

## Features

- LDO1: 2.75V (Default) and 1.8V (Programmable by TWI), 70 mA Linear Very Low Drop Out Regulator with High PSRR and Low Noise.
- LDO2: 1.8V (Default) and 1.5V (Programmable by TWI), 70 mA Linear Low Drop Out Regulator with High PSRR and Low Noise.
- LDO3: 1.8V (Default) and 1.5V or 1.2V (Programmable by TWI), 70 mA Linear Low Drop Out Regulator with high PSRR and Low noise.
- LDO4: 1.8V, 2mA Linear Low Drop Out Regulator with Very Low Quiescent Current, +/- 100 mV Adjustable.
- Main Supply Rail from 2.8V to 5.5V
- Independent Auxiliary Supply for LDO4 Backup Section, 2.8V to 5.5V
- Internal State Machine for Startup and Delayed Reset Generation
- Additional External Reset Input
- Two Wire Interface for Independent Power Up/Power Down and Output Voltage Programming for Each LDO.
- LDOs Voltage Customization Possible on Request
- Available in 3 x 3 x 0.9 mm 16-pin QFN Package
- Applications: GPS Modules, WLAN Devices, Wireless Modules.

## 1. Description

The AT73C237 is a four-channel Power Supply Power Management Unit (PMU) available in a small outline QFN 3 x 3mm package. It is a fully integrated, attractively priced, combined Power Management device for wireless modules, GPS and WLAN devices. It integrates 4X Linear Low Drop Out Regulators, three of which (LDO1, 2, 3) provide high-accuracy RF performance and 1X (LDO4) with very low quiescent current, that can be supplied by an external backup battery (VDD4) on a separate rail. An internal Low Power Bandgap (LPBG) requiring no external capacitor for decoupling, is used as reference voltage for LDO4 and starts when VDD4 is present. LDO4 regulates its output voltage with extremely low quiescent current, maximizing the lifetime of the backup battery.

An Internal State Machine manages the startup of the other LDOs. An economic High Precision Bandgap (HPBG) provides highly accurate, low noise voltage reference to LDOs 1, 2, 3 while operating in switching mode to optimize the quiescent current.

The AT73C237 features a Two-wire Interface (TWI) to increase the efficiency of the system by disabling individually each LDO when not needed.

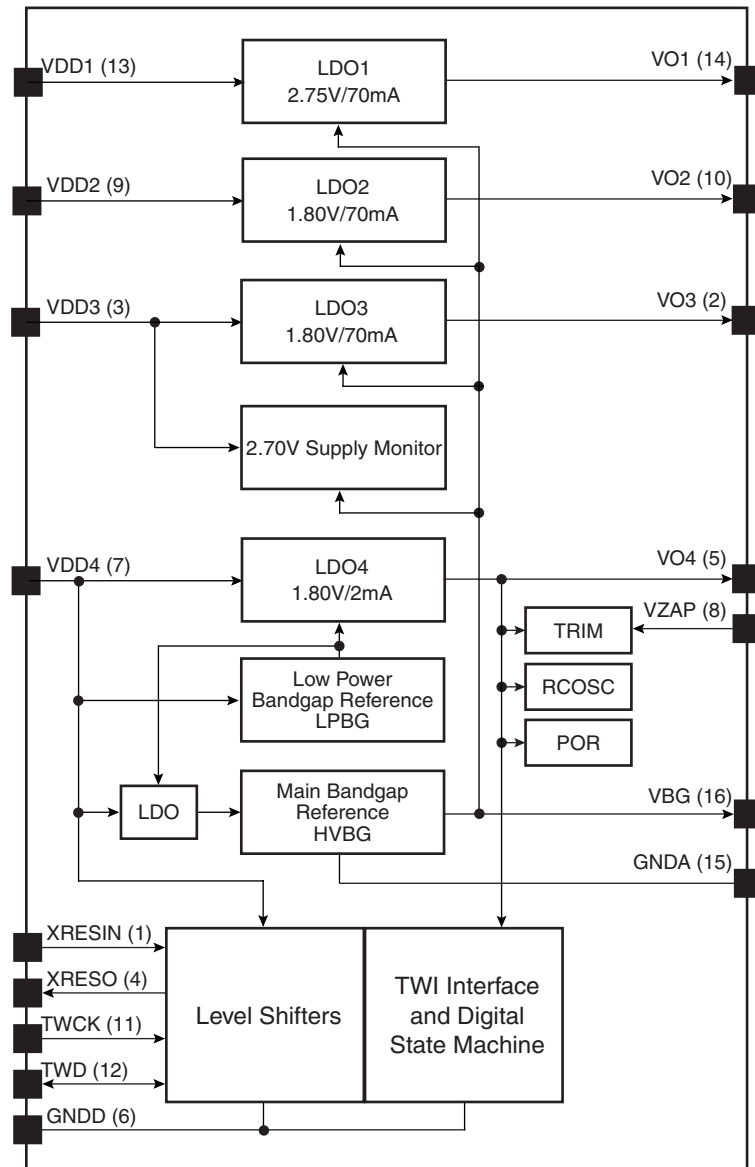


## Power Management and Analog Companions (PMAAC)

## AT73C237 4-channel Power Management for Wireless Modules

## 2. Block Diagram

Figure 2-1. AT73C237 Functional Block Diagram



### 3. Pin Description

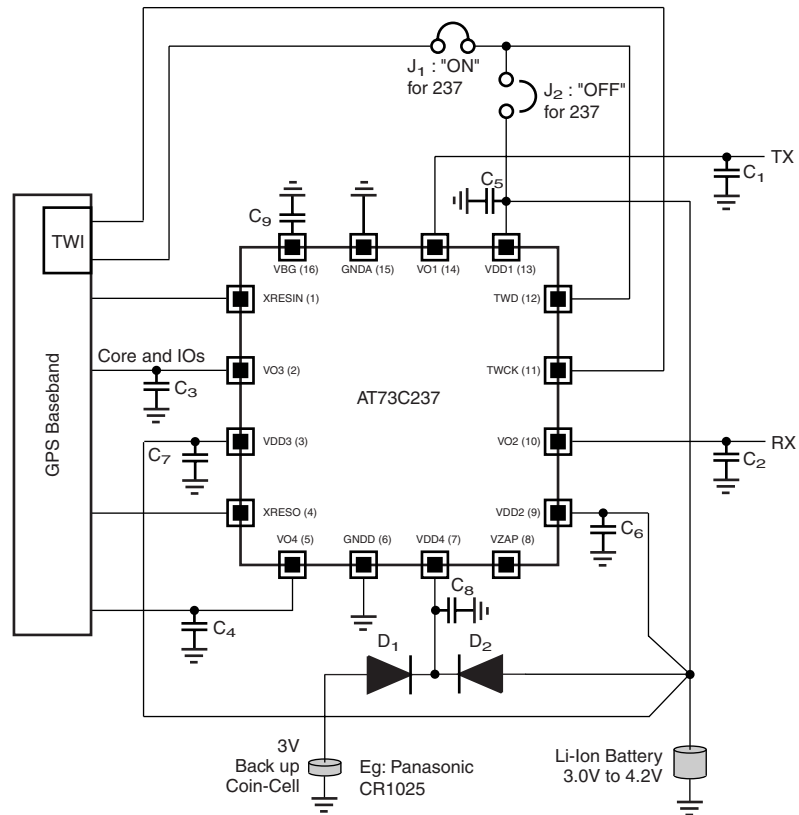
**Table 3-1.** Pin Description

Pin Name	I/O	Pin Number	Type	Function
XRESIN	Input	1	Digital	Reset in pin
VO3	Output	2	Analog	LDO3 output voltage
VDD3	Input	3	Power	LDO3 input voltage
XRESO	Output	4	Digital	Reset out pin
VO4	Output	5	Analog	LDO4 output voltage
GNDD	GND	6	Power	Digital ground
VDD4	Input	7	Power	LDO4 input voltage
VZAP <sup>(1)</sup>	Input	8	Digital	Reserved for manufacturing purposes.
VDD2	Input	9	Power	LDO2 input voltage
VO2	Output	10	Analog	LDO2 output voltage
TWCK <sup>(2)</sup>	Input	11	Digital	TWI input clock or LDO1,2,3 enable at logic "1", disable at "0"
TWD <sup>(3)</sup>	Input	12	Digital	TWI input/output or tied to Vdd
VDD1 <sup>(4)</sup>	Input	13	Power	LDO1 input voltage
VO1	Output	14	Analog	LDO1 output voltage
GNDA/AVSS	GND/Input	15	Analog	Analog ground and ESD ground
VBG	Output	16	Analog	Voltage reference for analog cells

- Note:
1. Connect to ground (via an internal pull-down)
  2. Connected to VDD1, 2 or 3 on AT73C237.
  3. Connected to VDD1, 2 or 3 on AT73C237.
  4. VDD1, 2, 3 should have the same input voltage.

## 4. Application Block Diagram

Figure 4-1. AT73C237 Application Block Diagram With GPS Module



Typical Application Components Design

Schematic Reference	Pin	Description
C1	VO1	2.2 $\mu\text{F} \pm 15\%$ Ceramic Capacitor, X5R, 0402, 6.3V MURATA®: GRM155R60J225ME15 TDK: C1005X5R0J225MT
C2	VO2	
C3	VO3	
C4	VO4	
C5	VDD1	1 $\mu\text{F} \pm 15\%$ Ceramic Capacitor, X5R, 0402, 6.3V MURATA: GRM155R60J105KE19 TDK: C1005X5R0J105KT
C6	VDD2	
C7	VDD3	
C8	VDD4	
C9	VBG	100 nF $\pm 15\%$ Ceramic Capacitor, X5R, 0402, 10V MURATA: GRM155R61A104KA01 TDK: C1005X5R1C104KT
D1, D2		ON-Semiconductor®: BAS70-04LT1

## 5. Electrical Characteristics

### 5.1 Absolute Maximum Ratings

**Table 5-1.** Absolute Maximum Ratings

Operating Temperature (Industrial).....	-40°C to + 85°C
Storage Temperature.....	-55°C to + 150°C
Power Supply Input on V <sub>DD</sub> .....	-0.3V to + 5.5V
Digital I/O Input Voltage.....	-0.3V to + 5.5V
All Other Pins.....	-0.3V to + 5.5V
ESD (all pins).....	2 KV

\*NOTICE: Stresses beyond those listed under “Absolute Maximum Ratings” may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or other conditions beyond those indicated in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

### 5.2 Recommended Operating Conditions

**Table 5-2.** Recommended Operating Conditions

Parameter	Condition	Min	Max	Units
Operating Temperature		-40	85	°C
Power Supply Input	V <sub>DD1</sub> , V <sub>DD2</sub> , V <sub>DD3</sub> , V <sub>DD4</sub>	2.8	5.5	V

### 5.3 Quiescent Current In Different Operating Modes

**Table 5-3.** Quiescent Current In Different Operating Modes

Modes	Conditions	Quiescent [ $\mu$ A]	
		Typ	Max
MODE0	VDD4 not present, chip disabled, all VDDs quiescent current	0	0.1
MODE1	VDD4 present, VDD3 not present (typical mode with back-up battery on VDD4) <ul style="list-style-type: none"> <li>• LDO4</li> <li>• LPBG</li> <li>• POR</li> <li>• HPBG in switching mode</li> </ul>	12	18
MODE2	VDD4 present, VDD3 present <ul style="list-style-type: none"> <li>• LDO4</li> <li>• LPBG</li> <li>• POR</li> <li>• Supply Monitor</li> <li>• Registers</li> <li>• Oscillator</li> <li>• State Machine</li> <li>• HPBG</li> <li>• LDO1</li> <li>• LDO2</li> <li>• LDO3</li> </ul>	800	1000

## 6. Startup Procedure

### 6.1 At VDD4 Rising

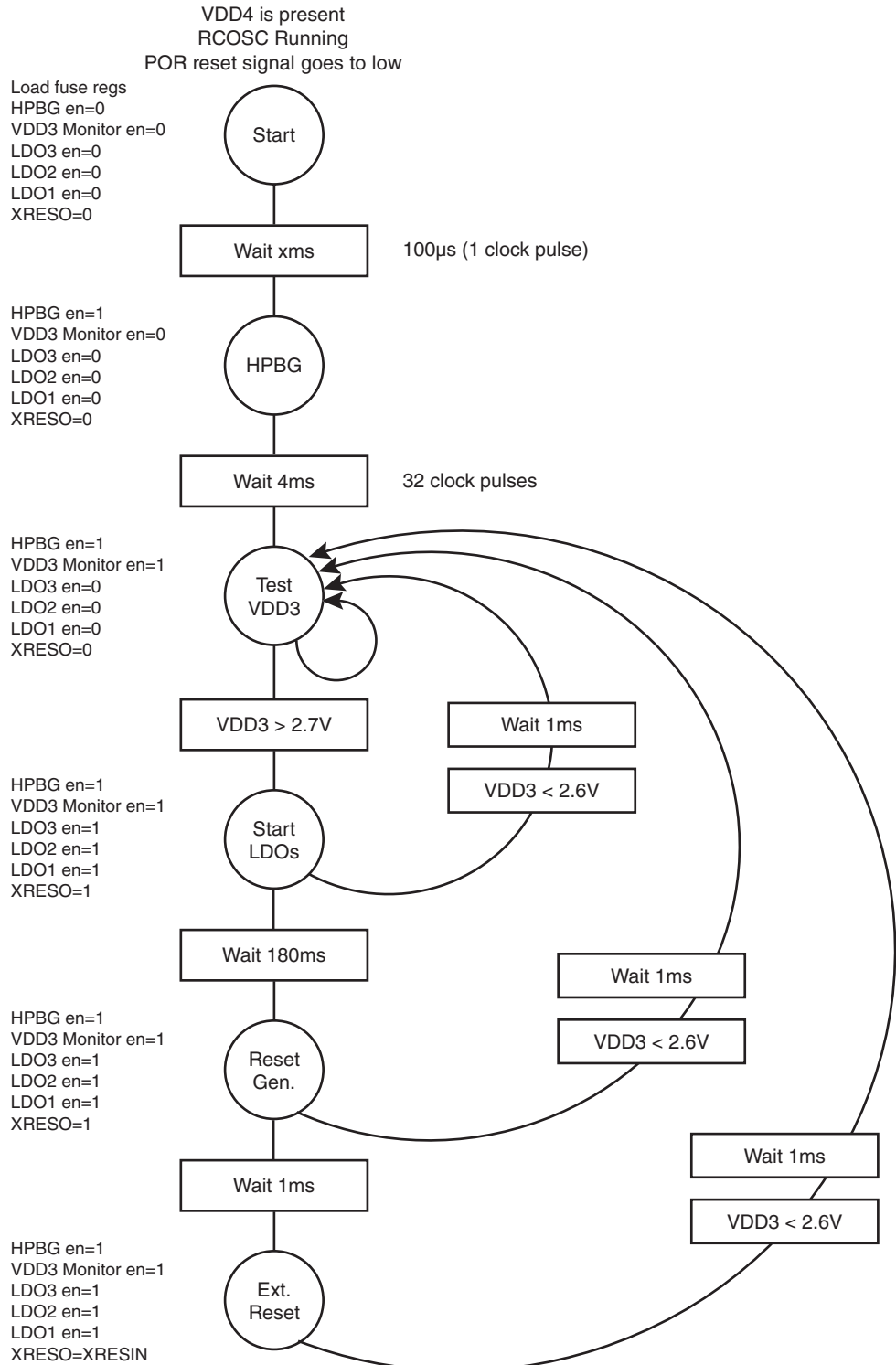
- LPBG, LDO4, RCOSC start up
- POR connected to LDO4 output VO4 resets the state machine and enables:
  - The reading of the internal fuses (TRIM cell in the application diagram) in order to set up the programmed output voltage of LDO1, LDO2, LDO3, and the correct reference voltage and oscillation frequency
  - The Two Wire Interface
  - Then under control of the state machine:
    - a. HPBG is turned on
    - b. After 4 ms, the Supply Monitor on VDD3 is turned on.
    - c. If VDD3 is present and greater than 2.7V, LDO1, 2, 3 are turned on. During LDO regulator startup VDD3 voltage is checked.
    - d. Then XRESO is kept grounded for 180 ms, and set to “1” for 1ms before following XRESIN. During that state VDD3 voltage is monitored and if lower than 2.6V, LDO regulators 1, 2 and 3 are stopped and XRESO grounded.

Both XRESIN and the Supply Monitor on VDD3 are debounced at rising and falling edges for two 10 kHz clock cycles. The debounce time is typically between 100  $\mu$ s and 200  $\mu$ s. Timings are defined  $\pm$  40%.

### 6.2 At VDD3 Falling

- The Supply monitor generates a shut down control signal when VDD3 reaches 2.6V
- The State machine sets XRESO to logic “0”.
- The State machine switches off LDO1, LDO2, LDO3. HPBG is kept enabled in order to assure a fast new startup of the LDOs.

**Figure 6-1. Startup Procedure**





## 7. Timing Diagram

Figure 7-1. AT73C237 Timings

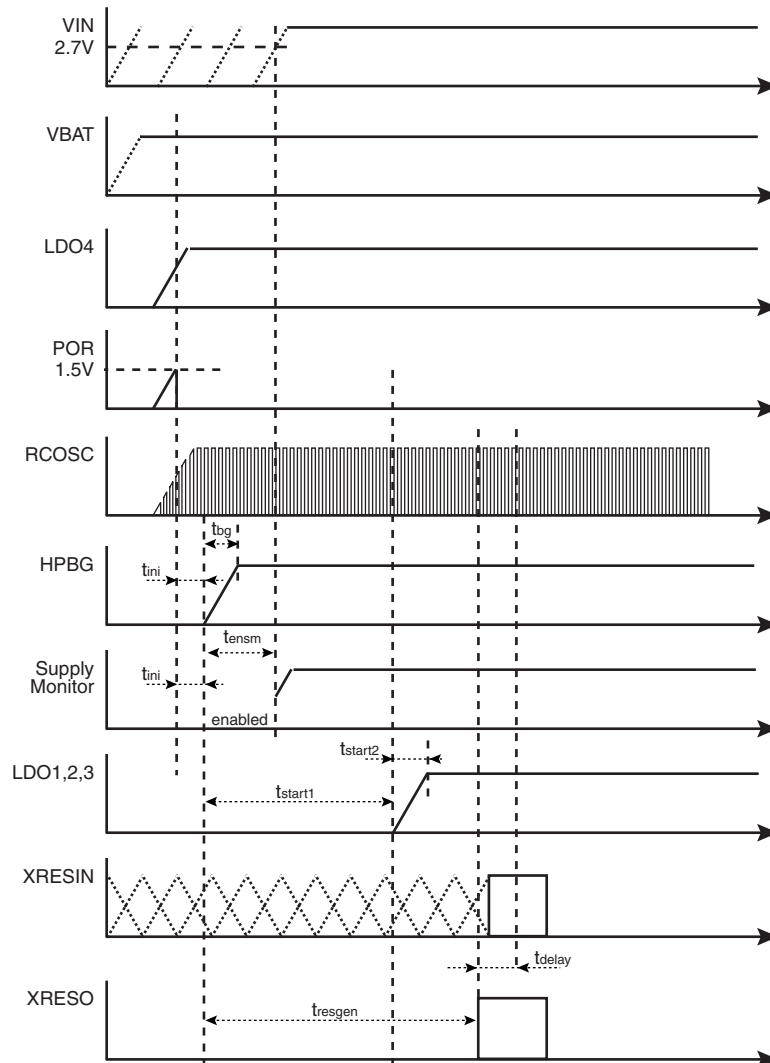


Table 7-1. Timing Parameters

Parameter	Signal	Constraint	Min	Max	Units
$t_{ini}$		Guard time		100	$\mu$ sec
$t_{bg}$	HPBG	HPBG startup time		2	msec
$t_{ensm}$	Supply monitor	Supply monitor enable		4	msec
$t_{start1}$	$V_{O1}, V_{O2}, V_{O3}$		3	5	$\mu$ sec
$t_{start2}$	$V_{O1}, V_{O2}, V_{O3}$	LDO1,2,3 Startup time	10	100	$\mu$ sec
$t_{resgen}$	XRESO		100	500	msec
$t_{delay}$				1	msec

## 8. Electrical Specification

### 8.1 LDO1

**Table 8-1.** LDO1 Parametric Table

Symbol	Parameter	Comments	Min	Typ	Max	Units
$V_{DD1}$	Operating supply voltage	Switching Regulated	2.8	3.3	5.5	V
$V_{O1}$	Output voltage	Default	2.70	2.75	2.8	V
		Programmed	1.75	1.80	1.85	
$I_1$	Load current	With at least 300mV drop out			100	mA
		With at least 200mV drop out			70	
$I_{QC}$	Quiescent current			250	300	$\mu$ A
$I_{SC}$	Shutdown current	HiZ output			1	$\mu$ A
$I_{SH}$	Short circuit current			350		mA
$t_R$	Startup time		1	10	100	$\mu$ sec
$\Delta V_{DC}$	Line regulation static	From $V_{DD}=3.0V$ to 3.6V			5	mV
$\Delta V_{DC}$	Load regulation static	From 10% to 100% $I_1$			30	mV
		From 0 to 100% $I_1$			40	
PSSR	Power Supply Rejection Ratio	Sine Wave, 100 kHz frequency, 3.3V mean +/- 100 m $V_{PP}$	65			dB
		Sine Wave, 10 kHz frequency, 3.3V mean +/- 100 m $V_{PP}$	60			dB
		Sine Wave, 1 kHz frequency, 3.3V mean +/- 100 m $V_{PP}$	45			dB
$\Delta V_{OUT}$	Startup Overshoot				100	mV
$V_{NT}$	Total Output Noise	10 Hz - 100 kHz		35	100	$\mu V_{RMS}$

**Table 8-2.** LDO1 External Components

Schematic Reference	Description
$C_1$ (Input Capacitor)	2.2 $\mu$ F $\pm$ 15% Ceramic Capacitor, X5R, 0402, 6.3V MURATA: GRM155R60J225ME15 TDK: C1005X5R0J225MT
$C_5$ (Output Capacitor)	1 $\mu$ F $\pm$ 15% Ceramic Capacitor, X5R, 0402, 6.3V MURATA: GRM155R60J105KE19 TDK: C1005X5R0J105KT

Figure 8-1. LDO Load Regulation

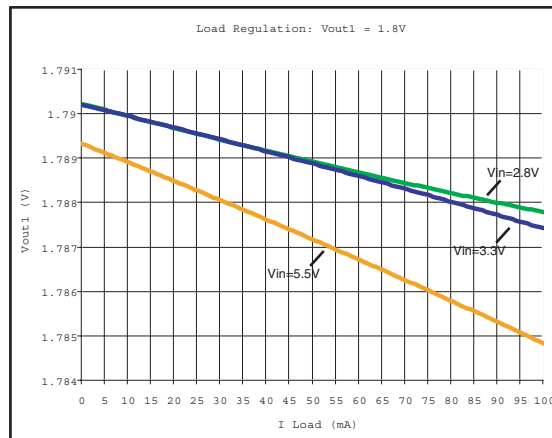
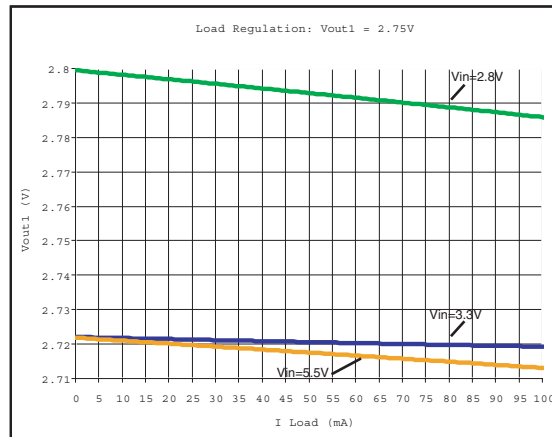
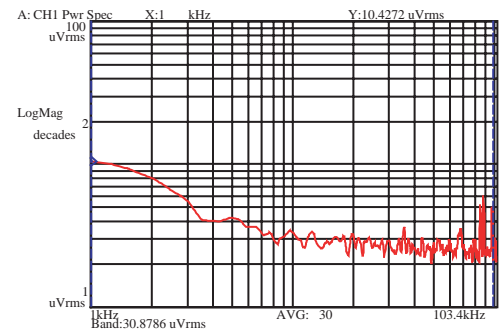
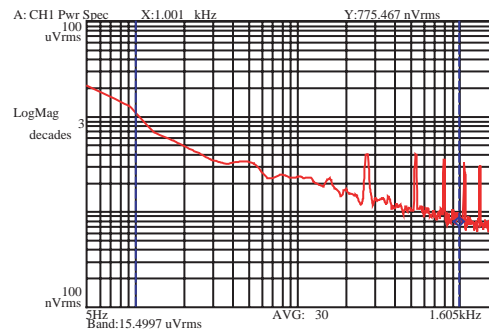


Figure 8-2. LDO1 Output Noise



## 8.2 LDO2

**Table 8-3.** LDO2 Parametric Table

Symbol	Parameter	Comments	Min	Typ	Max	Units
$V_{DD2}$	Operating supply voltage	Switching Regulated	2.8	3.3	5.5	V
$V_{O2}$	Output voltage	Default	1.75	1.80	1.85	V
		Programmed	1.45	1.50	1.55	
$I_2$	Load current	With at least 300mV drop out			100	mA
		With at least 200mV drop out			70	
$I_{OC}$	Quiescent current			250	300	$\mu$ A
$I_{SC}$	Shutdown current	HiZ output			1	$\mu$ A
$I_{SH}$	Short circuit current			350		mA
$t_R$	Startup time		1	10	100	$\mu$ sec
$\Delta V_{DC}$	Line regulation static	From VDD=3.0V to 3.6V			5	mV
$\Delta V_{DC}$	Load regulation static	From 10% to 100% $I_2$			30	mV
		From 0 to 100% $I_2$			40	
PSSR	Power Supply Rejection Ratio	Sine Wave, 100 kHz frequency, 3.3V mean +/- 100 m $V_{PP}$	70			dB
		Sine Wave, 10 kHz frequency, 3.3V mean +/- 100 m $V_{PP}$	65			dB
		Sine Wave, 1 kHz frequency, 3.3V mean +/- 100 m $V_{PP}$	45			dB
$\Delta V_{OUT}$	Startup Overshoot				100	mV
$V_{NT}$	Total Output Noise	10 Hz - 100 kHz		25	50	$\mu$ V <sub>RMS</sub>

**Table 8-4.** LDO2 External Components

Schematic Reference	Description
$C_2$ (Input Capacitor)	2.2 $\mu$ F $\pm$ 15% Ceramic Capacitor, X5R, 0402, 6.3V MURATA: GRM155R60J225ME15 TDK: C1005X5R0J225MT
$C_6$ (Output Capacitor)	1 $\mu$ F $\pm$ 15% Ceramic Capacitor, X5R, 0402, 6.3V MURATA: GRM155R60J105KE19 TDK: C1005X5R0J105KT

Figure 8-3. LDO2 Load Regulation

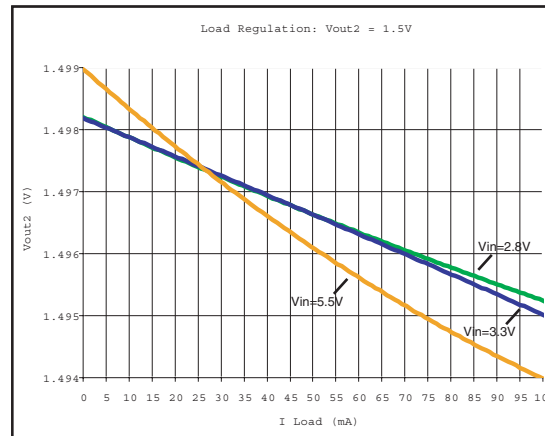
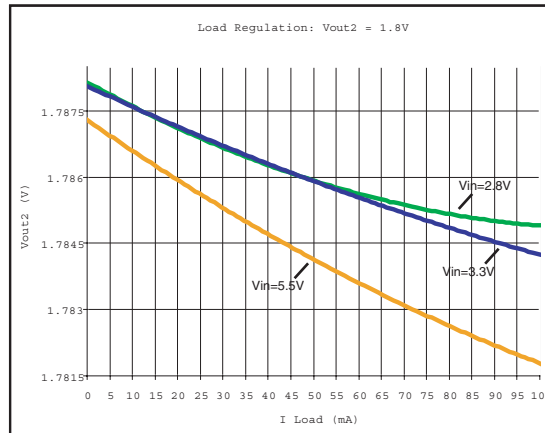
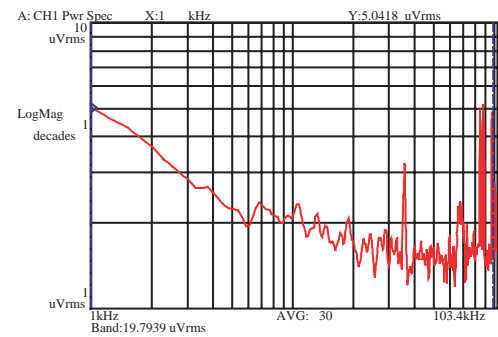
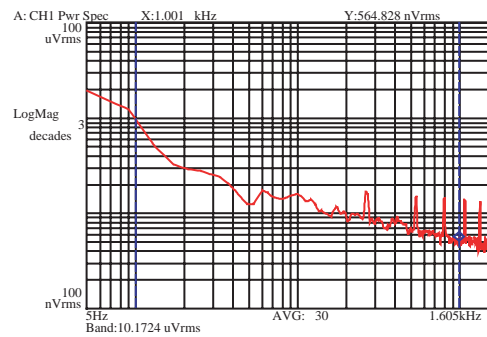


Figure 8-4. LDO2 Output Noise



### 8.3 LDO3

**Table 8-5.** LDO3 Parametric Table

Symbol	Parameter	Comments	Min	Typ	Max	Units
$V_{DD3}$	Operating supply voltage	Switching Regulated	2.8	3.3	5.5	V
$V_{O3}$	Output voltage	Default	1.75	1.80	1.85	V
		Programmed	1.45	1.50	1.55	
		Programmed	1.18	1.23	1.28	
$I_3$	Load current	With at least 300mV drop out			100	mA
		With at least 200mV drop out			70	
$I_{QC}$	Quiescent current			250	300	$\mu$ A
$I_{SC}$	Shutdown current	HiZ output			1	$\mu$ A
$I_{SH}$	Short circuit current			350		mA
$t_R$	Startup time		1	10	100	$\mu$ sec
$\Delta V_{DC}$	Line regulation static	From VDD=3.0V to 3.6V			5	mV
$\Delta V_{DC}$	Load regulation static	From 10% to 100% $I_3$			30	mV
		From 0 to 100% $I_3$			40	
PSSR	Power Supply Rejection Ratio	Sine Wave, 100 kHz frequency, 3.3V mean +/- 100 m $V_{PP}$	70			dB
		Sine Wave, 10 kHz frequency, 3.3V mean +/- 100 m $V_{PP}$	65			dB
		Sine Wave, 1 kHz frequency, 3.3V mean +/- 100 m $V_{PP}$	45			dB
$\Delta V_{OUT}$	Startup Overshoot				100	mV
$V_{NT}$	Total Output Noise	10 Hz - 100 kHz		20	50	$\mu$ V <sub>RMS</sub>

**Table 8-6.** LDO3 External Components

Schematic Reference	Description
$C_3$ (Input Capacitor)	2.2 $\mu$ F $\pm$ 15% Ceramic Capacitor, X5R, 0402, 6.3V MURATA: GRM155R60J225ME15 TDK: C1005X5R0J225MT
$C_7$ (Output Capacitor)	1 $\mu$ F $\pm$ 15% Ceramic Capacitor, X5R, 0402, 6.3V MURATA: GRM155R60J105KE19 TDK: C1005X5R0J105KT

Figure 8-5. LDO3 Load Regulation

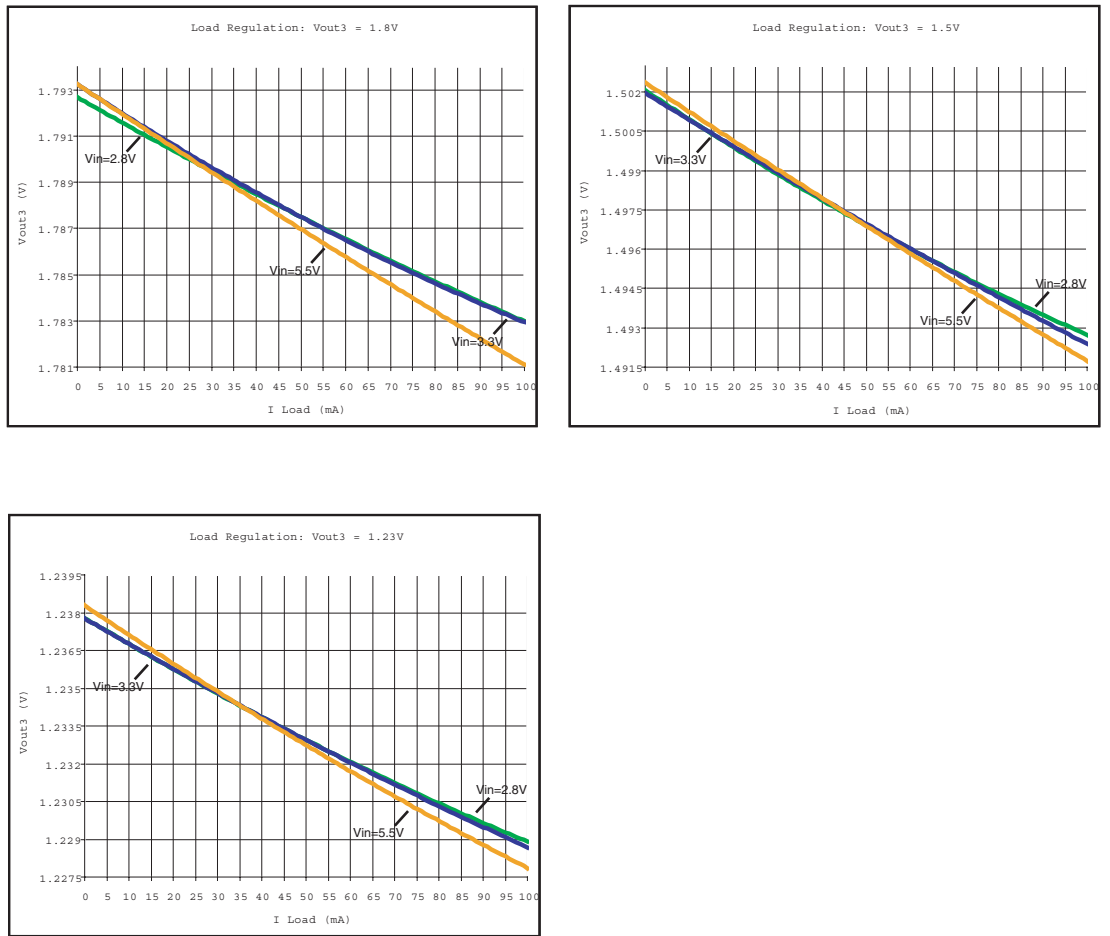
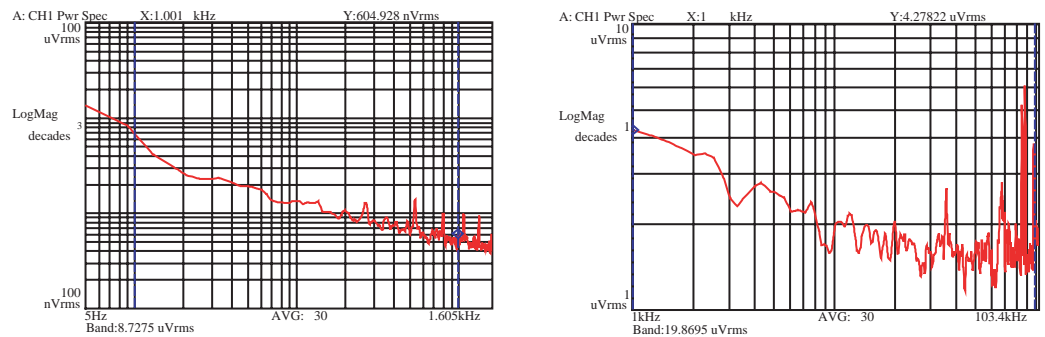


Figure 8-6. LDO3 Output Noise



## 8.4 LDO4

**Table 8-7.** LDO4 Parametric Table

Symbol	Parameter	Comments	Min	Typ	Max	Units
$V_{DD4}$	Operating supply voltage	Switching Regulated	2.8	3.3	5.5	V
$V_{O4}$	Output voltage	Default	1.7	1.8	1.9	V
$I_4$	Load current				2	mA
TVO4	Trimming range		-80	0	80	mV
$I_{QC}$	Quiescent current			1	3	$\mu$ A
$I_{SC}$	Shutdown current	HiZ output			0.5	$\mu$ A
$t_R$	Startup time		1	10	100	$\mu$ sec
$\Delta V_{DC}$	Line regulation static	$2.8V < V_{DD4} < 5.5V$			100	mV
$\Delta V_{DC}$	Load regulation static	$0 < I_4 < 1.8mA$			100	mV

**Table 8-8.** LDO4 External Components

Schematic Reference	Description
$C_4$ (Input Capacitor)	2.2 $\mu$ F $\pm$ 15% Ceramic Capacitor, X5R, 0402, 6.3V MURATA: GRM155R60J225ME15 TDK: C1005X5R0J225MT
$C_8$ (Output Capacitor)	1 $\mu$ F $\pm$ 15% Ceramic Capacitor, X5R, 0402, 6.3V MURATA: GRM155R60J105KE19 TDK: C1005X5R0J105KT



## 8.5 High Performance Bandgap (HPBG)

**Table 8-9.** HPBG Parametric Table

Symbol	Parameter	Conditions	Min	Typ	Max	Units
$V_I$	Operating supply voltage	Backup Battery or Supercap	2.4		3.6	V
$V_{BG}$	Output voltage	Factory trimmed		1.231		V
$I_{SC}$	Shutdown current	encore = en = 0, dcrun = 0 (1)		1	6	$\mu A$
$I_{QC}$	Quiescent current	Not pulsed			300	$\mu A$
		Pulsed			30	
$t_S$	Startup time	$C_9 = 100$ nF		1	2	ms
$V_N$	Output noise	BW 10 Hz to 100 kHz		7		$\mu V_{RMS}$

**Table 8-10.** External Components

Schematic Reference	Description
$C_9$ (Output Capacitor)	100 nF $\pm$ 15% Ceramic Capacitor, X5R, 0402, 10V MURATA P/N: GRM155R61A104KA01 TDK: C1005X5R1C104KT

## 8.6 Low Power Bandgap (LPBG)

**Table 8-11.** LPBG Parametric Table

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
$V_I$	Operating supply voltage	Backup Battery or Supercap	2.8		5.5	V
$I_{QC}$	Quiescent current	At $V_{BAT} 3. = V$		4	7.5	$\mu A$
$t_S$	Startup time			50	100	$\mu s$
$V_{LPBG}$	Bandgap Voltage		1.15	1.2	1.25	V

## 8.7 Voltage Monitor

**Table 8-12.** Voltage Monitor Parametric Table

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
$I_{QC}$	Quiescent current			5	20	$\mu A$
$V_{PON}$	SM on threshold		2.7		2.72	V
$V_{POFF}$	SM on threshold		2.6		2.62	V

## 8.8 XRESIN

**Table 8-13.** XRESIN Parametric Table

Symbol	Parameter	Conditions	Limits			Unit
			Min	Typ	Max	
V <sub>I</sub>	Input supply voltage range	Driven by CPU GPIO		V <sub>DD4</sub>		V
		Driven by CPU open drain output		Hiz		V
		Connected to V <sub>DD4</sub> when not used		V <sub>DD4</sub>		V
I <sub>IH</sub>	High input current				5	μA
I <sub>IL</sub>	Low input current				50	μA

## 8.9 XRESO

**Table 8-14.** XRESO Parametric Table

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V <sub>I</sub>	Input supply voltage range			V <sub>DD4</sub>		V
V <sub>OH</sub>	High output voltage				200	mV
V <sub>OL</sub>	Low output voltage				150	mV

## 8.10 TWCK

**Table 8-15.** TWCK Parametric Table

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V <sub>I</sub>	Input supply voltage range			V <sub>DD4</sub>		V
I <sub>IH</sub>	High input current				15	μA
I <sub>IL</sub>	Low input current				13	μA

## 8.11 TWD

**Table 8-16.** TWD Parametric Table

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V <sub>I</sub>	Input supply voltage range			V <sub>DD4</sub>		V
I <sub>IH</sub>	High input current			20		μA
I <sub>IL</sub>	Low input current			20		μA
V <sub>OH</sub>	High output voltage				200	mV
V <sub>OL</sub>	Low output voltage				150	mV

## 9. Functional Description

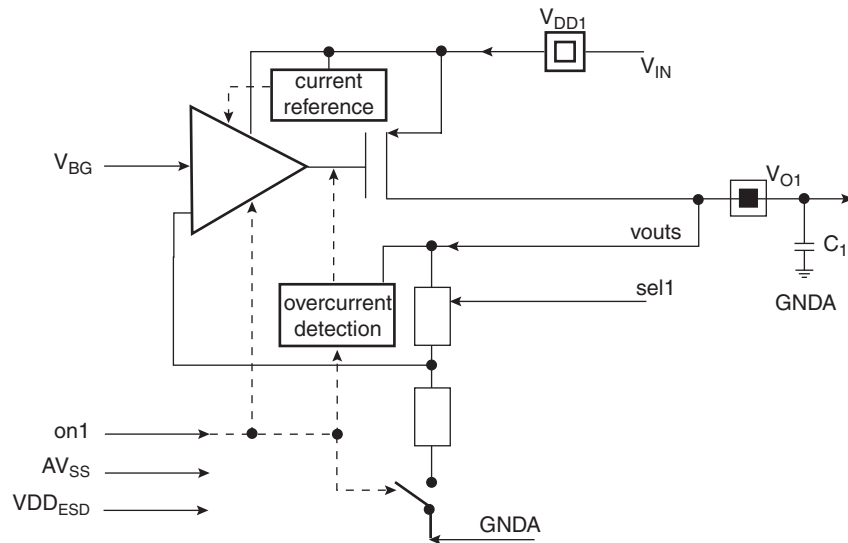
The AT73C237 is a fully integrated, attractively priced, combined Power Management. It integrates the following power supplies channels.

### 9.1 LDO1

LDO1 is a 2.75V/70mA LDO, compatible with RF performances. LDO1 can work with supply from 3.0V up to 5.5V and needs at least 300 mV of minimum drop-out. This LDO is designed to supply the RF section of wireless devices, showing high PSRR up to 100 kHz with very low noise on wide frequency bandwidth. LDO1 requires a 2.2  $\mu$ F output capacitor.

- Additionally, 1.80V output voltages programming is possible via the TWI serial interface.

**Figure 9-1.** LDO1 Functional Diagram

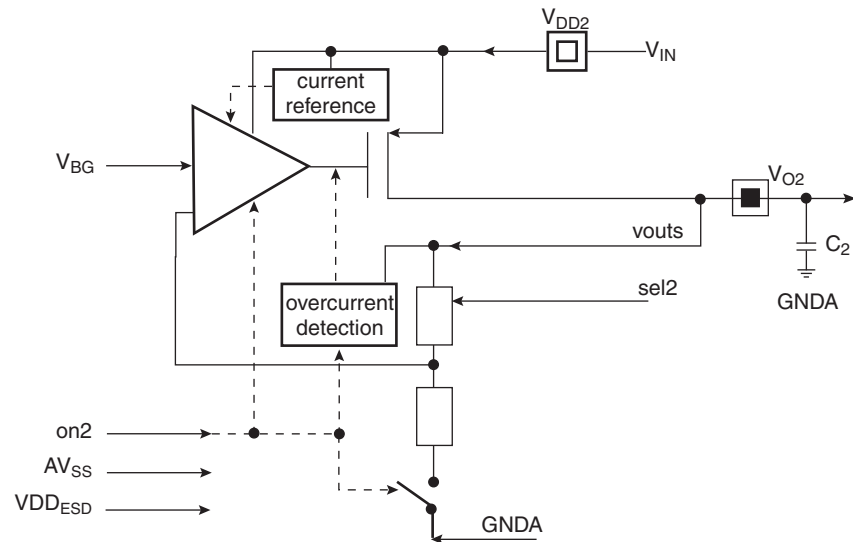


## 9.2 LDO2

LDO2 is a 1.80V/70mA LDO, compatible with RF performances. LDO2 can work with supply from 3.0V up to 5.5V and needs at least 300 mV of minimum drop-out. This LDO is designed to supply RF section of wireless devices, showing high PSRR up to 100kHz, very low noise on wide frequency bandwidth. LDO2 requires a 2.2  $\mu$ F output capacitor.

- Additionally, 1.50V output voltages programming is possible via the TWI serial interface.

**Figure 9-2.** LDO2 Functional Diagram

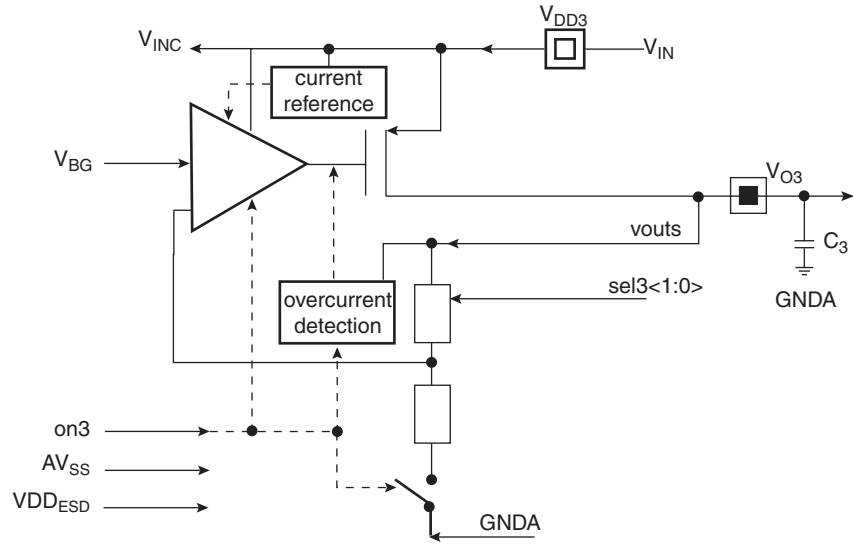


9.3 LDO3

LDO3 is a 1.80V/70mA LDO, compatible with RF performances (see electrical specifications for details). LDO3 can work with supply from 3.0V up to 5.5V and needs at least 300mV of minimum drop-out. This LDO is designed to supply RF section of wireless devices, showing high PSRR up to 100 kHz, low noise on wide frequency bandwidth. LDO3 requires a 2.2  $\mu$ F output capacitor.

- Additionally, 1.50V or 1.20V output voltages programming is possible via the TWI serial interface on AT73C237.

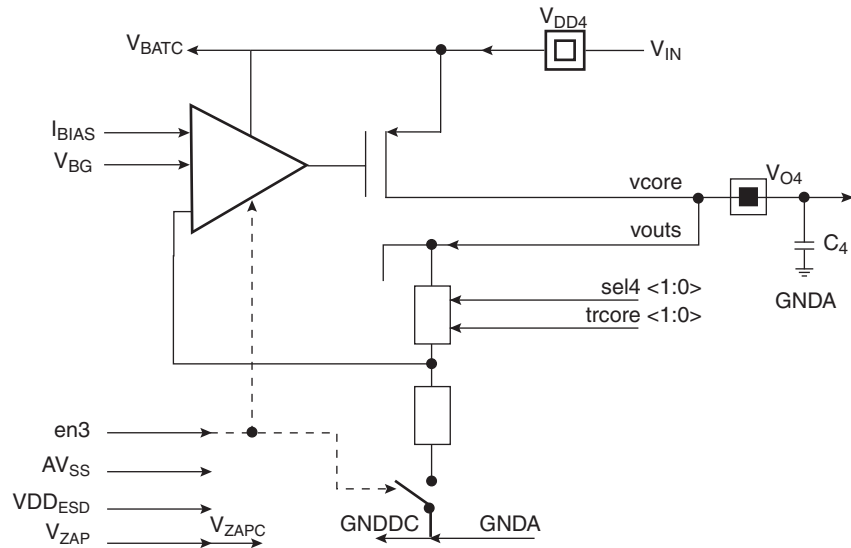
Figure 9-3. LDO3 Functional Diagram



## 9.4 LDO4

LDO4 is a 1.80V/2mA LDO with very low quiescent current. LDO4 can work with supply from 2.8V up to 5.5V. LDO4 requires a 1  $\mu$ F output capacitor. It needs at least 300 mV of minimum drop-out. LDO4 is always active once the pin VDD4 is supplied since it is used as internal reference supply. The VDD4 rail is independent from the other input rails (VDD1, 2, 3), allowing LDO4 to be used to supply a Real Time Clock from a separate backup battery, for example.

**Figure 9-4.** LDO4 Functional Diagram



## 9.5 High Performance Bandgap (HPBG)

HPBG is a low power, low noise Band Gap circuit providing very accurate voltage reference to LDOs that then can supply RF sections. HPBG operates in switching mode decreasing its current consumption. Economic high performance Bandgap is particularly interesting when RF LDOs are in idle mode (output voltage provided with very low output current e.g. <1mA). HPBG is biased from an internal regulator supplied by VDD4, thus it is not active when only VDD3 is present. HPBG requires at least external 100nF capacitor to achieve very low noise/high accuracy voltage reference.

HPBG is trimmed to 1.231V during product test.

## 9.6 Low Power Bandgap (LPBG)

LPBG is a low power Bandgap circuit used as reference voltage for LDO4. LPBG starts up as soon as VDD4 is present and doesn't require any external capacitor for decoupling.

## 9.7 Reset Generator

A Reset Generator produces an output reset (rising from "0" to "1"), called XRESO, at least 100 ms after the input reset state is activated. The input reset state can be produced by:

- VDD3 rising up, XRESIN not used or at "1".
- External signal rising up on XRESIN and VDD3 present.

## 9.8 State Machine

An Internal State Machine supervises the start up of the regulators connected to VDD1, VDD2 and VDD3. The startup configuration is in the following order LDO3 then LDO1 then LDO2. A voltage must be present on VDD4 to supply LDO4.

## 9.9 Oscillator

An Internal Oscillator (RCOSC) is used to generate the internal master clock which synchronizes the state machine controlling the start up of the LDOs and HPBG.

## 9.10 Power-On-Reset

A Power-On-Reset (POR) monitors the output of LDO4 (VO4) and generates an internal signal to enable the trimming registers to be loaded for LDO1, LDO2, LDO3 output voltage programming, as well as for the reference voltages and internal oscillator trimming. This internal signal is released when VO4 is higher than  $1.5V \pm 300\text{ mV}$ .

## 9.11 Supply Monitor

A Supply Monitor is set on VDD3 and generates an internal signal to enable state machine to startup the LDOs and to generate the XRESO signal. The threshold has been set to 2.7V when rising up and 2.6V when falling down.

## 9.12 Digital Control

On AT73C237, the pins TWCK, TWD are respectively the clock and data lines of a true two-wire interface, allowing to activate and disable the output voltage delivered by the regulators LDO1, LDO2, LDO3 and also to change their output voltage value.

### 9.13 Two-wire Interface (TWI) Protocol

The two-wire interface interconnects components on a unique two-wire bus, made up of one clock line and one data line with speeds up to 400 Kbits per second, based on a byte oriented transfer format. The TWI is slave only and single byte access.

The interface adds flexibility to the power supply solution, enabling LDO regulators to be controlled depending on the instantaneous application requirements.

The AT73C237 has the following 7-bit address:1001000.

Attempting to read data from register addresses not listed in this section results in 0xFF being read out.

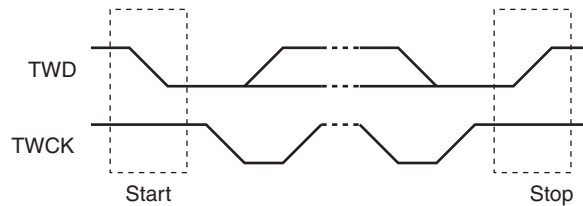
- TWCK is an input pin for the clock
- TWD is an open-drain pin that drives or receives the serial data

The data put on the TWD line must be 8 bits long. Data is transferred MSB first. Each byte must be followed by an acknowledgement.

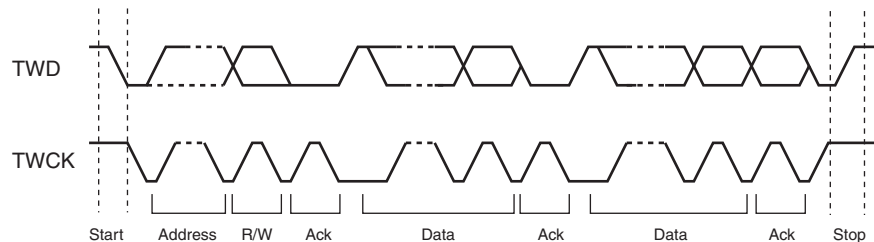
Each transfer begins with a START condition and terminates with a STOP condition.

- A high-to-low transition on TWD while TWCK is high defines a START condition.
- A low-to-high transition on TWD while TWCK is high defines a STOP condition.

**Figure 9-5.** TWI Start/Stop Cycle



**Figure 9-6.** TWI Data Cycle



After the host initiates a Start condition, it sends the 7-bit slave address defined above to notify the slave device. A Read/Write bit follows (Read = 1, Write = 0).

The device acknowledges each received byte.

The first byte sent after device address and R/W bit is the address of the device register the host wants to read or write.

For a write operation the data follows the internal address

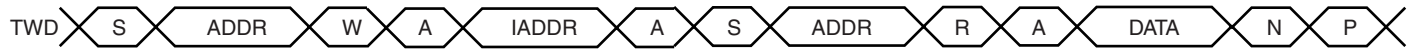
For a read operation a repeated Start condition needs to be generated followed by a read on the device.



**Figure 9-7.** TWD Write Operation



**Figure 9-8.** TWD Read Operation



- S = Start
- P = Stop
- W = Write
- R = Read
- A = Acknowledge
- N = Not Acknowledge
- ADDR = Device address
- IADDR = Internal address

## 10. Registers

**Table 10-1.** Registers

Address	Register	Description	Access	Reset value
0x00	LDO_CTRL	LDO control	Read / Write	0x0F
0x08	LDO_TRIM1	LDO 1,2,3 trim	Read / Write	0x00
0x0A	LDO_TRIM4	LDO4 trim	Read / Write	0x00

### 10.1 LDO Control: LDO\_CTRL (0x00)

7	6	5	4	3	2	1	0
-	-	-	-	Onldo4	Onldo3	Onldo2	Onldo1

**Table 10-2.** LDO\_CTRL (0x00) Structure

Bit	Name	Description	Reset value
7:4	-	Not used	-
3	Onldo4	LDO4 enable (active high, HiZ when off)	1
2	Onldo3	LDO3 enable (active high, HiZ when off)	1
1	Onldo2	LDO2 enable (active high, HiZ when off)	1
0	Onldo1	LDO1 enable (active high, HiZ when off)	1

### 10.2 LDO 1,2,3 trim: LDO\_TRIM1 (0x08)

7	6	5	4	3	2	1	0
-	-	-	Sel1	Sel2	Sel3		-

**Table 10-3.** LDO\_TRIM1 (0x08) Structure

Bit	Name	Description	Reset value
7:5	-	Not used	-
4	Sel1	LDO1 output voltage select	0
3	Sel2	LDO2 output voltage select	0
2:1	Sel3	LDO3 output voltage select	00
0	-	Not used	-

**Table 10-4.** LDO\_TRIM1 (0x08) - Output Voltages Selection

Sel1	VO1	Sel2	VO2	Sel3	VO3
0	2.75V	0	1.8V	00	1.8V
1	1.8V	1	1.5V	01	1.5V
-	-	-	-	10	1.23V
-	-	-	-	11	1.8

### 10.3 LDO 4 trim: LDO\_TRIM4 (0x0A)

7	6	5	4	3	2	1	0
-	-	-	-	Sel4		trcore1	trcore0

**Table 10-5.** LDO\_TRIM1 (0x08) Structure

Bit	Name	Description	Reset value
7:4	-	Not used	-
3:2	Sel4	LDO4 output voltage select	00
1:0	trcore	LDO4 output voltage trimming	00

**Table 10-6.** LDO\_TRIM1 (0x08) - Sel4

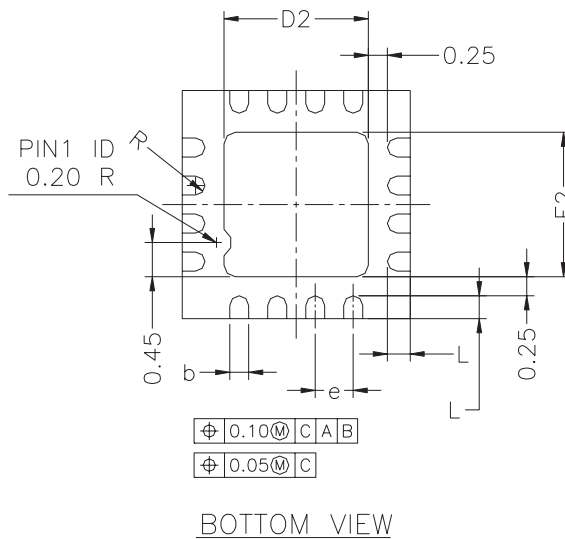
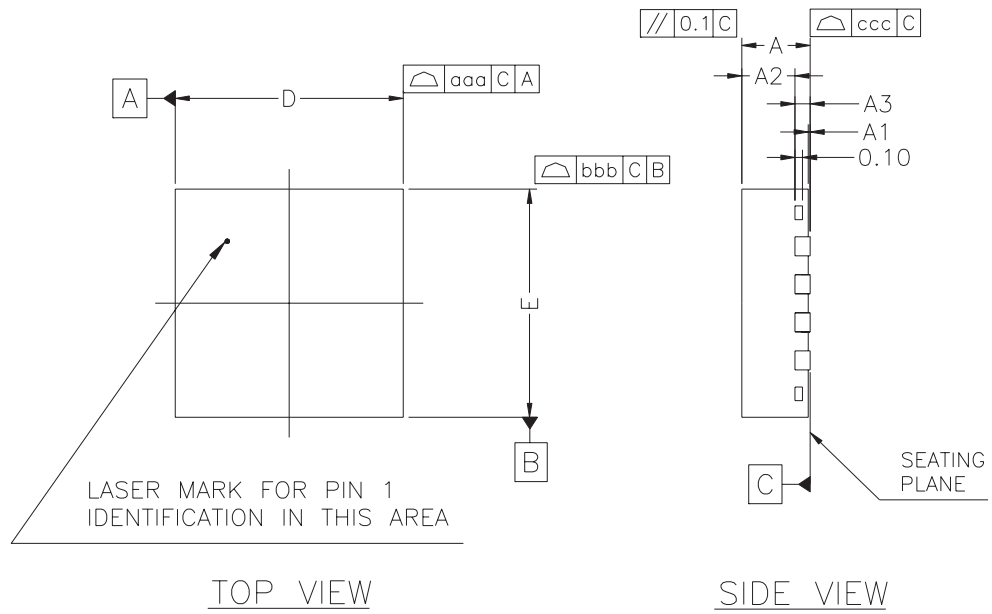
Sel4	VO4
00	1.8V
01	-
10	-
11	-

**Table 10-7.** LDO\_TRIM1 (0x08) - trcore

trcore	VO4
00	Typ value (1.8V)
01	+80mV
10	-80mV
11	Typ value (1.8V)

11. Package Information

Figure 11-1. Mechanical Package Drawing for 16-lead Quad Flat No Lead Package



NOTES :  
 1.ALL DIMENSIONS ARE IN MILLIMETERS.  
 2.PACKAGE WARPAGE MAX 0.08 mm.

\* CONTROLLING DIMENSION : MM

SYMBOL	MILLIMETER			INCH		
	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.
A	---	---	0.90	---	---	0.035
A1	---	---	0.05	---	---	0.002
A2	---	0.65	0.70	---	0.026	0.028
A3	0.20 REF.			0.008 REF.		
b	0.18	0.25	0.30	0.007	0.010	0.012
D	2.90	3.00	3.10	0.114	0.118	0.122
E	2.90	3.00	3.10	0.114	0.118	0.122
E2	1.80	1.90	2.00	0.071	0.075	0.079
L	0.25	0.30	0.35	0.010	0.012	0.014
e	0.50 bsc			0.020 bsc		
R	0.09	---	---	0.004	---	---
TOLERANCES OF FORM AND POSITION						
aaa	0.10			0.004		
bbb	0.10			0.004		
ccc	0.05			0.002		

## 12. Ordering Information

**Table 12-1.** Ordering Information

Ordering Code	Package	Package Type	Temperature Operating Range
AT73C237	QFN 3x3 mm	Green	0°C to +70°C

### 13. Revision History

Doc. Rev	Comments	Change Request Ref.
6362A	First issue	

Table of Contents

**Features ..... 1**

**1 Description ..... 1**

**2 Block Diagram ..... 2**

**3 Pin Description ..... 3**

**4 Application Block Diagram ..... 4**

**5 Electrical Characteristics ..... 5**

    5.1 Absolute Maximum Ratings .....5

    5.2 Recommended Operating Conditions .....5

    5.3 Quiescent Current In Different Operating Modes .....6

**6 Startup Procedure ..... 7**

    6.1 At VDD4 Rising .....7

    6.2 At VDD3 Falling .....7

**7 Timing Diagram ..... 9**

**8 Electrical Specification ..... 10**

    8.1 LDO1 ..... 10

    8.2 LDO2 ..... 12

    8.3 LDO3 ..... 14

    8.4 LDO4 ..... 16

    8.5 High Performance Bandgap (HPBG) ..... 17

    8.6 Low Power Bandgap (LPBG) ..... 17

    8.7 Voltage Monitor ..... 17

    8.8 XRESIN ..... 18

    8.9 XRESO ..... 18

    8.10 TWCK ..... 18

    8.11 TWD ..... 18

**9 Functional Description ..... 19**

    9.1 LDO1 ..... 19

    9.2 LDO2 .....20

    9.3 LDO3 .....21

    9.4 LDO4 .....22

    9.5 High Performance Bandgap (HPBG) .....22





9.6	Low Power Bandgap (LPBG) .....	22
9.7	Reset Generator .....	22
9.8	State Machine .....	23
9.9	Oscillator .....	23
9.10	Power-On-Reset .....	23
9.11	Supply Monitor .....	23
9.12	Digital Control .....	23
9.13	Two-wire Interface (TWI) Protocol .....	24
<b>10</b>	<b>Registers .....</b>	<b>26</b>
10.1	LDO Control: LDO_CTRL (0x00) .....	26
10.2	LDO 1,2,3 trim: LDO_TRIM1 (0x08) .....	26
10.3	LDO 4 trim: LDO_TRIM4 (0x0A) .....	27
<b>11</b>	<b>Package Information .....</b>	<b>29</b>
<b>12</b>	<b>Ordering Information .....</b>	<b>30</b>
<b>13</b>	<b>Revision History .....</b>	<b>31</b>
	<b>Table of Contents.....</b>	<b>i</b>





## Headquarters

**Atmel Corporation**  
2325 Orchard Parkway  
San Jose, CA 95131  
USA  
Tel: 1(408) 441-0311  
Fax: 1(408) 487-2600

## International

**Atmel Asia**  
Room 1219  
Chinachem Golden Plaza  
77 Mody Road Tsimshatsui  
East Kowloon  
Hong Kong  
Tel: (852) 2721-9778  
Fax: (852) 2722-1369

**Atmel Europe**  
Le Krebs  
8, Rue Jean-Pierre Timbaud  
BP 309  
78054 Saint-Quentin-en-  
Yvelines Cedex  
France  
Tel: (33) 1-30-60-70-00  
Fax: (33) 1-30-60-71-11

**Atmel Japan**  
9F, Tonetsu Shinkawa Bldg.  
1-24-8 Shinkawa  
Chuo-ku, Tokyo 104-0033  
Japan  
Tel: (81) 3-3523-3551  
Fax: (81) 3-3523-7581

## Product Contact

**Web Site**  
[www.atmel.com](http://www.atmel.com)  
[www.atmel.com/PowerManage](http://www.atmel.com/PowerManage)

**Technical Support**  
[pmaac@atmel.com](mailto:pmaac@atmel.com)  
Atmel technical support

**Sales Contacts**  
[www.atmel.com/contacts/](http://www.atmel.com/contacts/)

**Literature Requests**  
[www.atmel.com/literature](http://www.atmel.com/literature)

**Disclaimer:** The information in this document is provided in connection with Atmel products. No license, express or implied, by estoppel or otherwise, to any intellectual property right is granted by this document or in connection with the sale of Atmel products. **EXCEPT AS SET FORTH IN ATMEL'S TERMS AND CONDITIONS OF SALE LOCATED ON ATMEL'S WEB SITE, ATMEL ASSUMES NO LIABILITY WHATSOEVER AND DISCLAIMS ANY EXPRESS, IMPLIED OR STATUTORY WARRANTY RELATING TO ITS PRODUCTS INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTY OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, OR NON-INFRINGEMENT. IN NO EVENT SHALL ATMEL BE LIABLE FOR ANY DIRECT, INDIRECT, CONSEQUENTIAL, PUNITIVE, SPECIAL OR INCIDENTAL DAMAGES (INCLUDING, WITHOUT LIMITATION, DAMAGES FOR LOSS OF PROFITS, BUSINESS INTERRUPTION, OR LOSS OF INFORMATION) ARISING OUT OF THE USE OR INABILITY TO USE THIS DOCUMENT, EVEN IF ATMEL HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES.** Atmel makes no representations or warranties with respect to the accuracy or completeness of the contents of this document and reserves the right to make changes to specifications and product descriptions at any time without notice. Atmel does not make any commitment to update the information contained herein. Unless specifically provided otherwise, Atmel products are not suitable for, and shall not be used in, automotive applications. Atmel's products are not intended, authorized, or warranted for use as components in applications intended to support or sustain life.

© 2008 Atmel Corporation. All rights reserved. Atmel®, logo and combinations thereof and others, are registered trademarks or trademarks of Atmel Corporation or its subsidiaries. Other terms and product names may be trademarks of others.