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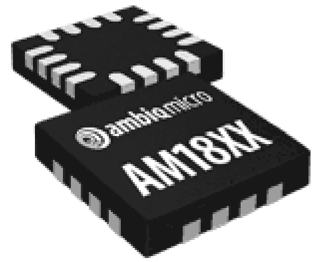
AM18X5 Real-Time Clock with Power Management Family

Features

- Ultra-low supply current (all at 3V):
  - 14 nA with RC oscillator
  - 22 nA with RC oscillator and Autocalibration
  - 55 nA with crystal oscillator
- Baseline timekeeping features:
  - 32.768 kHz crystal oscillator with integrated load capacitor/resistor
  - Counters for hundredths, seconds, minutes, hours, date, month, year, century, and weekday
  - Alarm capability on all counters
  - Programmable output clock generation (32.768 kHz to 1 year)
  - Countdown timer with repeat function
  - Automatic leap year calculation
- Advanced timekeeping features:
  - Integrated power optimized RC oscillator
  - Advanced crystal calibration to ± 2 ppm
  - Advanced RC calibration to ± 16 ppm
  - Automatic calibration of RC oscillator to crystal oscillator
  - Watchdog timer with hardware reset
  - 256 bytes of general purpose RAM
- Power management features:
  - Integrated ~1Ω power switch for off-chip components such as a host MCU
  - System sleep manager for managing host processor wake/sleep states
  - External reset signal monitor
  - Reset output generator
  - Supercapacitor trickle charger with programmable charging current
  - Automatic switchover to VBAT
  - External interrupt monitor
  - Programmable low battery detection threshold
  - Programmable analog voltage comparator
- I^2C (up to 400 kHz) and 3-wire or 4-wire SPI (up to 2 MHz) serial interfaces available
- Operating voltage 1.5-3.6 V
- Clock and RAM retention voltage 1.5-3.6 V
- Operating temperature –40 to 85 °C
- All inputs include Schmitt Triggers
- 3x3 mm QFN-16 package
- Also available in wafer form



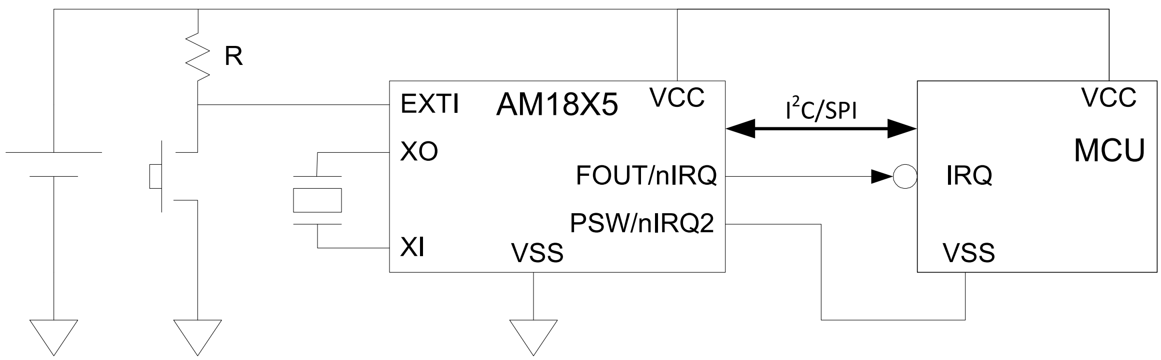
Applications

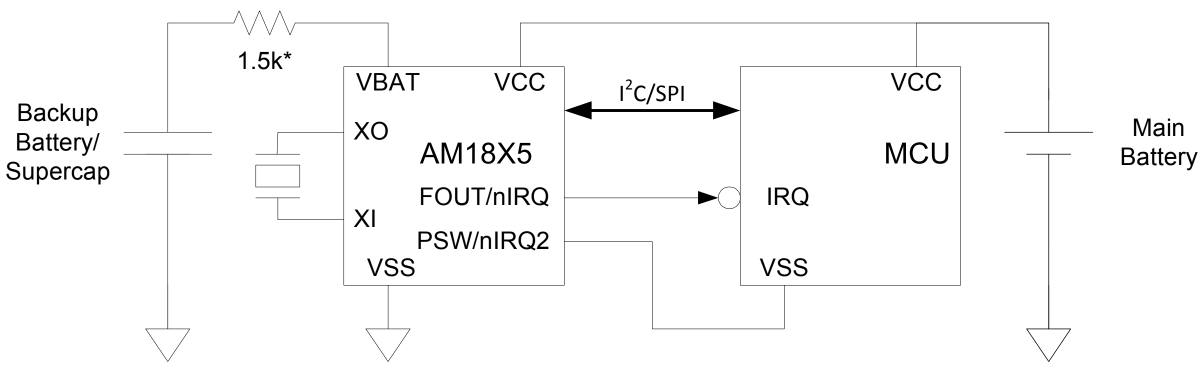
- Smart cards
- Wireless sensors and tags
- Medical electronics
- Utility meters
- Data loggers
- Appliances
- Handsets
- Consumer electronics
- Communications equipment

Description

The Ambiq Micro AM18X5 Real-Time Clock with Power Management family provides a groundbreaking combination of ultra-low power coupled with a highly sophisticated feature set. With power requirements significantly lower than any other industry RTC (as low as 14 nA), these are the first semiconductors based on Ambiq Micro's innovative SPOT™ (Subthreshold Power Optimized Technology) CMOS platform. The AM18X5 includes on-chip oscillators to provide minimum power consumption, full RTC functions including battery backup and programmable counters and alarms for timer and watchdog functions, and either an I^2C or SPI serial interface for communication with a host controller. An integrated power switch and a sophisticated system sleep manager with counter, timer, alarm, and interrupt capabilities allows the AM18X5 to be used as a supervisory component in a host microcontroller based system.

Typical Application Circuits





* Total battery series impedance = 1.5k ohms, which may require an external resistor

Contents

List of Figures

List of Tables

1. Family Summary

The AM18X5 family consists of several members (see Table 1). All devices are supplied in a standard 3x3 mm QFN-16 package. Members of the software and pin compatible AM08X5 RTC family are also listed.

Table 1: Family Summary

Part #	Baseline Timekeeping		Advanced Timekeeping				Power Management				Interface
	XT Osc	Number of GP Outputs	RC Osc	Calib/ Auto-calib	Watch-dog	RAM (B)	VBAT Switch	Reset Mgmt	Ext Int	Power Switch and Sleep FSM	
AM1805	■	4	■	■	■	256	■	■	■	■	I^2C
AM1815	■	3	■	■	■	256	■	■	■	■	SPI
Software and Pin Compatible AM08X5 Family Components											
AM0805	■	3	■	■	■	256	■		■		I^2C
AM0815	■	2	■	■	■	256	■		■		SPI

2. Package Pins

2.1 Pin Configuration and Connections

Figure 1 and Table 2 show the QFN-16 pin configurations for the AM18X5 parts. Pins labeled NC must be left unconnected. The thermal pad, pin 17, on the QFN-16 packages must be connected to VSS.

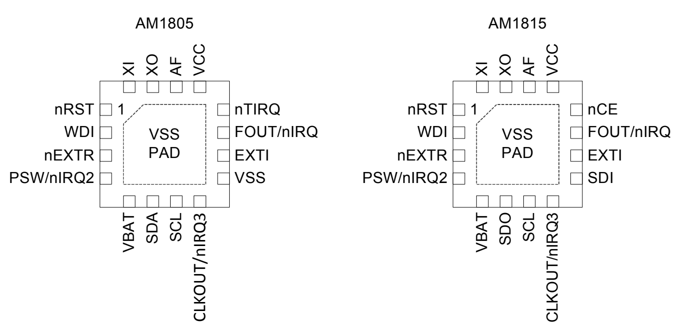


Figure 1. Pin Configuration Diagram

Table 2: Pin Connections

Pin Name	Pin Type	Function	Pin Number	
			AM1805	AM1815
VSS	Power	Ground	9,17	17
VCC	Power	System power supply	13	13
XI	XT	Crystal input	16	16

Table 2: Pin Connections

Pin Name	Pin Type	Function	Pin Number	
			AM1805	AM1815
XO	XT	Crystal output	15	15
AF	Output	Autocalibration filter	14	14
VBAT	Power	Battery power supply	5	5
SCL	Input	I^2C or SPI interface clock	7	7
SDO	Output	SPI data output		6
SDI	Input	SPI data input		9
nCE	Input	SPI chip select		12
SDA	Input	I^2C data input/output	6	
EXTI	Input	External interrupt input	10	10
WDI	Input	Watchdog reset input	2	2
nEXTR	Input	External reset input	3	3
FOUT/nIRQ	Output	Int 1/function output	11	11
PSW/nIRQ2	Output	Int 2 /power switch output	4	4
CLKOUT/nIRQ3	Output	Int 3/clock output	8	8
nTIRQ	Output	Timer interrupt output	12	
nRST	Output	Reset output	1	1

2.2 Pin Descriptions

Table 3 provides a description of the pin connections.

Table 3: Pin Descriptions

Pin Name	Description
VSS	Ground connection. In the QFN-16 packages the ground slug on the bottom of the package must be connected to VSS.
VCC	Primary power connection. If a single power supply is used, it must be connected to VCC.
VBAT	Battery backup power connection. If a backup battery is not present, VBAT must be connected directly to VSS, but it may also be used to provide the analog input to the internal comparator (see Analog Comparator).
XI	Crystal oscillator input connection.
XO	Crystal oscillator output connection.
AF	Autocalibration filter connection. A 47pF ceramic capacitor must be placed between this pin and VSS for improved Autocalibration mode timing accuracy.
SCL	I/O interface clock connection. It provides the SCL input in both I^2C and SPI interface parts. A pull-up resistor is required on this pin.
SDA (only available in I^2C environments)	I/O interface I^2C data connection. A pull-up resistor is required on this pin.
SDO (only available in SPI environments)	I/O interface SPI data output connection.
SDI	I/O interface SPI data input connection.

Table 3: Pin Descriptions

Pin Name	Description
nCE (only available in SPI environments)	I/O interface SPI chip select input connection. It is an active low signal. A pull-up resistor is recommended to be connected to this pin to ensure it is not floating. A pull-up resistor also prevents inadvertent writes to the RTC during power transitions.
EXTI	External interrupt input connection. It may be used to generate an External 1 interrupt with polarity selected by the EX1P bit if enabled by the EX1E bit. The value of the EXTI pin may be read in the EXIN register bit. This pin does not have an internal pull-up or pull-down resistor and so one must be added externally. It must not be left floating or the RTC may consume higher current. Instead, it must be connected directly to either VCC or VSS if not used.
WDI	Watchdog Timer reset input connection. It may also be used to generate an External 2 interrupt with polarity selected by the EX2P bit if enabled by the EX2E bit. The value of the WDI pin may be read in the WDIN register bit. This pin does not have an internal pull-up or pull-down resistor and so one must be added externally. It must not be left floating or the RTC may consume higher current. Instead, it must be connected directly to either VCC or VSS if not used.
nEXTR	External reset input connection. If nEXTR is low and the RS1E bit is set, the nRST output will be driven to its asserted value as determined by the RSP bit. This pin does not have an internal pull-up or pull-down resistor and so one must be added externally. It must not be left floating or the RTC may consume higher current. Instead, it must be connected directly to either VCC or VSS if not used.
FOUT/nIRQ	Primary interrupt output connection. This pin is an open drain output. An external pull-up resistor must be added to this pin. It should be connected to the host device and is used to indicate when the RTC can be accessed via the serial interface. FOUT/nIRQ may be configured to generate several signals as a function of the OUT1S field (see 0x11 - Control2). FOUT/nIRQ is also asserted low on a power up until the AM18X5 has exited the reset state and is accessible via the I/O interface. 1. FOUT/nIRQ can drive the value of the OUT bit. 2. FOUT/nIRQ can drive the inverse of the combined interrupt signal IRQ (see Interrupts). 3. FOUT/nIRQ can drive the square wave output (see 0x13 - SQW) if enabled by SQWE. 4. FOUT/nIRQ can drive the inverse of the alarm interrupt signal AIRQ (see Interrupts).
PSW/nIRQ2	Secondary interrupt output connection. It is an open drain output. This pin can be left floating if not used. PSW/nIRQ2 may be configured to generate several signals as a function of the OUT2S field (see 0x11 - Control2). This pin will be configured as an ~1 Ω switch if the PWR2 bit is set. 1. PSW/nIRQ2 can drive the value of the OUTB bit. 2. PSW/nIRQ2 can drive the square wave output (see 0x13 - SQW) if enabled by SQWE. 3. PSW/nIRQ2 can drive the inverse of the combined interrupt signal IRQ (see Interrupts). 4. PSW/nIRQ2 can drive the inverse of the alarm interrupt signal AIRQ (see Interrupts). 5. PSW/nIRQ2 can drive either sense of the timer interrupt signal TIRQ. 6. PSW/nIRQ2 can function as the power switch output for controlling the power of external devices (see Sleep Control).
nTIRQ (only available in I^2C environments)	Timer interrupt output connection. It is an open drain output. nTIRQ always drives the active low nTIRQ signal. If this pin is used, an external pull-up resistor must be added to this pin. If the pin is not used, it can be left floating.
CLKOUT/nIRQ3	Square Wave output connection. It is a push-pull output, and may be configured to generate one of two signals. 1. CLKOUT/nIRQ3 can drive the value of the OUT bit. 2. CLKOUT/nIRQ3 can drive the square wave output (see 0x13 - SQW) if enabled by SQWE.
nRST	External reset output connection. It is an open drain output. If this pin is used, an external pull-up resistor must be added to this pin. If the pin is not used, it can be left floating.The polarity is selected by the RSP bit, which will initialize to 0 on power up to produce an active low output. See Autocalibration Fail Interrupt ACIRQ for details of the generation of nRST.

3. Digital Architecture Summary

Figure 2 illustrates the overall architecture of the pin inputs and outputs of the AM18X5.

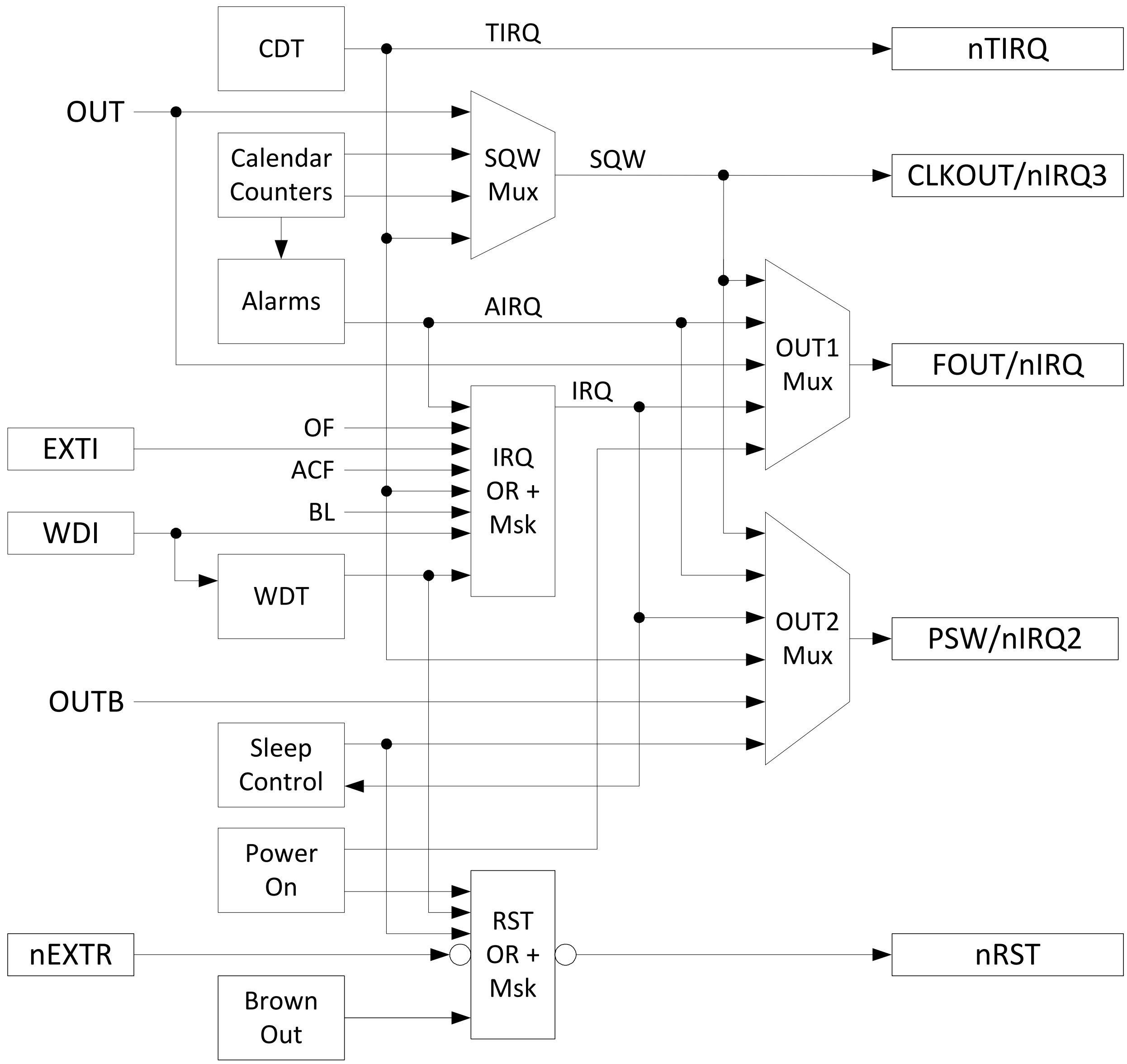


Figure 2. Digital Architecture Summary

4. Electrical Specifications

4.1 Absolute Maximum Ratings

Table 4 lists the absolute maximum ratings.

Table 4: Absolute Maximum Ratings

SYMBOL	PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
V_{CC}	System Power Voltage		-0.3		3.8	V
V_{BAT}	Battery Voltage		-0.3		3.8	V
V_I	Input voltage	VCC Power state	-0.3		V_{CC}+ 0.3	V
V_I	Input voltage	VBAT Power state	-0.3		V_{BAT}+ 0.3	V
V_O	Output voltage	VCC Power state	-0.3		V_{CC}+ 0.3	V
V_O	Output voltage	VBAT Power state	-0.3		V_{BAT}+ 0.3	V
I_I	Input current		-10		10	mA
I_O	Output current		-20		20	mA
I_{OPC}	PSW Output continuous current				50	mA
I_{OPP}	PSW Output pulsed current	1 second pulse			150	mA
V_{ESD}	ESD Voltage	CDM			±500	V
		HBM			±4000	V
I_{LU}	Latch-up Current				100	mA
T_{STG}	Storage Temperature		-55		125	°C
T_{OP}	Operating Temperature		-40		85	°C
T_{SLD}	Lead temperature	Hand soldering for 10 seconds			300	°C
T_{REF}	Reflow soldering temperature	Reflow profile per JEDEC J-STD-020D.1			260	°C

4.2 Power Supply Parameters

Figure 3 and Table 5 describe the power supply and switchover parameters. See Power Control and Switching for a detailed description of the operations.

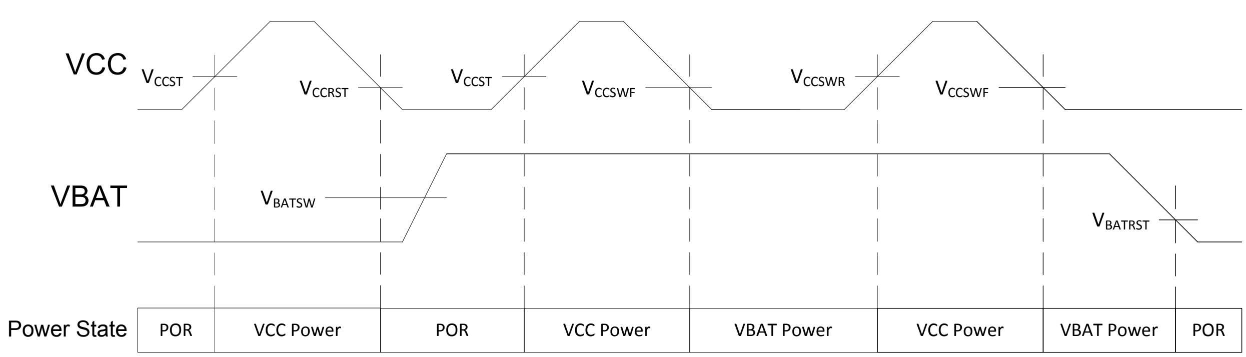


Figure 3. Power Supply Switchover

For Table 5, T_A = -40 °C to 85 °C, TYP values at 25 °C.

Table 5: Power Supply and Switchover Parameters

SYMBOL	PARAMETER	PWR	TYPE	POWER STATE	TEST CONDITIONS	MIN	TYP	MAX	UNIT
V_{CC}	System Power Voltage	VCC	Static	VCC Power	Clocks operating and RAM and registers retained	1.5		3.6	V
V_{CCIO}	VCC I/O Interface Voltage	VCC	Static	VCC Power	I^2C or SPI operation	1.5		3.6	V
V_{CCST}	VCC Start-up Voltage(1)	VCC	Rising	POR -> V_{CC} Power		1.6			V
V_{CCRST}	VCC Reset Voltage	VCC	Falling	VCC Power -> POR	$V_{BAT} < V_{BAT,MIN}$ or no V_{BAT}		1.3	1.5	V
V_{CCSWR}	VCC Rising Switch-over Threshold Voltage	VCC	Rising	VBAT Power -> VCC Power	$V_{BAT} \geq V_{BATRST}$		1.6	1.7	V
V_{CCSWF}	VCC Falling Switch-over Threshold Voltage	VCC	Falling	VCC Power -> VBAT Power	$V_{BAT} \geq V_{BATSW,MIN}$	1.2	1.5		V
V_{CCSWH}	VCC Switchover Threshold Hysteresis(2)	VCC	Hyst.	VCC Power <-> VBAT Power			70		mV
V_{CCFS}	VCC Falling Slew Rate to switch to VBAT state(4)	VCC	Falling	VCC Power -> VBAT Power	$V_{CC} < V_{CCSW,MAX}$	0.7	1.4		V/ms
V_{BAT}	Battery Voltage	VBAT	Static	VBAT Power	Clocks operating and RAM and registers retained	1.4		3.6	V
V_{BATSW}	Battery Switchover Voltage Range(5)	VBAT	Static	VCC Power -> VBAT Power		1.6		3.6	V
V_{BATRST}	Falling Battery POR Voltage(7)	VBAT	Falling	VBAT Power -> POR	$V_{CC} < V_{CCSWF}$		1.1	1.4	V
V_{BMRG}	V_{BAT} Margin above V_{CC}(3)	VBAT	Static	V_{BAT} Power		200			mV
V_{BATESR}	V_{BAT} supply series resistance(6)	VBAT	Static	V_{BAT} Power		1.0	1.5		kΩ

(1) V_{CC} must be above V_{CCST} to exit the POR state, independent of the V_{BAT} voltage.
(2) Difference between V_{CCSWR} and V_{CCSWF}.
(3) V_{BAT} must be higher than V_{CC} by at least this voltage to ensure the AM18X5 remains in the VBAT Power state.
(4) Maximum VCC falling slew rate to guarantee correct switchover to VBAT Power state. There is no V_{CC} falling slew rate requirement if switching to the VBAT power source is not required.
(5) V_{BAT} voltage to guarantee correct transition to VBAT Power state when V_{CC} falls.
(6) Total series resistance of the power source attached to the VBAT pin. The optimal value is 1.5kΩ, which may require an external resistor. VBAT power source ESR + external resistor value = 1.5kΩ.
(7) V_{BATRST} is also the static voltage required on V_{BAT} for register data retention.

4.3 Operating Parameters

Table 6 lists the operating parameters.

For Table 6, T_A = -40 °C to 85 °C, TYP values at 25 °C.

Table 6: Operating Parameters

SYMBOL	PARAMETER	TEST CONDITIONS	V_{CC}	MIN	TYP	MAX	UNIT
V_{T+}	Positive-going Input Threshold Voltage		3.0V		1.5	2.0	V
			1.8V		1.1	1.25	
V_{T-}	Negative-going Input Threshold Voltage		3.0V	0.8	0.9		V
			1.8V	0.5	0.6		
I_{ILEAK}	Input leakage current		3.0V		0.02	80	nA
C_I	Input capacitance				3		pF
V_{OH}	High level output voltage on push-pull outputs		1.7V – 3.6V	$0.8 \cdot V_{CC}$			V
V_{OL}	Low level output voltage		1.7V – 3.6V			$0.2 \cdot V_{CC}$	V
I_{OH}	High level output current on push-pull outputs	$V_{OH} = 0.8 \bullet V_{CC}$	1.7V	-2	-3.8		mA
			1.8V	-3	-4.3		
			3.0V	-7	-11		
			3.6V	-8.8	-15		
I_{OL}	Low level output current	$V_{OL} = 0.2 \bullet V_{CC}$	1.7V	3.3	5.9		mA
			1.8V	6.1	6.9		
			3.0V	17	19		
			3.6V	18	20		
R_{DSON}	PSW output resistance to VSS	PSW Enabled	1.7V		1.7	5.8	Ω
			1.8V		1.6	5.4	
			3.0V		1.1	3.8	
			3.6V		1.05	3.7	
I_{OLEAK}	Output leakage current		1.7V – 3.6V		0.02	80	nA

4.4 Oscillator Parameters

Table 7 lists the oscillator parameters.

For Table 7, T_A = -40 °C to 85 °C unless otherwise indicated.
V_{CC} = 1.7 to 3.6V, TYP values at 25 °C and 3.0V.

Table 7: Oscillator Parameters

SYMBOL	PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
F_{XT}	XI and XO pin Crystal Frequency			32.768		kHz
F_{OF}	XT Oscillator failure detection frequency			8		kHz
C_{INX}	Internal XI and XO pin capacitance			1		pF
C_{EX}	External XI and XO pin PCB capacitance			1		pF
OA_{XT}	XT Oscillation Allowance	At 25°C using a 32.768 kHz crystal	270	320		kΩ
F_{RCC}	Calibrated RC Oscillator Frequency(1)	Factory Calibrated at 25°C, VCC = 2.8V		128		Hz
F_{RCU}	Uncalibrated RC Oscillator Frequency	Calibration Disabled (OFFSETR = 0)	89	122	220	Hz
J_{RCCC}	RC Oscillator cycle-to-cycle jitter	Calibration Disabled (OFFSETR = 0) – 128 Hz		2000		ppm
		Calibration Disabled (OFFSETR = 0) – 1 Hz		500		
A_{XT}	XT mode digital calibration accuracy(1)	Calibrated at an initial temperature and voltage	-2		2	ppm
A_{AC}	Autocalibration mode timing accuracy, 512 second period, T_A = -10°C to 60°C(1)	24 hour run time		35		ppm
		1 week run time		20		
		1 month run time		10		
		1 year run time		3		
T_{AC}	Autocalibration mode operating temperature(2)		-10		60	°C

(1) Timing accuracy is specified at 25°C after digital calibration of the internal RC oscillator and 32.768 kHz crystal. A typical 32.768 kHz tuning fork crystal has a negative temperature coefficient with a parabolic frequency deviation, which due to the crystal alone can result in a change of up to 150 ppm across the entire operating temperature range of -40°C to 85°C in XT mode. Autocalibration mode timing accuracy is specified relative to XT mode timing accuracy from -10°C to 60°C.

(2) Outside of this temperature range, the RC oscillator frequency change due to temperature may be outside of the allowable RC digital calibration range (+/-12%) for autocalibration mode.If this happens, an autocalibration failure will occur and the ACF interrupt flag is set. The AM18X5 should be switched to use the XT oscillator as its clock source. Please see the Autocalibration Fail section for more details.

Figure 4 shows the typical calibrated RC oscillator frequency variation vs. temperature. RC oscillator calibrated at 2.8V, 25°C.

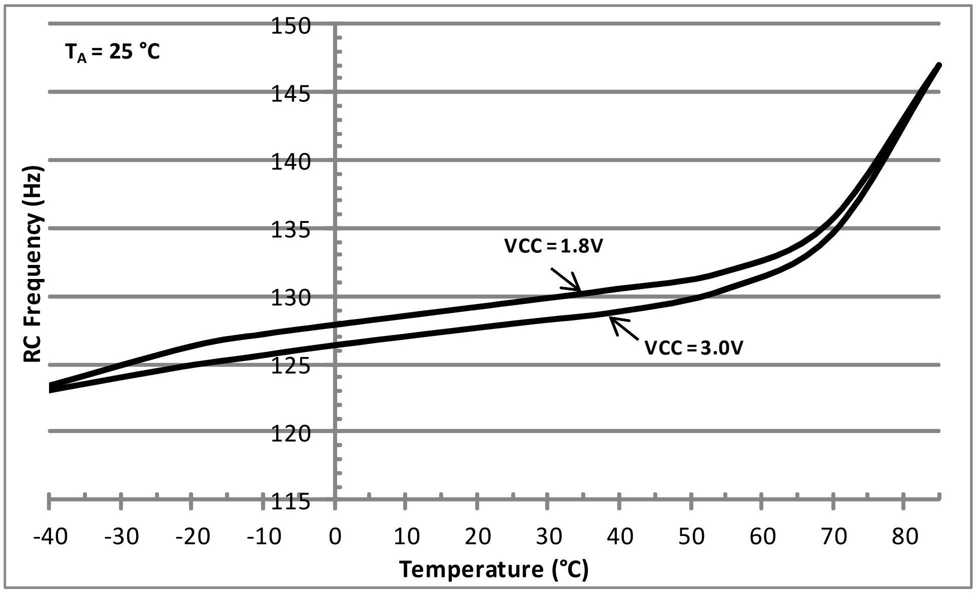


Figure 4. Calibrated RC Oscillator Typical Frequency Variation vs. Temperature

Figure 5 shows the typical uncalibrated RC oscillator frequency variation vs. temperature.

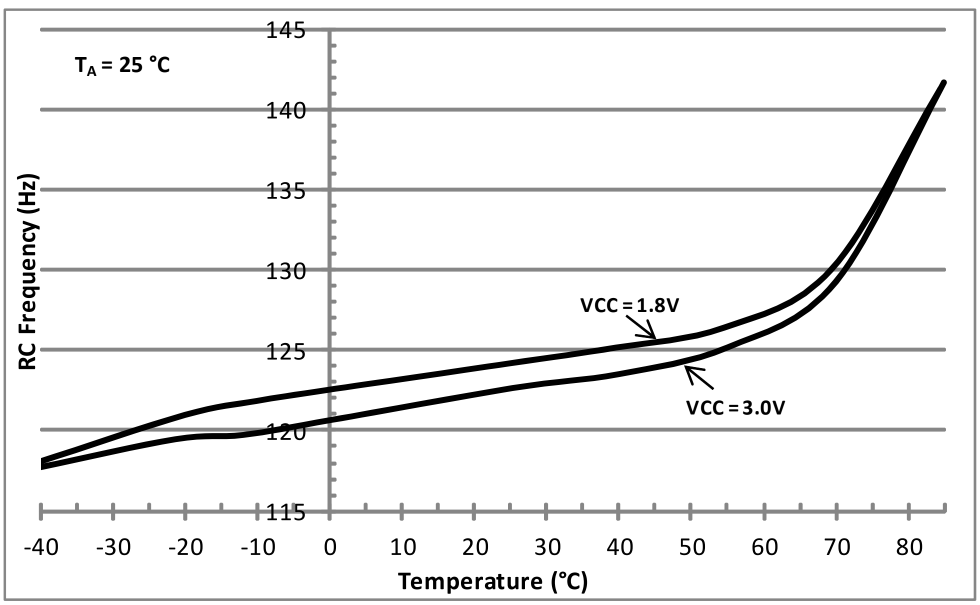


Figure 5. Uncalibrated RC Oscillator Typical Frequency Variation vs. Temperature

4.5 V_{CC} Supply Current

Table 8 lists the current supplied into the VCC power input under various conditions.

For Table 8, T_A = -40 °C to 85 °C, VBAT = 0 V to 3.6 V
TYP values at 25 °C, MAX values at 85 °C, VCC Power state

Table 8: V_{CC} Supply Current

SYMBOL	PARAMETER	TEST CONDITIONS	VCC	MIN	TYP	MAX	UNIT
$I_{VCC:I2C}$	V_{CC} supply current during I^2C burst read/write	400kHz bus speed, 2.2k pull-up resistors on SCL/SDA(1)	3.0V		6	10	µA
			1.8V		1.5	3	
$I_{VCC:SPIW}$	V_{CC} supply current during SPI burst write	2 MHz bus speed (2)	3.0V		8	12	µA
			1.8V		4	6	
$I_{VCC:SPIR}$	V_{CC} supply current during SPI burst read	2 MHz bus speed (2)	3.0V		23	37	µA
			1.8V		13	21	
$I_{VCC:XT}$	V_{CC} supply current in XT oscillator mode	Time keeping mode with XT oscillator running(3)	3.0V		55	330	nA
			1.8V		51	290	
$I_{VCC:RC}$	V_{CC} supply current in RC oscillator mode	Time keeping mode with only the RC oscillator running (XT oscillator is off)(3)	3.0V		14	220	nA
			1.8V		11	170	
$I_{VCC:ACAL}$	Average V_{CC} supply current in Autocalibrated RC oscillator mode	Time keeping mode with only RC oscillator running and Autocalibration enabled. ACP = 512 seconds(3)	3.0V		22	235	nA
			1.8V		18	190	
$I_{VCC:CK32}$	Additional V_{CC} supply current with CLKOUT at 32.786 kHz	Time keeping mode with XT oscillator running, 32.786 kHz square wave on CLKOUT(4)	3.0V		3.6	8	µA
			1.8V		2.2	5	
$I_{VCC:CK128}$	Additional V_{CC} supply current with CLKOUT at 128 Hz	All time keeping modes, 128 Hz square wave on CLKOUT(4)	3.0V		7	35	nA
			1.8V		2.5	20	

(1) Excluding external peripherals and pull-up resistor current. All other inputs (besides SDA and SCL) are at 0V or V_{CC}. AM1805 only. Test conditions: Continuous burst read/write, 0x55 data pattern, 25 µs between each data byte, 20 pF load on each bus pin.

(2) Excluding external peripheral current. All other inputs (besides SDI, nCE and SCL) are at 0V or V_{CC}. AM1815 only. Test conditions: Continuous burst write, 0x55 data pattern, 25 µs between each data byte, 20 pF load on each bus pin.

(3) All inputs and outputs are at 0 V or V_{CC}All inputs and outputs except CLKOUT are at 0 V or V_{CC}. 15 pF capacitive load on CLKOUT.

Figure 6 shows the typical VCC power state operating current vs. temperature in XT mode.

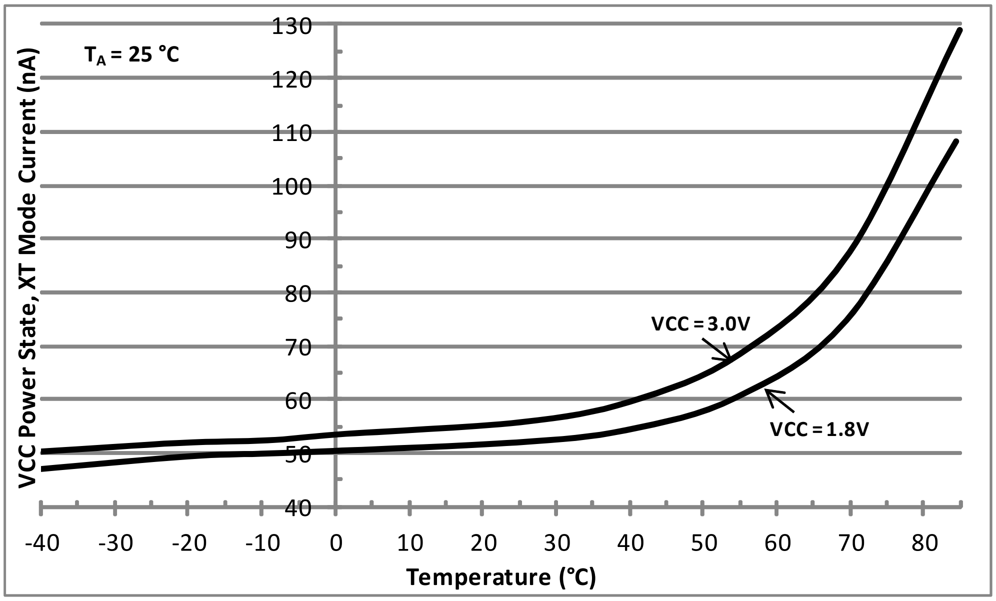


Figure 6. Typical VCC Current vs. Temperature in XT Mode

Figure 7 shows the typical VCC power state operating current vs. temperature in RC mode.

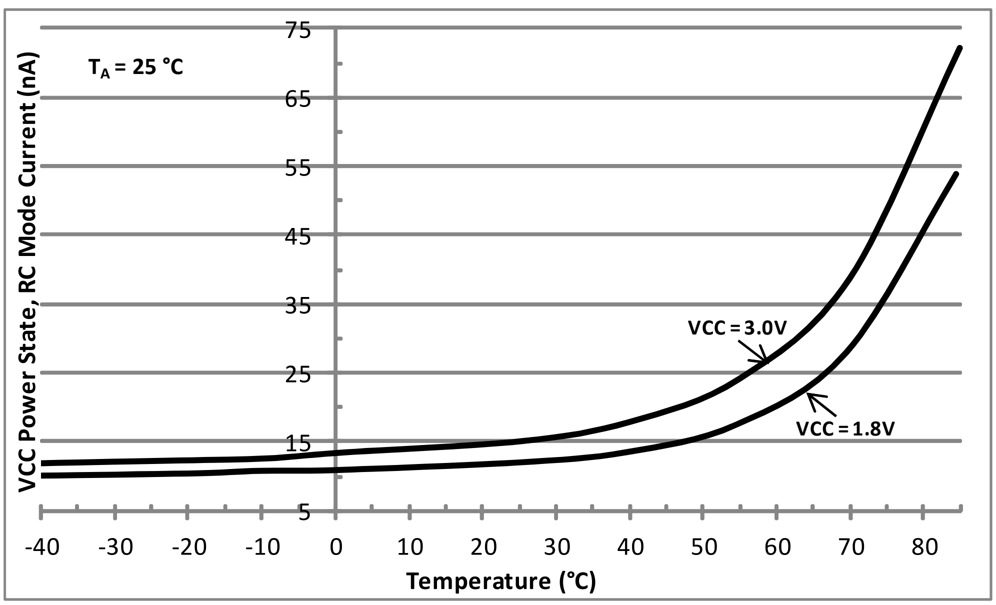


Figure 7. Typical VCC Current vs. Temperature in RC Mode

Figure 8 shows the typical VCC power state operating current vs. temperature in RC Autocalibration mode.

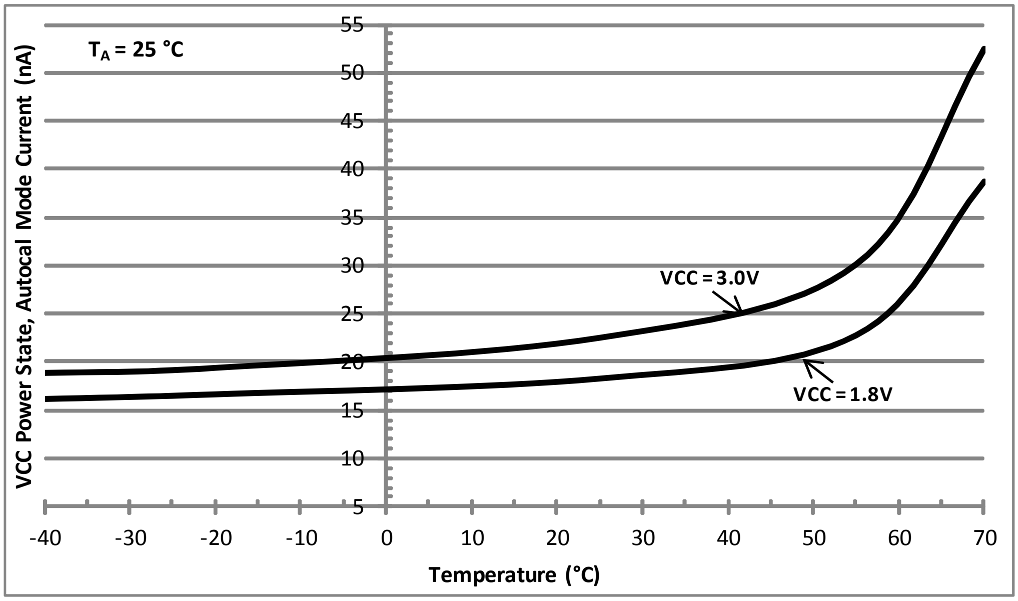


Figure 8. Typical VCC Current vs. Temperature in RC Autocalibration Mode

Figure 9 shows the typical VCC power state operating current vs. voltage for XT Oscillator and RC Oscillator modes and the average current in RC Autocalibrated mode.

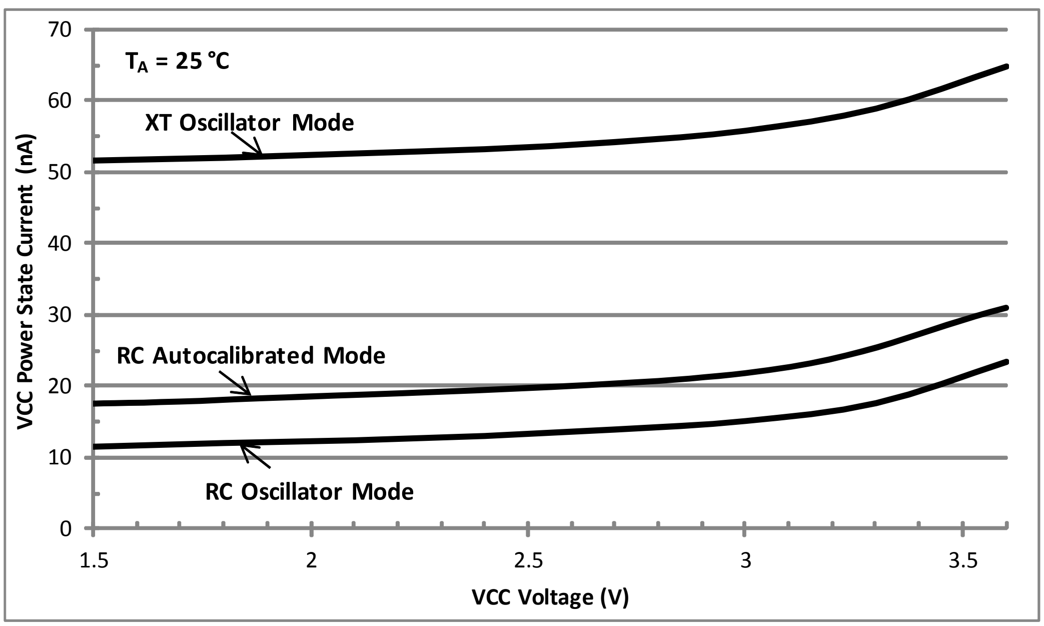


Figure 9. Typical VCC Current vs. Voltage, Different Modes of Operation

Figure 10 shows the typical VCC power state operating current during continuous I^2C and SPI burst read and write activity. Test conditions: T_A = 25 °C, 0x55 data pattern, 25 µs between each data byte, 20 pF load on each bus pin, pull-up resistor current not included.

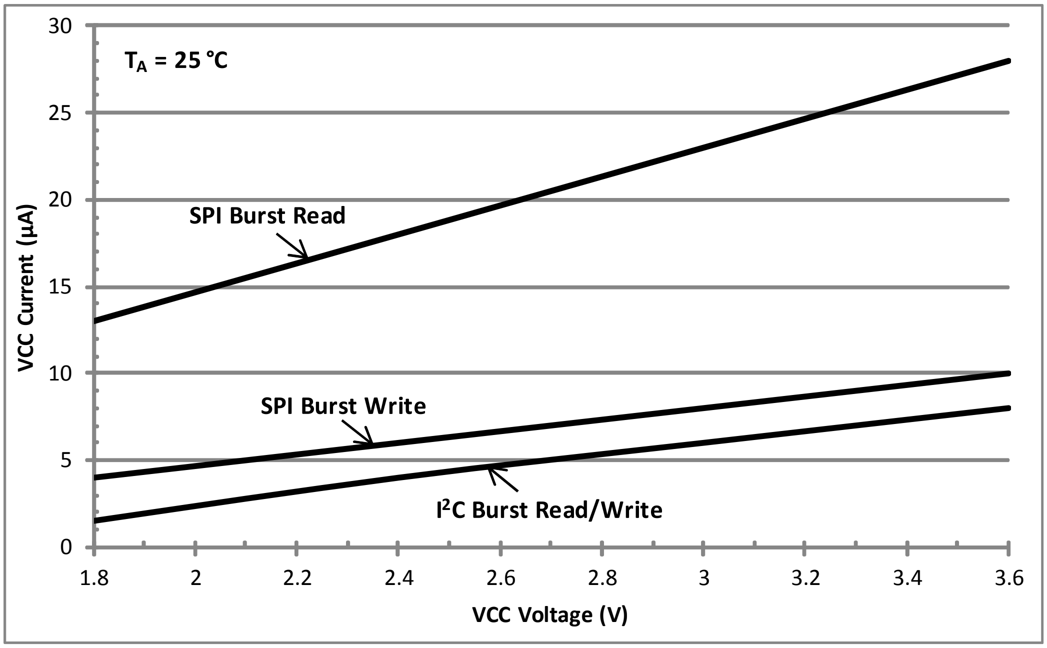


Figure 10. Typical VCC Current vs. Voltage, I^2C and SPI Burst Read/Write

Figure 11 shows the typical VCC power state operating current with a 32.768 kHz clock output on the CLKOUT pin. Test conditions: T_A = 25 °C, All inputs and outputs except CLKOUT are at 0 V or VCC. 15 pF capacitive load on the CLKOUT pin.

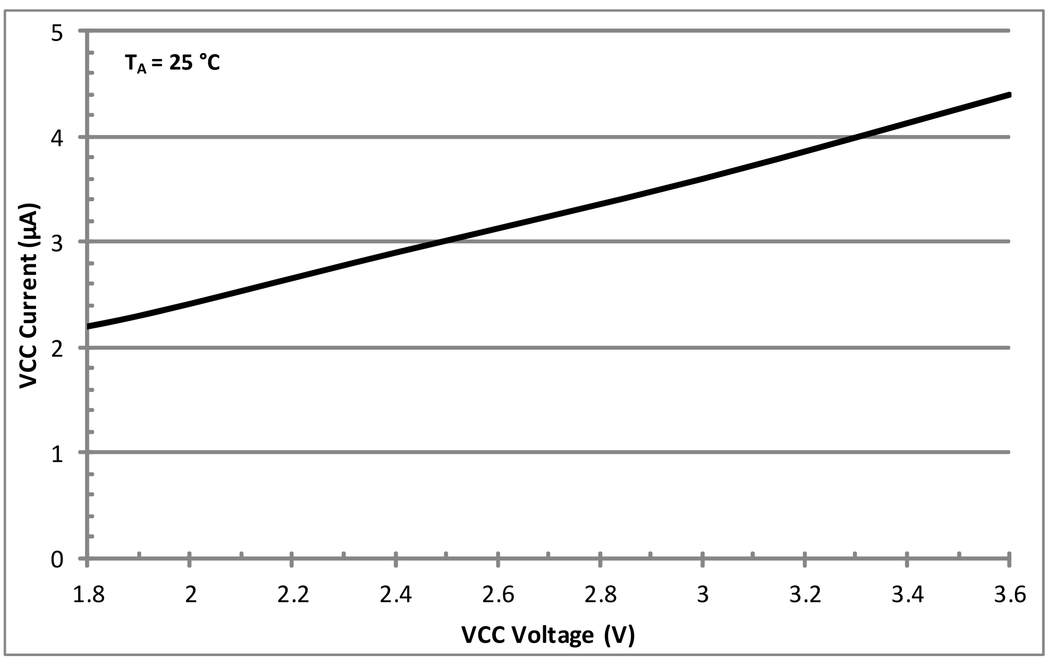


Figure 11. Typical VCC Current vs. Voltage, 32.768 kHz Clock Output

4.6 VBAT Supply Current

Table 9 lists the current supplied into the VBAT power input under various conditions.

For Table 9, T_A = -40 °C to 85 °C, TYP values at 25 °C, MAX values at 85 °C, V_{BAT} Power state.

Table 9: V_{BAT} Supply Current

SYMBOL	PARAMETER	TEST CONDITIONS	V_{CC}	V_{BAT}	MIN	TYP	MAX	UNIT
$I_{VBAT:XT}$	VBAT supply current in XT oscillator mode	Time keeping mode with XT oscillator running(1)	< V_{CCSWF}	3.0V		56	330	nA
				1.8V		52	290	
$I_{VBAT:RC}$	VBAT supply current in RC oscillator mode	Time keeping mode with only the RC oscillator running (XT oscillator is off)(1)	< V_{CCSWF}	3.0V		16	220	nA
				1.8V		12	170	
$I_{VBAT:ACAL}$	Average VBAT supply current in Autocalibrated RC oscillator mode	Time keeping mode with the RC oscillator running. Autocalibration enabled. ACP = 512 seconds(1)	< V_{CCSWF}	3.0V		24	235	nA
				1.8V		20	190	
$I_{VBAT:VCC}$	VBAT supply current in VCC powered mode	V_{CC} powered mode(1)	1.7 - 3.6 V	3.0V	-5	0.6	20	nA
				1.8V	-10	0.5	16	

(1) Test conditions: All inputs and outputs are at 0 V or V_{CC}.

Figure 12 shows the typical VBAT power state operating current vs. temperature in XT mode.

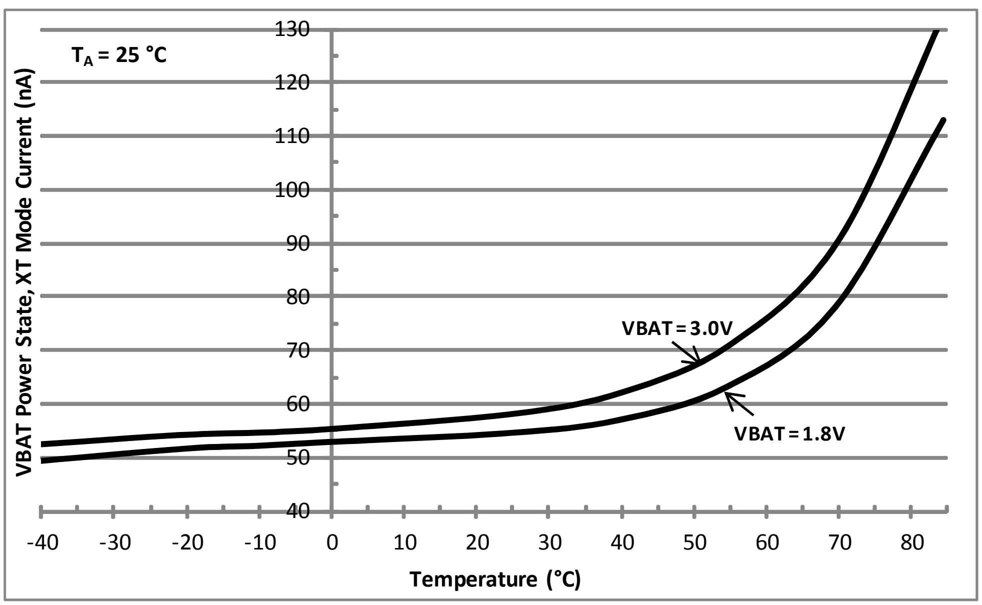


Figure 12. Typical VBAT Current vs. Temperature in XT Mode

Figure 13 shows the typical VBAT power state operating current vs. temperature in RC mode.

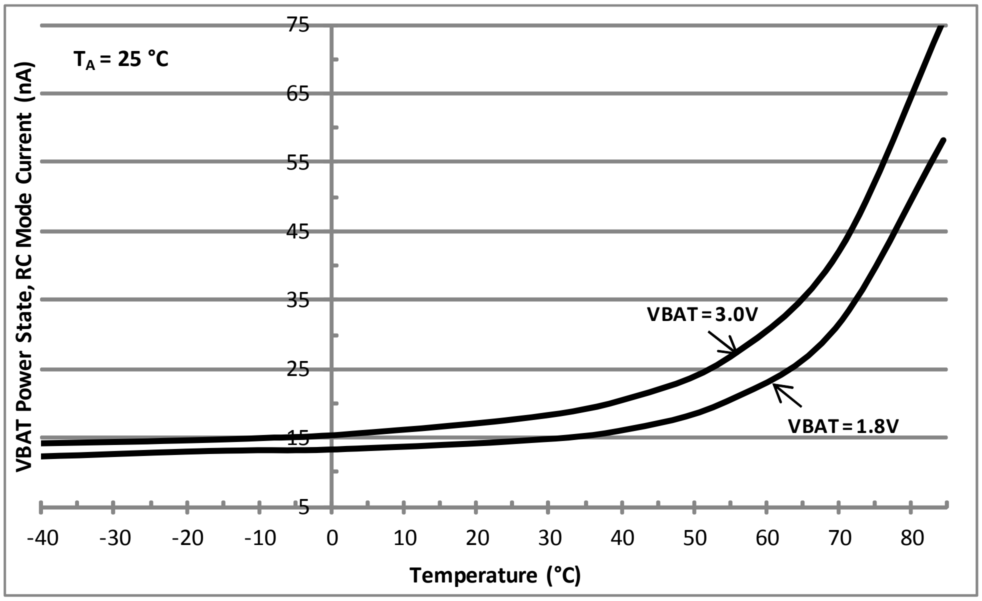


Figure 13. Typical VBAT Current vs. Temperature in RC Mode

Figure 14 shows the typical VBAT power state operating current vs. temperature in RC Autocalibration mode.

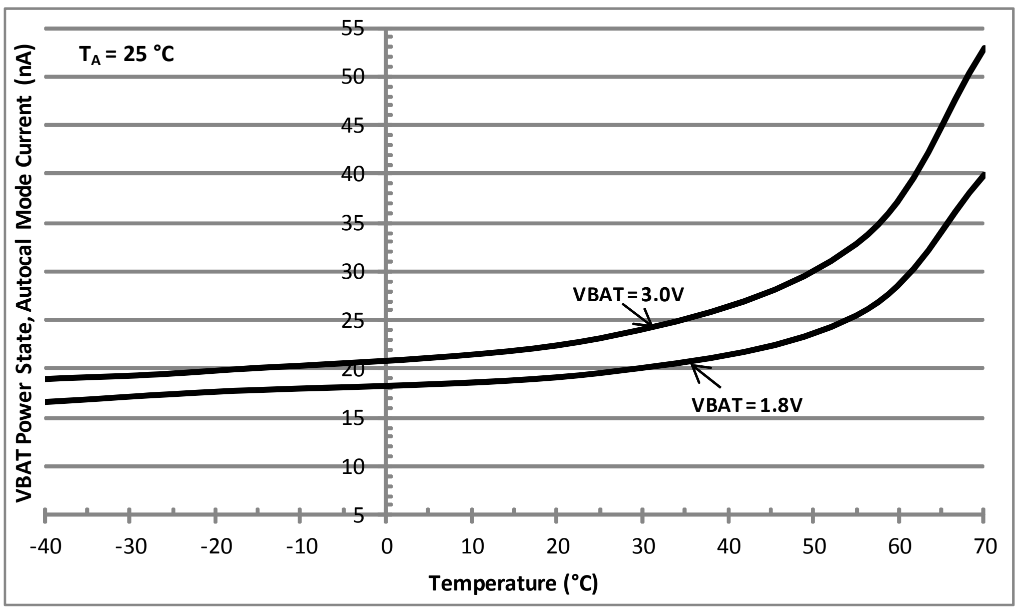


Figure 14. Typical VBAT Current vs. Temperature in RC Autocalibration Mode

Figure 15 shows the typical VBAT power state operating current vs. voltage for XT Oscillator and RC Oscillator modes and the average current in RC Autocalibrated mode, VCC = 0 V.

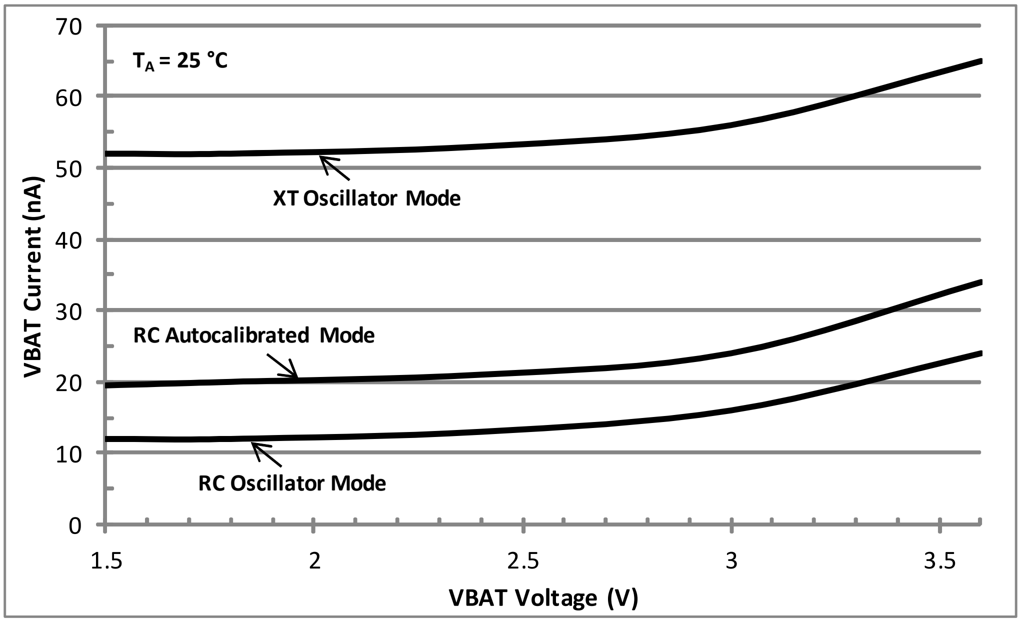


Figure 15. Typical VBAT Current vs. Voltage, Different Modes of Operation

Figure 16 shows the typical VBAT current when operating in the VCC power state, VCC = 1.7 V.

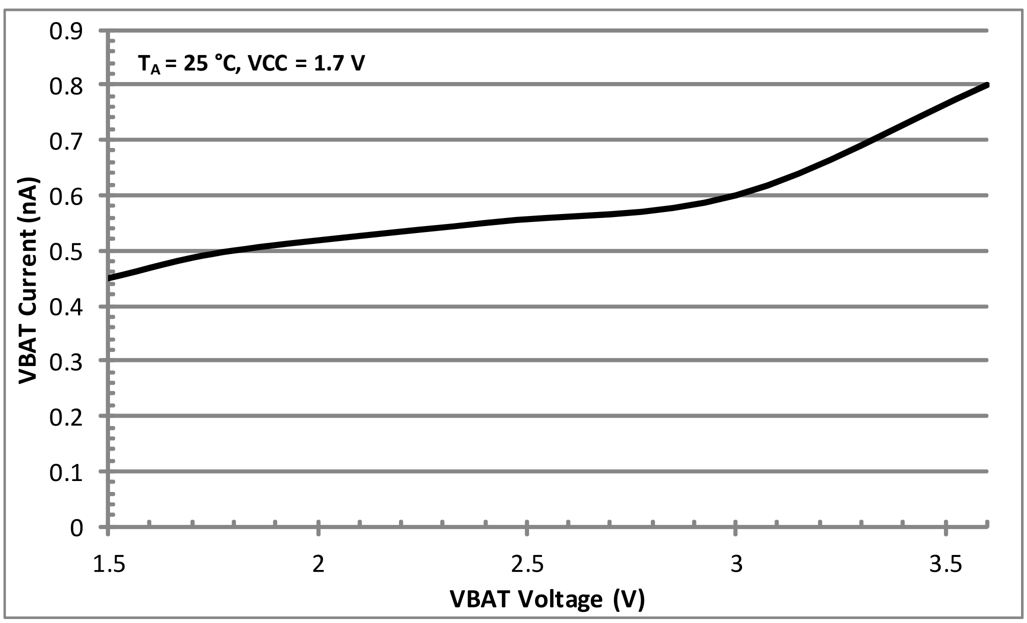


Figure 16. Typical VBAT Current vs. Voltage in VCC Power State