

## Advanced PMU for Samsung S5PC100, S5PC110 and S5PV210 Processors

### FEATURES

- Optimized for Samsung S5PC100, S5PC110 and S5PV210 Processors
- Three Step-Down DC/DC Converters
- Four Low-Dropout Linear Regulators
- I<sup>2</sup>C™ Serial Interface
- Advanced Enable/Disable Sequencing Controller
- Minimal External Components
- Tiny 4×4mm TQFN44-32 Package
  - 0.75mm Package Height
  - Pb-Free and RoHS Compliant

### GENERAL DESCRIPTION

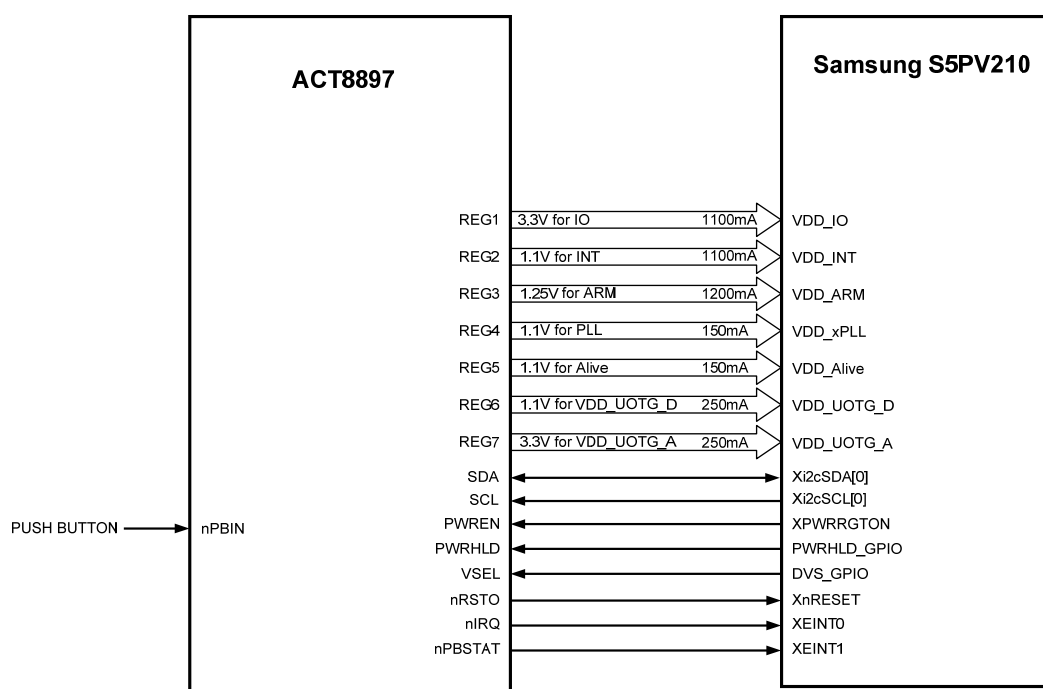
The ACT8897 is a complete, cost effective, highly-efficient *ActivePMU™* power management solution, optimized for the unique power, voltage-sequencing, and control requirements of the Samsung S5PC100, S5PC110 and S5PV210 processors.

This device features three step-down DC/DC converters and four low-noise, low-dropout linear regulators.

The three DC/DC converters utilize a high-efficiency, fixed-frequency (2MHz), current-mode PWM control architecture that requires a minimum number of external components. Two DC/DCs are capable of supplying up to 1100mA of output current, while the third supports up to 1200mA. All four low-dropout linear regulators are high-performance, low-noise, regulators that supply up to 150mA, 150mA, 250mA, and 250mA, respectively.

The ACT8897 is available in a compact, Pb-Free and RoHS-compliant TQFN44-32 package.

### TYPICAL APPLICATION DIAGRAM



## TABLE OF CONTENTS

|                                                             |       |
|-------------------------------------------------------------|-------|
| General Information .....                                   | p. 01 |
| Functional Block Diagram .....                              | p. 03 |
| Ordering Information .....                                  | p. 04 |
| Pin Configuration .....                                     | p. 04 |
| Pin Descriptions .....                                      | p. 05 |
| Absolute Maximum Ratings .....                              | p. 07 |
| I <sup>2</sup> C Interface Electrical Characteristics ..... | p. 08 |
| Global Register Map .....                                   | p. 09 |
| Register and Bit Descriptions .....                         | p. 10 |
| System Control Electrical Characteristics .....             | p. 13 |
| Step-Down DC/DC Electrical Characteristics .....            | p. 14 |
| Low-Noise LDO Electrical Characteristics .....              | p. 15 |
| Typical Performance Characteristics .....                   | p. 16 |
| System control information .....                            | p. 21 |
| Interfacing with the Samsung S5PV210 .....                  | p. 21 |
| Control Signals .....                                       | p. 22 |
| Push-Button Control .....                                   | p. 23 |
| Control Sequences .....                                     | p. 23 |
| Functional Description .....                                | p. 26 |
| I <sup>2</sup> C Interface .....                            | p. 26 |
| Voltage Monitor and Interrupt .....                         | p. 26 |
| Thermal Shutdown .....                                      | p. 26 |
| Step-Down DC/DC Regulators .....                            | p. 27 |
| General Description .....                                   | p. 27 |
| 100% Duty Cycle Operation .....                             | p. 27 |
| Synchronous Rectification .....                             | p. 27 |
| Soft-Start .....                                            | p. 27 |
| Compensation .....                                          | p. 27 |
| Configuration Options .....                                 | p. 27 |
| OK[ ] and Output Fault Interrupt .....                      | p. 28 |
| PCB Layout Considerations .....                             | p. 28 |
| Low-Noise, Low-Dropout Linear Regulators .....              | p. 29 |
| General Description .....                                   | p. 29 |
| Output Current Limit .....                                  | p. 29 |
| Compensation .....                                          | p. 29 |
| Configuration Options .....                                 | p. 29 |
| OK[ ] and Output Fault Interrupt .....                      | p. 29 |
| PCB Layout Considerations .....                             | p. 29 |
| TQFN44-32 Package Outline and Dimensions .....              | p. 31 |



## ORDERING INFORMATION<sup>①②</sup>

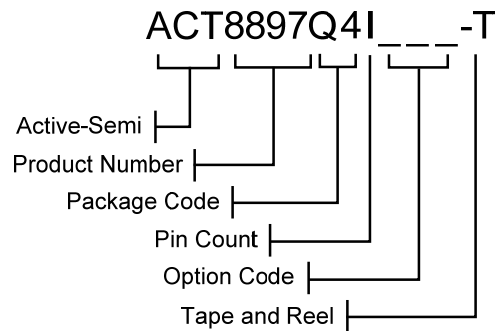
| PART NUMBER <sup>④</sup> | V <sub>OUT1</sub> | V <sub>OUT2/V<sub>STBY2</sub></sub> <sup>③</sup> | V <sub>OUT3/V<sub>STBY3</sub></sub> | V <sub>OUT4</sub> | V <sub>OUT5</sub> | V <sub>OUT6</sub> | V <sub>OUT7</sub> | PACKAGE   | PINS | TEMPERATURE RANGE |
|--------------------------|-------------------|--------------------------------------------------|-------------------------------------|-------------------|-------------------|-------------------|-------------------|-----------|------|-------------------|
| ACT8897Q4I1PQ-T          | 3.3V              | 1.3V/1.2V                                        | 1.35V/1.2V                          | 1.2V              | 1.2V              | 1.2V              | 3.3V              | TQFN44-32 | 32   | -40°C to +85°C    |
| ACT8897Q4I11C-T          | 3.3V              | 1.1V/1.1V                                        | 1.25V/1.25V                         | 1.1V              | 1.1V              | 1.1V              | 3.3V              | TQFN44-32 | 32   | -40°C to +85°C    |
| ACT8897Q4I106-T          | 1.8V              | 1.1V/1.1V                                        | 1.25V/1.25V                         | 1.1V              | 1.1V              | 1.1V              | 3.3V              | TQFN44-32 | 32   | -40°C to +85°C    |

①: All Active-Semi components are RoHS Compliant and with Pb-free plating unless specified differently. The term Pb-free means semiconductor products that are in compliance with current RoHS (Restriction of Hazardous Substances) standards.

②: Standard product options are identified in this table. Contact factory for custom options, minimum order quantity is 12,000 units.

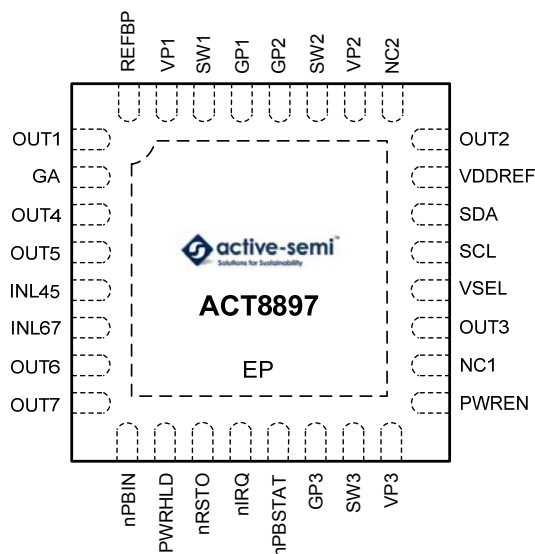
③: To select V<sub>STBYx</sub> as a output regulation voltage of REGx, drive VSEL to a logic high. The V<sub>STBYx</sub> can be set by software via I<sup>2</sup>C interface, refer to appropriate sections of this datasheet for V<sub>STBYx</sub> setting.

④: ACT8897Q4I1PQ-T is optimized for S5PC100, ACT8897Q4I11C-T and ACT8897Q4I106-T are optimized for S5PC110 and S5PV210.



## PIN CONFIGURATION

TOP VIEW



Thin - QFN (TQFN44-32)

## PIN DESCRIPTIONS

| PIN | NAME    | DESCRIPTION                                                                                                                                                                                                                                                                                               |
|-----|---------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1   | OUT1    | Output Feedback Sense for REG1. Connect this pin directly to the output node to connect the internal feedback network to the output voltage.                                                                                                                                                              |
| 2   | GA      | Analog Ground. Connect GA directly to a quiet ground node. Connect GA, GP1, GP2 and GP3 together at a single point as close to the IC as possible.                                                                                                                                                        |
| 3   | OUT4    | Output Voltage for REG4. Capable of delivering up to 150mA of output current. Connect a 1.5μF ceramic capacitor from OUT4 to GA. The output is discharged to GA with 1.5kΩ resistor when disabled.                                                                                                        |
| 4   | OUT5    | Output Voltage for REG5. Capable of delivering up to 150mA of output current. Connect a 1.5μF ceramic capacitor from OUT5 to GA. The output is discharged to GA with 1.5kΩ resistor when disabled.                                                                                                        |
| 5   | INL45   | Power Input for REG4 and REG5. Bypass to GA with a high quality ceramic capacitor placed as close to the IC as possible.                                                                                                                                                                                  |
| 6   | INL67   | Power Input for REG6 and REG7. Bypass to GA with a high quality ceramic capacitor placed as close to the IC as possible.                                                                                                                                                                                  |
| 7   | OUT6    | Output Voltage for REG6. Capable of delivering up to 250mA of output current. Connect a 2.2μF ceramic capacitor from OUT6 to GA. The output is discharged to GA with 1.5kΩ resistor when disabled.                                                                                                        |
| 8   | OUT7    | Output Voltage for REG7. Capable of delivering up to 250mA of output current. Connect a 2.2μF ceramic capacitor from OUT7 to GA. The output is discharged to GA with 1.5kΩ resistor when disabled.                                                                                                        |
| 9   | nPBIN   | Master Enable Input. Drive nPBIN to GA through a 50kΩ resistor to enable the IC, drive nPBIN directly to GA to assert a manual reset condition. Refer to the <i>nPBIN Multi-Function Input</i> section for more information. nPBIN is internally pulled up to V <sub>DDREF</sub> through a 35kΩ resistor. |
| 10  | PWRHLD  | Power Hold Input. Refer to the <i>Control Sequences</i> section for more information.                                                                                                                                                                                                                     |
| 11  | nRSTO   | Active Low Reset Output. See the <i>nRSTO Output</i> section for more information.                                                                                                                                                                                                                        |
| 12  | nIRQ    | Open-Drain Interrupt Output. nIRQ asserts any time an unmasked fault condition exists or an interrupt occurs. See the <i>nIRQ Output</i> section for more information.                                                                                                                                    |
| 13  | nPBSTAT | Active-Low Open-Drain Push-Button Status Output. nPBSTAT is asserted low whenever the nPBIN is pushed, and is high-Z otherwise. See the <i>nPBSTAT Output</i> section for more information.                                                                                                               |
| 14  | GP3     | Power Ground for REG3. Connect GA, GP1, GP2, and GP3 together at a single point as close to the IC as possible.                                                                                                                                                                                           |
| 15  | SW3     | Switching Node Output for REG3. Connect this pin to the switching end of the inductor.                                                                                                                                                                                                                    |
| 16  | VP3     | Power Input for REG3. Bypass to GP3 with a high quality ceramic capacitor placed as close to the IC as possible.                                                                                                                                                                                          |
| 17  | PWREN   | Power Enable Input. Refer to the <i>Control Sequences</i> section for more information.                                                                                                                                                                                                                   |
| 18  | NC1     | Connect NC1 to GA.                                                                                                                                                                                                                                                                                        |
| 19  | OUT3    | Output Feedback Sense for REG3. Connect this pin directly to the output node to connect the internal feedback network to the output voltage.                                                                                                                                                              |
| 20  | VSEL    | Step-Down DC/DCs Output Voltage Selection. Drive to logic low to select default output voltage. Drive to logic high to select secondary output voltage. See the <i>Output Voltage Programming</i> section for more information.                                                                           |
| 21  | SCL     | Clock Input for I <sup>2</sup> C Serial Interface.                                                                                                                                                                                                                                                        |
| 22  | SDA     | Data Input for I <sup>2</sup> C Serial Interface. Data is read on the rising edge of SCL.                                                                                                                                                                                                                 |

## PIN DESCRIPTIONS CONT'D

| PIN | NAME   | DESCRIPTION                                                                                                                                                                                                                           |
|-----|--------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 23  | VDDREF | Power supply for the internal reference. Connect this pin directly to the system power supply. Bypass VDDREF to GA with a 1 $\mu$ F capacitor placed as close to the IC as possible. Star connection with VP1, VP2 and VP3 preferred. |
| 24  | OUT2   | Output Feedback Sense for REG2. Connect this pin directly to the output node to connect the internal feedback network to the output voltage.                                                                                          |
| 25  | NC2    | Not Connected. Not internally connected.                                                                                                                                                                                              |
| 26  | VP2    | Power Input for REG2 and System Control. Bypass to GP2 with a high quality ceramic capacitor placed as close to the IC as possible.                                                                                                   |
| 27  | SW2    | Switching Node Output for REG2. Connect this pin to the switching end of the inductor.                                                                                                                                                |
| 28  | GP2    | Power Ground for REG2. Connect GA, GP1, GP2 and GP3 together at a single point as close to the IC as possible.                                                                                                                        |
| 29  | GP1    | Power Ground for REG1. Connect GA, GP1, GP2 and GP3 together at a single point as close to the IC as possible.                                                                                                                        |
| 30  | SW1    | Switching Node Output for REG1. Connect this pin to the switching end of the inductor.                                                                                                                                                |
| 31  | VP1    | Power Input for REG1. Bypass to GP1 with a high quality ceramic capacitor placed as close to the IC as possible.                                                                                                                      |
| 32  | REFBP  | Reference Bypass. Connect a 0.047 $\mu$ F ceramic capacitor from REFBP to GA. This pin is discharged to GA in shutdown.                                                                                                               |
| EP  | EP     | Exposed Pad. Must be soldered to ground on PCB.                                                                                                                                                                                       |

## ABSOLUTE MAXIMUM RATINGS<sup>①</sup>

| PARAMETER                                                | VALUE                          | UNIT |
|----------------------------------------------------------|--------------------------------|------|
| VP1 to GP1, VP2 to GP2, VP3 to GP3                       | -0.3 to + 6                    | V    |
| INL, VDDREF to GA                                        | -0.3 to + 6                    | V    |
| nPBIN, SCL, SDA, REFBP, PWRHLD, PWREN, VSEL to GA        | -0.3 to ( $V_{VDDREF} + 0.3$ ) | V    |
| nRSTO, nIRQ, nPBSTAT to GA                               | -0.3 to + 6                    | V    |
| SW1, OUT1 to GP1                                         | -0.3 to ( $V_{VP1} + 0.3$ )    | V    |
| SW2, OUT2 to GP2                                         | -0.3 to ( $V_{VP2} + 0.3$ )    | V    |
| SW3, OUT3 to GP3                                         | -0.3 to ( $V_{VP3} + 0.3$ )    | V    |
| OUT4, OUT5, OUT6, OUT7 to GA                             | -0.3 to ( $V_{INL} + 0.3$ )    | V    |
| GP1, GP2, GP3 to GA                                      | -0.3 to + 0.3                  | V    |
| Junction to Ambient Thermal Resistance ( $\theta_{JA}$ ) | 27.5                           | °C/W |
| Operating Ambient Temperature                            | -40 to 85                      | °C   |
| Maximum Junction Temperature                             | 125                            | °C   |
| Storage Temperature                                      | -65 to 150                     | °C   |
| Lead Temperature (Soldering, 10 sec)                     | 300                            | °C   |

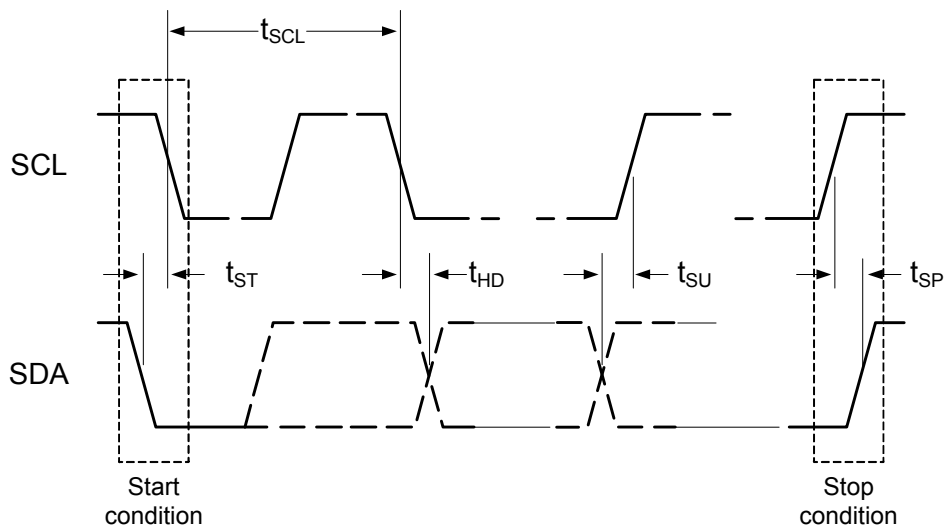
①: Do not exceed these limits to prevent damage to the device. Exposure to absolute maximum rating conditions for long periods may affect device reliability.

## I<sup>2</sup>C INTERFACE ELECTRICAL CHARACTERISTICS

( $V_{VP1} = V_{VP2} = V_{VP3} = 3.6V$ ,  $T_A = 25^\circ C$ , unless otherwise specified.)

| PARAMETER                     | TEST CONDITIONS                                                     | MIN  | TYP | MAX  | UNIT    |
|-------------------------------|---------------------------------------------------------------------|------|-----|------|---------|
| SCL, SDA Input Low            | $V_{VDDREF} = 3.1V$ to $5.5V$ , $T_A = -40^\circ C$ to $85^\circ C$ |      |     | 0.35 | V       |
| SCL, SDA Input High           | $V_{VDDREF} = 3.1V$ to $5.5V$ , $T_A = -40^\circ C$ to $85^\circ C$ | 1.55 |     |      | V       |
| SDA Leakage Current           |                                                                     |      |     | 1    | $\mu A$ |
| SCL Leakage Current           |                                                                     |      | 1   | 2    | $\mu A$ |
| SDA Output Low                | $I_{OL} = 5mA$                                                      |      |     | 0.35 | V       |
| SCL Clock Period, $t_{SCL}$   |                                                                     | 1.5  |     |      | $\mu s$ |
| SDA Data Setup Time, $t_{SU}$ |                                                                     | 100  |     |      | ns      |
| SDA Data Hold Time, $t_{HD}$  |                                                                     | 300  |     |      | ns      |
| Start Setup Time, $t_{ST}$    | For Start Condition                                                 | 100  |     |      | ns      |
| Stop Setup Time, $t_{SP}$     | For Stop Condition                                                  | 100  |     |      | ns      |

**Figure 1:**  
**I<sup>2</sup>C Compatible Serial Bus Timing**



## GLOBAL REGISTER MAP

| OUTPUT | ADDRESS |                      | BITS     |          |            |                       |                       |                       |           |           |
|--------|---------|----------------------|----------|----------|------------|-----------------------|-----------------------|-----------------------|-----------|-----------|
|        |         |                      | D7       | D6       | D5         | D4                    | D3                    | D2                    | D1        | D0        |
| SYS    | 0x00    | NAME                 | TRST     | nSYSMODE | nSYSLEVMSK | nSYSSTAT              | SYSLEV[3]             | SYSLEV[2]             | SYSLEV[1] | SYSLEV[0] |
|        |         | DEFAULT <sup>①</sup> | 0        | 1        | 0          | R                     | 0                     | 1                     | 1         | 1         |
| SYS    | 0x01    | NAME                 | Reserved | Reserved | Reserved   | Reserved              | SCRATCH               | SCRATCH               | SCRATCH   | SCRATCH   |
|        |         | DEFAULT <sup>①</sup> | 0        | 0        | 0          | 0                     | 0                     | 0                     | 0         | 0         |
| REG1   | 0x20    | NAME                 | Reserved | Reserved | VSET1[5]   | VSET1[4]              | VSET1[3]              | VSET1[2]              | VSET1[1]  | VSET1[0]  |
|        |         | DEFAULT <sup>①</sup> | 0        | 0        | 1          | 0                     | 0                     | 1                     | 0         | 0         |
| REG1   | 0x21    | NAME                 | Reserved | Reserved | VSET2[5]   | VSET2[4]              | VSET2[3]              | VSET2[2]              | VSET2[1]  | VSET2[0]  |
|        |         | DEFAULT <sup>①</sup> | 0        | 0        | 1          | 1                     | 1                     | 0                     | 0         | 1         |
| REG1   | 0x22    | NAME                 | ON       | PHASE    | MODE       | DELAY[2] <sup>②</sup> | DELAY[1] <sup>②</sup> | DELAY[0] <sup>②</sup> | nFLTMSK   | OK        |
|        |         | DEFAULT <sup>①</sup> | 0        | 0        | 0          | 0                     | 0                     | 0                     | 0         | R         |
| REG2   | 0x30    | NAME                 | Reserved | Reserved | VSET1[5]   | VSET1[4]              | VSET1[3]              | VSET1[2]              | VSET1[1]  | VSET1[0]  |
|        |         | DEFAULT <sup>①</sup> | 0        | 0        | 0          | 1                     | 1                     | 0                     | 0         | 0         |
| REG2   | 0x31    | NAME                 | Reserved | Reserved | VSET2[5]   | VSET2[4]              | VSET2[3]              | VSET2[2]              | VSET2[1]  | VSET2[0]  |
|        |         | DEFAULT <sup>①</sup> | 0        | 0        | 0          | 1                     | 1                     | 0                     | 0         | 0         |
| REG2   | 0x32    | NAME                 | ON       | PHASE    | MODE       | DELAY[2] <sup>②</sup> | DELAY[1] <sup>②</sup> | DELAY[0] <sup>②</sup> | nFLTMSK   | OK        |
|        |         | DEFAULT <sup>①</sup> | 0        | 0        | 0          | 0                     | 1                     | 1                     | 0         | R         |
| REG3   | 0x40    | NAME                 | Reserved | Reserved | VSET1[5]   | VSET1[4]              | VSET1[3]              | VSET1[2]              | VSET1[1]  | VSET1[0]  |
|        |         | DEFAULT <sup>①</sup> | 0        | 0        | 0          | 1                     | 1                     | 0                     | 0         | 0         |
| REG3   | 0x41    | NAME                 | Reserved | Reserved | VSET2[5]   | VSET2[4]              | VSET2[3]              | VSET2[2]              | VSET2[1]  | VSET2[0]  |
|        |         | DEFAULT <sup>①</sup> | 0        | 0        | 0          | 1                     | 1                     | 0                     | 0         | 0         |
| REG3   | 0x42    | NAME                 | ON       | PWRSTAT  | MODE       | DELAY[2] <sup>②</sup> | DELAY[1] <sup>②</sup> | DELAY[0] <sup>②</sup> | nFLTMSK   | OK        |
|        |         | DEFAULT <sup>①</sup> | 0        | 0        | 0          | 0                     | 1                     | 1                     | 0         | R         |
| REG4   | 0x50    | NAME                 | Reserved | Reserved | VSET[5]    | VSET[4]               | VSET[3]               | VSET[2]               | VSET[1]   | VSET[0]   |
|        |         | DEFAULT <sup>①</sup> | 0        | 0        | 0          | 1                     | 1                     | 0                     | 0         | 0         |
| REG4   | 0x51    | NAME                 | ON       | DIS      | LOWIQ      | DELAY[2] <sup>②</sup> | DELAY[1] <sup>②</sup> | DELAY[0] <sup>②</sup> | nFLTMSK   | OK        |
|        |         | DEFAULT <sup>①</sup> | 0        | 1        | 0          | 0                     | 1                     | 1                     | 0         | R         |
| REG5   | 0x54    | NAME                 | Reserved | Reserved | VSET[5]    | VSET[4]               | VSET[3]               | VSET[2]               | VSET[1]   | VSET[0]   |
|        |         | DEFAULT <sup>①</sup> | 0        | 0        | 0          | 1                     | 1                     | 0                     | 0         | 0         |
| REG5   | 0x55    | NAME                 | ON       | DIS      | LOWIQ      | DELAY[2] <sup>②</sup> | DELAY[1] <sup>②</sup> | DELAY[0] <sup>②</sup> | nFLTMSK   | OK        |
|        |         | DEFAULT <sup>①</sup> | 0        | 1        | 0          | 0                     | 0                     | 0                     | 0         | R         |
| REG6   | 0x60    | NAME                 | Reserved | Reserved | VSET[5]    | VSET[4]               | VSET[3]               | VSET[2]               | VSET[1]   | VSET[0]   |
|        |         | DEFAULT <sup>①</sup> | 0        | 0        | 1          | 1                     | 1                     | 0                     | 0         | 1         |
| REG6   | 0x61    | NAME                 | ON       | DIS      | LOWIQ      | DELAY[2] <sup>②</sup> | DELAY[1] <sup>②</sup> | DELAY[0] <sup>②</sup> | nFLTMSK   | OK        |
|        |         | DEFAULT <sup>①</sup> | 0        | 1        | 0          | 0                     | 0                     | 0                     | 0         | R         |
| REG7   | 0x64    | NAME                 | Reserved | Reserved | VSET[5]    | VSET[4]               | VSET[3]               | VSET[2]               | VSET[1]   | VSET[0]   |
|        |         | DEFAULT <sup>①</sup> | 0        | 0        | 1          | 1                     | 1                     | 0                     | 0         | 1         |
| REG7   | 0x65    | NAME                 | ON       | DIS      | LOWIQ      | DELAY[2] <sup>②</sup> | DELAY[1] <sup>②</sup> | DELAY[0] <sup>②</sup> | nFLTMSK   | OK        |
|        |         | DEFAULT <sup>①</sup> | 0        | 1        | 0          | 0                     | 0                     | 0                     | 0         | R         |

①: Default values of ACT8897Q4I11C-T.

②: Regulator turn-on delay bits. Automatically cleared to default values when the input power is removed or falls below the system UVLO.

## REGISTER AND BIT DESCRIPTIONS

Table 1:

Global Register Map

| OUTPUT | ADDRESS | BIT   | NAME       | ACCESS | DESCRIPTION                                                                                                                                                                                                                                           |
|--------|---------|-------|------------|--------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| SYS    | 0x00    | [7]   | TRST       | R/W    | Reset Timer Setting. Defines the reset time-out threshold. Reset time-out is 65ms when value is 1, reset time-out is 260ms when value is 0. See <i>nRSTO Output</i> section for more information.                                                     |
| SYS    | 0x00    | [6]   | nSYSMODE   | R/W    | SYSLEV Mode Select. Defines the response to the SYSLEV voltage detector, 1: Generate an interrupt when $V_{VDDREF}$ falls below the programmed SYSLEV threshold, 0: automatic shutdown when $V_{VDDREF}$ falls below the programmed SYSLEV threshold. |
| SYS    | 0x00    | [5]   | nSYSLEVMSK | R/W    | System Voltage Level Interrupt Mask. Disabled interrupt by default, set to 1 to enable this interrupt. See the <i>Programmable System Voltage Monitor</i> section for more information                                                                |
| SYS    | 0x00    | [4]   | nSYSSTAT   | R      | System Voltage Status. Value is 1 when $V_{VDDREF}$ is lower than the SYSLEV voltage threshold, value is 0 when $V_{VDDREF}$ is higher than the system voltage detection threshold.                                                                   |
| SYS    | 0x00    | [3:0] | SYSLEV     | R/W    | System Voltage Detect Threshold. Defines the SYSLEV voltage threshold. See the <i>Programmable System Voltage Monitor</i> section for more information.                                                                                               |
| SYS    | 0x01    | [7:4] | -          | R/W    | Reserved.                                                                                                                                                                                                                                             |
| SYS    | 0x01    | [3:0] | SCRATCH    | R/W    | Scratchpad Bits. Non-functional bits, maybe be used by user to store system status information. Volatile bits, which are cleared upon system shutdown.                                                                                                |
| REG1   | 0x20    | [7:6] | -          | R      | Reserved.                                                                                                                                                                                                                                             |
| REG1   | 0x20    | [5:0] | VSET1      | R/W    | Primary Output Voltage Selection. Valid when VSEL is driven low. See the <i>Output Voltage Programming</i> section for more information.                                                                                                              |
| REG1   | 0x21    | [7:6] | -          | R      | Reserved.                                                                                                                                                                                                                                             |
| REG1   | 0x21    | [5:0] | VSET2      | R/W    | Secondary Output Voltage Selection. Valid when VSEL is driven high. See the <i>Output Voltage Programming</i> section for more information.                                                                                                           |
| REG1   | 0x22    | [7]   | ON         | R/W    | Regulator Enable Bit. Set bit to 1 to enable the regulator, clear bit to 0 to disable the regulator.                                                                                                                                                  |
| REG1   | 0x22    | [6]   | PHASE      | R/W    | Regulator Phase Control. Set bit to 1 for regulator to operate 180° out of phase with the oscillator, clear bit to 0 for regulator to operate in phase with the oscillator.                                                                           |
| REG1   | 0x22    | [5]   | MODE       | R/W    | Regulator Mode Select. Set bit to 1 for fixed-frequency PWM under all load conditions, clear bit to 0 to transit to power-savings mode under light-load conditions.                                                                                   |
| REG1   | 0x22    | [4:2] | DELAY      | R/W    | Regulator Turn-On Delay Control. See the <i>REG1, REG2, REG3 Turn-on Delay</i> section for more information.                                                                                                                                          |
| REG1   | 0x22    | [1]   | nFLTMSK    | R/W    | Regulator Fault Mask Control. Set bit to 1 enable to fault-interrupts, clear bit to 0 to disable fault-interrupts.                                                                                                                                    |
| REG1   | 0x22    | [0]   | OK         | R      | Regulator Power-OK Status. Value is 1 when output voltage exceeds the power-OK threshold, value is 0 otherwise.                                                                                                                                       |
| REG2   | 0x30    | [7:6] | -          | R      | Reserved.                                                                                                                                                                                                                                             |
| REG2   | 0x30    | [5:0] | VSET1      | R/W    | Primary Output Voltage Selection. Valid when VSEL is driven low. See the <i>Output Voltage Programming</i> section for more information.                                                                                                              |
| REG2   | 0x31    | [7:6] | -          | R      | Reserved.                                                                                                                                                                                                                                             |
| REG2   | 0x31    | [5:0] | VSET2      | R/W    | Secondary Output Voltage Selection. Valid when VSEL is driven high. See the <i>Output Voltage Programming</i> section for more information.                                                                                                           |

## REGISTER AND BIT DESCRIPTIONS CONT'D

| OUTPUT | ADDRESS | BIT   | NAME    | ACCESS | DESCRIPTION                                                                                                                                                                                                 |
|--------|---------|-------|---------|--------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| REG2   | 0x32    | [7]   | ON      | R/W    | Regulator Enable Bit. Set bit to 1 to enable the regulator, clear bit to 0 to disable the regulator.                                                                                                        |
| REG2   | 0x32    | [6]   | PHASE   | R/W    | Regulator Phase Control. Set bit to 1 for regulator to operate 180° out of phase with the oscillator, clear bit to 0 for regulator to operate in phase with the oscillator.                                 |
| REG2   | 0x32    | [5]   | MODE    | R/W    | Regulator Mode Select. Set bit to 1 for fixed-frequency PWM under all load conditions, clear bit to 0 to transit to power-savings mode under light-load conditions.                                         |
| REG2   | 0x32    | [4:2] | DELAY   | R/W    | Regulator Turn-On Delay Control. See the <i>REG1, REG2, REG3 Turn-on Delay</i> section for more information.                                                                                                |
| REG2   | 0x32    | [1]   | nFLTMSK | R/W    | Regulator Fault Mask Control. Set bit to 1 enable to fault-interrupts, clear bit to 0 to disable fault-interrupts.                                                                                          |
| REG2   | 0x32    | [0]   | OK      | R      | Regulator Power-OK Status. Value is 1 when output voltage exceeds the power-OK threshold, value is 0 otherwise.                                                                                             |
| REG3   | 0x40    | [7:6] | -       | R      | Reserved.                                                                                                                                                                                                   |
| REG3   | 0x40    | [5:0] | VSET1   | R/W    | Primary Output Voltage Selection. Valid when VSEL is driven low. See the <i>Output Voltage Programming</i> section for more information.                                                                    |
| REG3   | 0x41    | [7:6] | -       | R      | Reserved.                                                                                                                                                                                                   |
| REG3   | 0x41    | [5:0] | VSET2   | R/W    | Secondary Output Voltage Selection. Valid when VSEL is driven high. See the <i>Output Voltage Programming</i> section for more information.                                                                 |
| REG3   | 0x42    | [7]   | ON      | R/W    | Regulator Enable Bit. Set bit to 1 to enable the regulator, clear bit to 0 to disable the regulator.                                                                                                        |
| REG3   | 0x42    | [6]   | PWRSTAT | R/W    | Configures regulator behavior with respect to the nPBIN input. Set bit to 0 to enable regulator when nPBIN is asserted.                                                                                     |
| REG3   | 0x42    | [5]   | MODE    | R/W    | Regulator Mode Select. Set bit to 1 for fixed-frequency PWM under all load conditions, clear bit to 0 to transition to power-savings mode under light-load conditions.                                      |
| REG3   | 0x42    | [4:2] | DELAY   | R/W    | Regulator Turn-On Delay Control. See the <i>REG1, REG2, REG3 Turn-on Delay</i> section for more information.                                                                                                |
| REG3   | 0x42    | [1]   | nFLTMSK | R/W    | Regulator Fault Mask Control. Set bit to 1 enable to fault-interrupts, clear bit to 0 to disable fault-interrupts.                                                                                          |
| REG3   | 0x42    | [0]   | OK      | R      | Regulator Power-OK Status. Value is 1 when output voltage exceeds the power-OK threshold, value is 0 otherwise.                                                                                             |
| REG4   | 0x50    | [7:6] | -       | R      | Reserved.                                                                                                                                                                                                   |
| REG4   | 0x50    | [5:0] | VSET    | R/W    | Output Voltage Selection. See the <i>Output Voltage Programming</i> section for more information.                                                                                                           |
| REG4   | 0x51    | [7]   | ON      | R/W    | Regulator Enable Bit. Set bit to 1 to enable the regulator, clear bit to 0 to disable the regulator.                                                                                                        |
| REG4   | 0x51    | [6]   | DIS     | R/W    | Output Discharge Control. When activated, discharges LDO output to GA through 1.5kΩ when in shutdown. Set bit to 1 to enable output voltage discharge in shutdown, clear bit to 0 to disable this function. |
| REG4   | 0x51    | [5]   | LOWIQ   | R/W    | LDO Low-IQ Mode Control. Set bit to 1 for low-power operating mode, clear bit to 0 for normal mode.                                                                                                         |
| REG4   | 0x51    | [4:2] | DELAY   | R/W    | Regulator Turn-On Delay Control. See the <i>REG4, REG5, REG6, REG7 Turn-on Delay</i> section for more information.                                                                                          |
| REG4   | 0x51    | [1]   | nFLTMSK | R/W    | Regulator Fault Mask Control. Set bit to 1 enable to fault-interrupts, clear bit to 0 to disable fault-interrupts.                                                                                          |
| REG4   | 0x51    | [0]   | OK      | R      | Regulator Power-OK Status. Value is 1 when output voltage exceeds the power-OK threshold, value is 0 otherwise.                                                                                             |

## REGISTER AND BIT DESCRIPTIONS CONT'D

| OUTPUT | ADDRESS | BIT   | NAME    | ACCESS | DESCRIPTION                                                                                                                                                                                                 |
|--------|---------|-------|---------|--------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| REG5   | 0x54    | [7:6] | -       | R      | Reserved.                                                                                                                                                                                                   |
| REG5   | 0x54    | [5:0] | VSET    | R/W    | Output Voltage Selection. See the <i>Output Voltage Programming</i> section for more information.                                                                                                           |
| REG5   | 0x55    | [7]   | ON      | R/W    | Regulator Enable Bit. Set bit to 1 to enable the regulator, clear bit to 0 to disable the regulator.                                                                                                        |
| REG5   | 0x55    | [6]   | DIS     | R/W    | Output Discharge Control. When activated, discharges LDO output to GA through 1.5kΩ when in shutdown. Set bit to 1 to enable output voltage discharge in shutdown, clear bit to 0 to disable this function. |
| REG5   | 0x55    | [5]   | LOWIQ   | R/W    | LDO Low-IQ Mode Control. Set bit to 1 for low-power operating mode, clear bit to 0 for normal mode.                                                                                                         |
| REG5   | 0x55    | [4:2] | DELAY   | R/W    | Regulator Turn-On Delay Control. See the <i>REG4, REG5, REG6, REG7 Turn-on Delay</i> section for more information.                                                                                          |
| REG5   | 0x55    | [1]   | nFLTMSK | R/W    | Regulator Fault Mask Control. Set bit to 1 enable to fault-interrupts, clear bit to 0 to disable fault-interrupts.                                                                                          |
| REG5   | 0x55    | [0]   | OK      | R      | Regulator Power-OK Status. Value is 1 when output voltage exceeds the power-OK threshold, value is 0 otherwise.                                                                                             |
| REG6   | 0x60    | [7:6] | -       | R      | Reserved.                                                                                                                                                                                                   |
| REG6   | 0x60    | [5:0] | VSET    | R/W    | Output Voltage Selection. See the <i>Output Voltage Programming</i> section for more information.                                                                                                           |
| REG6   | 0x61    | [7]   | ON      | R/W    | Regulator Enable Bit. Set bit to 1 to enable the regulator, clear bit to 0 to disable the regulator.                                                                                                        |
| REG6   | 0x61    | [6]   | DIS     | R/W    | Output Discharge Control. When activated, discharges LDO output to GA through 1.5kΩ when in shutdown. Set bit to 1 to enable output voltage discharge in shutdown, clear bit to 0 to disable this function. |
| REG6   | 0x61    | [5]   | LOWIQ   | R/W    | LDO Low-IQ Mode Control. Set bit to 1 for low-power operating mode, clear bit to 0 for normal mode.                                                                                                         |
| REG6   | 0x61    | [4:2] | DELAY   | R/W    | Regulator Turn-On Delay Control. See the <i>REG4, REG5, REG6, REG7 Turn-on Delay</i> section for more information.                                                                                          |
| REG6   | 0x61    | [1]   | nFLTMSK | R/W    | Regulator Fault Mask Control. Set bit to 1 enable to fault-interrupts, clear bit to 0 to disable fault-interrupts.                                                                                          |
| REG6   | 0x61    | [0]   | OK      | R      | Regulator Power-OK Status. Value is 1 when output voltage exceeds the power-OK threshold, value is 0 otherwise.                                                                                             |
| REG7   | 0x64    | [7:6] | -       | R      | Reserved.                                                                                                                                                                                                   |
| REG7   | 0x64    | [5:0] | VSET    | R/W    | Output Voltage Selection. See the <i>Output Voltage Programming</i> section for more information.                                                                                                           |
| REG7   | 0x65    | [7]   | ON      | R/W    | Regulator Enable Bit. Set bit to 1 to enable the regulator, clear bit to 0 to disable the regulator.                                                                                                        |
| REG7   | 0x65    | [6]   | DIS     | R/W    | Output Discharge Control. When activated, discharges LDO output to GA through 1.5kΩ when in shutdown. Set bit to 1 to enable output voltage discharge in shutdown, clear bit to 0 to disable this function. |
| REG7   | 0x65    | [5]   | LOWIQ   | R/W    | LDO Low-IQ Mode Control. Set bit to 1 for low-power operating mode, clear bit to 0 for normal mode.                                                                                                         |
| REG7   | 0x65    | [4:2] | DELAY   | R/W    | Regulator Turn-On Delay Control. See the <i>REG4, REG5, REG6, REG7 Turn-on Delay</i> section for more information.                                                                                          |
| REG7   | 0x65    | [1]   | nFLTMSK | R/W    | Regulator Fault Mask Control. Set bit to 1 enable to fault-interrupts, clear bit to 0 to disable fault-interrupts.                                                                                          |
| REG7   | 0x65    | [0]   | OK      | R      | Regulator Power-OK Status. Value is 1 when output voltage exceeds the power-OK threshold, value is 0 otherwise.                                                                                             |

## SYSTEM CONTROL ELECTRICAL CHARACTERISTICS

( $V_{VP1} = V_{VP2} = V_{VP3} = 3.6V$ ,  $T_A = 25^\circ C$ , unless otherwise specified.)

| PARAMETER                             | TEST CONDITIONS                                                 | MIN | TYP              | MAX  | UNIT       |
|---------------------------------------|-----------------------------------------------------------------|-----|------------------|------|------------|
| Input Voltage Range                   |                                                                 | 2.7 |                  | 5.5  | V          |
| UVLO Threshold Voltage                | $V_{VDDREF}$ Rising                                             | 2.2 | 2.45             | 2.65 | V          |
| UVLO Hysteresis                       | $V_{VDDREF}$ Falling                                            |     | 200              |      | mV         |
| Supply Current                        | REG1 and REG5 Enabled. REG2, REG3, REG4, REG6 and REG7 Disabled |     | 190              |      | $\mu A$    |
|                                       | REG1, REG2, REG3, REG4 and REG5 Enabled. REG6 and REG7 Disabled |     | 340              |      |            |
|                                       | REG1, REG2, REG3, REG4, REG5, REG6 and REG7 Enabled             |     | 420              |      |            |
| Shutdown Supply Current               | All Regulators Disabled                                         |     | 1.5              | 3.0  | $\mu A$    |
| Oscillator Frequency                  |                                                                 | 1.8 | 2                | 2.2  | MHz        |
| Logic High Input Voltage <sup>①</sup> |                                                                 | 1.4 |                  |      | V          |
| Logic Low Input Voltage               |                                                                 |     |                  | 0.4  | V          |
| Leakage Current                       | $V_{nIRQ} = V_{nRSTO} = 4.2V$                                   |     |                  | 1    | $\mu A$    |
| Low Level Output Voltage <sup>②</sup> | $I_{SINK} = 5mA$                                                |     |                  | 0.35 | V          |
| nRSTO Delay                           |                                                                 |     | 260 <sup>③</sup> |      | ms         |
| Thermal Shutdown Temperature          | Temperature rising                                              |     | 160              |      | $^\circ C$ |
| Thermal Shutdown Hysteresis           |                                                                 |     | 20               |      | $^\circ C$ |

①: PWRHLD, PWREN, VSEL are logic inputs.

②: nPBSTAT, nIRQ, nRSTO are open drain outputs.

③: Typical value shown. Actual value may vary from 227.9ms to 291.2ms.

## STEP-DOWN DC/DC ELECTRICAL CHARACTERISTICS

( $V_{VP1} = V_{VP2} = V_{VP3} = 3.6V$ ,  $T_A = 25^\circ C$ , unless otherwise specified.)

| PARAMETER                | CONDITIONS                                                         | MIN  | TYP                         | MAX  | UNIT        |
|--------------------------|--------------------------------------------------------------------|------|-----------------------------|------|-------------|
| Operating Voltage Range  |                                                                    | 2.7  |                             | 5.5  | V           |
| UVLO Threshold           | Input Voltage Rising                                               | 2.5  | 2.6                         | 2.7  | V           |
| UVLO Hysteresis          | Input Voltage Falling                                              |      | 100                         |      | mV          |
| Quiescent Supply Current | Regulator Enabled                                                  |      | 65                          | 90   | $\mu A$     |
| Shutdown Current         | $V_{VP} = 5.5V$ , Regulator Disabled                               |      | 0                           | 1    | $\mu A$     |
| Output Voltage Accuracy  | $V_{OUT} \geq 1.2V$ , $I_{OUT} = 10mA$                             | -1%  | $V_{NOM}^{\textcircled{1}}$ | 1%   | V           |
|                          | $V_{OUT} < 1.2V$ , $I_{OUT} = 10mA$                                | -2%  | $V_{NOM}^{\textcircled{1}}$ | 2%   |             |
| Line Regulation          | $V_{VP} = \text{Max}(V_{NOM}^{\textcircled{1}} + 1, 3.2V)$ to 5.5V |      | 0.15                        |      | %/V         |
| Load Regulation          | $I_{OUT} = 10mA$ to $IMAX^{\textcircled{2}}$                       |      | 0.0017                      |      | %/mA        |
| Power Good Threshold     | $V_{OUT}$ Rising                                                   |      | 93                          |      | % $V_{NOM}$ |
| Power Good Hysteresis    | $V_{OUT}$ Falling                                                  |      | 2                           |      | % $V_{NOM}$ |
| Oscillator Frequency     | $V_{OUT} \geq 20\%$ of $V_{NOM}$                                   | 1.8  | 2                           | 2.2  | MHz         |
|                          | $V_{OUT} = 0V$                                                     |      | 500                         |      | kHz         |
| Soft-Start Period        |                                                                    |      | 400                         |      | $\mu s$     |
| Minimum On-Time          |                                                                    |      | 75                          |      | ns          |
| <b>REG1</b>              |                                                                    |      |                             |      |             |
| Maximum Output Current   |                                                                    | 1.1  |                             |      | A           |
| Current Limit            |                                                                    | 1.55 | 1.80                        | 2.05 | A           |
| PMOS On-Resistance       | $I_{SW1} = -100mA$                                                 |      | 0.16                        |      | $\Omega$    |
| NMOS On-Resistance       | $I_{SW1} = 100mA$                                                  |      | 0.16                        |      | $\Omega$    |
| SW1 Leakage Current      | $V_{VP1} = 5.5V$ , $V_{SW1} = 0$ or 5.5V                           |      | 0                           | 1    | $\mu A$     |
| <b>REG2</b>              |                                                                    |      |                             |      |             |
| Maximum Output Current   |                                                                    | 1.1  |                             |      | A           |
| Current Limit            |                                                                    | 1.55 | 1.80                        | 2.05 | A           |
| PMOS On-Resistance       | $I_{SW2} = -100mA$                                                 |      | 0.16                        |      | $\Omega$    |
| NMOS On-Resistance       | $I_{SW2} = 100mA$                                                  |      | 0.16                        |      | $\Omega$    |
| SW2 Leakage Current      | $V_{VP2} = 5.5V$ , $V_{SW2} = 0$ or 5.5V                           |      | 0                           | 1    | $\mu A$     |
| <b>REG3</b>              |                                                                    |      |                             |      |             |
| Maximum Output Current   |                                                                    | 1.2  |                             |      | A           |
| Current Limit            |                                                                    | 1.55 | 1.80                        | 2.05 | A           |
| PMOS On-Resistance       | $I_{SW3} = -100mA$                                                 |      | 0.16                        |      | $\Omega$    |
| NMOS On-Resistance       | $I_{SW3} = 100mA$                                                  |      | 0.16                        |      | $\Omega$    |
| SW3 Leakage Current      | $V_{VP3} = 5.5V$ , $V_{SW3} = 0$ or 5.5V                           |      | 0                           | 1    | $\mu A$     |

$\textcircled{1}$ :  $V_{NOM}$  refers to the nominal output voltage level for  $V_{OUT}$  as defined by the *Ordering Information* section.

$\textcircled{2}$ :  $IMAX$  Maximum Output Current.

## LOW-NOISE LDO ELECTRICAL CHARACTERISTICS

( $V_{INL} = 3.6V$ ,  $C_{OUT4} = C_{OUT5} = 1.5\mu F$ ,  $C_{OUT6} = C_{OUT7} = 2.2\mu F$ ,  $LOWIQ[ ] = [0]$ ,  $T_A = 25^\circ C$ , unless otherwise specified.)

| PARAMETER                    | TEST CONDITIONS                                                          | MIN | TYP                         | MAX | UNIT          |
|------------------------------|--------------------------------------------------------------------------|-----|-----------------------------|-----|---------------|
| Operating Voltage Range      |                                                                          | 2.5 |                             | 5.5 | V             |
| Output Voltage Accuracy      | $V_{OUT} \geq 1.2V$ , $T_A = 25^\circ C$ , $I_{OUT} = 10mA$              | -1% | $V_{NOM}^{\textcircled{1}}$ | 2%  | V             |
|                              | $V_{OUT} < 1.2V$ , $T_A = 25^\circ C$ , $I_{OUT} = 10mA$                 | -2% | $V_{NOM}^{\textcircled{1}}$ | 4%  |               |
| Line Regulation              | $V_{INL} = \text{Max}(V_{OUT} + 0.5V, 3.6V)$ to 5.5V<br>$LOWIQ[ ] = [0]$ |     | 0.05                        |     | mV/V          |
|                              | $V_{INL} = \text{Max}(V_{OUT} + 0.5V, 3.6V)$ to 5.5V<br>$LOWIQ[ ] = [1]$ |     | 0.5                         |     |               |
| Load Regulation              | $I_{OUT} = 1mA$ to $IMAX^{\textcircled{2}}$                              |     | 0.08                        |     | V/A           |
| Power Supply Rejection Ratio | $f = 1kHz$ , $I_{OUT} = 20mA$ , $V_{OUT} = 1.2V$                         |     | 75                          |     | dB            |
|                              | $f = 10kHz$ , $I_{OUT} = 20mA$ , $V_{OUT} = 1.2V$                        |     | 65                          |     |               |
| Supply Current per Output    | Regulator Enabled, $LOWIQ[ ] = [0]$                                      |     | 37                          | 60  | $\mu A$       |
|                              | Regulator Enabled, $LOWIQ[ ] = [1]$                                      |     | 31                          | 52  |               |
|                              | Regulator Disabled                                                       |     | 0                           | 1   |               |
| Soft-Start Period            | $V_{OUT} = 2.9V$                                                         |     | 140                         |     | $\mu s$       |
| Power Good Threshold         | $V_{OUT}$ Rising                                                         |     | 89                          |     | %             |
| Power Good Hysteresis        | $V_{OUT}$ Falling                                                        |     | 3                           |     | %             |
| Output Noise                 | $I_{OUT} = 20mA$ , $f = 10Hz$ to $100kHz$ , $V_{OUT} = 1.2V$             |     | 50                          |     | $\mu V_{RMS}$ |
| Discharge Resistance         | LDO Disabled, $DIS[ ] = 1$                                               |     | 1.5                         |     | $k\Omega$     |
| <b>REG4</b>                  |                                                                          |     |                             |     |               |
| Dropout Voltage <sup>③</sup> | $I_{OUT} = 80mA$ , $V_{OUT} > 3.1V$                                      |     | 90                          | 180 | mV            |
| Maximum Output Current       |                                                                          | 150 |                             |     | mA            |
| Current Limit <sup>④</sup>   | $V_{OUT} = 95\%$ of regulation voltage                                   | 200 |                             |     | mA            |
| Stable $C_{OUT4}$ Range      |                                                                          | 1.5 |                             | 20  | $\mu F$       |
| <b>REG5</b>                  |                                                                          |     |                             |     |               |
| Dropout Voltage              | $I_{OUT} = 80mA$ , $V_{OUT} > 3.1V$                                      |     | 140                         | 280 | mV            |
| Maximum Output Current       |                                                                          | 150 |                             |     | mA            |
| Current Limit                | $V_{OUT} = 95\%$ of regulation voltage                                   | 200 |                             |     | mA            |
| Stable $C_{OUT5}$ Range      |                                                                          | 1.5 |                             | 20  | $\mu F$       |
| <b>REG6</b>                  |                                                                          |     |                             |     |               |
| Dropout Voltage              | $I_{OUT} = 120mA$ , $V_{OUT} > 3.1V$                                     |     | 90                          | 180 | mV            |
| Maximum Output Current       |                                                                          | 250 |                             |     | mA            |
| Current Limit                | $V_{OUT} = 95\%$ of regulation voltage                                   | 300 |                             |     | mA            |
| Stable $C_{OUT6}$ Range      |                                                                          | 2.2 |                             | 20  | $\mu F$       |
| <b>REG7</b>                  |                                                                          |     |                             |     |               |
| Dropout Voltage              | $I_{OUT} = 120mA$ , $V_{OUT} > 3.1V$                                     |     | 140                         | 280 | mV            |
| Maximum Output Current       |                                                                          | 250 |                             |     | mA            |
| Current Limit                | $V_{OUT} = 95\%$ of regulation voltage                                   | 300 |                             |     | mA            |
| Stable $C_{OUT7}$ Range      |                                                                          | 2.2 |                             | 20  | $\mu F$       |

①:  $V_{NOM}$  refers to the nominal output voltage level for  $V_{OUT}$  as defined by the *Ordering Information* section.

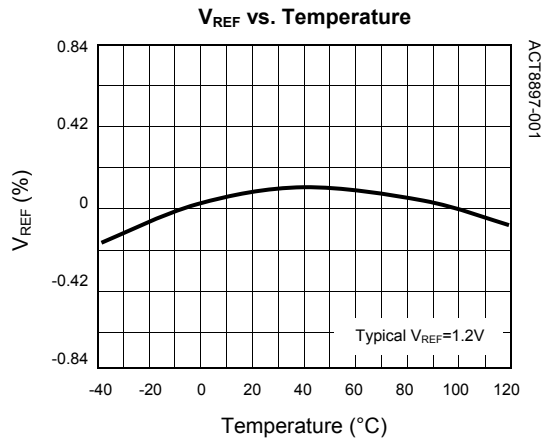
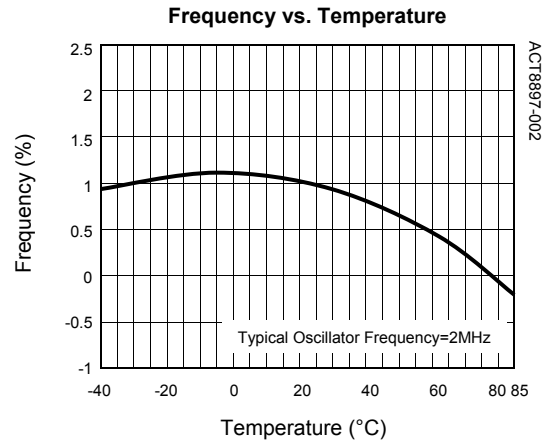
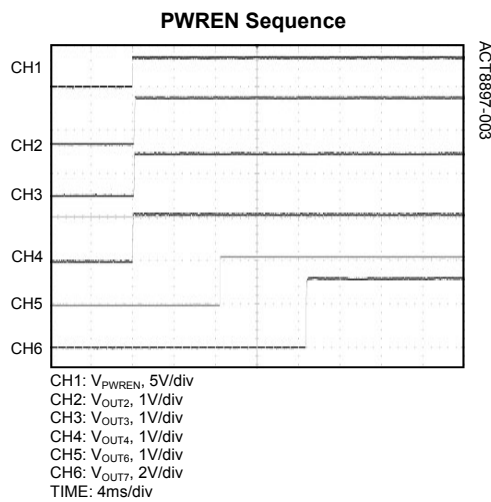
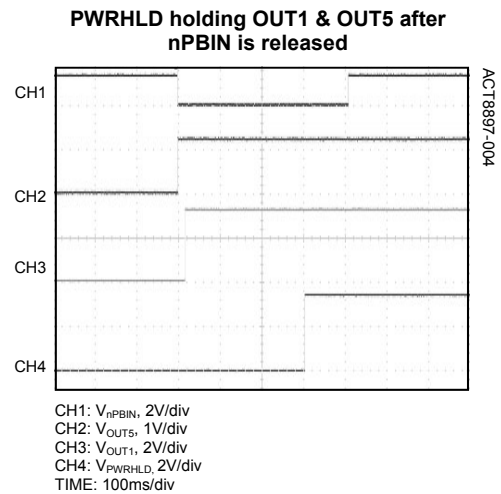
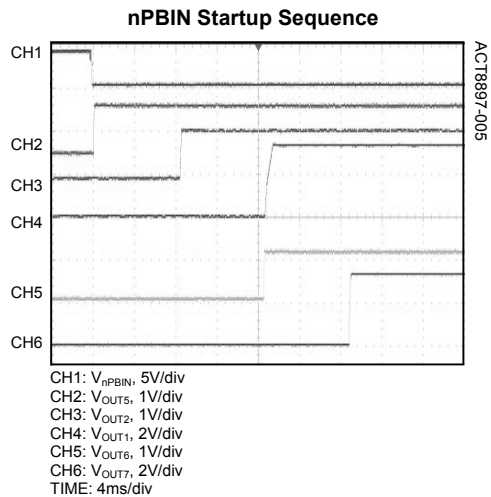
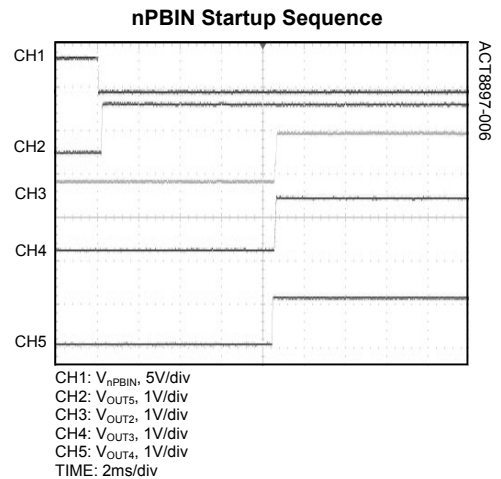
②:  $IMAX$  Maximum Output Current.

③: Dropout Voltage is defined as the differential voltage between input and output when the output voltage drops 100mV below the regulation voltage (for 3.1V output voltage or higher)

④: LDO current limit is defined as the output current at which the output voltage drops to 95% of the respective regulation voltage. Under heavy overload conditions the output current limit folds back by 30% (typ)

## TYPICAL PERFORMANCE CHARACTERISTICS

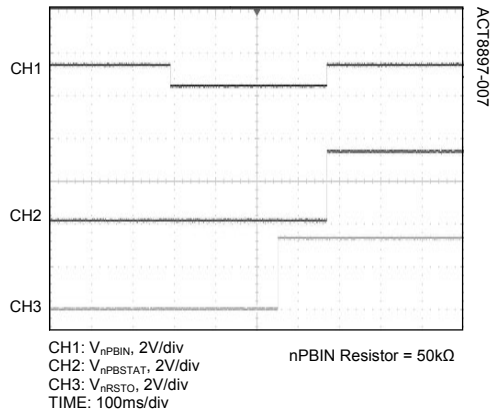
( $V_{VP1} = V_{VP2} = V_{VP3} = 3.6V$ ,  $T_A = 25^\circ C$ , unless otherwise specified.)



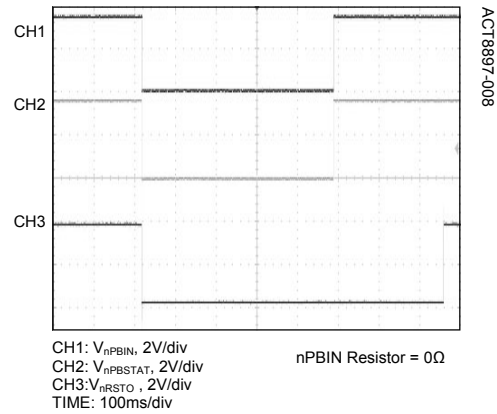
## TYPICAL PERFORMANCE CHARACTERISTICS CONT'D

( $T_A = 25^\circ\text{C}$ , unless otherwise specified.)

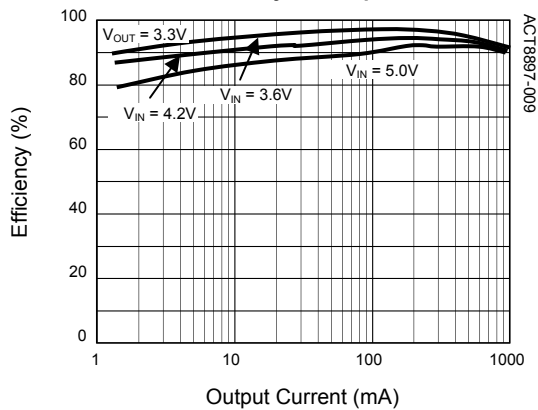
**Push-Button Response (First Power-Up)**



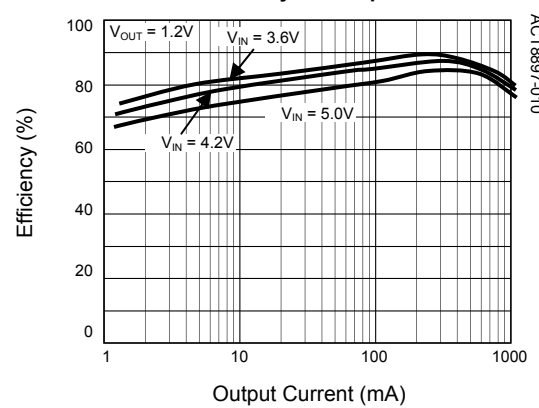
**Manual Reset Response**



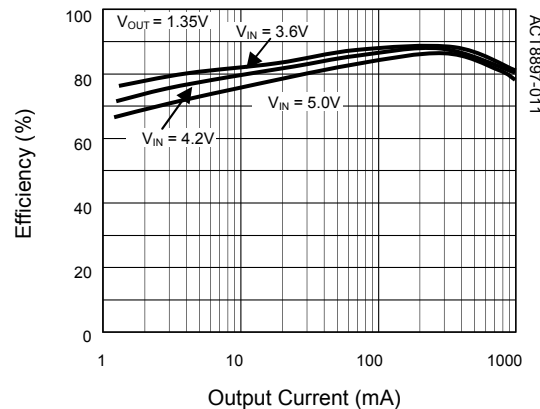
**REG1 Efficiency vs. Output Current**



**REG2 Efficiency vs. Output Current**

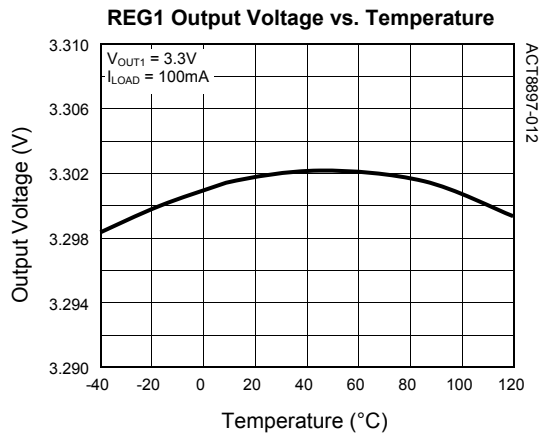
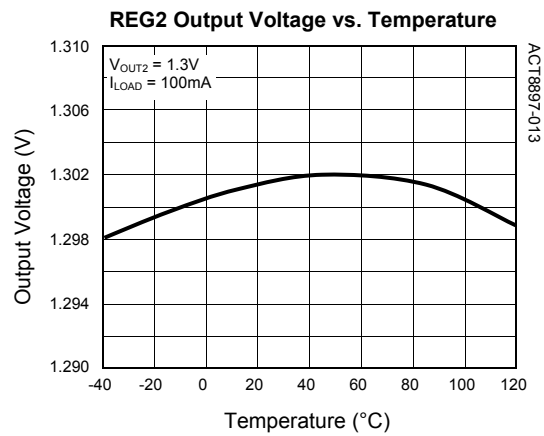
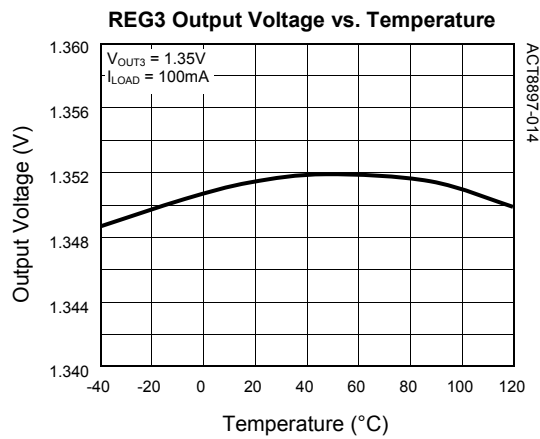
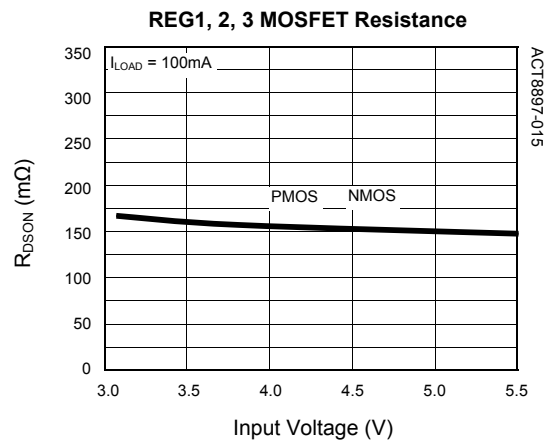


**REG3 Efficiency vs. Output Current**



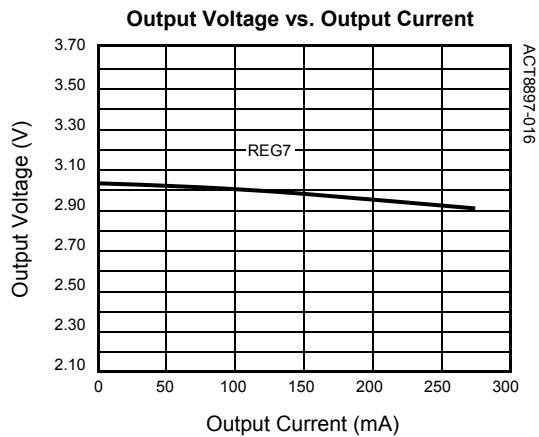
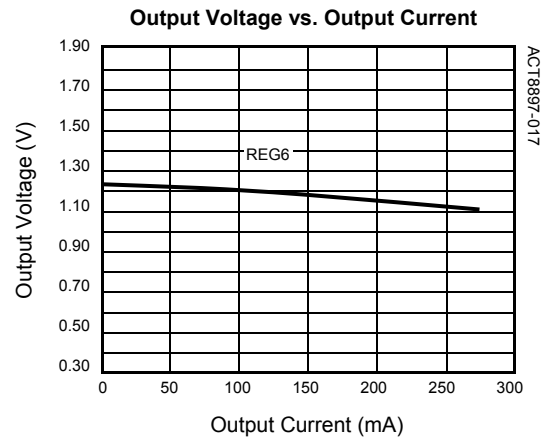
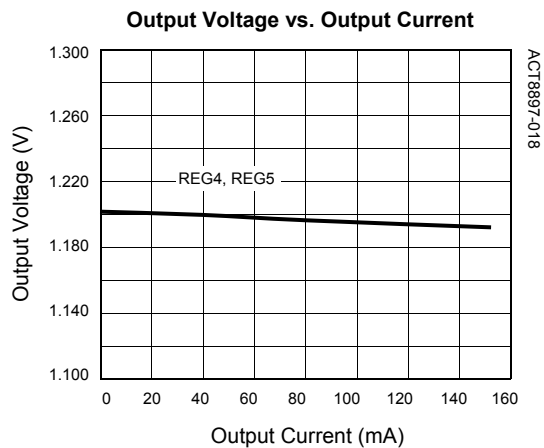
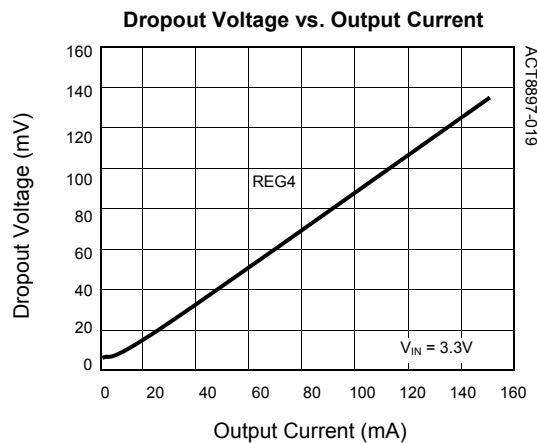
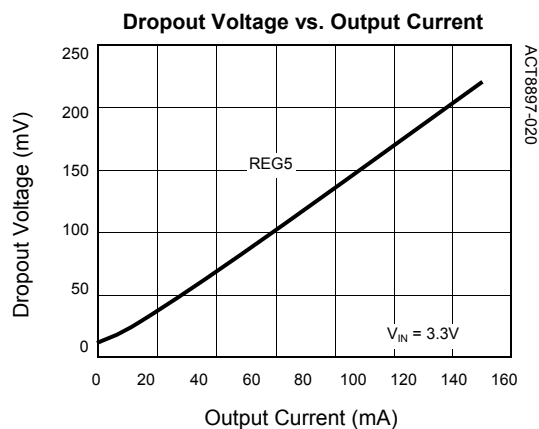
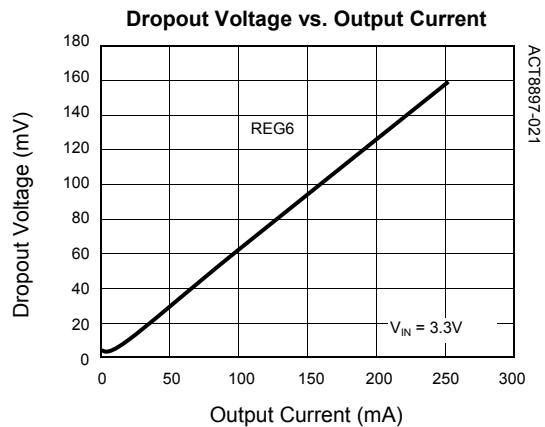
## TYPICAL PERFORMANCE CHARACTERISTICS CONT'D

( $T_A = 25^\circ\text{C}$ , unless otherwise specified.)



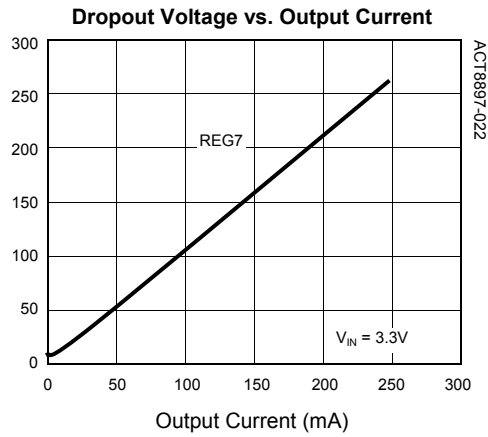
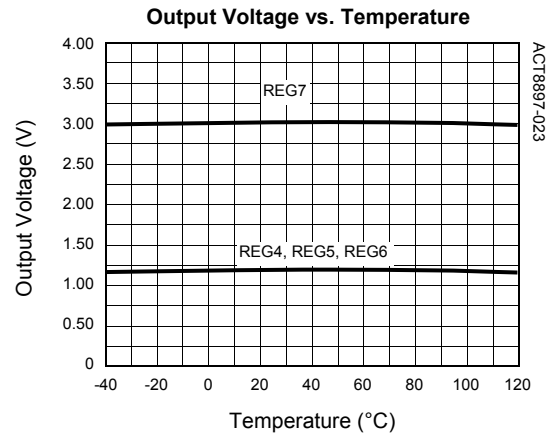
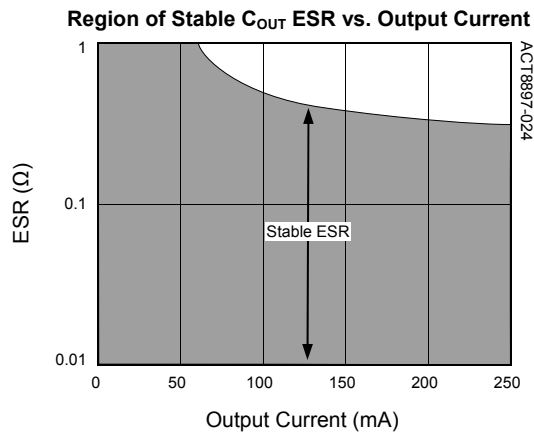
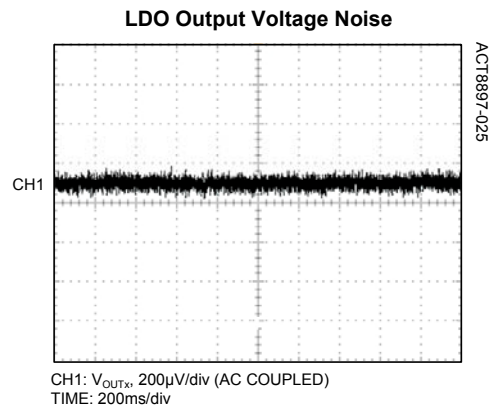
## TYPICAL PERFORMANCE CHARACTERISTICS CONT'D

( $T_A = 25^\circ\text{C}$ , unless otherwise specified.)



## TYPICAL PERFORMANCE CHARACTERISTICS CONT'D

( $T_A = 25^\circ\text{C}$ , unless otherwise specified.)



## SYSTEM CONTROL INFORMATION

### Interfacing with the Samsung S5PC100, S5PC110 and S5PV210 Processors

The ACT8897 is optimized for use in applications using the S5PC100, S5PC110 and S5PV210 processors, supporting both the power domains as well as the signal interface for these processors.

The following paragraphs describe how to design ACT8897 with S5PV210 Processor, but the design guidelines are directly applicable to S5PC100 and S5PC110 as well.

While the ACT8897 supports many possible configurations for powering these processors, one of the most common configurations is detailed in this datasheet. In general, this document refers to the ACT8897 pin names and functions. However, in cases where the description of interconnections

between these devices benefits by doing so, both the ACT8897 pin names and the Samsung processor pin names are provided. When this is done, the S5PV210 pin names are located after the ACT8897 pin names, and are italicized and located inside parentheses. For example, PWREN (*XPWRRGTON*) refers to the logic signal applied to the ACT8897's PWREN input, identifying that it is driven from the S5PV210's *XPWRRGTON* output. Likewise, OUT1 (*VDD\_IO*) refers to ACT8897's OUT1 pin, identifying that it is connected to the S5PV210's *VDD\_IO* power domain.

**Table 2:**

**ACT8897 and Samsung S5PV210 Power Domains**

| POWER DOMAIN | ACT8897 CHANNEL | TYPE  | DEFAULT VOLTAGE | CURRENT CAPABILITY |
|--------------|-----------------|-------|-----------------|--------------------|
| VDD_IO       | REG1            | DC/DC | 3.3V            | 1100mA             |
| VDD_INT      | REG2            | DC/DC | 1.1V            | 1100mA             |
| VDD_ARM      | REG3            | DC/DC | 1.25V/1.25V     | 1200mA             |
| VDD_xPLL     | REG4            | LDO   | 1.1V            | 150mA              |
| VDD_Alive    | REG5            | LDO   | 1.1V            | 150mA              |
| VDD_UOTG_D   | REG6            | LDO   | 1.1V            | 250mA              |
| VDD_UOTG_A   | REG7            | LDO   | 3.3V            | 250mA              |

**Table 3:**

**ACT8897 and Samsung S5PV210 Power Modes**

| POWER MODE | CONTROL STATE                                                                            | POWER DOMAIN STATE                                            | QUIESCENT CURRENT |
|------------|------------------------------------------------------------------------------------------|---------------------------------------------------------------|-------------------|
| ALL ON     | PWRHLD is asserted, PWREN is asserted                                                    | REG1, REG2, REG3, REG4, REG5, REG6 and REG7 are all on        | 420μA             |
| NORMAL     | PWRHLD is asserted, PWREN is asserted, REG6 and REG7 are disabled after system boots up. | REG1, REG2, REG3, REG4 and REG5 are on. REG6 and REG7 are off | 340μA             |
| SLEEP      | PWRHLD is asserted, PWREN is de-asserted, REG6 and REG7 are disabled default.            | REG1 and REG5 are on. REG2, REG3, REG4, REG6 and REG7 are off | 190μA             |
| ALL OFF    | PWRHLD is de-asserted, PWREN is de-asserted                                              | REG1, REG2, REG3, REG4, REG5, REG6 and REG7 are all off       | <18μA             |

**Table 4:**  
**ACT8897 and Samsung S5PV210 Signal Interface**

| ACT8897 | DIRECTION | SAMSUNG S5PV210  |
|---------|-----------|------------------|
| PWREN   | ←         | XPWRRGTON        |
| SCL     | ←         | Xi2cSCL[0]       |
| SDA     | ↔         | Xi2cSDA[0]       |
| VSEL    | ←         | DVS_GPIO®        |
| nRSTO   | →         | XnRESET          |
| nIRQ    | →         | XEINT0®          |
| nPBSTAT | →         | XEINT1®          |
| PWRHLD  | ←         | Power hold GPIO® |

①: Optional connection for DVS control.

②, ③: Typical connections shown, actual connections may vary.

④: Optional connection for power hold control.

### Table 5: Control Pins

| PIN NAME | OUTPUT                                   |
|----------|------------------------------------------|
| nPBIN    | REG1, REG2, REG3, REG4, REG5, REG6, REG7 |
| PWRHLD   | REG1, REG5                               |
| PWREN    | REG2, REG3, REG4, REG6, REG7             |

## Control Signals

### ***Enable Inputs***

The ACT8897 features a variety of control inputs, which are used to enable and disable outputs depending upon the desired mode of operation. PWREN, PWRHLD are logic inputs, while nPBIN is a unique, multi-function input. Refer to Table 5 for a description of which channels are controlled by each input.

### *n*PBIN Multi-Function Input

ACT8897 features the nPBIN multi-function pin, which combines system enable/disable control with a hardware reset function. Select either of the two pin functions by asserting this pin, either through a direct connection to GA, or through a 50kΩ resistor to GA, as shown in Figure 2.

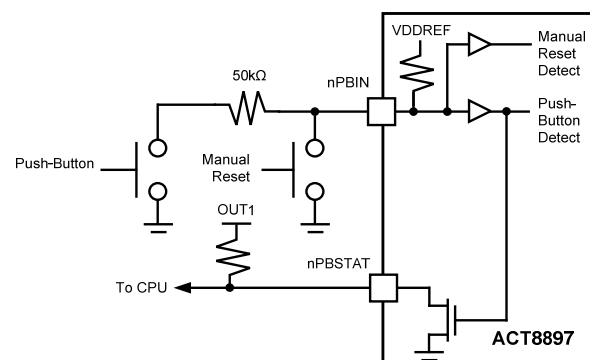
### Manual Reset Function

The second major function of the nPBIN input is to provide a manual-reset input for the processor. To manually-reset the processor, drive nPBIN directly to GA through a low impedance (less than 2.5kΩ). When this occurs, nRSTO immediately asserts low, then remains asserted low until the nPBIN input is de-asserted and the reset timeout period expires.

### *nPBSTAT* Output

nPBSTAT is an open-drain output that reflects the state of the nPBIN input; nPBSTAT is asserted low whenever nPBIN is asserted, and is high-Z otherwise. This output is typically used as an interrupt signal to the processor, to initiate a software-programmable routine such as operating mode selection or to open a menu. Connect nPBSTAT to an appropriate supply voltage (typically OUT1) through a 10kΩ or greater resistor.

**Figure 2:**  
**nPBIN Input**



### ***nRSTO Output***

nRSTO is an open-drain output which asserts low upon startup or when manual reset is asserted via the nPBIN input. When asserted on startup, nRSTO remains low until reset timeout period expires after OUT5 reaches its power-OK threshold. When asserted due to manual-reset, nRSTO immediately asserts low, then remains asserted low until the nPBIN input is de-asserted and the reset timeout period expires.

Connect a 10kΩ or greater pull-up resistor from nRSTO to an appropriate voltage supply (typically OUT1).

### ***nIRQ Output***

nIRQ is an open-drain output that asserts low any time an interrupt is generated. Connect a 10kΩ or greater pull-up resistor from nIRQ to an appropriate voltage supply. nIRQ is typically used to drive the interrupt input of the system processor.

Many of the ACT8897's functions support interrupt-generation as a result of various conditions. These are typically masked by default, but may be unmasked via the I<sup>2</sup>C interface. For more information about the available fault conditions, refer to the appropriate sections of this datasheet.

Note that under some conditions a false interrupt may be generated upon initial startup. For this reason, it is recommended that the interrupt service routine check and validate nSYSLEVMSK[ ] and nFLTMSK[ ] bits before processing an interrupt generated by these bits. These interrupts may be validated by nSYSSTAT[ ], OK[ ] bits.

## **Push-Button Control**

The ACT8897 is designed to initiate a system enable sequence when the nPBIN multi-function input is asserted. Once this occurs, a power-on sequence commences, as described below. The power-on sequence must complete and the microprocessor must take control (by asserting PWREN or PWRHLD) before nPBIN is de-asserted. If the microprocessor is unable to complete its power-up routine successfully before the user lets the push-button go off, the ACT8897 automatically shuts the system down. This provides protection against accidental or momentary assertions of the push-button. If desired, longer "push-and-hold" times can be easily implemented by simply adding an additional time delay before asserting PWREN or PWRHLD.

## **Control Sequences**

The ACT8897 features a variety of control

sequences that are optimized for supporting system enable and disable, as well as SLEEP mode of the Samsung S5PV210 processor.

### ***Enabling/Disabling Sequence***

A typical enable sequence initiates as a result of asserting nPBIN, and begins by enabling REG5. When REG5 reaches its power-OK threshold, nRSTO is asserted low, resetting the microprocessor. REG2, REG3 and REG4 are enabled after REG5 reaches its power-OK threshold for 8ms. When REG2 reaches its power-OK threshold for 8ms, REG1 and REG6 are enabled. When REG2 reaches its power-OK threshold for 16ms, REG7 is enabled. If REG5 is above its power-OK threshold when the reset timer expires, nRSTO is de-asserted, allowing the microprocessor to begin its boot sequence.

During the boot sequence, the microprocessor must assert PWRHLD, holding REG1 and REG5, and assert PWREN(XPWRRGTON), holding REG2, REG3, REG4, REG6 and REG7 to ensure that the system remains powered after nPBIN is released. REG6 and REG7 can also be enabled/disabled via I<sup>2</sup>C after microprocessor completes its boot sequence.

Once the power-up routine is completed, the system remains enabled after the push-button is released as long as either PWRHLD or PWREN are asserted high. If the processor does not assert PWRHLD or PWREN(XPWRRGTON) before the user releases the push-button, the boot-up sequence is terminated and all regulators are disabled. This provides protection against "false-enable", when the pushbutton is accidentally depressed, and also ensures that the system remains enabled only if the processor successfully completes the boot-up sequence. To disable REG6 (or REG7) via I<sup>2</sup>C after the power-up, the software needs to set register bit REG6.ON[ ] (or REG7.ON[ ]) to "1" first, then set it back to "0" to turn off the regulator.

As with the enable sequence, a typical disable sequence is initiated when the user presses the push-button, which interrupts the processor via the nPBSTAT output. The actual disable sequence is completely software-controlled, but typically involved initiating various "clean-up" processes before the processor finally de-asserts PWRHLD, which disables REG1 and REG5 after push-button is released. Since the processor loses power of VDD\_IO and VDD\_Alive, it automatically de-asserts PWREN (XPWRRGTON), and hence shuts the system down by disabling REG2, REG3, REG4, REG6 and REG7.

## SLEEP Mode Sequence

The ACT8897 supports Samsung S5PC100, S5PC110 and S5PV210 processors' SLEEP mode operation. Once a successful power-up routine has been completed, SLEEP mode may be initiated through a variety of software-controlled mechanisms.

SLEEP mode is typically initiated when the user presses the push-button during normal operation. Pressing the push-button asserts the nPBIN input, which asserts the nPBSTAT output, which interrupts the processor. In response to this interrupt the processor should de-assert PWREN(XPWRRGTON), disabling REG2, REG3, REG4, REG6 and REG7. PWRHLD should remain

asserted during SLEEP mode so that REG1 and REG5 remain enabled.

Waking up from SLEEP mode is typically initiated when the user presses the push-button again, which enables REG2, REG3, REG4, REG6 and REG7 and asserts nPBSTAT. Processors should respond by asserting PWREN(XPWRRGTON), which holds REG2, REG3, REG4, REG6 and REG7 so that normal operation may resume. An external interrupt, for instance a RTC interrupt, can also initiate a wake up sequence. When an external interrupt is sent to the processor, the processor should response by getting itself ready to wake up from SLEEP mode first, then assert PWREN(XPWRRGTON), which enables REG2, REG3, REG4, REG6 and REG7 so that the normal operation may resume.

**Figure 3:**  
**Enable/Disable Sequence**

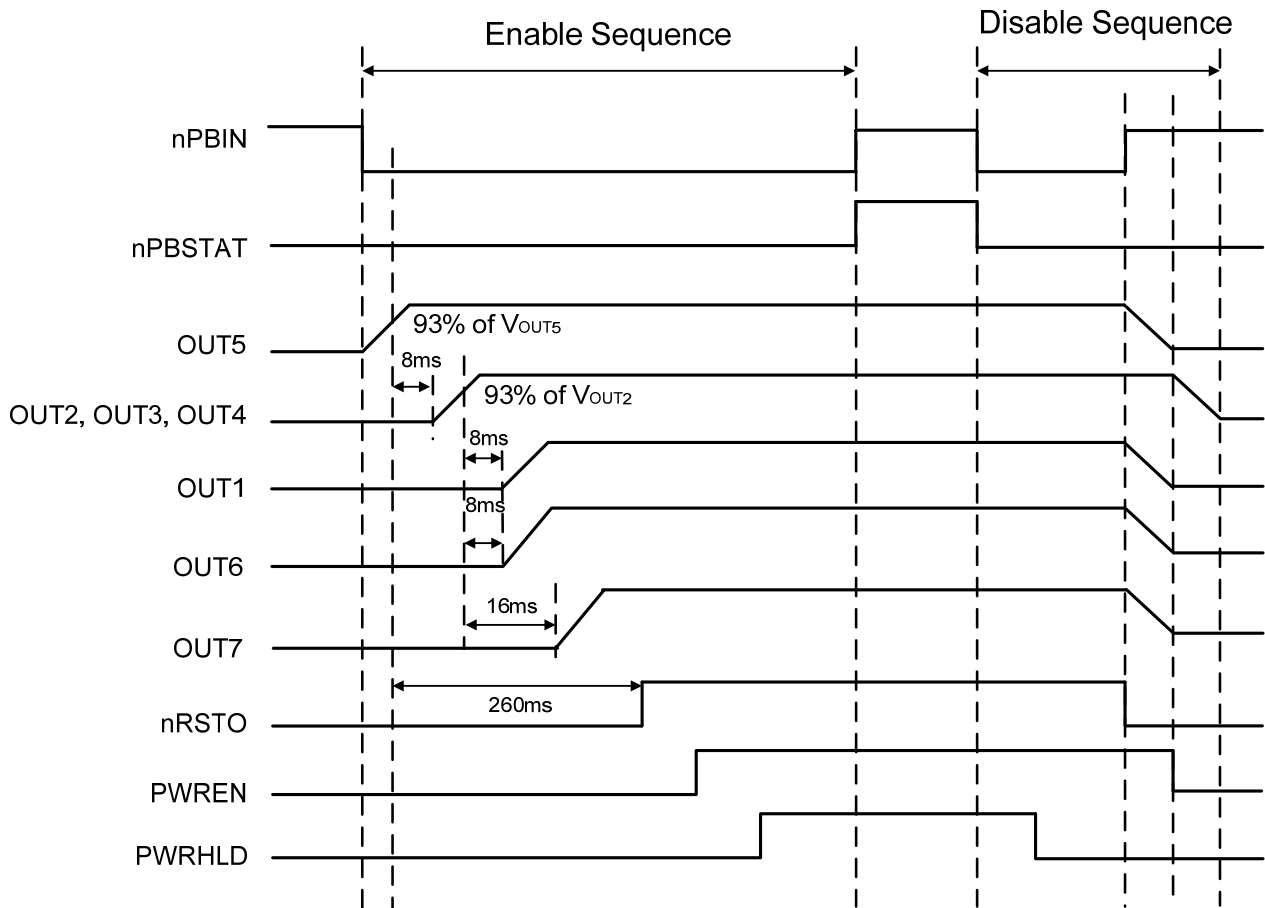


**Figure 4:**  
**Sleep Mode and Wake up Sequence (from Push Button)**

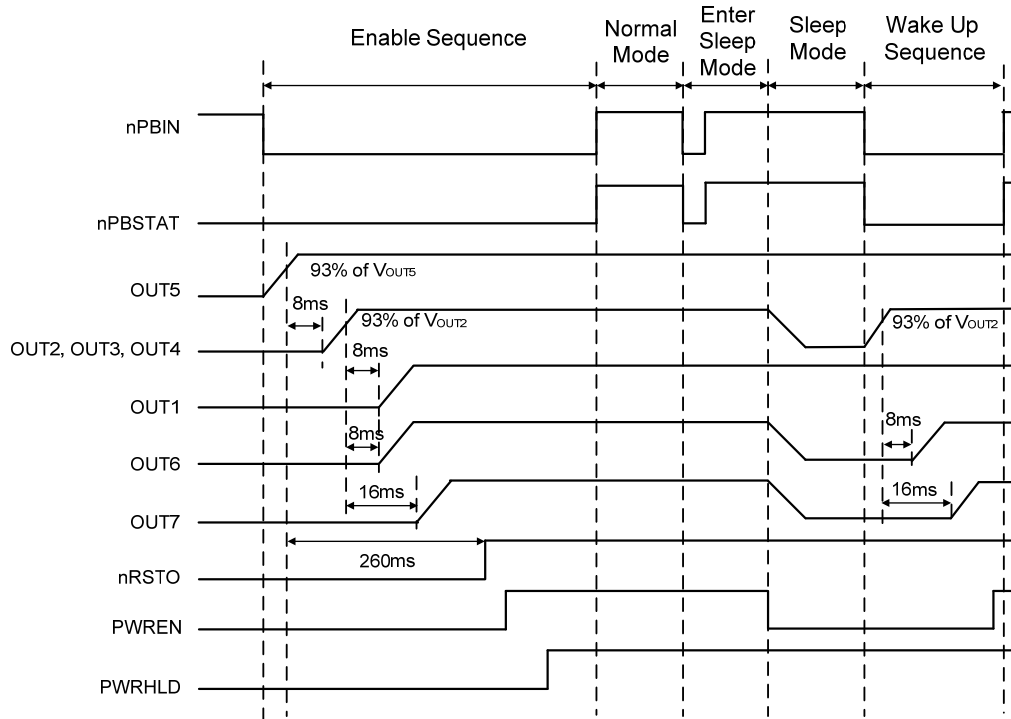
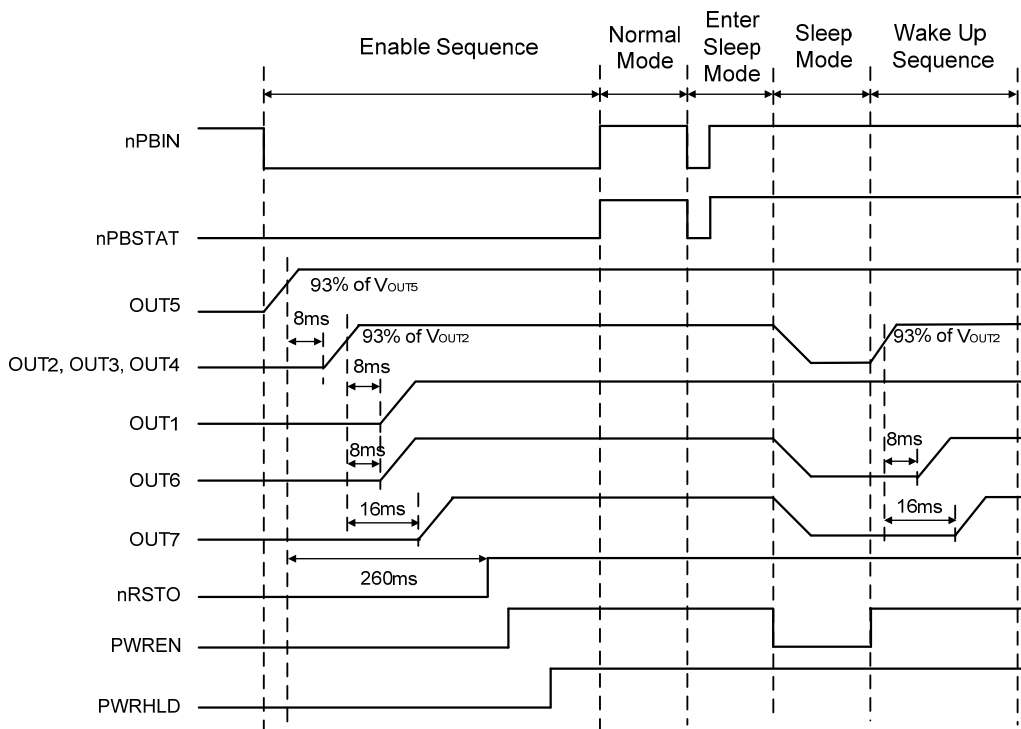


**Figure 5:**  
**Sleep Mode and Wake up Sequence (from External Interrupt)**



## FUNCTIONAL DESCRIPTION

### I<sup>2</sup>C Interface

The ACT8897 features an I<sup>2</sup>C interface that allows advanced programming capability to enhance overall system performance. To ensure compatibility with a wide range of system processors, the I<sup>2</sup>C interface supports clock speeds of up to 400kHz ("Fast-Mode" operation) and uses standard I<sup>2</sup>C commands. I<sup>2</sup>C write-byte commands are used to program the ACT8897, and I<sup>2</sup>C read-byte commands are used to read the ACT8897's internal registers. The ACT8897 always operates as a slave device, and is addressed using a 7-bit slave address followed by an eighth bit, which indicates whether the transaction is a read-operation or a write-operation, [1011011x].

SDA is a bi-directional data line and SCL is a clock input. The master device initiates a transaction by issuing a START condition, defined by SDA transitioning from high to low while SCL is high. Data is transferred in 8-bit packets, beginning with the MSB, and is clocked-in on the rising edge of SCL. Each packet of data is followed by an "Acknowledge" (ACK) bit, used to confirm that the data was transmitted successfully.

For more information regarding the I<sup>2</sup>C 2-wire serial interface, go to the NXP website: <http://www.nxp.com>.

### Voltage Monitor and Interrupt

#### Programmable System Voltage Monitor

The ACT8897 features a programmable system-voltage monitor, which monitors the voltage at VDDREF and compares it to a programmable threshold voltage. The programmable voltage threshold is programmed by SYSLEV[3:0], as shown in Table 6.

SYSLEV[ ] is set to 3.0V by default. There is a 200mV rising hysteresis on SYSLEV[ ] threshold such that VDDREF needs to be 3.2V(typ) or higher in order to power up the IC.

The nSYSSTAT[ ] bit reflects the output of an internal voltage comparator that monitors VDDREF relative to the SYSLEV[ ] voltage threshold, the value of nSYSTAT[ ] = 1 when VDDREF is lower than the SYSLEV[ ] voltage threshold, and nSYSTAT[ ] = 0 when VDDREF is higher than the SYSLEV[ ] voltage threshold. Note that the SYSLEV[ ] voltage threshold is defined for falling voltages, and that the comparator produces about 200mV of hysteresis at VDDREF. As a result, once VDDREF falls below the SYSLEV threshold, its voltage must increase by more than about 200mV to clear that condition.

After the IC is powered up, the ACT8897 responds in one of two ways when the voltage at VDDREF falls

below the SYSLEV[ ] voltage threshold:

1) If nSYSMODE[ ] = 1 (default case), when system voltage level interrupt is unmasked (nSYSLEVMSK[ ]=1) and VDDREF falls below the programmable threshold, the ACT8897 asserts nIRQ, providing a software "under-voltage alarm". The response to this interrupt is controlled by the CPU, but will typically initiate a controlled shutdown sequence either or alert the user that the battery is low. In this case the interrupt is cleared when VDDREF rises up again above the SYSLEV rising threshold and nSYSSTAT[ ] is read via I<sup>2</sup>C.

2) If nSYSMODE[ ] = 0, when VDDREF falls below the programmable threshold the ACT8897 shuts down, immediately disabling all regulators. This option is useful for implementing a programmable "under-voltage lockout" function that forces the system off when the battery voltage falls below the SYSLEV threshold voltage. Since this option does not support a controlled shutdown sequence, it is generally used as a "fail-safe" to shut the system down when the battery voltage is too low.

**Table 6:**

**SYSLEV Falling Threshold**

| SYSLEV[3:0] | SYSLEV Falling Threshold<br>(Hysteresis = 200mV) |
|-------------|--------------------------------------------------|
| 0000        | 2.3                                              |
| 0001        | 2.4                                              |
| 0010        | 2.5                                              |
| 0011        | 2.6                                              |
| 0100        | 2.7                                              |
| 0101        | 2.8                                              |
| 0110        | 2.9                                              |
| 0111        | 3.0                                              |
| 1000        | 3.1                                              |
| 1001        | 3.2                                              |
| 1010        | 3.3                                              |
| 1011        | 3.4                                              |
| 1100        | 3.5                                              |
| 1101        | 3.6                                              |
| 1110        | 3.7                                              |
| 1111        | 3.8                                              |

### Thermal Shutdown

The ACT8897 integrates thermal shutdown protection circuitry to prevent damage resulting from excessive thermal stress, as may be encountered under fault conditions. This circuitry disables all regulators if the ACT8897 die temperature exceeds 160°C, and prevents the regulators from being enabled until the IC temperature drops by 20°C (typ).

## STEP-DOWN DC/DC REGULATORS

### General Description

The ACT8897 features three synchronous, fixed-frequency, current-mode PWM step down converters that achieve peak efficiencies of up to 97%. REG1 and REG2 are capable of supplying up to 1100mA of output current, while REG3 supports up to 1200mA. These regulators operate with a fixed frequency of 2MHz, minimizing noise in sensitive applications and allowing the use of small external components.

### 100% Duty Cycle Operation

Each regulator is capable of operating at up to 100% duty cycle. During 100% duty-cycle operation, the high-side power MOSFET is held on continuously, providing a direct connection from the input to the output (through the inductor), ensuring the lowest possible dropout voltage in battery powered applications.

### Synchronous Rectification

REG1, REG2, and REG3 each feature integrated n-channel synchronous rectifiers, maximizing efficiency and minimizing the total solution size and cost by eliminating the need for external rectifiers.

### Soft-Start

When enabled, each output voltages tracks an internal 400 $\mu$ s soft-start ramp, minimizing input current during startup and allowing each regulator to power up in a smooth, monotonic manner that is independent of output load conditions.

### Compensation

Each buck regulator utilizes current-mode control and a proprietary internal compensation scheme to simultaneously simplify external component selection and optimize transient performance over its full operating range. No compensation design is required; simply follow a few simple guidelines described below when choosing external components.

#### *Input Capacitor Selection*

The input capacitor reduces peak currents and noise induced upon the voltage source. A 4.7 $\mu$ F ceramic capacitor is recommended for each regulator in most applications.

#### *Output Capacitor Selection*

For most applications, 22 $\mu$ F ceramic output capacitors are recommended for REG1, REG2 and REG3.

Despite the advantages of ceramic capacitors, care

must be taken during the design process to ensure stable operation over the full operating voltage and temperature range. Ceramic capacitors are available in a variety of dielectrics, each of which exhibits different characteristics that can greatly affect performance over their temperature and voltage ranges.

Two of the most common dielectrics are Y5V and X5R. Whereas Y5V dielectrics are inexpensive and can provide high capacitance in small packages, their capacitance varies greatly over their voltage and temperature ranges and are not recommended for DC/DC applications. X5R and X7R dielectrics are more suitable for output capacitor applications, as their characteristics are more stable over their operating ranges, and are highly recommended.

#### *Inductor Selection*

REG1, REG2, and REG3 utilize current-mode control and a proprietary internal compensation scheme to simultaneously simplify external component selection and optimize transient performance over their full operating range. These devices were optimized for operation with 2.2 $\mu$ H inductors, although inductors in the 1.5 $\mu$ H to 3.3 $\mu$ H range can be used. Choose an inductor with a low DC-resistance, and avoid inductor saturation by choosing inductors with DC ratings that exceed the maximum output current by at least 30%.

### Configuration Options

#### *Output Voltage Programming*

By default, each regulator powers up and regulates to its default output voltage. Output voltage is selectable by setting VSEL pin that when VSEL is low, output voltage is programmed by VSET1[ ] bits, and when VSEL is high, output voltage is programmed by VSET2[ ] bits. However, once the system is enabled, each regulator's output voltage may be independently programmed to a different value, typically in order to minimize the power consumption of the microprocessor during some operating modes. Program the output voltages via the I<sup>2</sup>C serial interface by writing to the regulator's VSET1[ ] register if VSEL is low or VSET2[ ] register if VSEL is high as shown in Table 8.

#### *Enable / Disable Control*

During normal operation, each buck may be enabled or disabled via the I<sup>2</sup>C interface by writing to that regulator's ON[ ] bit. The regulator accept rising or falling edge of ON[ ] bit as on/off signal. To enable the regulator, clear ON[ ] to 0 first then set to 1. To disable the regulator, set ON[ ] to 1 first then clear it to 0.

## REG1, REG2, REG3 Turn-on Delay

Each of REG1, REG2 and REG3 features a programmable Turn-on Delay which help ensure a reliable qualification. This delay is programmed by DELAY[2:0], as shown in Table 7.

**Table 7:**

**REGx/DELAY[ ] Turn-On Delay**

| DELAY[2] | DELAY[1] | DELAY[0] | TURN-ON DELAY |
|----------|----------|----------|---------------|
| 0        | 0        | 0        | 0 ms          |
| 0        | 0        | 1        | 2 ms          |
| 0        | 1        | 0        | 4 ms          |
| 0        | 1        | 1        | 8 ms          |
| 1        | 0        | 0        | 16 ms         |
| 1        | 0        | 1        | 32 ms         |
| 1        | 1        | 0        | 64 ms         |
| 1        | 1        | 1        | 128 ms        |

## Operating Mode

By default, REG1, REG2, and REG3 each operate in fixed-frequency PWM mode at medium to heavy loads, while automatically transitioning to a proprietary power-saving mode at light loads in order to maximize standby battery life. In applications where low noise is critical, force fixed-frequency PWM operation across the entire load current range, at the expense of light-load efficiency, by setting the MODE[ ] bit to 1.

## OK[ ] and Output Fault Interrupt

Each DC/DC features a power-OK status bit that can be read by the system microprocessor via the I<sup>2</sup>C

interface. If an output voltage is lower than the power-OK threshold, typically 7% below the programmed regulation voltage, that regulator's OK[ ] bit will be 0.

If a DC/DC's nFLTMSK[ ] bit is set to 1, the ACT8897 will interrupt the processor if that DC/DC's output voltage falls below the power-OK threshold. In this case, nIRQ will assert low and remain asserted until the OK[ ] bit has been read via I<sup>2</sup>C.

## PCB Layout Considerations

High switching frequencies and large peak currents make PC board layout an important part of step-down DC/DC converter design. A good design minimizes excessive EMI on the feedback paths and voltage gradients in the ground plane, both of which can result in instability or regulation errors.

Step-down DC/DCs exhibit discontinuous input current, so the input capacitors should be placed as close as possible to the IC, and avoiding the use of via if possible. The inductor, input filter capacitor, and output filter capacitor should be connected as close together as possible, with short, direct, and wide traces. The ground nodes for each regulator's power loop should be connected at a single point in a star-ground configuration, and this point should be connected to the backside ground plane with multiple via. The output node for each regulator should be connected to its corresponding OUTx pin through the shortest possible route, while keeping sufficient distance from switching nodes to prevent noise injection. Finally, the exposed pad should be directly connected to the backside ground plane using multiple via to achieve low electrical and thermal resistance.

**Table 8:**

**REGx/VSET[ ] Output Voltage Setting**

| REGx/VSET[2:0] | REGx/VSET[5:3] |       |       |       |       |       |       |       |
|----------------|----------------|-------|-------|-------|-------|-------|-------|-------|
|                | 000            | 001   | 010   | 011   | 100   | 101   | 110   | 111   |
| 000            | 0.600          | 0.800 | 1.000 | 1.200 | 1.600 | 2.000 | 2.400 | 3.200 |
| 001            | 0.625          | 0.825 | 1.025 | 1.250 | 1.650 | 2.050 | 2.500 | 3.300 |
| 010            | 0.650          | 0.850 | 1.050 | 1.300 | 1.700 | 2.100 | 2.600 | 3.400 |
| 011            | 0.675          | 0.875 | 1.075 | 1.350 | 1.750 | 2.150 | 2.700 | 3.500 |
| 100            | 0.700          | 0.900 | 1.100 | 1.400 | 1.800 | 2.200 | 2.800 | 3.600 |
| 101            | 0.725          | 0.925 | 1.125 | 1.450 | 1.850 | 2.250 | 2.900 | 3.700 |
| 110            | 0.750          | 0.950 | 1.150 | 1.500 | 1.900 | 2.300 | 3.000 | 3.800 |
| 111            | 0.775          | 0.975 | 1.175 | 1.550 | 1.950 | 2.350 | 3.100 | 3.900 |

## LOW-NOISE, LOW-DROPOUT LINEAR REGULATORS

### General Description

REG4, REG5, REG6, and REG7 are low-noise, low-dropout linear regulators (LDOs) that supply up to 150mA, 150mA, 250mA, and 250mA, respectively. Each LDO has been optimized to achieve low noise and high-PSRR, achieving more than 65dB PSRR at frequencies up to 10kHz.

### Output Current Limit

Each LDO contains current-limit circuitry featuring a current-limit fold-back function. During normal and moderate overload conditions, the regulators can support more than their rated output currents. During extreme overload conditions, however, the current limit is reduced by approximately 30%, reducing power dissipation within the IC.

### Compensation

The LDOs are internally compensated and require very little design effort, simply select input and output capacitors according to the guidelines below.

#### Input Capacitor Selection

Each LDO requires a small ceramic input capacitor to supply current to support fast transients at the input of the LDO. Bypassing each INL pin to GA with 1μF. High quality ceramic capacitors such as X7R and X5R dielectric types are strongly recommended.

#### Output Capacitor Selection

Each LDO requires a small ceramic output capacitor for stability. Capacitance value is 1.5μF for REG4 and REG5, 2.2μF for REG6 and REG7. For best performance, each output capacitor should be connected directly between the output and GA pins, as close to the output as possible, and with a short, direct connection. High quality ceramic capacitors such as X7R and X5R dielectric types are strongly recommended.

### Configuration Options

#### Output Voltage Programming

By default, each LDO powers up and regulates to its default output voltage. Once the system is enabled, each output voltage may be independently programmed to a different value by writing to the regulator's VSET[ ] register via the I<sup>2</sup>C serial interface as shown in Table 8.

#### Enable / Disable Control

During normal operation, each LDO may be enabled or disabled via the I<sup>2</sup>C interface by writing

to that LDO's ON[ ] bit. The regulator accept rising or falling edge of ON[ ] bit as on/off signal. To enable the regulator, clear ON[ ] to 0 first then set to 1. To disable the regulator, set ON[ ] to 1 first then clear it to 0.

#### REG4, REG5, REG6, REG7 Turn-on Delay

Each of REG4, REG5, REG6 and REG7 features a programmable Turn-on Delay which help ensure a reliable qualification. This delay is programmed by DELAY[2:0], as shown in Table 7.

#### Output Discharge

Each of the ACT8897's LDOs features an optional output discharge function, which discharges the output to ground through a 1.5kΩ resistance when the LDO is disabled. This feature may be enabled or disabled by setting DIS[ ] via; set DIS[ ] to 1 to enable this function, clear DIS[ ] to 0 to disable it.

#### Low-Power Mode

Each of ACT8897's LDOs features a LOWIQ[ ] bit which, when set to 1, reduces the LDO's quiescent current by about 16%, saving power and extending battery lifetime.

### OK[ ] and Output Fault Interrupt

Each LDO features a power-OK status bit that can be read by the system microprocessor via the interface. If an output voltage is lower than the power-OK threshold, typically 11% below the programmed regulation voltage, the value of that regulator's OK[ ] bit will be 0.

If a LDO's nFLTMSK[ ] bit is set to 1, the ACT8897 will interrupt the processor if that LDO's output voltage falls below the power-OK threshold. In this case, nIRQ will assert low and remain asserted until the OK[ ] bit has been read via I<sup>2</sup>C.

### PCB Layout Considerations

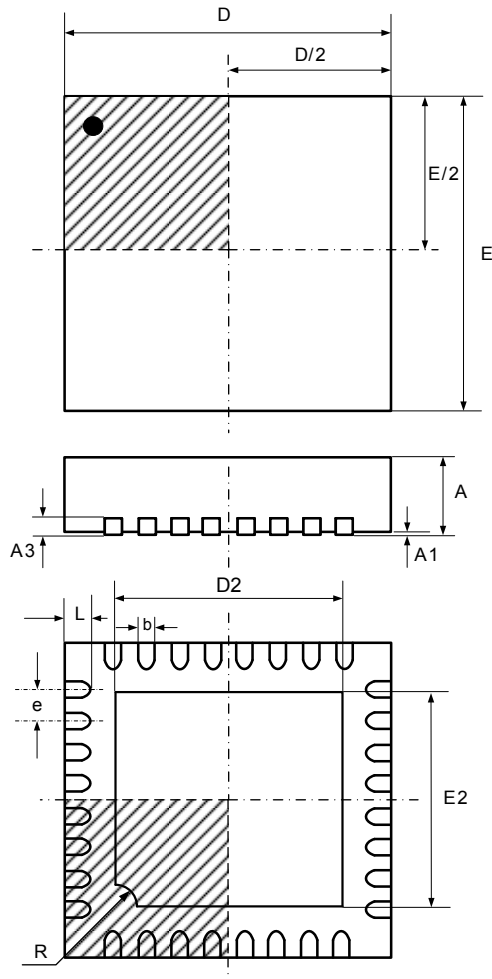
**PCB Layout Considerations** The ACT8897's LDOs provide good DC, AC, and noise performance over a wide range of operating conditions, and are relatively insensitive to layout considerations. When designing a PCB, however, careful layout is necessary to prevent other circuitry from degrading LDO performance.

A good design places input and output capacitors as close to the LDO inputs and output as possible, and utilizes a star-ground configuration for all regulators to prevent noise-coupling through ground. Output traces should be routed to avoid close proximity to noisy nodes, particularly the SW

nodes of the DC/DCs.

REFBP is a filtered reference noise, and internally has a direct connection to the linear regulator controller. Any noise injected onto REFBP will directly affect the outputs of the linear regulators, and therefore special care should be taken to ensure that no noise is injected to the outputs via REFBP. As with the LDO output capacitors, the REFBP bypass capacitor should be placed as close to the IC as possible, with short, direct connections to the star-ground. Avoid the use of via whenever possible. Noisy nodes, such as from the DC/DCs, should be routed as far away from REFBP as possible.

## TQFN44-32 PACKAGE OUTLINE AND DIMENSIONS



| SYMBOL | DIMENSION IN MILLIMETERS |       | DIMENSION IN INCHES |       |
|--------|--------------------------|-------|---------------------|-------|
|        | MIN                      | MAX   | MIN                 | MAX   |
| A      | 0.700                    | 0.800 | 0.028               | 0.031 |
| A1     | 0.000                    | 0.050 | 0.000               | 0.002 |
| A3     | 0.200                    |       | 0.008               |       |
| b      | 0.150                    | 0.250 | 0.006               | 0.010 |
| D      | 4.000 TYP                |       | 0.158 TYP           |       |
| E      | 4.000 TYP                |       | 0.158 TYP           |       |
| D2     | 2.550                    | 2.800 | 0.100               | 0.110 |
| E2     | 2.550                    | 2.800 | 0.100               | 0.110 |
| e      | 0.400 TYP                |       | 0.016 TYP           |       |
| L      | 0.250                    | 0.450 | 0.010               | 0.018 |
| R      | 0.250                    |       | 0.010               |       |

Active-Semi, Inc. reserves the right to modify the circuitry or specifications without notice. Users should evaluate each product to make sure that it is suitable for their applications. Active-Semi products are not intended or authorized for use as critical components in life-support devices or systems. Active-Semi, Inc. does not assume any liability arising out of the use of any product or circuit described in this datasheet, nor does it convey any patent license.

Active-Semi and its logo are trademarks of Active-Semi, Inc. For more information on this and other products, contact [sales@active-semi.com](mailto:sales@active-semi.com) or visit <http://www.active-semi.com>.

 is a registered trademark of Active-Semi.

# Mouser Electronics

Authorized Distributor

Click to View Pricing, Inventory, Delivery & Lifecycle Information:

[Active-Semi:](#)

[ACT8897Q4I11C-T](#)