact Pad Spacing	C1		5.00	
Contact Pad Spacing	C2		5.00	
Contact Pad Width (X32)	X1			0.30
Contact Pad Length (X32)	Y1			0.85
Contact Pad to Center Pad (X32)	G1	0.23		
Contact Pad to Contact Pad (X28)	G2	0.20		
Thermal Via Diameter	V		0.30	
Thermal Via Pitch	EV		1.00	

Notes:

- Dimensioning and tolerancing per ASME Y14.5M
BSC: Basic Dimension. Theoretically exact value shown without tolerances.
- For best soldering results, thermal vias, if used, should be filled or tented to avoid solder loss during reflow process

Microchip Technology Drawing C04-23402 Rev A

APPENDIX A: REVISION HISTORY

Revision C (June 2023)

The following is the list of modifications:

- Updated [Section “General Description”](#).
- Updated [Section 5.0 “Packaging Information”](#).
- Updated [Section “Product Identification System”](#).

Revision B (October 2021)

The following is the list of modifications:

- Updated the V_{BAT} value in the [Section 1.1 “Absolute Maximum Ratings†”](#) section.
- Added the IRCAP Voltage entry in the [Section “Electrical Specifications”](#) table.
- Updated [Figure 3-1](#).
- Updated the Operating Temperature Range in the [Section “Temperature Specification”](#) table.

Revision A (September 2021)

- Initial release of this document.

NOTES:

PRODUCT IDENTIFICATION SYSTEM

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

<u>PART NO.</u>	<u>X</u>	<u>XX</u>	<u>X⁽¹⁾</u>	Examples:
Device	Package	Number of Pins	Tape and Reel Option	
Device:	RE46C420:	Photoelectric Smoke Detector AFE		a) RE46C420V28T = VQFN Package, 28LD, Tape and Reel
	RE46C421:	Photoelectric Smoke Detector AFE		a) RE46C421V28T = VQFN Package, 28LD, Tape and Reel
	RE46C422:	Photoelectric Smoke Detector AFE		a) RE46C422V32 = VQFN Package, 32LD
Package:	V	= Very Thin Plastic Quad Flat, No Lead (STX), 4 x 4 mm body, 28-Lead (VQFN) (RE46C420 and RE46C421 only)		b) RE46C422V32T = VQFN Package, 32LD, Tape and Reel
	V	= Very Thin Plastic Quad Flat, No Lead (S8B), 5 x 5 mm body, 32-Lead (VQFN) (RE46C422 only)		
Pin Number:	28	= 28-Lead, VQFN		
	32	= 32-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.				

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ISBN: 978-1-6683-2447-9

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