Click here for production status of specific part numbers.

MAX20310

Ultra-Low Quiescent Current PMIC with SIMO Buck-Boost for Wearable Applications

General Description

The MAX20310 is a compact power management integrated circuit (PMIC) for space-constrained, battery-powered applications where size and efficiency are critical. The device combines two single inductor, multiple output (SIMO) buck-boosted outputs with two LDOs and other system power management features like a push-button monitor and sequencing controller.

The device includes a SIMO buck-boost switching regulator that provides two programmable voltage rails using a single inductor, minimizing solution footprint. The MAX20310 operates with battery voltages down to 0.7V for use with Zinc Air, Silver Oxide, or Alkaline batteries. The architecture allows for output voltages above or below the battery voltage.

Additionally, the MAX20310 has two programmable low-dropout (LDO) linear regulators. The linear regulators can also operate as power switches that can disconnect the quiescent load of system peripherals.

The MAX20310 includes a programmable power controller that allows the device to be configured for use in applications that require a true off state or for always-on applications. This controller provides a delayed reset signal, voltage sequencing, and customized button timing for on/off control and recovery hard reset.

The device also features a multiplexer for monitoring the power inputs and outputs of each function. The MAX20310 is available in a 16-bump 0.4mm pitch 1.63mm x 1.63mm wafer-level package (WLP) and operates over the -40°C to +85°C extended temperature range.

Typical Operating Circuit

Benefits and Features

- Extend System Battery Use Time
  - Single Inductor, Multiple Output (SIMO) Ultra-Low I_Q Buck-Boost Regulator
    - Battery Input Voltage from 0.7V to 2.0V
    - Output Voltage Programmable From 0.9V to 4.05V
    - 250mW Maximum Total Input Power
    - Incremental CAP Quiescent Current 1µA per channel
    - 84% Efficiency for 1.8V, 10mA Output
    - Input Current Limited
  - Dual Ultra-Low I_Q 50mA LDO
    - Inputs Supplied by Dual Buck-Boost Outputs
    - Output Programmable from 0.5V to 3.65V
    - Quiescent Current 1.1µA per LDO / 600nA per Load Switch
    - Configurable as Load Switch
- Extend Product Shelf-Life
  - Battery Seal Mode
    - 10nA Battery Current (typ)
- Minimize Board Area
  - 1.63mm x 1.63mm WLP
- Easy-to-Implement System Control
  - Voltage Monitor Multiplexer
    - 1% Accurate Battery Inverter (±10mV at 1.0V)
  - Power Button Monitor
    - Buffered Output
  - Power Sequencing
  - Reset Output
  - I^2C Control Interface

Applications

- Wearable Medical Devices
- Wearable Fitness Devices
- Portable Medical Devices

***Ordering Information* appears at end of data sheet.**

19-8611; Rev 2; 3/18

Absolute Maximum Ratings

(Voltages reference to GND unless otherwise noted)
CAP, BB1OUT, BB2OUT, L1OUT, L2OUT
MPC, SDA, SCL, $\overline{RST}$, $\overline{KOUT}$ to GND, BATN ....-0.3V to +6V
$\overline{KIN}$..... (BATN – 0.3V) to (GND + 0.3V)
LX to BATN.....-0.3V to +6V
MPO, MON to BATIN .....-0.3V to +6V
GND to BATN .....-0.3V to +2.2V
Continuous Current into LX, BATN .....+0.5A
Continuous Current into any other terminal .....±100mA
Continuous Power Dissipation (T_A = +70°C):
16-bump WLP 1.65mm x 1.65mm 0.4mm Pitch
(derate 17.4mW/°C above +70°C) 957mW
Operating Temperature Range..... -40°C to +85°C
Junction Temperature.....+150°C
Storage Temperature Range..... -65°C to +150°C
Soldering Temperature (reflow).....+260°C

Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only; functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Package Information

PACKAGE TYPE: 16 WLP	
Package Code	W161F1+1
Outline Number	**21-0491**
Land Pattern Number	Refer to **Application Note 1891**
THERMAL RESISTANCE, FOUR-LAYER BOARD	
Junction to Ambient (θ_{JA})	58°C/W

For the latest package outline information and land patterns (footprints), go to **www.maximintegrated.com/packages**. Note that a "+", "#", or "-" in the package code indicates RoHS status only. Package drawings may show a different suffix character, but the drawing pertains to the package regardless of RoHS status.

Package thermal resistances were obtained using the method described in JEDEC specification JESD51-7, using a four-layer board. For detailed information on package thermal considerations, refer to **www.maximintegrated.com/thermal-tutorial**.

Electrical Characteristics

(V_{BAT} = +1.2V, V_{BB1OUT} = +1.8V, V_{BB2OUT} = +1.2V, V_{L1OUT} = +1.5V, V_{L2OUT} = +1.0V, I_{BB1OUT} = I_{BB2OUT} = I_{L1OUT} = I_{L2OUT} = 0A, T_A = -40°C to +85°C, all registers in their default state, unless otherwise noted. Typical values are at T_A = +25°C) (Note 1) (Note 2)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
SUPPLY CURRENT						
Seal Input Current	I_{SEAL}	Seal mode, all functions disabled, T_A = +25°C		0.01	0.2	µA
$\overline{KIN}$ Pullup Resistor to GND	$\overline{KIN}_{PULLUP}$			465		kΩ
CAP Quiescent Current	I_{Q_CAP}	Buck-boost 1 enabled		4		µA
		Buck-boost 1 and 2 enabled		5		µA
		Buck-boost 1 and 2 and LDO 1 enabled		5.25		µA
		Buck-boost 1 and 2 and LDO 1 and 2 enabled		5.5		µA
POWER SEQUENCE						
Reset Time Accuracy	t_{RST}		-10		+10	%
BUCK-BOOST REGULATOR						
Input Voltage	V_{BAT}	Operating	0.7		2	V
		Startup	0.8		2	
Output Voltage Range	V_{OUT}	50mV steps, (Note 3)	0.9		4.05	V
Quiescent Supply Current From CAP	I_{Q_BB}	Burst mode, no switching, V_{BB_OUT} = +1.8V		1		µA
Output Accuracy	$V_{OUT_ACC_BB_OUT}$	T_A = +25°C	-1		1	%
		T_A = 0°C to +85°C	-1.8		+1.8	
		T_A = -40°C to +85°C	-3		+3	
Power Supply Rejection Ratio	PSRR	C_{BB_OUT} = 10µF		40		dB
Maximum Input Power	P_{IN}	(Note 5)	250			mW
Maximum Input Current	I_{IN}	V_{BB_OUT} = +1.8V		200		mA
		V_{BB_OUT} = +3.3V		244		
Short-Circuit Current Limit	I_{LIM}	Maximum programmable current setting		0.6		A
Passive Discharge Resistance	$R_{PAS_BB_OUT}$			10		kΩ
LDO						
Quiescent Supply Current	I_{Q_LDO}	LDO UVLO enabled		1.1	2	µA
		Switch mode, V_{BB_OUT} = +1.8V		0.4		
Quiescent supply Current in Dropout	$I_{Q_LDO_D}$	V_{BB_OUT} = V_{LDO_SET} – 0.1V		1.7	3.5	µA
Maximum Output Current	I_{MAX_LDO}	(Note 4)	50			mA
Output Voltage	V_{OUT_LDO}	50mV steps	0.5		3.65	V

Electrical Characteristics (continued)

(V_{BAT} = +1.2V, V_{BB1OUT} = +1.8V, V_{BB2OUT} = +1.2V, V_{L1OUT} = +1.5V, V_{L2OUT} = +1.0V, I_{BB1OUT} = I_{BB2OUT} = I_{L1OUT} = I_{L2OUT} = 0A, T_A = -40°C to +85°C, all registers in their default state, unless otherwise noted. Typical values are at T_A = +25°C) (Note 1) (Note 2)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Output Accuracy	$V_{OUT_ACC_LDO}$	V_{BB_OUT} = (V_{LDO_SET} + 0.5V) or higher, I_{LOAD} = 1mA	T_A = 0°C to +85°C	-3		3	%
			T_A = -40°C to +85°C	-3.5		+3.5	
Dropout Voltage	V_{DROP_LDO}	V_{BB_OUT} = V_{LDO_SET} = +1.8V, I_{LOAD} = 50mA				100	mV
Line Regulation	$LINEREG_{LDO}$	V_{BB_OUT} = (V_{LDO_SET} + 0.5V) to +4.05V		-1		1	%/V
Load Regulation	$LOADREG_{LDO}$	I_{LOAD} = 50µA to 50mA			0.003		%/mA
Passive Discharge Resistance	R_{PAS_LDO}				10		kΩ
Power Switch Mode Resistance	R_{ON_LS}	V_{BB_OUT} = +1.2V				1	Ω
Turn-On Time	t_{ON_SLOPE}	I_{LDO_OUT} = 0mA			0.7		V/µs
		I_{LDO_OUT} = 0mA. Switch mode.			2.8		
Thermal Shutdown Threshold	T_{SD}	T_J rising			150		°C
Thermal Shutdown Hysteresis	T_{HYS}				21		°C
MONITOR MULTIPLEXER							
MON Impedance	R_{MON}	Sense pin voltage > +0.5V				500	Ω
Battery Voltage Buffer Precision	V_{BAT_OFF}			-10		10	mV
DIGITAL SIGNALS							
SDA, SCL, MPC Input Logic-High	V_{IH}			1.4			V
SDA, SCL, MPC Input Logic-Low	V_{IL}					0.5	V
SDA, $\overline{RST}$, $\overline{KOUT}$ Output Logic-Low	V_{OL}	I_{OL} = 4mA				0.4	V
MPO Output Logic-Low	V_{OL_MPO}	I_{OL} = 4mA to GND				0.4	V
		I_{OL} = 4mA to BATN				0.4	
SCL Clock Frequency	f_{SCL}	(Note 5)		0		400	kHz
Bus Free Time Between a STOP and START Condition	t_{BUF}			1.3			µs

Electrical Characteristics (continued)

(V_{BAT} = +1.2V, V_{BB1OUT} = +1.8V, V_{BB2OUT} = +1.2V, V_{L1OUT} = +1.5V, V_{L2OUT} = +1.0V, I_{BB1OUT} = I_{BB2OUT} = I_{L1OUT} = I_{L2OUT} = 0A, T_A = -40°C to +85°C, all registers in their default state, unless otherwise noted. Typical values are at T_A = +25°C) (Note 1) (Note 2)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
START Condition (Repeated) Hold Time	$t_{HD:STA}$	(Note 6)	0.6			µs
Low Period of SCL Clock	t_{LOW}		1.3			µs
High Period of SCL Clock	t_{HIGH}		0.6			µs
Setup Time for a Repeated START Condition	$t_{SU:STA}$		0.6			µs µs
Data Hold Time	$t_{HD:DAT}$	(Notes 7, 8)	0			µs
Data Setup Time	$t_{SU:DAT}$	(Note 7)	100			ns
Setup Time for STOP Condition	$t_{SU:STO}$		0.6			µs

Note 1: All devices are 100% production tested at T_A = +25°C. Limits over the operating temperature range are guaranteed by design.
Note 2: V_{BAT} refers to the voltage across the battery terminals; $V_{BAT} = V_{GND} – V_{BATN}$.
Note 3: Output voltage must not exceed V_{BB_OUT} - V_{BATN} = 5.0V.
Note 4: Actual value may be limited by the lower of the capability of the source (battery) or the maximum input power of the MAX20310.
Note 5: Timing must be fast enough to prevent the device from entering sleep mode due to bus low for period > t_{SLEEP}.
Note 6: f_{SCL} must meet the minimum clock low time plus the rise/fall times.
Note 7: The maximum $t_{HD:DAT}$ has to be met only if the device does not stretch the low period (t_{LOW}) of the SCL signal.
Note 8: The device internally provides a hold time of at least 100ns for the SDA signal (referred to the V_{IH_MIN} of the SCL signal) to bridge the undefined region of the falling edge of SCL.

Typical Operating Characteristics

(V_{BAT} = 1.2V, V_{BB1OUT} = 1.8V, V_{BB2OUT} = 1.2V, V_{L1OUT} = 1.5V, V_{L2OUT} = 1.0V, L = 1.5µH, C_{BB_OUT} = 10µF (effective), C_{CAP} = 1µF (effective), C_{LDO} = 2.2µF (effective) no load on any rail, T_A = +25°C, unless otherwise noted.)

SEAL MODE INPUT CURRENT vs. V_{BAT}

QUIESCENT CURRENT vs. V_{BAT}

QUIESCENT CURRENT vs. TEMPERATURE

BB1OUT EFFICIENCY vs. LOAD CURRENT

BB1OUT LOAD REGULATION ERROR

BB2OUT EFFICIENCY vs. LOAD CURRENT

BB2OUT LOAD REGULATION ERROR

Typical Operating Characteristics (continued)

(V_{BAT} = 1.2V, V_{BB1OUT} = 1.8V, V_{BB2OUT} = 1.2V, V_{L1OUT} = 1.5V, V_{L2OUT} = 1.0V, L = 1.5µH, C_{BB_OUT} = 10µF (effective), C_{CAP} = 1µF (effective), C_{LDO} = 2.2µF (effective) no load on any rail, T_A = +25°C, unless otherwise noted.)

Typical Operating Characteristics (continued)

(V_{BAT} = 1.2V, V_{BB1OUT} = 1.8V, V_{BB2OUT} = 1.2V, V_{L1OUT} = 1.5V, V_{L2OUT} = 1.0V, L = 1.5µH, C_{BB_OUT} = 10µF (effective), C_{CAP} = 1µF (effective), C_{LDO} = 2.2µF (effective) no load on any rail, T_A = +25°C, unless otherwise noted.)

L2OUT LOAD TRANSIENT RESPONSE 10µA TO 10mA

L2OUT LOAD TRANSIENT RESPONSE 50µA TO 50mA

BB1OUT LOAD TRANSIENT RESPONSE 50µA TO 50mA

BB1OUT LINE TRANSIENT RESPONSE

BB_OUT RIPPLE AND INDUCTOR CURRENT

BB_OUT RIPPLE AND INDUCTOR CURRENT

BB_OUT RIPPLE AND INDUCTOR CURRENT

Bump Configuration

Bump Description

BUMP	NAME	FUNCTION
A1	GND	Ground/Battery Positive Terminal
A2	L2OUT	LDO/Switch 2 Output
A3	L1OUT	LDO/Switch 1 Output
A4	CAP	Internal Supply Decoupling. Connect a minimum 1µF of capacitance to GND.
B1	MPC	Multipurpose Control Input
B2	SDA	I^2C Serial Data
B3	MON	Monitor Multiplexer Output
B4	BB1OUT	Buck-Boost 1 Output
C1	$\overline{KIN}$	Key Input, Internally Pulled to GND. To signal active, short $\overline{KIN}$ to BATN.
C2	SCL	I^2C Serial Clock
C3	MPO	Multipurpose Output. Level shifted digital output for controlling devices referenced to the negative battery terminal.
C4	BB2OUT	Buck-Boost 2 Output
D1	$\overline{KOUT}$	Key Output. Active-low, level-shifted button status output.
D2	$\overline{RST}$	Reset Output. Active-low, open-drain output indicates completion of sequencer.
D3	BATN	Battery Negative Terminal
D4	LX	Inductor Switch Connection

Functional Block Diagram

Detailed Description

Power Regulation

The MAX20310 features an ultra-low I_Q SIMO buck-boost switching regulator that provides two programmable voltagle rails and two low-I_Q LDOs. The regulators minimize quiescent current and operate on low input voltages. This makes the MAX20310 ideal for applications powered by singe-cell Alkaline, Zinc Air, or Silver Oxide batteries. All regulator outputs are capable of being discharged through a resistive load (passive discharge) when turned off. The discharge mode is set by the PDsc bits in each regulator's configuration register.

Switching Regulator

In order to maximize efficiency, the switching regulator is implemented with an inverting buck-boost topology. Referencing the battery's positive terminal to ground configures the battery as a negative supply and the switching regulator output is positive. The switching regulator operates at supplies from -2.0V down to -0.7V, but requires -0.8V to start up. The outputs are independently configurable in 50mV increments.

LDO

For applications that require lower noise supplies, or simply need additional regulated voltages, the MAX20310 includes two LDO regulators. In normal operation, each LDO can source up to 50mA. The LDO inputs are supplied by the buck-boost outputs. As such, an LDO cannot be enabled unless its corresponding switching regulator output is active. The LDOs can be used as switches to disconnect the quiescent loads of peripheral systems, increasing battery life. The LDO outputs are configurable from 0.5 to 3.65V in 50mV increments.

Voltage Monitor Multiplexer

In addition to the four regulator outputs, the MAX20310 includes a voltage monitor multiplexer. The I^2C controlled multiplexer connects the MON pin to any one of the regulator outputs or to BATN. This provides access to the different voltage rails in the device for ADC measurements. An inverting amplifier buffers the BATN channel in order to allow a positive, single-ended ADC to measure the voltage.

Multipurpose Control Input

The MAX20310 includes a multipurpose control (MPC) pin that can control various functions inside the part based on the buck-boost and LDO configuration and sequence register settings. For devices with at least one BBst_Seq[2:0] or LDO_Seq[2:0] field set by the factory to 101 (enabled by MPC, active-low) or 110 (enabled by MPC, active-high) according to Table 19, the MPC pin can be configured to control the multipurpose output (MPO) pin for level-shifting to the battery voltage. See the *Multipurpose Output* section below for details. If the MPC pin is unused, it must be tied to GND.

Multipurpose Output

In addition to the MPC pin, the MAX20310 also features a multipurpose output (MPO). The MPO pin can be configured to pull down to BATN, to pull up to GND, to pullup/down (push/pull), or be disabled (no pull). On devices with at least one BBst_Seq[2:0] or LDO_Seq[2:0] field set by the factory to 101 (enabled by MPC, active-low) or 110 (enabled by MPC, active-high), as detailed in table 19, the MPOCfg register allows the state of the MPO pin to be controlled either by I^{2}C command or by the MPC pin, regardless of polarity. Table 1 below shows the truth table associated with such devices. Devices with none of the one BBst_Seq[2:0] or LDO_Seq[2:0] fields set by the factory to 101 (enabled by MPC, active-low) or 110 (enabled by MPC, active-high) allow the MPO output to be controlled by I^{2}C command only. Table 2 below shows the truth table associated with such devices. An example implementation is included in Figure 1 to show how to use this pin to control an external regulator powered directly from the battery.

Table 1. MPO Truth Table for Devices with One or More BBst_Seq[2:0]/LDO_Seq[2:0] Field Set to 101 or 110 by the Factory

MPOPull[1:0]		MPOEn[1:0]		MPC	OUTPUT STATE
0	0	X	X	X	High-Impedance
0	1	0	0	X	High-Impedance
0	1	0	1	X	Pulled to BATN
0	1	1	0	0	Pulled to BATN
0	1	1	0	1	High-Impedance
0	1	1	1	0	High-Impedance
0	1	1	1	1	Pulled to BATN
1	0	0	0	X	Pulled to GND
1	0	0	1	X	High-Impedance
1	0	1	0	0	High-Impedance
1	0	1	0	1	Pulled to GND
1	0	1	1	0	Pulled to GND
1	0	1	1	1	High-Impedance
1	1	0	0	X	Pulled to GND
1	1	0	1	X	Pulled to BATN
1	1	1	0	0	Pulled to BATN
1	1	1	0	1	Pulled to GND
1	1	1	1	0	Pulled to GND
1	1	1	1	1	Pulled to BATN

Table 2. MPO Truth Table for Devices with None of the BBst_Seq[2:0]/LDO_Seq[2:0] Fields Set to 101 or 110 by the Factory

MPOPull[1:0]		MPOEn[1:0]		MPC	OUTPUT STATE
0	0	X	X	X	High-Impedance
0	1	0	0	X	High-Impedance
0	1	0	1	X	Pulled to BATN
1	0	0	0	X	Pulled to GND
1	0	0	1	X	High-Impedance
1	1	0	0	X	Pulled to GND
1	1	0	1	X	Pulled to BATN

Power On/Off and Reset Control

The MAX20310 is intended for use in small battery-powered applications. It includes an off mode to minimize drain on the battery. In the off mode, all outputs are disabled and the part waits until the $\overline{KIN}$ input goes active to wake the device. The $\overline{KIN}$ input is internally pulled to GND and needs to be shorted to BATN to wake the device. An open-drain buffered copy of the state of $\overline{KIN}$ is available at $\overline{KOUT}$ allowing the system to monitor the status of the button. When the device is powered on, each function can be automatically enabled by a sequencing controller or remain off until an I²C command enables it. This behavior is determined by the factory settings. A button monitor is present on the MAX20310 and can produce different actions for long or short button presses.

The list of settings and corresponding actions is shown in Table 18. A button press always wakes up the device, and the factory configuration determines other behavior.

Reverse Battery Protection

Some applications use batteries like AAA's that do not have mechanical reverse installation protection. In such applications, an optional external nMOSFET and resistor connected as shown in Figure 2 provide reverse battery protection for the system. In normal operation, the 100Ω resistor slows the charging of C_{IN} at startup until V_{CAP}-V_{BATN} exceeds the threshold of the external MOSFET. Thereafter, the circuit functions nominally. In the case of battery reversal, the 100Ω resistor limits the current from the battery and protects the downstream system.

Figure 1. Controlling an External Regulator with MPO

Figure 2. Reverse Battery Protection Using an External MOSFET

Power Sequencing

The sequencing of the voltage regulators during power-on is configurable. Regulators can be configured to turn on at one of four points during the power on process. The four points are: 100ms after the power-on event, after the $\overline{RST}$ signal is released, or at two points in between. The two points are fixed proportionally to the duration of the Power-On Reset (POR) process, but the overall time of the reset delay is configurable (refer to PwrCfg register). The timing relationship is presented graphically in Figure 3. Additionally, the regulators are controllable by the sequencer, an input pin, or I²C command after reset is released. Note that the LDOs will not turn on until the associated switching output is also enabled.

I²C Interface

The MAX20310 uses the two-wire I²C interface to communicate with a host microcontroller. The configuration settings and status information provided through this interface are detailed in the register descriptions. The slave address is 0x50 for writes and 0x51 for reads.

Applications Information

Always-On Devices

Due to its low power consumption, the MAX20310 is ideal for always-on applications. Products targeting these always-on, buttonless applications should select a version of the MAX20310 with PwrCfgMd[1:0] = 00 and connect the $\overline{KIN}$ input to BATN as shown in Figure 4. This PwrCfgMd setting configures a $\overline{KIN}$ press to only turn on the device. When a fresh battery is inserted, or when a battery tab used during product shelf life is removed, $\overline{KIN}$ is pulled to BATN and the device turns on.

Additional Voltage Regulators

In applications with additional voltage regulators operating directly from the battery, careful consideration must be given to battery and system power domains. Due to the negative battery implementation of the MAX20310, the common node for the system power domain (GND) is connected to the positive terminal of the battery.

Regulators using the battery as a positive supply should connect BATN as the local ground and GND as the input supply. However, the output must always be referenced to the positive terminal of the battery (GND). This causes the output voltage of the regulator, referenced to GND, to equal $V_{OUT} - V_{BAT}$. As the battery discharges, this voltage might change over time.

For example, in Figure 1, the external MAX1724 step-up converter produces 5V with respect to the regulator ground (BATN). Because the battery voltage is 1.2V, the output voltage in the system power domain is 3.8V. Due to the relative flatness of the discharge curves for Silver-Oxide, Zinc-Air, and other common coin cell batteries, the challenges associated with a changing reference node are reduced. However, designs should account for some variation of the BATN node.

I²C Interface

The MAX20310 contains an I²C-compatible interface for data communication with a host controller (SCL and SDA). The interface supports a clock frequency of up to 400kHz. SCL and SDA require pullup resistors that are connected to a positive supply.

Start, Stop, and Repeated Start Conditions

When writing to the MAX20310 using I²C, the master sends a START condition (S) followed by the MAX20310

Figure 3. Reset Sequence Programming

Figure 4. $\overline{KIN}$ Connected to BATN for Always-On Applications

I2C address. After the address, the master sends the register address of the register that is to be programmed. The master then ends communication by issuing a STOP condition (P) to relinquish control of the bus, or a REPEATED START condition (Sr) to communicate to another I2C slave. See Figure 5.

Figure 5. I2C START, STOP and REPEATED START Conditions

Slave Address

Set the Read/$\overline{\text{Write}}$ bit high to configure the MAX20310 to read mode. Set the Read/$\overline{\text{Write}}$ bit low to configure the MAX20310 to write mode. The address is the first byte of information sent to the MAX20310 after the START condition.

Bit Transfer

One data bit is transferred on the rising edge of each SCL clock cycle. The data on SDA must remain stable during the high period of the SCL clock pulse. Changes in SDA while SCL is high and stable are considered control signals (see the START, STOP and REPEATED START Conditions section). Both SDA and SCL remain high when the bus is not active.

Figure 6. Write Byte Sequence

Figure 7. Burst Write Sequence

Single-Byte Write

In this operation, the master sends an address and two data bytes to the slave device (Figure 6). The following procedure describes the single byte write operation:

The master sends a START condition

The master sends the 7-bit slave address plus a write bit (low)

The addressed slave asserts an ACK on the data line

The master sends the 8-bit register address

The slave asserts an ACK on the data line only if the address is valid (NAK if not)

The master sends 8 data bits

The slave asserts an ACK on the data line

The master generates a STOP condition

Burst Write

In this operation, the master sends an address and multiple data bytes to the slave device (Figure 7). The slave device automatically increments the register address after each data byte is sent, unless the register being accessed is 0x00, in which case the register address remains the same. The following procedure describes the burst write operation:

The master sends a START condition

The master sends the 7-bit slave address plus a write bit (low)

The addressed slave asserts an ACK on the data line

The master sends the 8-bit register address

The slave asserts an ACK on the data line only if the address is valid (NAK if not)

The master sends 8 data bits

The slave asserts an ACK on the data line

Repeat 6 and 7 N-1 times

The master generates a STOP condition

Single-Byte Read

In this operation, the master sends an address plus two data bytes and receives one data byte from the slave device (Figure 8). The following procedure describes the single byte read operation:

The master sends a START condition

The master sends the 7-bit slave address plus a write bit (low)

The addressed slave asserts an ACK on the data line

The master sends the 8-bit register address

The slave asserts an ACK on the data line only if the address is valid (NAK if not)

The master sends a REPEATED START condition

The master sends the 7-bit slave address plus a read bit (high)

The addressed slave asserts an ACK on the data line

The slave sends 8 data bits

The master asserts a NACK on the data line

The master generates a STOP condition

Figure 8. Read Byte Sequence

Figure 9. Burst Read Sequence

Burst Read

In this operation, the master sends an address plus two data bytes and receives multiple data bytes from the slave device (Figure 9). The following procedure describes the burst byte read operation:

The master sends a START condition

The master sends the 7-bit slave address plus a write bit (low)

The addressed slave asserts an ACK on the data line

The master sends the 8-bit register address

The slave asserts an ACK on the data line only if the address is valid (NAK if not)

The master sends a REPEATED START condition

The master sends the 7-bit slave address plus a read bit (high)

The slave asserts an ACK on the data line

The slave sends 8 data bits

The master asserts an ACK on the data line

Repeat 9 and 10 N-2 times

The slave sends the last 8 data bits

The master asserts a NACK on the data line

The master generates a STOP condition

Figure 10. Acknowledge

Acknowledge Bits

Data transfers are acknowledged with an acknowledge bit (ACK) or a not-acknowledge bit (NACK). Both the master and the MAX20310 generate ACK bits. To generate an ACK, pull SDA low before the rising edge of the ninth clock pulse and hold it low during the high period of the ninth clock pulse (see Figure 10). To generate a NACK, leave SDA high before the rising edge of the ninth clock pulse and leave it high for the duration of the ninth clock pulse. Monitoring for NACK bits allows for detection of unsuccessful data transfers.

I²C Register Map

REGISTER ADDRESS	REGISTER NAME	R/W	B7	B6	B5	B4	B3	B2	B1	B0
0x00	ChipId	R	ChipId[7]	ChipId[6]	ChipId[5]	ChipId[4]	ChipId[3]	ChipId[2]	ChipId[1]	ChipId[0]
0x01	ChipRev	R	ChipRev[7]	ChipRev[6]	ChipRev[5]	ChipRev[4]	ChipRev[3]	ChipRev[2]	ChipRev[1]	ChipRev[0]
0x02	BBstCfg	R/W	BBstDmpEn	—	—	—	ILimSet[1]	ILimSet[0]	FetScale[1]	FetScale[0]
0x03	Reserved	—	—	—	—	—	—	—	—	—
0x04	BBst1VSet	R/W	—	—	BBst1VSet[5]	BBst1VSet[4]	BBst1VSet[3]	BBst1VSet[2]	BBst1VSet[1]	BBst1VSet[0]
0x05	BBst1VCfg	R/W	BBst1En[1]	BBst1En[0]	BBst1PDsc	BBst1ADsc	BBst1RmpDis	—	—	—
0x06	BBst2VSet	R/W	—	—	BBst2VSet[5]	BBst2VSet[4]	BBst2VSet[3]	BBst2VSet[2]	BBst2VSet[1]	BBst2VSet[0]
0x07	BBst2VCfg	R/W	BBst2En[1]	BBst2En[0]	BBst2PDsc	BBst2ADsc	BBst2RmpDis	—	—	—
0x08	LDO1Vset	R/W	—	—	LDO1VSet[5]	LDO1VSet[4]	LDO1VSet[3]	LDO1VSet[2]	LDO1VSet[1]	LDO1VSet[0]
0x09	LDO1Cfg	R/W	LDO1En[1]	LDO1En[0]	LDO1PDsc	LDO1ADsc	—	—	—	LDO1Mode
0x0A	LDO2Vset	R/W	—	—	LDO2VSet[5]	LDO2VSet[4]	LDO2VSet[3]	LDO2VSet[2]	LDO2VSet[1]	LDO2VSet[0]
0x0B	LDO2Cfg	R/W	LDO2En[1]	LDO2En[0]	LDO2PDsc	LDO2ADsc	—	—	—	LDO2Mode
0x0C	MonCfg	R/W	—	—	—	—	MonHiZ	MonSel[2]	MonSel[1]	MonSel[0]
0x0D	MPOCfg	R/W	MPOEn[1]	MPOEn[0]	—	—	—	—	MPOPull[1]	MPOPull[0]
0x0E	PwrCmd	R/W	PwrCmd[7]	PwrCmd[6]	PwrCmd[5]	PwrCmd[4]	PwrCmd[3]	PwrCmd[2]	PwrCmd[1]	PwrCmd[0]
0x0F	Status	R	LDO2UVLO	LDO1UVLO	LDO2Thm	LDO1Thm	LDO2CrMd	LDO1CrMd	KINSts	MPCSts
0x10	PwrCfg	R	PwrCfgMd[1]	PwrCfgMd[0]	GPasDsc	—	—	—	BootDly[1]	BootDly[0]
0x11	BBstSeq	R	—	BBst2Seq[2]	BBst2Seq[1]	BBst2Seq[0]	—	BBst1Seq[2]	BBst1Seq[1]	BBst1Seq[0]
0x12	LDOSeq	R	—	LDO2Seq[2]	LDO2Seq[1]	LDO2Seq[0]	—	LDO1Seq[2]	LDO1Seq[1]	LDO1Seq[0]

I²C Register Descriptions

Table 3. ChipId Register (0x00)

ADDRESS	0x00 (Read-Only)							
BIT	7	6	5	4	3	2	1	0
NAME	ChipId[7:0]							
ChipId[7:0]	ChipId[7:0] bits show information about the version of the MAX20310							

Table 4. ChipRev Register (0x01)

ADDRESS	0x01 (Read-Only)							
BIT	7	6	5	4	3	2	1	0
NAME	ChipRev[7:0]							
ChipRev[7:0]	ChipRev shows information about the revision of the MAX20310 silicon							

Table 5. BBstCfg Register (0x02)

ADDRESS	0x02 (Read, Write)							
BIT	7	6	5	4	3	2	1	0
NAME	BBstDmpEn	-	-	-	ILimSet[1:0]		FetScale[1:0]	
BBstDmpEn	Buck-Boost Dump Enable This enables a dump switch to reduce LX oscillations 0: Switch disabled 1: Switch enabled							
ILimSet[1:0]	Buck-Boost Peak Current Limit Setting Sets the peak current supplied by the buck-boost regulator 00: 300mA 01: 400mA 10: 500mA 11: 600mA							
FetScale[1:0]	FetScale Scales the switching FETs to optimize efficiency at a given load 00: 28% 01: 60% 10: 80% 11: 100%							

Table 6. BBst1VSet Register (0x04)

ADDRESS	0x04 (Read, Write)							
BIT	7	6	5	4	3	2	1	0
NAME	-	-	BBst1VSet[5:0]					
BBst1VSet[5:0]	Buck-Boost 1 Output Voltage Setting 0.90V to 4.05V, linear scale, 50mV increments 000000 = 0.90V 000001 = 0.95V … 111110 = 4.00V 111111 = 4.05V							

Table 7. BBst1Cfg Register (0x05)

ADDRESS	0x05 (Read, Write)							
BIT	7	6	5	4	3	2	1	0
NAME	BBst1En[1:0]		BBst1PDsc	—	BBst1RmpDis	—	—	—
BBst1En[1:0]	Buck-Boost 1 Enable 00: Disabled 01: Enabled 10: Controlled by MPC (active low) 11: Controlled by MPC (active high)							
BBst1PDsc	Buck-Boost 1 Passive Discharge 0: Disabled 1: Enabled when output is off							
BBst1RmpDis	Disable the ramped output of Buck-Boost output 1. If disabled, the BBst1VSet value is immediately applied to the output. 1: Immediate transition to set value 0: Ramp to set value mode							

Table 8. BBst2VSet Register (0x06)

ADDRESS	0x06 (Read, Write)							
BIT	7	6	5	4	3	2	1	0
NAME	-	-	BBst2VSet[5:0]					
BBst2VSet[5:0]	Buck-Boost 2 Output Voltage Setting 0.90V to 4.05V, linear scale, 50mV increments 000000 = 0.90V 000001 = 0.95V … 111110 = 4.00V 111111 = 4.05V							

Table 9. BBst2Cfg Register (0x07)

ADDRESS	0x07 (Read, Write)							
BIT	7	6	5	4	3	2	1	0
NAME	BBst2En[1:0]		BBst2PDsc	-	BBst2RmpDis	-	-	-
BBst2En[1:0]	Buck-Boost 2 Output Enable 00: Disabled 01: Enabled 10: Controlled by MPC (active-low) 11: Controlled by MPC (active-high)							
BBst2PDsc	Buck-Boost 2 Passive Discharge 0: Disabled 1: Enabled when output is off							
BBst2RmpDis	Disable the ramped output of Buck-Boost output 2. If disabled, the BBst2VSet value is immediately applied to the output. 1: Immediate transition to set value 0: Ramp to set value mode							

Table 10. LDO1VSet Register (0x08)

ADDRESS	0x08 (Read, Write)							
BIT	7	6	5	4	3	2	1	0
NAME	—	—	LDO1VSet[5:0]					
LDO1VSet[5:0]	LDO 1 Output Voltage Setting 0.50V to 3.65V, 50mV increments 000000 = 0.50V 000001 = 0.55V … 111110 = 3.60V 111111 = 3.65V							

Table 11. LDO1Cfg Register (0x09)

ADDRESS	0x09 (Read, Write)							
BIT	7	6	5	4	3	2	1	0
NAME	LDO1En[1:0]		LDO1PDsc	LDO1ADsc	—	—	—	LDO1Mode
LDO1En[1:0]	LDO 1 Output Enable 00: Disabled 01: Enabled 10: Controlled by MPC (active-low) 11: Controlled by MPC (active-high)							
LDO1PDsc	LDO 1 Passive Discharge 0: Disabled 1: Enabled when output is off							
LDO1Mode	LDO 1 Mode Configure LDO1 as an LDO or a load switch 0: LDO 1: Load Switch							

Table 12. LDO2VSet Register (0x0A)

ADDRESS	0x0A (Read, Write)							
BIT	7	6	5	4	3	2	1	0
NAME	—	—	LDO2VSet[5:0]					
LDO2VSet[5:0]	LDO 2 Output Voltage Setting 0.50V to 3.65V, 50mV increments 000000 = 0.50V 000001 = 0.55V … 111110 = 3.60V 111111 = 3.65V							

Table 13. LDO2Cfg Register (0x0B)

ADDRESS	0x0B (Read, Write)							
BIT	7	6	5	4	3	2	1	0
NAME	LDO2En[1:0]		LDO2PDsc	—	—	—	—	LDO2Mode
LDO2En[1:0]	LDO 2 Output Enable 00: Disabled 01: Enabled 10: Controlled by MPC (active-low) 11: Controlled by MPC (active-high)							
LDO2PDsc	LDO 2 Passive Discharge 0: Disabled 1: Enabled when output is off							
LDO2Mode	LDO 2 Mode Configure LDO2 as an LDO or a load switch 0: LDO 1: Load Switch							

Table 14. MonCfg Register (0x0C)

ADDRESS	0x0C (Read, Write)							
BIT	7	6	5	4	3	2	1	0
NAME	—	—	—	—	MonHiZ	MonSel[2:0]		
MonHiZ	Monitor Off Mode Condition 0: 100kΩ pulldown when disabled 1: High impedance when disabled							
MonSel[2:0]	Monitor Pin Source Selection 000: Disabled 001: BB1OUT selected 010: BB2OUT selected 011: L1OUT selected 100: L2OUT selected 101: BATIN selected 110: CAP selected 111: Reserved							

Table 15. MPOCfg Register (0x0D)

ADDRESS	0x0D (Read, Write)							
BIT	7	6	5	4	3	2	1	0
NAME	MPOEn[1:0]		—	—	—	—	MPOPull[1:0]	
MPOEn[1:0]	Multipurpose Output Enable 00: Pull up (to GND) 01: Pull down (to BATN) 10: Pull up when MPC high, pull down when MPC low 11: Pull up when MPC low, pull down when MPC high							
MPOPull[1:0]	Multipurpose Output Pull Mode 00: Disabled 01: Pull down (to BATN) 10: Pull up (to GND) 11: Pull up/down (Push/Pull)							

Table 16. PwrCmd Register (0x0E)

ADDRESS	0x0E (Read, Write)							
BIT	7	6	5	4	3	2	1	0
NAME	PwrCmd[7:0]							
PwrCmd[7:0]	Power Command Register 10110010: Power Off - Turn off and stay off 11000011: Hard Reset - Turn off and return back on 11010100: Soft Reset - Pulse $\overline{RST}$ low							

Table 17. Status Register (0x0F)

ADDRESS	0x0F (Read-Only)							
BIT	7	6	5	4	3	2	1	0
NAME	LDO2UVLO	LDO1UVLO	LDO2Thm	LDO1Thm	LDO2CrMd	LDO1CrMd	KINSts	MPCSts
LDO2UVLO	LDO 2 Undervoltage Lockout Status 0: Normal 1: Undervoltage							
LDO1UVLO	LDO 1 Undervoltage Lockout Status 0: Normal 1: Undervoltage							
LDO2Thm	LDO 2 Thermal Limit Status 0: Normal 1: Thermal shutdown							
LDO1Thm	LDO 1 Thermal Limit Status 0: Normal 1: Thermal shutdown							
LDO2CrMd	LDO 2 Current Mode 0: LDO 1: Switch							
LDO1CrMd	LDO 1 Current Mode 0: LDO 1: Switch							
KINSts	$\overline{\text{KIN}}$ Status 0: Low 1: High							
MPCSts	Multi-Purpose Control Status 0: Low 1: High							

Table 18. PwrCfg Register (0x10)

ADDRESS	0x10 (Read-Only)							
BIT	7	6	5	4	3	2	1	0
NAME	PwrCfgMd[1:0]		GPasDsc	—	—	—	BootDly[1:0]	
PwrCfgMd[1:0]	Power Configuration Mode A short button press will always wake the device from the off state. 00: Button only wakes device (can be turned off by I^2C command) 01: Long button press generates reset pulse 10: Long button press power cycles and reboots device 11: Long button press turns device off							
GPasDsc	Global Passive Discharge 0: Passive discharge disabled in off state 1: Passive discharged enabled in off state							
BootDly[1:0]	Boot Sequence Delay (t_{RST}) 00: 80ms 01: 120ms 10: 160ms 11: 200ms							

Table 19. BBstSeq Register (0x11)

ADDRESS	0x11 (Read-Only)							
BIT	7	6	5	4	3	2	1	0
NAME	—	BBst2Seq[2:0]			—	BBst1Seq[2:0]		
BBst2Seq[2:0]	Buck-Boost 2 Sequencing Configuration 000: Disabled 001: Reserved 010: Enabled at 0% of power on delay 011: Enabled at 25% of power on delay 100: Enabled at 50% of power on delay 101: Enabled by MPC (active low) 110: Enabled by MPC (active high) 111: Controlled by BBst2En[1:0] after 100% of power on delay							
BBst1Seq[2:0]	Buck-Boost 2 Sequencing Configuration 000: Disabled 001: Reserved 010: Enabled at 0% of power on delay 011: Enabled at 25% of power on delay 100: Enabled at 50% of power on delay 101: Enabled by MPC (active low) 110: Enabled by MPC (active high) 111: Controlled by BBst1En[1:0] after 100% of power on delay							

Table 20. LDOSeq Register (0x12)

ADDRESS	0x12 (Read-Only)							
BIT	7	6	5	4	3	2	1	0
NAME	—	LDO2Seq[2:0]			—	LDO1Seq[2:0]		
LDO2Seq[2:0]	LDO 2 Sequencing Configuration 000: Disabled 001: Reserved 010: Enabled at 0% of power on delay 011: Enabled at 25% of power on delay 100: Enabled at 50% of power on delay 101: Enabled by MPC (active low) 110: Enabled by MPC (active high) 111: Controlled by LDO2En[1:0] after 100% of power on delay							
LDO1Seq[2:0]	LDO 1 Sequencing Configuration 000: Disabled 001: Reserved 010: Enabled at 0% of power on delay 011: Enabled at 25% of power on delay 100: Enabled at 50% of power on delay 101: Enabled by MPC (active low) 110: Enabled by MPC (active high) 111: Controlled by LDO1En[1:0] after 100% of power on delay							

Table 21. Register Bit Default Values

REGISTER BITS	MAX20310A	MAX20310B	MAX20310C	MAX20310D	MAX20310E
ILimSet[1:0]	400mA	600mA	300mA	300mA	300mA
FetScale[1:0]	100%	100%	80%	80%	80%
LDO1En[1:0]	Disabled	Disabled	Disabled	Disabled	Disabled
LDO1VSet[5:0]	1.5V	0.5V	1.5V	3.0V	1.2V
LDO2En[1:0]	Disabled	Disabled	Disabled	Disabled	Disabled
LDO2VSet[5:0]	1.0V	1.8V	1.0V	1.2V	1.0V
BBst1En[1:0]	Disabled	Disabled	Enabled	Enabled	Enabled
BBst1VSet[5:0]	1.8V	3.0V	2.5V	3.3V	1.8V
BBst2En[1:0]	Disabled	Disabled	Disabled	Disabled	Disabled
BBst2VSet[5:0]	1.2V	2.1V	1.2V	1.5V	1.2V
BBstDmpEn	Disabled	Disabled	Disabled	Disabled	Disabled
LDO2Mode	Switch	LDO	LDO	LDO	LDO
LDO1Mode	LDO	Switch	LDO	LDO	LDO
MPOEn[1:0]	GND	GND	GND	GND	GND
PullMode[1:0]	Disabled	Disabled	Disabled	Disabled	Disabled
PwrCfgMd[1:0]	ON/off	ON	Hard Reset	Soft Reset	On/Off
GPasDsc	Disabled	Disabled	Enabled	Enabled	Enabled
BootDly[1:0]	120ms	80ms	200ms	160ms	80ms
BBst2Seq[2:0]	0% boot	25% boot	I^2C after 100% boot	I^2C after 100% boot	I^2C after 100% boot
BBst1Seq[2:0]	0% boot	0% boot	I^2C after 100% boot	I^2C after 100% boot	I^2C after 100% boot
LDO2Seq[2:0]	I^2C after 100% boot	50% boot	I^2C after 100% boot	I^2C after 100% boot	I^2C after 100% boot
LDO1Seq[2:0]	I^2C after 100% boot	I^2C after 100% boot	I^2C after 100% boot	I^2C after 100% boot	I^2C after 100% boot

Table 22. Register Default Values

REGISTER ADDRESS	REGISTER NAME	DEFAULT VALUES				
		MAX20310A	MAX20310B	MAX20310C	MAX20310D	MAX20310E
0x00	ChipId	0x00	0x00	0x00	0x00	0x00
0x01	ChipRev	0x00	0x00	0x00	0x00	0x00
0x02	BBstCfg	0x07	0x0F	0x02	0x02	0x02
0x04	BBst1VSet	0x12	0x2A	0x20	0x30	0x12
0x05	BBst1VCfg	0x10	0x10	0x60	0x60	0x60
0x06	BBst2VSet	0x06	0x18	0x06	0x0C	0x06
0x07	BBst2VCfg	0x10	0x10	0x20	0x20	0x20
0x08	LDO1Vset	0x14	0x00	0x14	0x32	0x0E
0x09	LDO1Cfg	0x10	0x11	0x20	0x20	0x20
0x0A	LDO2Vset	0x0A	0x1A	0x0A	0x0E	0x0A
0x0B	LDO2Cfg	0x11	0x10	0x20	0x20	0x20
0x0D	MPOCfg	0x00	0x00	0x00	0x00	0x00
0x10	PwrCfg	0xD1	0x10	0xA3	0x62	0xE0
0x11	BBstSeq	0x22	0x32	0x77	0x77	0x77
0x12	LDOSeq	0x77	0x47	0x77	0x77	0x77

Typical Application Circuit

Note: *The capacitor values shown reflect an effective capacitance. Derate capacitors appropriately according to specific application requirements.*

Ordering Information

PART	TEMP RANGE	PIN-PACKAGE	TOP MARK
MAX20310AEWE+	-40°C to +85°C	16 WLP	AAK
MAX20310AEWE+T	-40°C to +85°C	16 WLP	AAK
MAX20310BEWE+	-40°C to +85°C	16 WLP	AAK
MAX20310BEWE+T	-40°C to +85°C	16 WLP	AAK
MAX20310CEWE+	-40°C to +85°C	16 WLP	AAK
MAX20310CEWE+T	-40°C to +85°C	16 WLP	AAK
MAX20310DEWE+	-40°C to +85°C	16 WLP	AAK
MAX20310DEWE+T	-40°C to +85°C	16 WLP	AAK
MAX20310EEWE+	-40°C to +85°C	16 WLP	AAK
MAX20310EEWE+T	-40°C to +85°C	16 WLP	AAK

+ Denotes a lead(Pb)-free/RoHS-compliant package.
T = Tape and reel.

Chip Information

PROCESS: BiCMOS

Revision History

REVISION NUMBER	REVISION DATE	DESCRIPTION	PAGES CHANGED
0	9/16	Initial release	—
1	5/17	Added future products. Updated *Typical Operating Characteristics*, *General Description, Benefits and Features, Power Regulation, Power Sequencing* sections, and *Typical Application Circuit*. Added *Always-On Devices* and *Additional Voltage Regulators* sections. Replaced Figure 1, added new Figure 4 and renumbered Figures 5-10. Updated Table 5 and replaced Tables 21-22.	1, 6–8 10, 12–16 18, 26–28
2	3/18	Updated the *Detailed Description* section, *I^2C Register Map,* and *Register Bit Default Values* table. Replaced *Typical Application Circuit* figure. Updated *Ordering Information* to show that the MAX20310A-E are released products.	10, 17, 27, 29

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- Техническая поддержка проекта;
- Защита от снятия компонента с производства.

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