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AS3683

1A Backlight and Camera LED Power Charge Pump

1 General Description

The AS3683 is a low-noise, high-current 1A charge pump designed for camera flash LEDs and LCD backlighting applications. The current sinks are capable of driving up to 960mA of load current.

The AS3683 integrates two independent current source blocks for driving a single flash LED (CURR11 to CURR13) with up to 480mA, and general purpose LEDs (CURR2 to CURR4) with up to 160mA/LED. The general purpose LEDs are controlled individually and can be used for backlighting, but also in support of an RGB fun-light or a movie indicator lamp. To meet high-flash current requirements (up to 960mA), both current source blocks can be connected together (CURR11 to CURR13 and CURR2 to CURR4).

The AS3683 utilizes austriamicrosystems' patent-pending Intelligent Adaptive Mode Setting (IAMS) to switch between 1:1, 1:1.5, and 1: 2 modes. In combination with very-low-drop-out current sinks, the device achieves high efficiency over the full single-cell Li+ battery voltage range. The charge pump operates at a fixed frequency of 1MHz allowing for tiny external components and its design ensures low EMI and low input-ripple.

The ultra-flexible brightness control scheme allows for simple adaptation of the device to different system architectures.

In Soft Flash Mode the device is controlled by an I²C interface. In these modes the LED brightness, flash duration, GPIOs and various charge pump states are controlled by internal register settings. The GPIO pins can act as programmable input or output pins and can also be set to trigger preview and flash light directly by a camera module.

In Hard Flash Mode the LED brightness is controlled by the Enable pins. These programming pins can be used as simple enable pins, or as PWM input, again offering ample flexibility for setting the LED brightness.

The AS3683 is available in a 24-pin QFN package.

2 Key Features

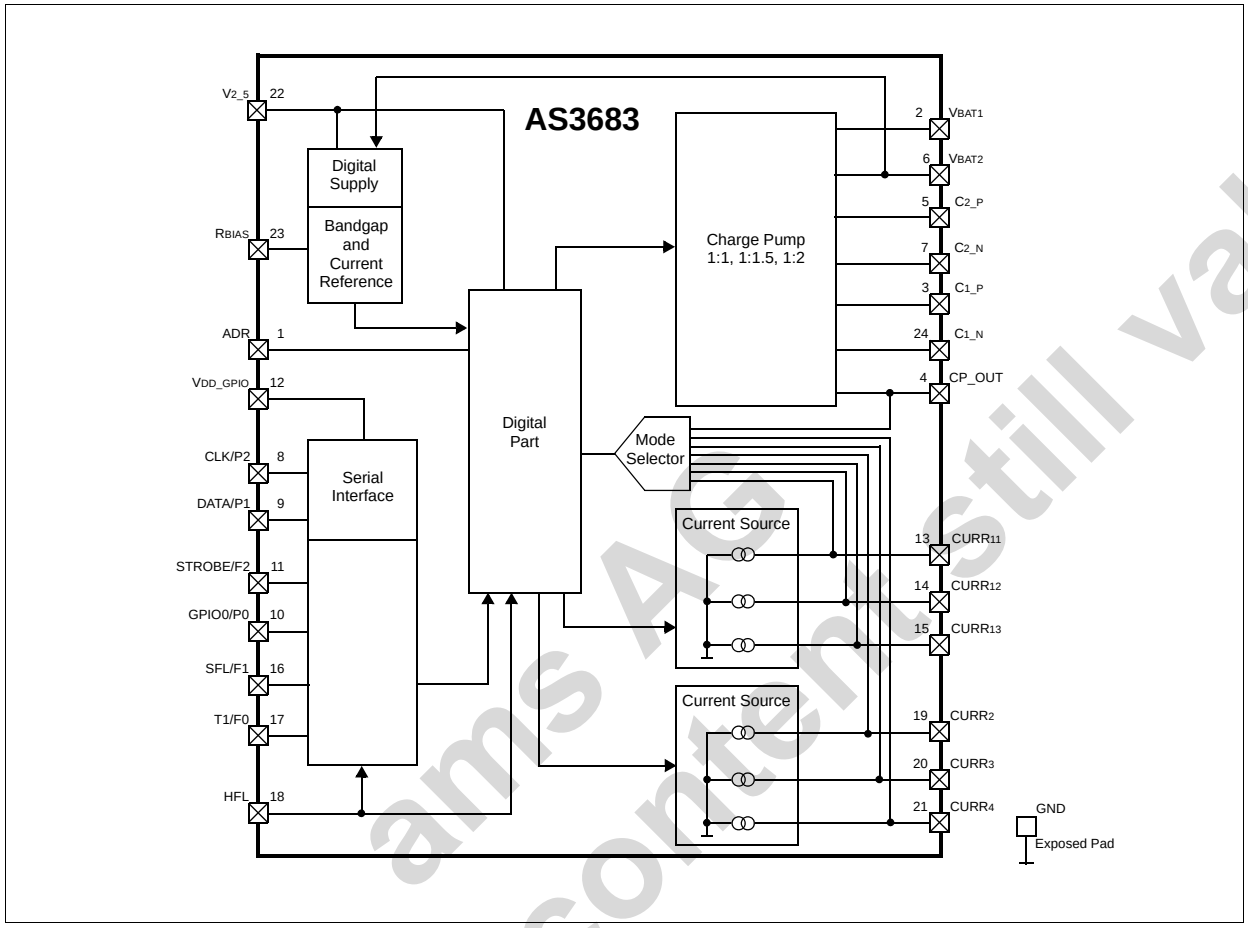
- High-Power 1A Charge Pump
  - 1:1, 1:1.5, and 1:2 Intelligent Adaptive Mode Setting (IAMS)
  - Efficiency up to 95%
  - Soft Start to Reduce Inrush Current
  - Low-Noise Constant-Frequency Operation
- Current Sinks
  - 400mA Continuous Current (@V_{IN} = 3.2 to 5V, V_{OUT} = 5V)
  - Up to 960mA Pulsed Flash Current
  - Programmable: 0 to 160mA, 0.625mA Resolution
- Flexible Brightness Control
  - Three 0 to 160mA LEDs
  - Individually Addressable via I²C Interface
- 2 Operating Modes
  - Soft Flash Mode (I²C Interface)
  - Hard Flash Mode (Dedicated Control Pins)
- 2 General Purpose Inputs/Outputs in Soft Flash Mode
  - Digital Input, Output, and Tristate
  - Programmable Pull-Up and Pull-Down
  - Strobe Pin can be used for Camera Flash Control
- LED Disconnect in Shutdown
- Open LED Detection
- Low Stand-By Current (6µA), Interface Fully Operating
- Low Shut-Down Current (0.2µA)
- Wide Battery Supply Range: 3.0 to 5.5V
- Thermal Protection
- 24-Pin, Small Form-Factor QFN Package
  - 4 x 4 x 0.85mm, 0.5mm Pitch
  - Enhanced Thermal Characteristics

3 Application

Lighting management for cameras, mobile telephones, PDAs, and other 1-cell Li+ or 3-cell NiMH powered devices.

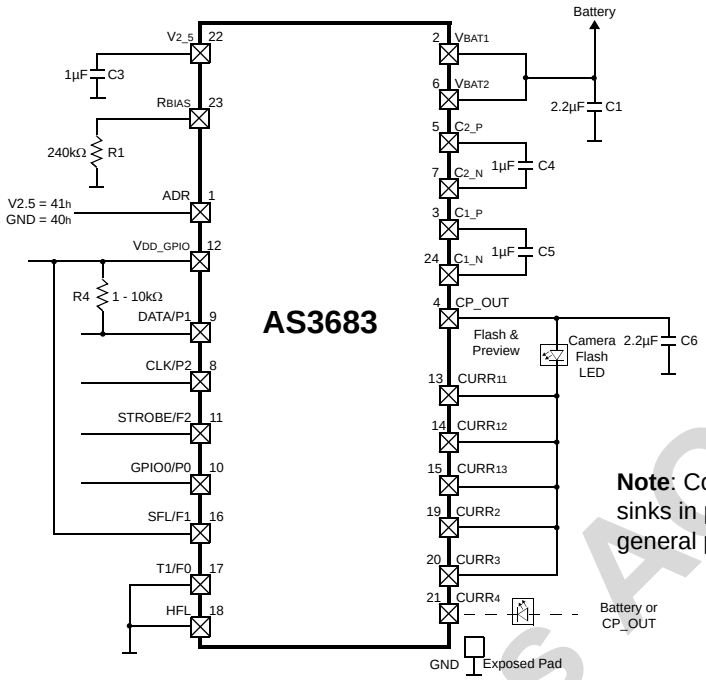
4 Block Diagram

Figure 1. AS3683 Block Diagram



5 Application Diagrams

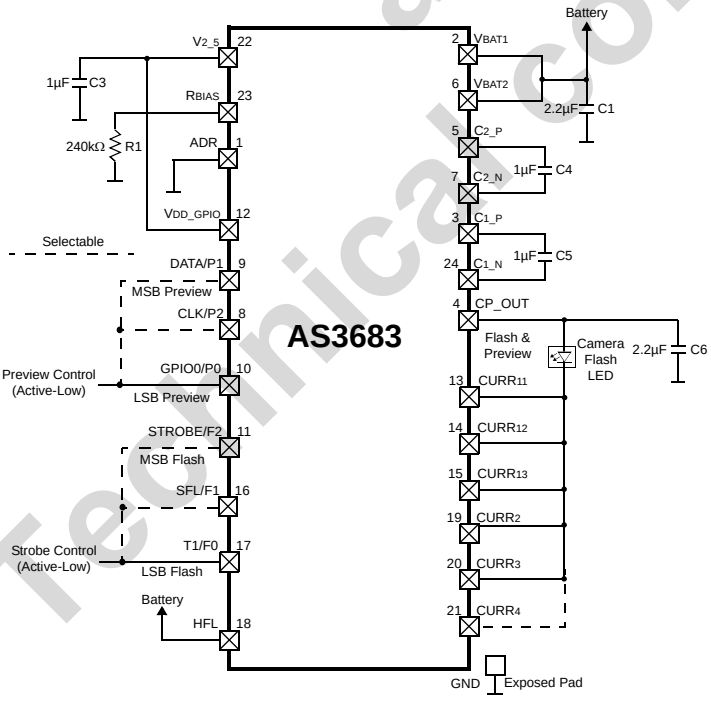
Figure 2. Soft Flash Mode Application Diagram



Feature		Soft Flash Mode
Interface		I²C
Flash LEDs	Current Sinks	3 to 6
	Total Current	0 to 960mA
	Addressable	Block
	Strobe Trigger	Pin STROBE/F2 or software
	Strobe Preview	Pin GPIO0/P0 or software
General Purpose LEDs (CURR2, CURR3, CURR4)	Current Sinks	3
	Current per Sink	0 to 160mA
	Addressable	Individually

Note: Connect all 6 current sinks in parallel or use general purpose current sink

Figure 3. Hard Flash Mode Application Diagram



Feature		Hard Flash Mode
Interface		Dedicated Control Pins for Strobe (3x) & Preview (3x)
Flash LEDs	Current Sinks	6
	Total Current	Strobe: 0 to 900mA Preview: 0 to 480mA
	Addressable	Block
	Strobe Trigger	By Strobe Control Pins
	Strobe Preview	By Preview Control Pins
General Purpose LEDs (CURR2, CURR3, CURR4)	Current Sinks	N/A
	Current per Sink	N/A
	Addressable	N/A

Contents

6 Characteristics

6.1 Absolute Maximum Ratings (Non-Operating)

Stresses beyond those listed in Table 1 may cause permanent damage to the device. These are stress ratings only, and functional operation of the device beyond those indicated in Section 6.2 is not implied.

Caution: Exposure to absolute maximum rating conditions may affect device reliability.

Table 1. Absolute Maximum Ratings

Symbol	Parameter	Min	Max	Unit	Note
V_{IN_MV}	5V Pins	-0.3	7.0	V	Applicable for 5V pins 1
V_{IN_LV}	3.3V Pins	-0.3	5.0, V_{DD_GPIO} + 0.3	V	Applicable for 3.3V pins 2
I_{IN}	Input Pin Current	-25	+25	mA	At 25ºC, Norm: *Jedec 17*
T_{STRG}	Storage Temperature Range	-55	125	ºC	
	Humidity	5	85	%	Non condensing
V_{ESD}	Electrostatic Discharge	-1000	1000	V	Norm: MIL 883 E Method 3015
PT	Total Power Dissipation		1	W	T_{AMB} = 70º
			2		T_{AMB} = 70º, max 800ms
			4		T_{AMB} = 70º, max 400ms
T_{BODY}	Body Temperature		260	º	*IPC/JEDEC J-STD-020C*

Notes:

1. 5V pins are V_{BAT1}, V_{BAT2}, HFL, current sink pins ($CURR_{11}$, $CURR_{12}$, $CURR_{13}$, $CURR_2$, $CURR_3$, and $CURR_4$) and the charge pump pins (C_{1_N}, C_{2_N}, C_{1_P}, C_{2_P}, and CP_OUT).
2. 3.3V pins are GPIO0/P0, STROBE/F2, interface pins (CLK/P2, DATA/P1, ADR) and all other pins.

6.2 Operating Conditions

Table 2. Operating Conditions

Symbol	Parameter	Min	Typ	Max	Unit	Note
V_{BAT}	Battery Voltage	3.0	3.6	5.5	V	V_{BAT1} and V_{BAT2}
V_{DD_GPIO}	Periphery Supply Voltage	1.5		3.3	V	
V_{2_5}	Voltage on Pin V_{2_5}	2.4	2.5	2.6	V	Internally generated; Hard Flash Mode: always on; Soft Flash Mode: always on except in shutdown.
T_{AMB}	Ambient Temperature	-30	25	85	ºC	
I_{BAT}	Operating Current			1	A	Depending on load current and charge pump mode.
				2		Limited lifetime, max 20,000s
$I_{STANDBY}$	Standby Mode Current		6	10.5	µA	Current consumption in standby mode; Only 2.5V regulator on; temperature supervision off. V_{DD_GPIO} (page 7) > $V_{GPIO\_Vdd\_TH\_RISING}$ (page 7).
	Standby Mode Current including Temperature Supervision		8	14.5	µA	Current consumption in standby mode; Only 2.5V regulator on and temperature supervision on. V_{DD_GPIO} > $V_{GPIO\_Vdd\_TH\_RISING}$. This is also the minimum current consumption in Hard Flash Mode.
$I_{SHUTDOWN}$	Shutdown Mode Current		0.2	1.5	µA	Current consumption in shutdown mode. V_{DD_GPIO} < 0.3V.

6.3 Electrical Characteristics

Table 3. Charge Pump Electrical Characteristics

Symbol	Parameter	Min	Typ	Max	Unit	Note
V_{CPOUT}	Output Voltage Without Load			V_{BAT} x CP-mode	V	
	Output Limitation		5.3	5.6	V	Internally regulated.
	Output Voltage With Load (I = 400mA)		3.32			1:1 Mode; V_{BAT} = 3.5V
			4.31			1:1.5 Mode; V_{BAT} = 3.5V
			5.24			1:2 Mode; V_{BAT} = 3.5V
R_{CP}	Charge Pump Effective Resistance			1.0	Ω	1:1 Mode; V_{BAT} = 3.2V, I_{LOAD} = 100mA, V_{LOAD} = 2.83V
				3.5		1:1.5 Mode; V_{BAT} = 3.3V, I_{LOAD} = 400mA, V_{LOAD} = 3.32V
				3.5		1:2 Mode; V_{BAT} = 3.3V, I_{LOAD} = 960mA, V_{LOAD} = 3.74V
I_{CPOUT}	Continuous Output Current			400	mA	In automatic mode (see bit **cp_man** (page 21)) only; $V_{BAT} \leq 4.2V$
	Pulsed Output Current [1]			1000	mA	$t_{ON} \leq 400ms$, $t_{OFF} \geq 2s$, automatic mode, total t_{ON} lifetime max 20,000s.
I_{CP}	Power Consumption Without Load, F_{CLK} = 1 MHz		0.1		mA	1:1 mode
			4.5			1:1.5 mode
			5			1:2 mode
Eta_1	Efficiency1 [2]	75		93	%	V_{IN} = 3.0 to 4.5V, I_{OUT} = 100mA
Eta_2	Efficiency2 [2]	65		82	%	V_{IN} = 3.0 to 4.5V, I_{OUT} = 10 to 350mA
t_R	Rising Time			1.0	ms	
V_{ORIP}	Output Ripple		10		mVpp	V_{IN} = 3.0 to 4.5V, I_{OUT} = 350mA, C_P = 2.2uF, X5R
f_{CLK}	Clock Frequency	-20%	1.0	20%	MHz	

Notes:

1. See the austriamicrosystems *Temperature Characteristic QFN4x4 AS3682/83/83B Application Note.* Actual lifetime tests are performed with t_{ON} = 500ms and t_{OFF} = 500ms. Only the sum of the tON time limits the total lifetime.
2. This parameter describes the efficiency of the charge pump only.

Table 4. Current Sink Electrical Characteristics

Symbol	Parameter	Min	Typ	Max	Unit	Note
$I_{CURR1x-MAX}$	$CURR_{1x}$ Maximum Output Current		160		mA	Soft Flash Mode
			150			Hard Flash Mode
$I_{CURR1x-RES}$	$CURR_{1x}$ Resolution		0.625		mA	Soft Flash Mode
			20			Hard Flash Mode
$I_{CURR2,3,4-MAX}$	$CURR_{2,3,4}$ Maximum Output Current		160		mA	Soft Flash Mode
			150			Hard Flash Mode
$I_{CURR2,3,4-RES}$	$CURR_{2,3,4}$ Resolution		0.625		mA	Soft Flash Mode
			20			Hard Flash Mode
Delta-abs	Absolute Accuracy	-20		+20	%	All current sinks
Delta-rel	Relative Accuracy		5		%	
$V_{PROTECT}$	Voltage Above V_{BAT} for Protection			V_{BAT} + 2.0	V	$I_{SINK} \geq 20mA$
V_{COMPL}	Voltage Compliance	0.2		V_{BAT} + 0.5	V	During normal operation
$V_{\_LOW}$	Under-Voltage Detection	50	150	200	mV	

Table 5. GPIO0/P0 and STROBE/F2 Electrical Characteristics

Symbol	Parameter	Min	Max	Unit	Notes
V_{DD_GPIO}	Supply Voltage	1.5	3.3	V	
V_{IH}	High Level Input Voltage	0.7 x V_{DD_GPIO}	V_{DD_GPIO}	V	V_{DD_GPIO} > 1.85V
		1.3V			V_{DD_GPIO} < 1.85V
V_{IL}	Low Level Input Voltage	0.0	0.3 x V_{DD_GPIO}	V	
V_{HYS}	Hysteresis	0.1 x V_{DD_GPIO}	0.4	V	
I_{LEAK}	Input Leakage Current (if not configured as Pullup/Pulldown)	-5	5	µA	To V_{DD_GPIO} and V_{SS}.
I_{PD}	Pulldown Current (if configured as Pulldown)	50	150	µA	To V_{SS}.
I_{PU}	Pullup Current (if configured as Pullup and in Hard Flash Mode)	20	347	µA	To V_{DD_GPIO} (1.5 to 3.3V)
V_{OH}	High Level Output Voltage	0.8 x V_{DD_GPIO}		V	500µA load
V_{OL}	Low Level Output Voltage		0.2 x V_{DD_GPIO}	V	500µA load
I_{OUT}	Driving Capability	4		mA	V_{DD_GPIO} = 2.8V
C_L	Capacitive Load		50	pF	

Table 6. CLK/P2, DATA/P1, SFL/F1, and T1/F0 Electrical Characteristics

Symbol	Parameter	Min	Max	Unit	Notes
V_{DD_GPIO}	Supply Voltage	1.5	3.3	V	
V_{IH}	High Level Input Voltage	0.7 x V_{DD_GPIO}	V_{DD_GPIO}	V	V_{DD_GPIO} > 1.85V
		1.3V			V_{DD_GPIO} < 1.85V
V_{IL}	Low Level Input Voltage	0.0	0.3 x V_{DD_GPIO}	V	
V_{HYS}	Hysteresis	0.07 x V_{DD_GPIO}	0.5	V	
I_{LEAK}	Input Leakage Current (in Soft Flash Mode)	-5	5	µA	To V_{DD_GPIO} and V_{SS}.
R_{PU}	Pullup Resistor (in Hard Flash Mode)	50k	200k	Ω	To V_{DD_GPIO}.

Table 7. Power-On Reset Electrical Characteristics

Symbol	Parameter	Min	Typ	Max	Unit	Notes
V_{POR_VBAT}	Overall Power-On Reset	1.5	2.0	2.38	V	Monitors voltage on pin V_{2_5}; power-on reset for all internal functions.
$V_{VDD\_GPIO\_TH\_RISING}$	Reset Level for V_{DD_GPIO} Rising		1.3		V	Monitors voltage on V_{DD_GPIO}; rising level.
$V_{VDD\_GPIO\_TH\_FALLING}$	Reset Level for V_{DD_GPIO} Falling		1.0		V	Monitors voltage on V_{DD_GPIO}; falling level.

Table 8. Over-Temperature Detection Electrical Characteristics

Symbol	Parameter	Min	Typ	Max	Unit	Notes
T_{140}	ov_temp Rising Threshold	130	140	150	ºC	
T_{HYST}	ov_temp Hysteresis		5		ºC	

7 Typical Operation Characteristics

Figure 4. Efficiency vs. VBAT (with 1 Flash LED, Type: Osram LWW5SG)

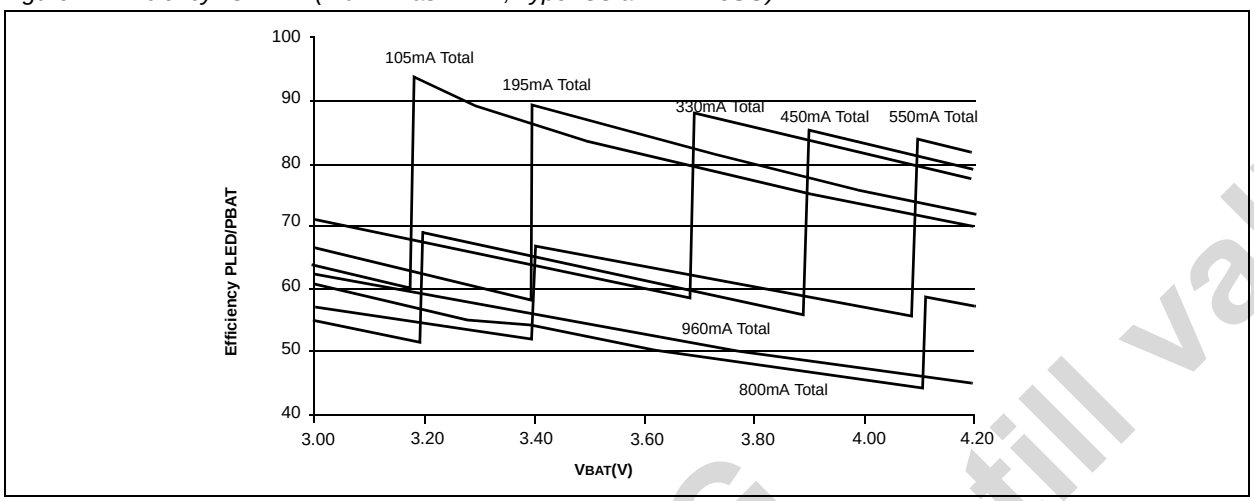


Figure 5. Battery Current vs. VBAT (with 1 Flash LED, Type: Osram LWW5SG)

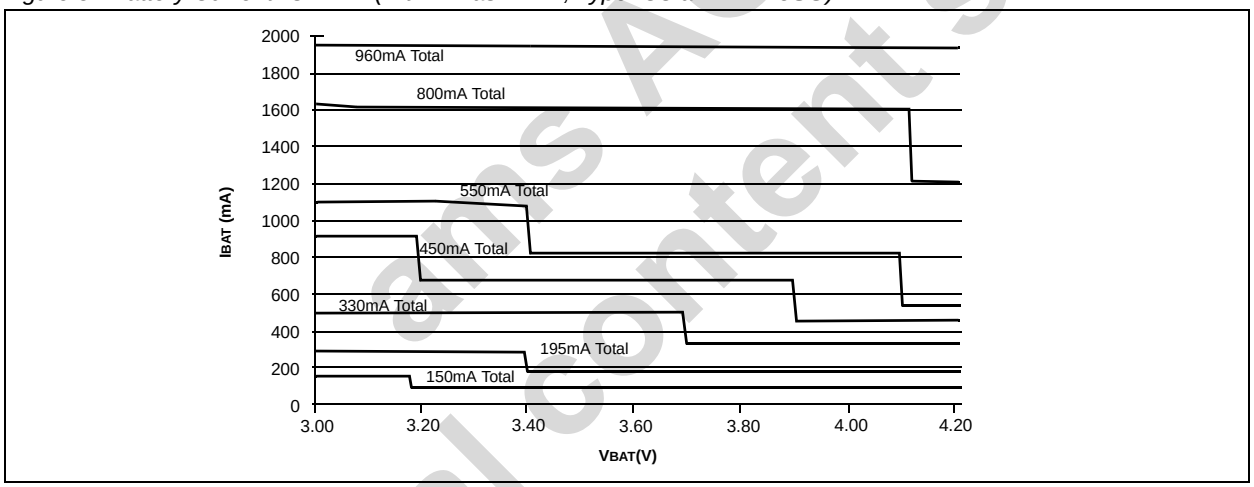


Figure 6. Linearity of 1 Current Sink with 10mA and 100mA Load

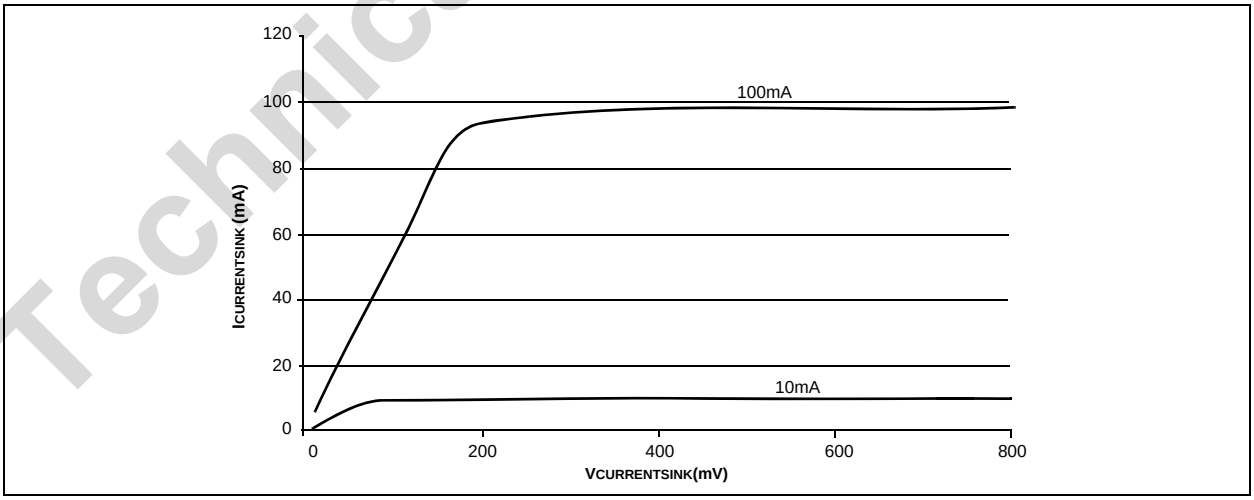
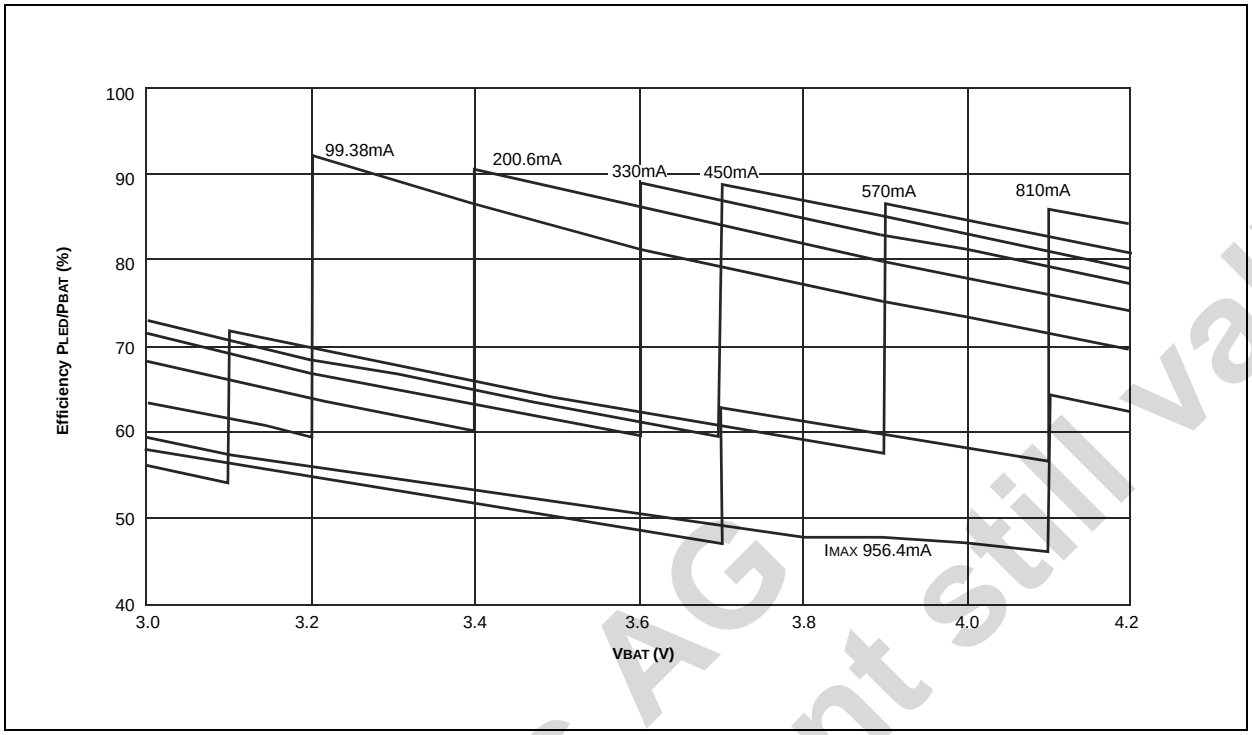


Figure 7. Charge Pump Efficiency using Lumiled PWM1



8 Detailed Functional Description

8.1 Charge Pump

The AS3683 charge pump uses two external flying capacitors to generate output voltages higher than the battery voltage.

The charge pump can operate in three different modes:

- 1:1 Bypass Mode
  - Battery input and output are connected by a low-impedance switch
  - Battery current = output current
- 1:1.5 Mode
  - The output voltage is 1.5 times the battery voltage (without load)
  - Battery current = 1.5 times output current
- 1:2 Mode
  - The output voltage is 2 times the battery voltage (without load)
  - Battery current = 2 times output current

8.1.1 Intelligent Adaptive Mode Switching (IAMS)

The integrated charge pump determines the best compromise between the required LED supply voltage (V_f) and the lowest internal power dissipation. The AS3683 examines the voltage at each current sink and automatically switches into a higher charge pump mode; the switch-down procedure is achieved after the AS3683 performs analog signal processing of all relevant parameters: the battery voltage, the actual charge pump voltage, the load current, and the resistance of the next charge pump mode. By predicting the efficiency of the next state, the AS3683 will accurately determine the switching point.

8.1.2 Soft Start

An implemented soft start mechanism reduces the inrush current. Battery current is smoothed when switching the charge pump on and also at each switching condition. This precaution reduces electromagnetic radiation significantly.

8.1.3 Open LED Detection

The voltages at the current sinks are used to determine the mode switching of the charge pump up, thus an open wire to the LED could lead to a to high-power dissipation of the circuit.

The AS3683 scans and compares all voltages on the current sinks continuously, so that if the charge pump is already at 1:2 mode and the required current cannot be provided, the circuit stops that current sink sensing until the next power-on condition. Using the circuit via the I^2C interface (Soft Flash Mode) the system can get information on the failing path from the **GPIO_output** (page 22) register.

Scanning occurs automatically upon first entering 1:2 mode.

9 Mode Settings

The AS3683 can be operated in two different application modes which can be easily selected by external pins.

- **Soft Flash Mode** – The AS3683 is fully programmable via an I²C interface allowing for access to all control registers. The maximum total Flash Current of 960mA can be set in 1.875mA steps. Preview and strobe timing can be controlled either by internal registers or by dedicated pins (STROBE/F2, GPIO0/P0) connected to the BB or a Camera Module. The 3 Flash LED current sinks can only be addressed as a single block.

  The three General Purpose LED current sinks can be addressed individually allowing for the realization of Back-lighting, Movie Indicator LEDs or an RGB Fun Light or can be connected to the Flash LED. The maximum current per sink is 160mA, and the current can be set in 2.5mA steps per channel.
- **Hard Flash Mode** – All AS3683 functions are controlled by dedicated Enable Pins. Seven different current levels can be set independently for Preview and Flash by the Preview pins (GPIO0/P0, DATA/P1, CLK/P2) and the Flash pins (T1/F0, SFL/F1, STROBE/F2). The maximum total current is 900mA for Strobe and 480mA for Preview when connecting six current sinks to the LED.

Table 9. AS3683 Function Settings

Feature		Soft Flash Mode	Hard Flash Mode
Interface		I²C	Dedicated Control Pins for Strobe (3x) and Preview (3x)
Flash LEDs	Current Sinks	3 to 6	6
	Total Current	0 to 960mA	Strobe: 0 to 900mA Preview: 0 to 480mA
	Addressable	Block	Block
	Strobe Trigger	GPIO pin or software	By Strobe Control Pins
	Strobe Preview	GPIO pin or software	By Preview Control Pins
General Purpose LEDs ($CURR_2$, $CURR_3$, $CURR_4$)	Current Sinks	3	N/A
	Current per Sink	0 to 160mA	N/A
	Addressable	Individual	N/A

Note: The AS3683 has been designed and qualified for the following operating conditions:
- Continuous output current of 400mA if operated in automatic mode (see bit **cp_man** (page 21)) at $V_{BAT} \leq 4.2V$.
- Maximum pulsed output current: 960mA.

10 Hard Flash Mode

Hard Flash Mode allows for simple and efficient control of the AS3683 using dedicated Enable Pins. Hard Flash Mode can be selected by defined pin connections (see Table 10 Hard Flash Mode Setting by Pin Configuration). Hard Flash Mode allows for individual control of Strobe and Preview signals as in Flash and Torch engaging all six current sinks.

An integrated temperature sensor provides over-temperature protection for the AS3683. If the device temperature exceeds the value of T_{140} (page 7), the current sources will be switched off. The device will resume operation when the temperature drops below T_{140} - T_{HYST} (page 7).

Note: In Hard Flash Mode, pins STROBE/F2, SFL/F1, T1/F0, CLK/P2, DATA/P1, and GPIO0/P0 are active-low (with internal pull-up resistors).

Table 10. Hard Flash Mode Setting by Pin Configuration

Pin HFL	Pin SFL/F1	Mode
GND	V_{DD_GPIO}	Soft Flash Mode
V_{BAT}	Don't Care	Hard Flash Mode

Table 11. Hard Flash Mode Functions

Feature		Hard Flash Mode
Interface		Dedicated Control Pins for Strobe (3x) and Preview (3x)
Flash LEDs	Current Sinks	6
	Total Current	Strobe: 0 to 900mA; Preview: 0 to 480mA
	Total Current Resolution	Strobe: 60mA; Preview: 30mA
	Addressable	Block
	Strobe Trigger	By Strobe Control Pins
	Strobe Preview	By Preview Control Pins
General Purpose LEDs ($CURR_2$, $CURR_3$, $CURR_4$)	Current Sinks	N/A
	Current per Sink	N/A
	Addressable	N/A

Figure 8. Hard Flash Mode Functional Diagram

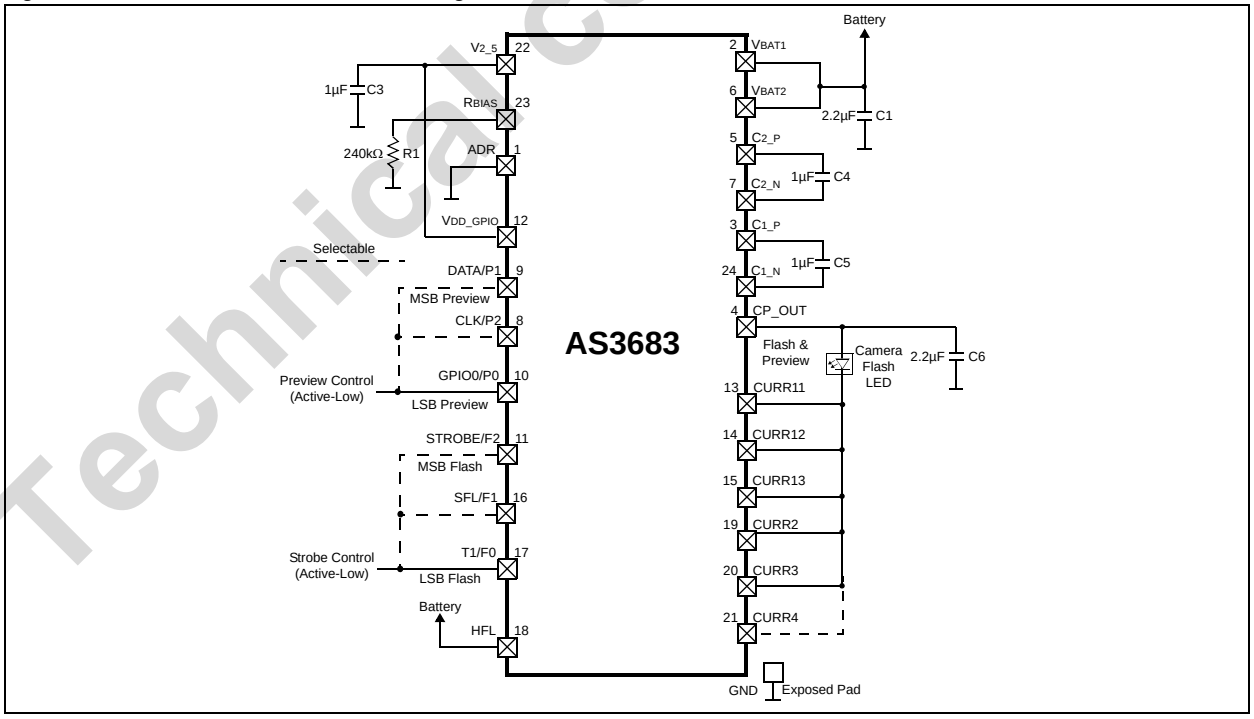


Figure 9. Hard Flash Mode Timing Diagram

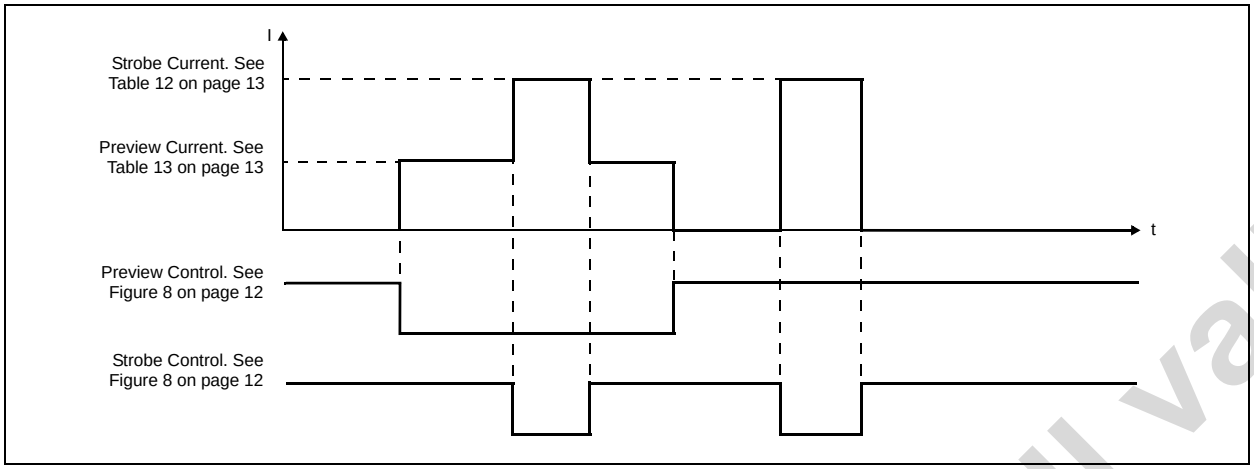


Table 12. Hard Flash Mode Strobe Current

STROBE/ F2 Bit 2	SFL/F1 Bit 1	T1/F0 Bit 0	Current/ Current Sink	Cumulative Active Current Sink					
				CURR11	CURR12	CURR13	CURR2	CURR3	CURR4
1	1	1	0mA	0mA	0mA	0mA	0mA	0mA	0mA
1	1	0	30mA	30mA	60mA	90mA	120mA	150mA	180mA
1	0	1	50mA	50mA	100mA	150mA	200mA	250mA	300mA
1	0	0	70mA	70mA	140mA	210mA	280mA	350mA	420mA
0	1	1	90mA	90mA	180mA	270mA	360mA	450mA	540mA
0	1	0	110mA	110mA	220mA	330mA	440mA	550mA	660mA
0	0	1	130mA	130mA	260mA	390mA	520mA	650mA	780mA
0	0	0	150mA	150mA	300mA	450mA	600mA	750mA	900mA

Table 13. Hard Flash Mode Preview Current

CLK/P2 Bit 2	DATA/P1 Bit 1	GPIO0/P0 Bit 0	Current/ Current Sink	Cumulative Active Current Sink					
				CURR11	CURR12	CURR13	CURR2	CURR3	CURR4
1	1	1	0mA	0mA	0mA	0mA	0mA	0mA	0mA
1	1	0	20mA	20mA	40mA	60mA	80mA	100mA	120mA
1	0	1	30mA	30mA	60mA	90mA	120mA	150mA	180mA
1	0	0	40mA	40mA	80mA	120mA	160mA	200mA	240mA
0	1	1	50mA	50mA	100mA	150mA	200mA	250mA	300mA
0	1	0	60mA	60mA	120mA	180mA	240mA	300mA	360mA
0	0	1	70mA	70mA	140mA	210mA	280mA	350mA	420mA
0	0	0	80mA	80mA	160mA	240mA	320mA	400mA	480mA

Note: Do not exceed maximum current of 400mA continuous operation.

The AS3683 allows for the parallel connection of up to six current sinks to obtain the desired current range (unused current sinks can be left open). For example, to obtain 280mA for Preview current, connect CURR11, CURR12, CURR13, and CURR2 together and set CLK/P2 and DATA/P1 = 0 and GPIO0/P0 = 1.

11 Soft Flash Mode

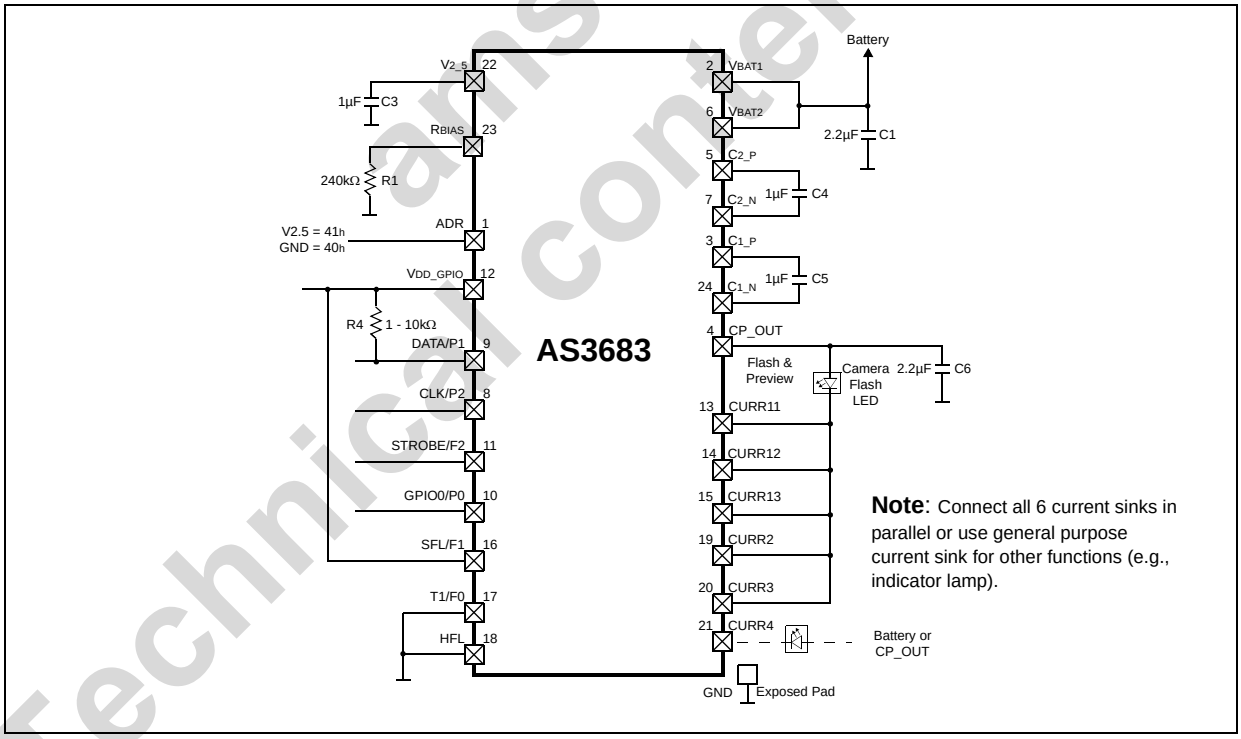
Table 14. Soft Flash Mode Settings

Pin HFL	Pin SFL/F1	Mode
GND	VDD_GPIO	Soft Flash Mode
VBAT	Do not Care	Hard Flash Mode

Table 15. Soft Flash Mode Functions

Feature		Soft Flash Mode
Interface		I2C
Flash LEDs	Current Sinks	3 to 6
	Total Current	0 to 960mA
	Total Current Resolution	8-Bit: 1.875mA
	Addressable	Block
	Strobe Trigger	Pin STROBE/F2 (active-low) or software
	Strobe Preview	Pin GPIO0/P0 (active-low) or software
General Purpose LEDs (CURR2, CURR3, CURR4)	Current Sinks	3
	Current per Sink	0 to 160mA
	Current Resolution per Sink	8-Bit: 0.625mA
	Addressable	Individual

Figure 10. Soft Flash Mode Functional Diagram



11.1 Current Settings

Table 16. Current Sink_1x Preview Current Definition Register

Addr: 01		Current1_preview		
		This register sets the current values of the current sinks CURR1x used during Preview.		
Bit	**Bit Name**	**Default**	**Access**	**Description**
7:0	current1_preview	0	R/W	00h = 0mA FFh = 160mA per current sink

Table 17. Current Sink_1x Strobe Current Definition Register

Addr: 02		Current1_strobe		
		This register sets the current values of the current sinks CURR1x used during Strobe.		
Bit	**Bit Name**	**Default**	**Access**	**Description**
7:0	current1_strobe	0	R/W	00h = 0mA FFh = 160mA per current sink

Table 18. Current Sink_2 Control Register

Addr: 06		Current2		
		This register sets the current values of current sink CURR2. Any value ≠ 0 activates the sink.. Exceptions are **Curr234_gpio0_ctrl** (page 20) and **Curr234_strobe_ctrl** (page 20).		
Bit	**Bit Name**	**Default**	**Access**	**Description**
7:0	current2	0	R/W	00h = 0mA FFh =160mA

Table 19. Current Sink_3 Control Register

Addr: 07		Current3		
		This register sets the current values of current sink CURR3. Any value ≠ 0 activates the sink.. Exceptions are **Curr234_gpio0_ctrl** (page 20) and **Curr234_strobe_ctrl** (page 20).		
Bit	**Bit Name**	**Default**	**Access**	**Description**
7:0	current3	0	R/W	00h = 0mA FFh = 160mA

Table 20. Current Sink_4 Control Register

Addr: 08		Current4		
		This register sets the current values of current sink CURR4. Any value ≠ 0 activates the sink.. Exceptions are **Curr234_gpio0_ctrl** (page 20) and **Curr234_strobe_ctrl** (page 20).		
Bit	**Bit Name**	**Default**	**Access**	**Description**
7:0	current4	0	R/W	00h = 0mA FFh = 160mA

11.2 Timing Control of CURR11, CURR12, CURR13 in Soft Flash Mode

Connecting the Current Sinks

The load of current sinks CURR11, CURR12, and CURR13 must be connected to the charge pump output (CP_OUT).

Setting the Current Values

Current sinks CURR11, CURR12, and CURR13 are all programmed by the same register settings (registers **Current1_preview** (page 15) and **Current1_strobe** (page 15)). They should be connected in parallel (pins CURR11, CURR12, and CURR13 must be connected externally) to increase the driving capability, e.g., for a photo camera flash LED.

The current defined in these registers (**Current1_preview** and **Current1_strobe**) is the total current, which means each current sink contributes one-third of the preset current value.

Turning the Current Sinks On/Off in Preview Mode

The current sinks in preview mode are controlled programmatically by bit **preview_on** (page 17) or by pin GPIO0/P0. Bit **preview_on** defines which sink is selected.

Turning the Current Sinks On/Off in Strobe Mode

The current sinks in strobe mode are controlled by pin STROBE/F2. This signal is called STROBE_SIGNAL. The duration of the strobe current is dependent on the following parameters:

- In Mode 1 (selected by bit **Strobe_mode** (page 17)) the strobe current is started by the rising edge of the STROBE_SIGNAL. The duration of the strobe current is defined by the value in register **Strobe_mode1** (page 17) only.
  The minimum duration of the strobe current is 100ms, the maximum is 800ms.
- In Mode 2 (selected by bit **Strobe_mode** (page 17)) the strobe current is started by the rising edge of the STROBE_SIGNAL. The duration of the strobe current is dependent on the length of the STROBE_SIGNAL and the value in register **Strobe_mode2** (page 18).
  If register **Strobe_mode2** setting = 000 to 111, strobe current stops with the falling edge of STROBE_SIGNAL but is limited to the value defined in the register (100ms to 800ms).
- In Mode 3 (selected by bit **Strobe_mode** (page 17)) the strobe current is started by the rising edge of the STROBE_SIGNAL and it stops with the falling edge of the STROBE_SIGNAL. In Mode 3 there is no limitation of the strobe time.

Table 21. Current Sink_1x Control Register

Addr: 00		**Powerdown_control**		
		This register switches the charge pump and current sinks 1x on and off.		
Bit	**Bit Name**	**Default**	**Access**	**Description**
0	cp_led_on			See **cp_led_on** (page 21).
1	curr11_on	0	R/W	$CURR_{11}$ enable/disable signal. 0 = Switch $CURR_{11}$ off. 1 = Switch $CURR_{11}$ on.
2	curr12_on	0	R/W	$CURR_{12}$ enable/disable signal. 0 = Switch $CURR_{12}$ off. 1 = Switch $CURR_{12}$ on.
3	curr13_on	0	R/W	$CURR_{13}$ enable/disable signal. 0 = Switch $CURR_{13}$ off. 1 = Switch $CURR_{13}$ on.
7:4	N/A			

Table 22. Current Sink_1x Mode and Control Registers

Addr: 03		Current1_control		
		This register controls the function of the current sinks.		
Bit	**Bit Name**	**Default**	**Access**	**Description**
1:0	Strobe_mode	01b	R/W	00 = Strobe mode 1 is selected. The strobe time is defined by the value in register **Strobe_mode1** (page 17) the maximum strobe time is limited to 800ms. 01 = Strobe mode 2 is selected. The strobe time is defined by the pulse length of the STROBE_SIGNAL and in addition it is affected by the setting of register **Strobe_mode2** (page 18). 1x = Strobe mode 3 is selected. The strobe time is defined by the pulse length of STROBE_SIGNAL. The maximum strobe time is unlimited.
3:2	N/A			
4	preview_on	0	R/W	0 = Current of current sinks is 0mA. 1 = Current of current sinks is defined by register **Current1_preview** (page 15). If preview is controlled via pin GPIO0/P0 (see bit **preview_ctrl**), this bit has no effect.
5	preview_ctrl	0	R/W	0 = Preview mode is controlled by bit **preview_on**. 1 = Preview mode is controlled by pin GPIO0/P0.
6	strobe_on	0	R/W	0 = Current of current sinks is 0mA. 1 = Current of current sinks is defined by register **Current1_strobe** (page 15). If preview mode is controlled via pin STROBE/F2 (see bit **xstrobe_ctrl**), this bit has no effect
7	xstrobe_ctrl	0	R/W	0 = Strobe mode is controlled by pin STROBE/F2. 1 = Strobe mode is controlled by bit **strobe_on**.

Addr: 04		Strobe_mode1		
		This register sets the strobe time in mode 1.		
Bit	**Bit Name**	**Default**	**Access**	**Description**
2:0	Strobe_mode	001b	R/W	000 = Ts is equal to 100ms. 001 = Ts is equal to 200ms. 010 = Ts is equal to 300ms. 011 = Ts is equal to 400ms. 100 = Ts is equal to 500ms. 101 = Ts is equal to 600ms. 110 = Ts is equal to 700ms. 111 = Ts is equal to 800ms.
7:3	N/A			

Addr: 05		Strobe_mode2		
		This register sets the strobe time in mode 2.		
Bit	**Bit Name**	**Default**	**Access**	**Description**
2:0	Mode2	111	R/W	000 = Ts is equal to TSTROBE_SIGNAL if T_STROBE_SIGNAL. ≤ 100ms. 000 = Ts is equal to 100ms is T_STROBE_SIGNAL ≥ 100ms. 001 = Ts is equal to TSTROBE_SIGNAL if T_STROBE_SIGNAL ≤ 200ms. 001 = Ts is equal to 200ms if T_STROBE_SIGNAL ≥ 200ms. 010 = Ts is equal to TSTROBE_SIGNAL if T_STROBE_SIGNAL ≤ 300ms. 010 = Ts is equal to 300ms if T_STROBE_SIGNAL ≥ 300ms. 011= Ts is equal to TSTROBE_SIGNAL if T_STROBE_SIGNAL ≤ 400ms. 011 = Ts is equal to 400ms if T_STROBE_SIGNAL ≥ 400ms. 100 = Ts is equal to TSTROBE_SIGNAL if T_STROBE_SIGNAL ≤ 500ms. 100 = Ts is equal to 500ms if T_STROBE_SIGNAL ≥ 500ms. 101 = Ts is equal to TSTROBE_SIGNAL if T_STROBE_SIGNAL ≤ 600ms. 101 = Ts is equal to 600ms if T_STROBE_SIGNAL ≥ 600ms. 110 = Ts is equal to TSTROBE_SIGNAL if T_STROBE_SIGNAL ≤ 700ms. 110 = Ts is equal to 700ms if T_STROBE_SIGNAL ≥ 700ms. 111 = Ts is equal to TSTROBE_SIGNAL if T_STROBE_SIGNAL ≤ 800ms. 111 = Ts is equal to 800ms if T_STROBE_SIGNAL ≥ 800ms.
7:3	N/A			

Table 23. Current Sink_1x Undervoltage Indication Register

Addr: 0F		Curr_voltage_control		
		This register indicates if the voltage at any current sink has dropped below a predefined value. If the charge pump is operating in automatic-mode (default), the contents of this register can be disregarded. The voltages at current sinks 1x are used for automatic mode selection of the charge pump (see bit **cp_man** (page 21)). The voltages at current sinks 2, 3, and 4 can be optionally used for automatic mode selection of the charge pump (see register **Curr234_ctrl** (page 20)).		
Bit	**Bit Name**	**Default**	**Access**	**Description**
0	curr11_low_voltage	N/A	R	0 = Normal operation. 1 = Undervoltage occurred.
1	curr12_low_voltage	N/A	R	0 = Normal operation. 1 = Undervoltage occurred.
2	curr13_low_voltage	N/A	R	0 = Normal operation. 1 = Undervoltage occurred.
3	Curr2_low_voltage	N/A	R	See **Curr2_low_voltage** (page 20).
4	Curr3_low_voltage	N/A	R	See **Curr3_low_voltage** (page 20).
5	Curr4_low_voltage	N/A	R	See **Curr4_low_voltage** (page 20).
7:6	cp_status	N/A	R	See **cp_status** (page 21).

Figure 11. Preview and Strobe Timing – Mode 1

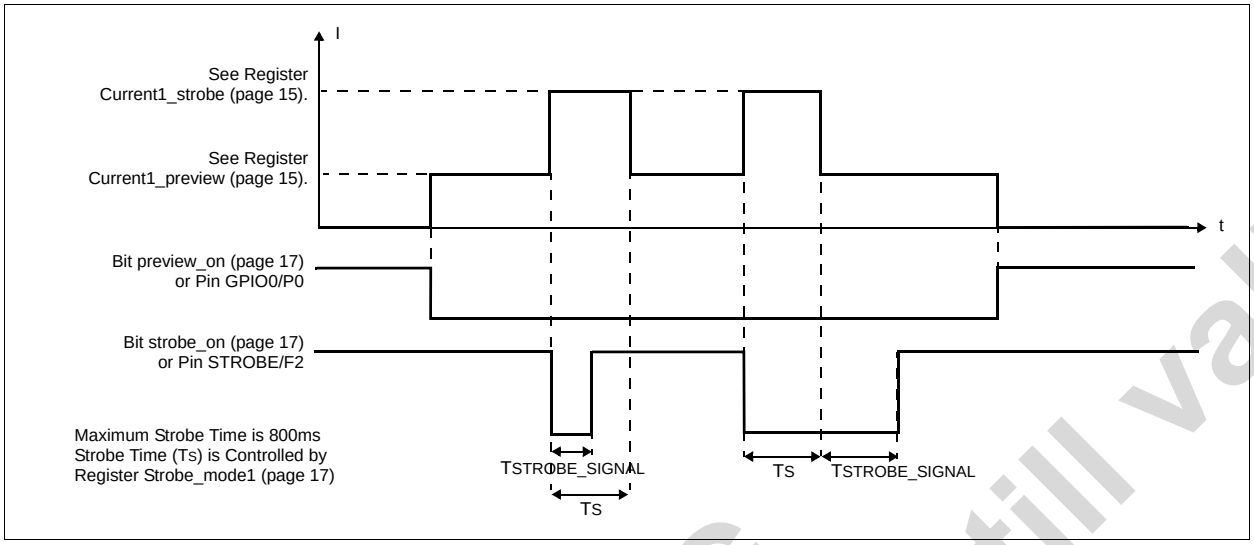


Figure 12. Preview and Strobe Timing – Mode 2

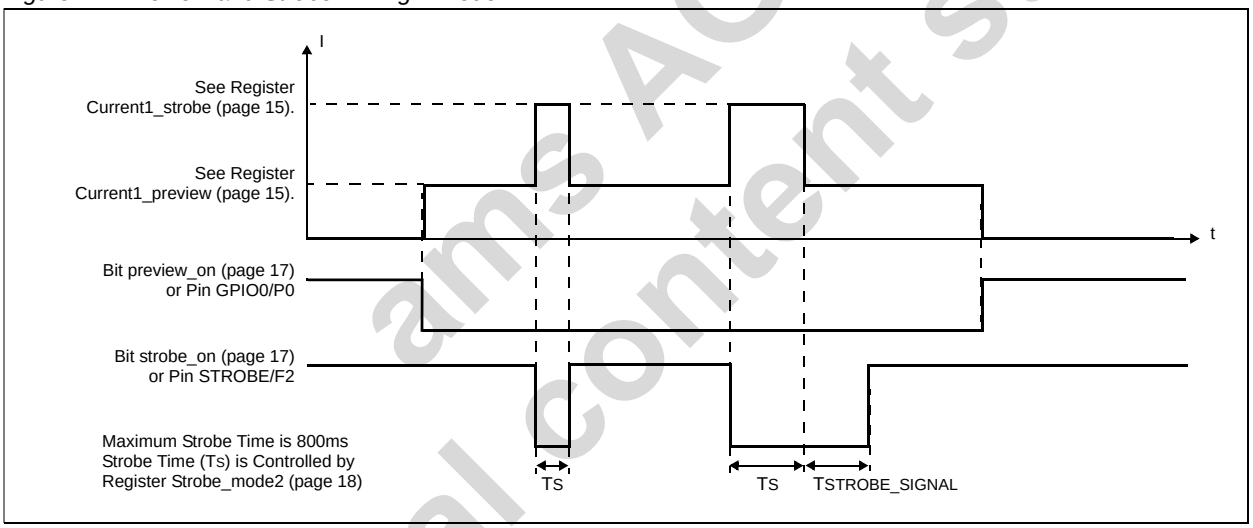
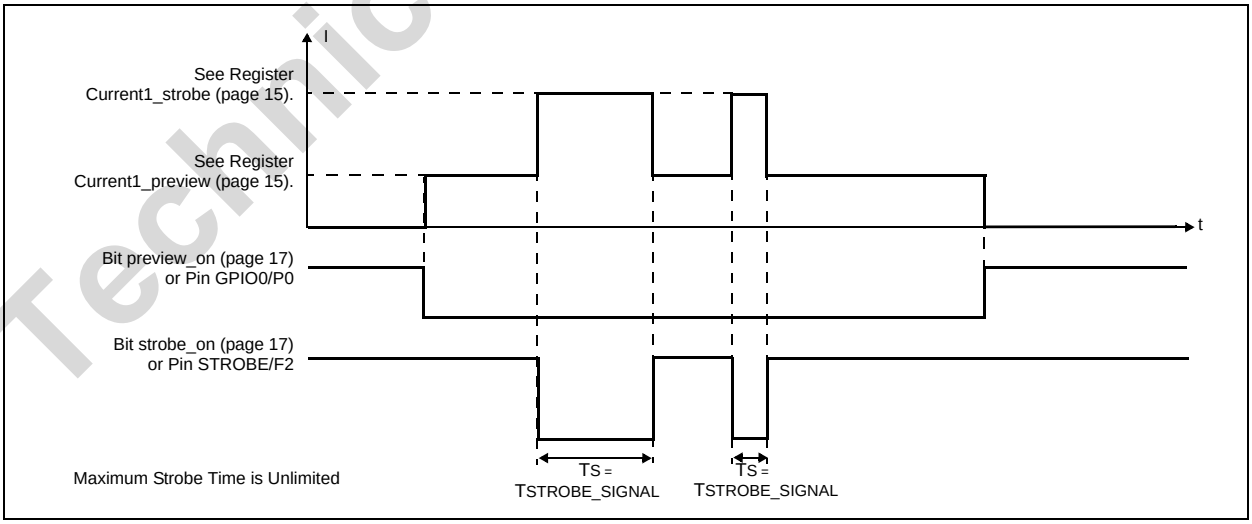


Figure 13. Preview and Strobe Timing – Mode 3



11.3 Control of CURR2, CURR3, CURR4 in Soft Flash Mode

CURR2, CURR3, and CURR4 are independent current sinks. The current value is determined by registers **Current2** (page 15), **Current3** (page 15), and **Current4** (page 15).

Any value other than zero will start the current sink. To stop the current, the register value must be set to zero.

Note: Unused current sinks should be left open and any associated register values must be set to 0mA.

Table 24. Current Sink2,3,4 Undervoltage Indication Registers

Addr: 0F		**Curr_voltage_control** This register indicates if the voltage at any current sink has dropped below a predefined value. If the charge pump is operating in automatic-mode (default), the contents of this register can be disregarded. The voltages at current sinks 1x are used for automatic mode selection of the charge pump (see bit **cp_man** (page 21)). The voltages at current sinks 2, 3, and 4 can be optionally used for automatic mode selection of the charge pump (see register **Curr234_ctrl**).		
Bit	**Bit Name**	**Default**	**Access**	**Description**
0	curr11_low_voltage	N/A	R	See **curr11_low_voltage** (page 18).
1	curr12_low_voltage	N/A	R	See **curr12_low_voltage** (page 18).
2	Curr13_low_voltage	N/A	R	See **curr12_low_voltage** (page 18).
3	Curr2_low_voltage	N/A	R	0 = Normal operation. 1 = Undervoltage occurred.
4	Curr3_low_voltage	N/A	R	0 = Normal operation. 1 = Undervoltage occurred.
5	Curr4_low_voltage	N/A	R	0 = Normal operation. 1 = Undervoltage occurred.
7:6	cp_status	N/A	R	See **cp_status** (page 21).

Addr: 09		**Curr234_ctrl** This register defines wether the load of the current sink is connected to pin VBAT or to pin CP_OUT. If the load of the current sink is connected to CP_OUT, that current sink will contribute to the charge pump mode-selection algorithm.		
Bit	**Bit Name**	**Default**	**Access**	**Description**
0	Curr2_onCP	0	R/W	0 = The output of the current sink will not be used for automatic mode selection of the charge pump (see bit **cp_man** (page 21)). 1 = The output of the current sink is used for automatic mode selection of the charge pump.
1	Curr3_onCP	0	R/W	0 = The output of the current sink will not be used for automatic mode selection of the charge pump. 1 = The output of the current sink is used for automatic mode selection of the charge pump.
2	Curr4_onCP	0	R/W	0 = The output of the current sink will not be used for automatic mode selection of the charge pump. 1 = The output of the current sink is used for automatic mode selection of the charge pump.
3	Curr234_gpio0_ctrl	0	R/W	0 = Curr2, Curr3, and Curr4 are switched on/off directly by registers **Current2** (page 15), **Current3** (page 15), and **Current4** (page 15). 1 = Curr2, Curr3, Curr4 are switched on/off by pin GPIO0/P0 (set bit **preview_ctrl** (page 17) = 1 and bit **Curr234_strobe_ctrl** = 0.
6:4	N/A			
7	Curr234_strobe_ctrl	0	R/W	0 = Curr2, Curr3, and Curr4 are switched on/off directly by registers **Current2** (page 15), **Current3** (page 15), and **Current4** (page 15). 1 = Curr2, Curr3, Curr4 are controlled by Strobe mode (enable at least one of **curr11_on** (page 16), **curr12_on** (page 16), or **curr13_on** (page 16).

11.4 Charge Pump Control Registers

Addr: 00		Powerdown_control		
		This register switches the charge pump and current sinks_1x on and off.		
Bit	**Bit Name**	**Default**	**Access**	**Description**
0	cp_led_on	0	R/W	Charge pump enable/disable. 0 = Switches the charge pump off. 1 = Switches the charge pump on.
1	curr11_on			See **curr11_on** (page 16).
2	curr12_on			See **curr12_on** (page 16).
3	curr13_on			See **curr13_on** (page 16).
7:4	N/A			

Addr: 0D		CP_control		
		This register sets the charge pump mode and reads the current charge pump mode.		
Bit	**Bit Name**	**Default**	**Access**	**Description**
0	cp_clk	0	R/W	Charge pump clock frequency selection. 0 = 1MHz 1 = 500 kHz
1	cp_man	0	R/W	Charge pump mode control. 0 = Automatic mode. 1 = Manual mode.
3:2	cp_mode	00b	R/W	Charge pump mode selection. 01 = N/A 01 = Charge pump mode 1:1. 10 = Charge pump mode 1:1.5. 11 = Charge pump mode 1:2.
4	cp_mode2	0	R/W	Used for test purposes only.
5:7	N/A			

Addr: 0F		Curr_voltage_control		
		This register indicates if the voltage at any current sink has dropped below a predefined value. If the charge pump is operating in automatic-mode (default), the contents of this register can be disregarded. The voltages at current sinks 1x are used for automatic mode selection of the charge pump (see bit **cp_man** (page 21)). The voltages at current sinks 2, 3, and 4 can be optionally used for automatic mode selection of the charge pump (see register **Curr234_ctrl** (page 20)).		
Bit	**Bit Name**	**Default**	**Access**	**Description**
0	curr11_low_voltage	N/A	R	See **curr11_low_voltage** (page 18).
1	curr12_low_voltage	N/A	R	See **curr12_low_voltage** (page 18).
2	Curr13_low_voltage	N/A	R	See **curr13_low_voltage** (page 18).
3	Curr2_low_voltage	N/A	R	See **Curr2_low_voltage** (page 20).
4	Curr3_low_voltage	N/A	R	See **Curr3_low_voltage** (page 20).
5	Curr4_low_voltage	N/A	R	See **Curr4_low_voltage** (page 20).
7:6	cp_status	N/A	R	01 = Charge pump mode 1:1. 10 = Charge pump mode 1:1.5. 11 = Charge pump mode 1:2.

11.5 General Purpose Inputs/Outputs

The general purpose input/output pins (GPIO0/P0, STROBE/F2) are highly configurable and can be used for the following functionality:

- Digital Schmidt-Trigger Input
- Digital Output with 4mA Driving Capability at 2.8V Supply (V_{DD_GPIO})
- Tristate Output
- Current Selection for $CURR_{1x}$

The default mode for pins GPIO0/P0 and STROBE/F2 is input (pull-down).

Note: Each GPIO pin is independent from the other GPIO pin.

Table 25. GPIO Registers

Addr: 0A		**GPIO_control**		
		This register controls pins GPIO0/P0 and STROBE/F2.		
Bit	**Bit Name**	**Default**	**Access**	**Description**
1:0	gpio0_mode	00b	R/W	Defines the direction for pin GPIO0/P0. 00 = Input only. 01 = Output (push and pull). 10 = Output (open drain, only NMOS is active). 11 = Output (open drain, only PMOS is active).
3:2	gpio0_pulls	01b	R/W	Adds pullup/pulldown functionality to pin GPIO0/P0. 00 = None 01 = Pulldown 10 = Pullup 11 = Analog input (for test purposes only).
5:4	strobe_mode	00b	R/W	Defines the direction for pin STROBE/F2. 00 = Input only. 01 = Output (push and pull). 10 = Output (open drain, only NMOS is active). 11 = Output (open drain, only PMOS is active).
7:6	strobe_pulls	01b	R/W	Adds pullup/pulldown functionality to pin STROBE/F2. 00 = None 01 = Pulldown 10 = Pullup 11 = Analog input (for test purposes only)
Addr: 0B		**GPIO_output**		
		This register selects internal signals to be switched to pins GPIO0/P0 and STROBE/F2 (if selected as output).		
Bit	**Bit Name**	**Default**	**Access**	**Description**
0	gpio0_out	0	R/W	If pin GPIO0/P0 is set to output, this bit is transferred to that output.
1	strobe_out	0	R/W	If pin STROBE/F2 is set to output, this bit is transferred to that output.
7:2	N/A			
Addr: 0C		**GPIO_input**		
		This register reads the signals at pins GPIO0/P0 and STROBE/F2 (if selected as input).		
Bit	**Bit Name**	**Default**	**Access**	**Description**
0	gpio0_in	N/A	R	
1	strobe_in	N/A	R	

11.6 Power-On Reset

The internal reset is controlled by two inputs:

- V_{BAT}1 Supply
- V_{DD_GPIO}

If either of these voltages is lower than their limit, an internal reset is forced.

The reset levels control the state of all registers. As long as V_{BAT} and V_{DD_GPIO} are below their reset thresholds, the register contents are set to default.

Access by serial interface is possible once the reset thresholds are exceeded.

Table 26. Reset Control

Reset Control	Register State (All Registers)
V_{BAT} < V_{POR_VBAT} and V_{VDD_GPIO} < $V_{GPIO\_VDD\_TH}$	Undefined
V_{BAT} < V_{POR_VBAT} and V_{VDD_GPIO} > $V_{GPIO\_VDD\_TH}$	Undefined
V_{BAT} > V_{POR_VBAT} and V_{VDD_GPIO} < $V_{GPIO\_VDD\_TH}$	Default
V_{BAT} > V_{POR_VBAT} and V_{VDD_GPIO} > $V_{GPIO\_VDD\_TH}$	Default
	Access by serial interface possible.

Note: $V_{VDD\_GPIO\_TH}$ – Use rising or falling threshold levels, depending on the slope of V_{DD_GPIO} (power up/power down).

11.7 Temperature Supervision

An integrated temperature sensor provides over-temperature protection for the AS3683. This sensor generates a flag if the device temperature reaches the over-temperature threshold (T_{140} page 7). The threshold has a hysteresis (T_{HYST} page 7) to prevent oscillation effects.

If the device temperature exceeds the T_{140} threshold, the current sources are switched off, and bit **ov_temp** in register **Overtemp_control** (page 23) is set to 1.

After decreasing the temperature by T_{HYST}, the current sources resume operation.

The **ov_temp** flag will only be reset (by the circuit when the temperature has reached operating condition again) after the software has written a 1 and then a 0 to bit **rst_ov_temp**).

Bit **ov_temp_on** activates temperature supervision.

Table 27. Overtemperature Bit Definitions

Addr: 0E		**Overtemp_control**		
		This register reads and resets the overtemperature flag.		
Bit	**Bit Name**	**Default**	**Access**	**Description**
0	ov_temp_on	1	R/W	Activates/deactivates device temperature supervision. 0 = Temperature supervision is disabled. 1 = Temperature supervision is enabled. All current sources will be switched off if the device temperature exceeds the **ov_temp** rising threshold (T_{140}) and resume operation when the temperature falls below the **ov_temp** falling threshold (T_{140} -T_{HYST}).
1	ov_temp	NA	R	1 = Indicates that the **ov_temp** rising threshold (T_{140}) has been reached. To clear this flag, it is mandatory to use bit **rst_ov_temp**. Bit **ov_temp** is only active if temperature supervision is activated.
2	rst_ov_temp	NA	R/W	The **ov_temp** flag is cleared by first setting this bit to 1, and then setting this bit to 0. Bit **rst_ov_temp** is only active if temperature supervision is activated.
7:3	N/A			

11.8 Serial Interface

The AS3683 is controlled by serial interface pins DATA/P1 and CLK/P2.

11.8.1 Features

- Fast Mode Capability (Maximum Clock Frequency is 400 kHz)
- 7-Bit Addressing Mode
- Write Formats
  - Single-Byte Write
  - Page-Write
- Read Formats
  - Current-Address Read
  - Random-Read
  - Sequential-Read
- DATA/P1 Input Delay and CLK/P2 Spike Filtering by Integrated RC Components

11.8.2 Device Address Selection

The serial interface address of the AS3683 can be selected between two fixed settings. The address is selected by connecting pin ADR to either GND or to V_{2_5} as shown in Table 28.

Table 28. AS3683 Device Address Selection

ADR Connected To	Serial Interface Address
GND	40h
V_{2_5} (Max Voltage = 2.5V)	41h

11.8.3 Data Transfer Formats

Definitions used in the serial data transfer format diagrams (Figures 15 to 19) are listed in Table 29.

Table 29. Serial Data Transfer Byte Definitions

Symbol	Definition
S	Start Condition after Stop
Sr	Repeated Start
DA	Device Address
WA	Word Address
A	Acknowledge
N	Not Acknowledge
P	Stop Condition
White Field	Slave as Receiver
Grey Field	Slave as Transmitter
WA++	Increment Word Address Internally

Figure 14. Complete Data Transfer

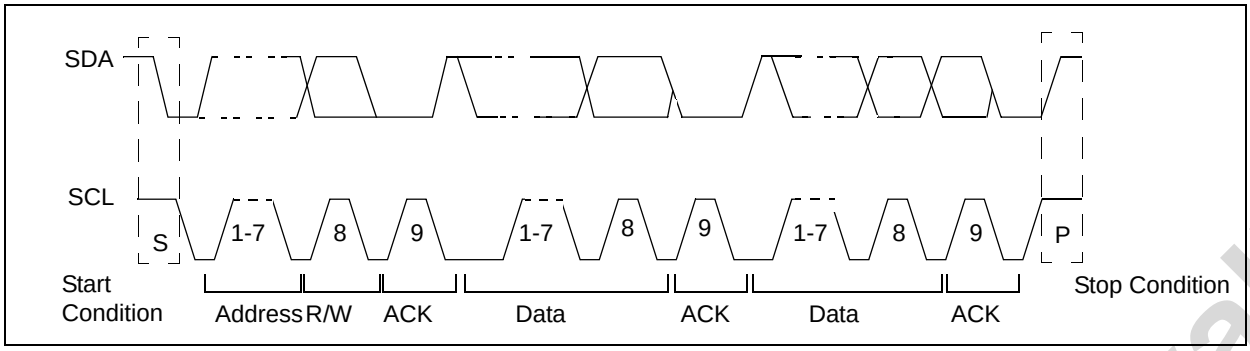


Figure 15. Byte Write

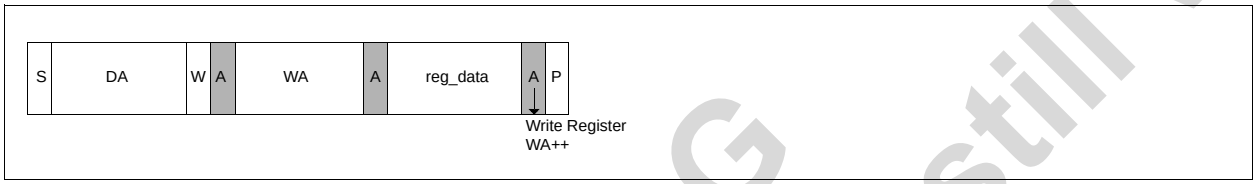
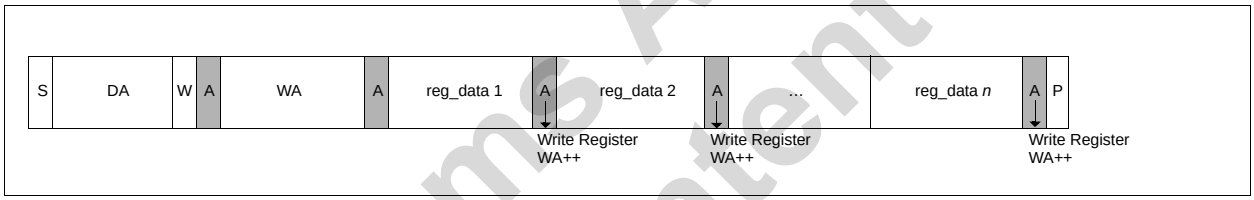


Figure 16. Page Write



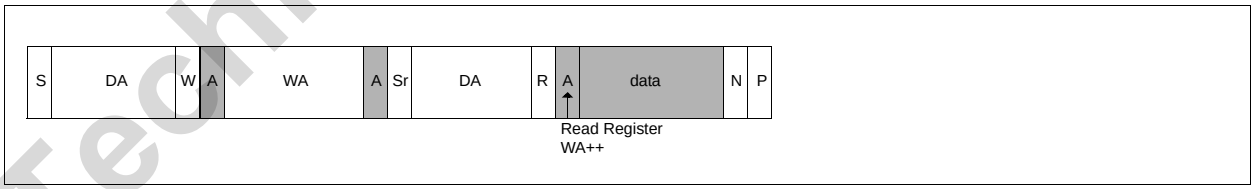
Byte Write and Page Write are used to write data to the slave.

The transmission begins with the START condition, which is generated by the master when the bus is in IDLE state (the bus is free). The device-write address is followed by the word address. After the word address any number of data bytes can be send to the slave. The word address is incremented internally, in order to write subsequent data bytes on subsequent address locations.

For reading data from the slave device, the master has to change the transfer direction. This can be done either with a repeated START condition followed by the device-read address, or simply with a new transmission START followed by the device-read address, when the bus is in IDLE state. The device-read address is always followed by the 1st register byte transmitted from the slave. In Read Mode any number of subsequent register bytes can be read from the slave. The word address is incremented internally.

The following diagrams show the various read formats available.

Figure 17. Random Read

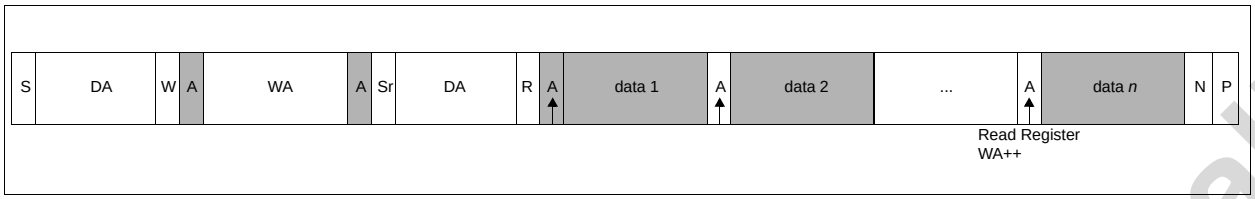


Random Read and Sequential Read are combined formats. The repeated START condition is used to change the direction after the data transfer from the master.

The word address transfer is initiated with a START condition issued by the master while the bus is idle. The START condition is followed by the device-write address and the word address.

In order to change the data direction a repeated START condition is issued on the 1st SCL pulse after the ACKNOWLEDGE bit of the word address transfer. After the reception of the device read address, the slave becomes the transmitter. In this state the slave transmits register data located by the previous received word address vector. The master responds to the data byte with a NOT ACKNOWLEDGE, and issues a STOP condition on the bus.

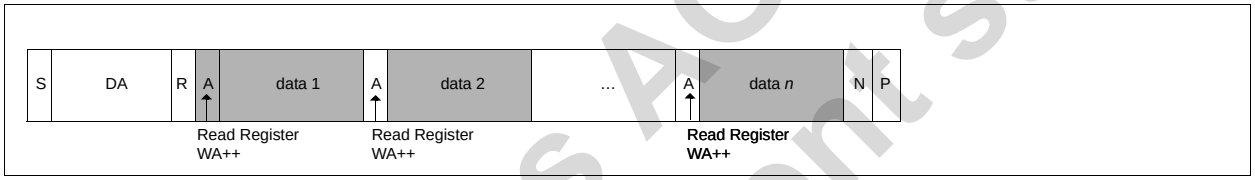
Figure 18. Sequential Read



Sequential Read is the extended form of Random Read, as multiple register-data bytes are subsequently transferred.

In contrast to the Random Read, in a Sequential Read the transferred register-data bytes are responded to by an ACKNOWLEDGE from the master. The number of data bytes transferred in one sequence is unlimited (consider the behavior of the word-address counter). To terminate the transmission the master has to send a NOT ACKNOWLEDGE following the last data byte and subsequently generate the STOP condition.

Figure 19. Current Address Read



To keep the access time as small as possible, this format allows a read access without the word address transfer in advance to the data transfer. The bus is idle and the master issues a START condition followed by the Device Read address. Analogous to Random Read, a single byte transfer is terminated with a NOT ACKNOWLEDGE after the first register byte. Analogous to Sequential Read an unlimited number of data bytes can be transferred, where the data bytes must be responded to with an ACKNOWLEDGE from the master. For termination of the transmission the master sends a NOT ACKNOWLEDGE following the last data byte and a subsequent STOP condition.

11.8.4 Fixed ID Register

Reading register 15h always returns CDh and can be used to verify the correct operation of the serial interface.

Table 30. Fixed ID Register

Addr: 15		**Fixed_ID**		
		This register holds the device ID value.		
Bit	**Bit Name**	**Default**	**Access**	**Description**
7:0	Device_ID	11001101	R	This is the device ID.

11.9 Register Map

The AS3683 control register addresses, default values, and pages where they are described are listed in Table 31.

Table 31. Register Summary

Register Name	Address	Default	B7	B6	B5	B4	B3	B2	B1	B0	Page
Powerdown_control	Addr: 00	00h	N/A				curr13_on	curr12_on	curr11_on	cp_led_on	16, 21
Current1_preview	Addr: 01	00h	current1_preview								15
Current1_strobe	Addr: 02	00h	current1_strobe								15
Current1_control	Addr: 03	01h	xstrobe_ctrl	strobe_on	preview_ctrl	preview_on	N/A		Strobe_mode		17
Strobe_mode1	Addr: 04	07h	N/A					Strobe_mode			17
Strobe_mode2	Addr: 05	07h	N/A					Mode2			18
Current2	Addr: 06	00h	current2								15
Current3	Addr: 07	00h	current3								15
Current4	Addr: 08	00h	current4								15
Curr234_ctrl	Addr: 09	00h	Curr234_strobe_ctrl	N/A			Curr234_gpio0_ctrl	Curr4_onCP	Curr3_onCP	Curr2_onCP	20
GPIO_control	Addr: 0A	44h	strobe_pulls		strobe_mode		gpio0_pulls		gpio0_mode		22
GPIO_output	Addr: 0B	00h	N/A						strobe_out	gpio0_out	22
GPIO_input	Addr: 0C	N/A	N/A						strobe_in	gpio0_in	22
CP_control	Addr: 0D	00h	N/A			cp_mode2	cp_mode		cp_man	cp_clk	21
Overtemp_control	Addr: 0E	01h	N/A					rst_ov_temp	ov_temp	ov_temp_on	23
Curr_voltage_control	Addr: 0F	N/A	cp_status		Curr4_low_voltage	Curr3_low_voltage	Curr2_low_voltage	curr13_low_voltage	curr12_low_voltage	curr11_low_voltage	21
Curr_voltage_control	Addr: 0F	N/A	cp_status		Curr4_low_voltage	Curr3_low_voltage	Curr2_low_voltage	curr13_low_voltage	curr12_low_voltage	curr11_low_voltage	18
Curr_voltage_control	Addr: 0F	N/A	cp_status		Curr4_low_voltage	Curr3_low_voltage	Curr2_low_voltage	curr13_low_voltage	curr12_low_voltage	curr11_low_voltage	20
Fixed_ID	Addr: 15	CDh	1	1	0	0	1	1	0	1	26

12 External Components

12.1 Capacitor and Resistor Selection

Use low-ESR ceramic capacitors with X7R or X5R dielectric – these capacitors allow good filtering and have a wide temperature range. The connections of all external capacitors should be kept as short as possible.

All resistors should have a tolerance of ±1%.

12.2 Usage of PCB Wire Inductance

The inductance between the battery and pins V_{BAT1} and V_{BAT2} can be used as a filter to reduce disturbance on the battery. Instead of using one capacitor (C1) it is recommended to split C1 into $C1_1$ and $C1_2$ with the capacitance equal:

$$C1_1 = C1_2 = 1/2 \times C_1 \quad \text{(EQ 1)}$$

It is recommended to apply a minimum of 20nH (maximum 200nH) with low impedance. This inductance can be realized on the PCB without any discrete coil. Assuming that 1mm signal line corresponds to approximately 1nH (valid if the length (L) is significantly bigger than the width (W) of the line (L/W <10)). Thus a line length of:

$$20mm < L < 200mm \quad \text{(EQ 2)}$$

is recommended. The shape of the line is not important.

Figure 20. PCB Wire Inductance Example 1

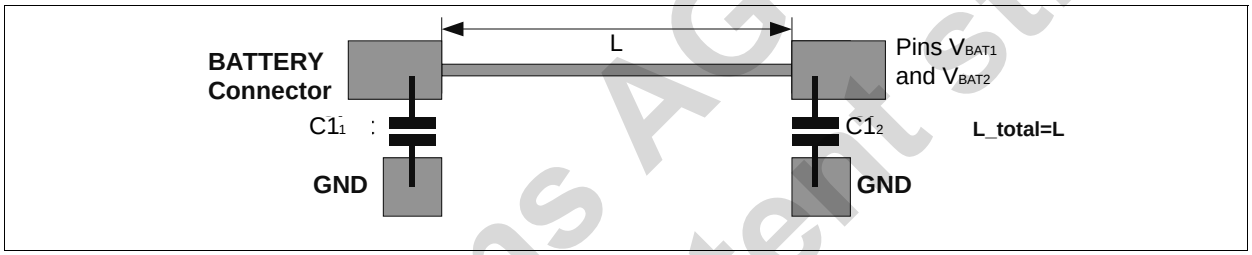
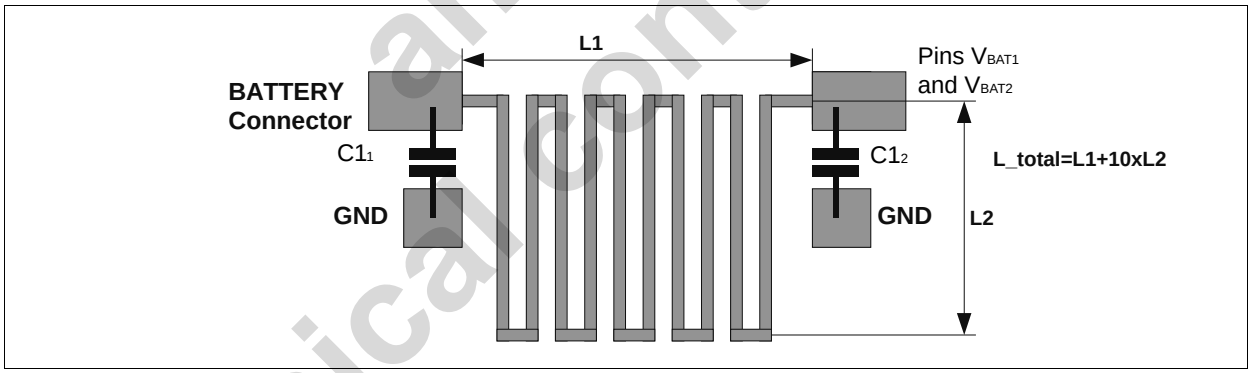


Figure 21. PCB Wire Inductance Example 2



12.3 External Component Specifications

Table 32. External Components List

Part Number	Value			Tol (Min)	Rating (Max)	Notes	Package (Min)
	Min	Typ	Max				
C1 [1]		2.2µF		±20%	6.3V	Ceramic, X5R	0603
C3	1µF		4.7µF	±20%	6.3V	Ceramic, X5R	0603
C4		1µF		±20%	6.3V	Ceramic, X5R	0603
C5		1µF		±20%	6.3V	Ceramic, X5R	0603
C6		2.2µF		±20%	6.3V	Ceramic, X5R	0603
R1		240kΩ		±1%		Bias Resistor	0201

Notes:

1. See Usage of PCB Wire Inductance on page 28.

13 Pinout and Packaging

Table 33. Pin Type Definitions

Type	Description
DI	Digital Input
DI3	3.3V Digital Input
DIO3	3.3V Digital Input/Output
AIO	Analog Pad
AI	Analog Input
AO	Analog Output
S	Supply Pad
GND	Ground Pad

13.1 Hard Flash Mode Pin Descriptions

Table 34. Pin List QFN24 – Hard Flash Mode

Pin	Name	Type (See Table 33)	Description
1	ADR	DI	Test input. Connect to V_{SS}.
2	V_{BAT1}	AIO	Charge pump supply pad; always connect to V_{BAT}.
3	C_{1_P}	AIO	Charge pump flying capacitor; connect to a ceramic capacitor of 2.2µF (±20%).
4	CP_OUT	AIO	Charge pump output voltage; connect to a ceramic capacitor of 1µF (±20%) or 2.2µF (+100%/-50%).
5	C_{2_P}	AIO	Charge pump flying capacitor; connect to a ceramic capacitor of 2.2µF (±20%).
6	V_{BAT2}	S	Charge pump supply pad; always connect to V_{BAT}.
7	C_{2_N}	AIO	Charge pump flying capacitor; connect to a ceramic capacitor of 1µF (±20%).
8	CLK/P2	DI3	MSB of Preview Control; internal pullup, active-low.
9	DATA/P1	DIO3	LSB+1/MSB of Preview Control; internal pullup, active-low.
10	GPIO0/P0	DIO3	LSB of Preview Control; internal pullup, active-low.
11	STROBE/F2	DIO3	MSB of Flash Control; internal pullup, active-low.
12	V_{DD_GPIO}	S	GPIO and serial interface supply pad.
13	$CURR_{11}$	AI	Analog current sink input.
14	$CURR_{12}$	AI	Analog current sink input.
15	$CURR_{13}$	AI	Analog current sink input.
16	SFL/F1	DI3	LSB+1 of Flash Control; internal pullup, active-low.
17	T1/F0	DI3	LSB of Flash Control; internal pullup, active-low.
18	HFL	DI	Hard Flash Mode selection pin; connect to V_{BAT}.
19	$CURR_2$	AI	Analog current sink input.
20	$CURR_3$	AI	Analog current sink input.
21	$CURR_4$	AI	Analog current sink input.
22	V_{2_5}	AO	Low-power LDO output voltage; always connect to a ceramic capacitor of 1µF (±20%) or 2.2µF (+100%/-50%). **Caution:** Do not load this pin during start-up.
23	R_{BIAS}	AIO	External resistor; always connect to a resistor of 240kΩ (±1%) to ground. **Caution:** Do not load this pin.
24	C_{1_N}	AIO	Charge pump flying capacitor; connect to a ceramic capacitor of 1µF (±20%).
25	V_{SS}	GND	Exposed pad.

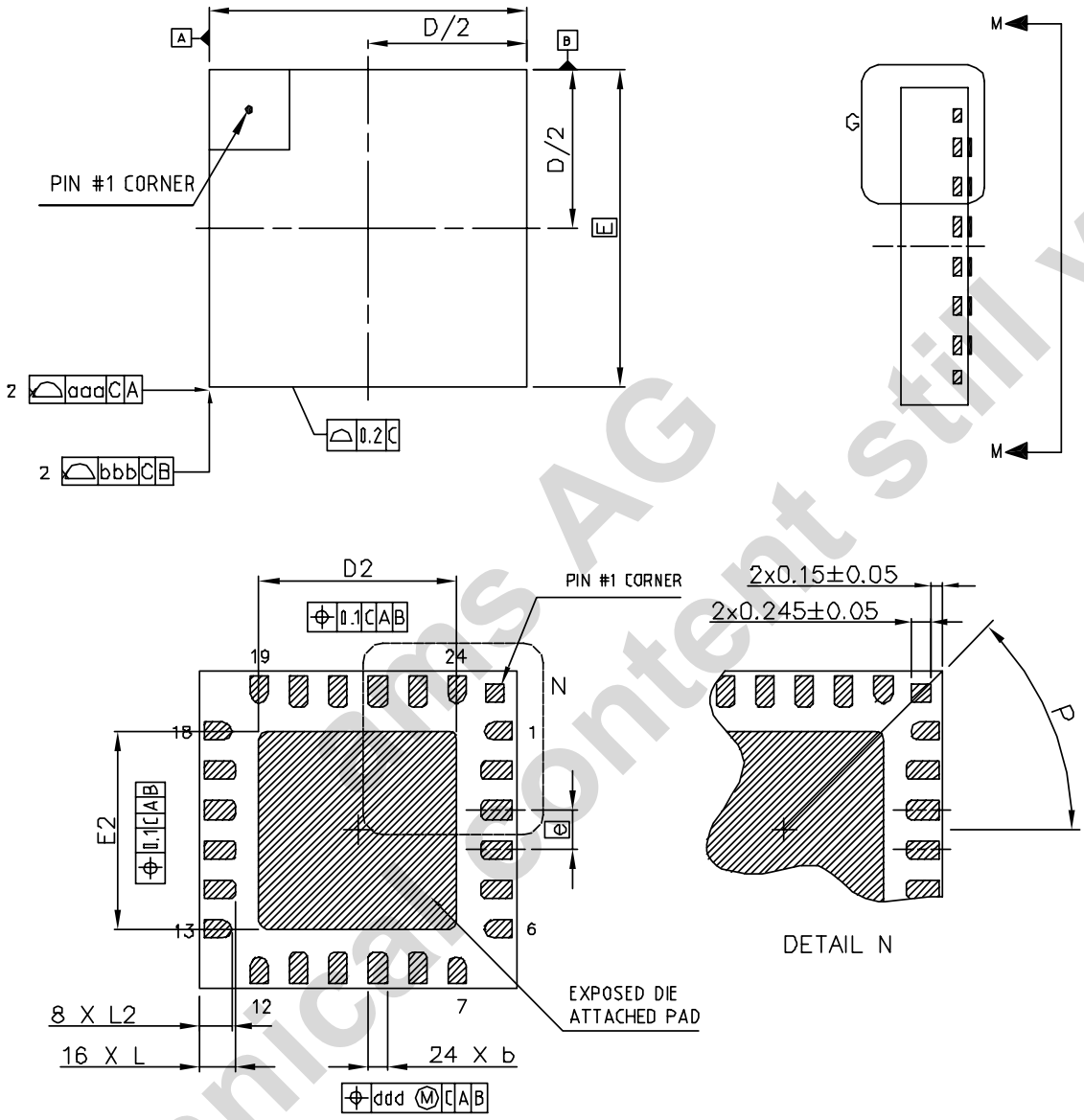
13.2 Soft Flash Mode Pin Descriptions

Table 35. Pin List QFN24 – Soft Flash Mode

Pin	Name	Type (See Table 33)	Description
1	ADR	DI	Input pin to select serial interface address. Connect to V_{2_5} or V_{SS}.
2	V_{BAT1}	S	Charge pump supply pad; always connect to V_{BAT}.
3	C_{1_P}	AIO	Charge pump flying capacitor; connect to a ceramic capacitor of 2.2µF (±20%).
4	CP_OUT	AIO	Charge pump output voltage; connect to a ceramic capacitor of 1µF (±20%) or 2.2µF (+100%/-50%).
5	C_{2_P}	AIO	Charge pump flying capacitor; connect to a ceramic capacitor of 2.2µF (±20%).
6	V_{BAT2}	S	Charge pump supply pad; always connect to V_{BAT}.
7	C_{2_N}	AIO	Charge pump flying capacitor; connect to a ceramic capacitor of 1µF (±20%).
8	CLK/P2	DI3	Serial interface clock input.
9	DATA/P1	DIO3	Serial interface data I/O.
10	GPIO0/P0	DIO3	General purpose I/O; active-low in Soft Flash Mode.
11	STROBE/F2	DIO3	General purpose I/O; active-low in Soft Flash Mode.
12	V_{DD_GPIO}	S	GPIO and serial interface supply pad.
13	$CURR_{11}$	AI	Analog current sink input (intended for LED flash).
14	$CURR_{12}$	AI	Analog current sink input (intended for LED flash).
15	$CURR_{13}$	AI	Analog current sink input (intended for LED flash).
16	SFL/F1	DI3	Connect to V_{DD_GPIO}.
17	T1/F0	DI3	Test input; connect to V_{SS}.
18	HFL	DI	Hard Flash Mode selection pin; connect to V_{SS}.
19	$CURR_2$	AI	Analog current sink input.
20	$CURR_3$	AI	Analog current sink input.
21	$CURR_4$	AI	Analog current sink input.
22	V_{2_5}	AO	Low-power LDO output voltage; always connect to a ceramic capacitor of 1µF (±20%) or 2.2µF (+100%/-50%). **Caution:** Do not load this pin during start-up.
23	R_{BIAS}	AIO	External resistor; always connect to a resistor of 240kΩ (±1%) to ground. **Caution:** Do not load this pin.
24	C_{1_N}	AIO	Charge pump flying capacitor; connect to a ceramic capacitor of 1µF (±20%).
25	V_{SS}	GND	Exposed pad.

13.3 Package Drawings and Markings

Figure 22. QFN 24 – 4x4mm with Exposed Paddle



Marking:

Line 1:austriamicrosystems Logo

Line 2:AYWWIZZ

A = Pb-Free Identifier

Y = Year

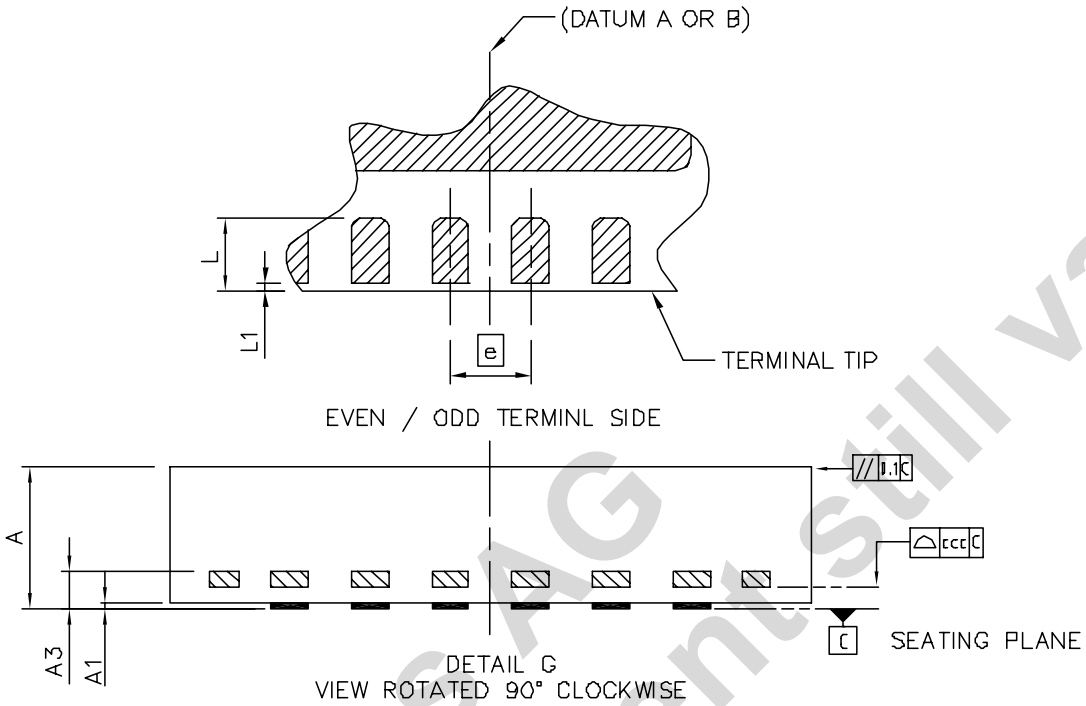
WW = Week

I = Plant Identifier

ZZ = Letters of Free Choice

Line 3:AS3683A

Figure 23. QFN 24 – Detail Dimensions



Notes:

1. Dimensioning and tolerancing conform to ASME Y14-5M – 1994.
2. All dimensions are in degrees; angles in degrees.
3. Dimension b applies to metalized terminal and is measured between 0.25 and 0.30mm from terminal tip. Dimension L1 represents terminal full back from package edge up to 0.1mm is acceptable.
4. Coplanarity applies to the exposed heat slug as well as the terminal.
5. Radius or terminal is optional.

Symbol	Min	Typ	Max
A	0.80	0.85	0.90
A1	0.00	0.02	0.05
A3		0.203REF	
b	0.18	0.23	0.30
D		4.0BSC	
E		4.0BSC	
e		0.50BSC	
D2	2.40	2.50	2.60
E2	2.40	2.50	2.60
L	0.40	0.45	0.50
L1	0.03	0.05	0.08
L2	0.35	0.40	0.45
P		45ºREF	
aaa	-	-	0.10
bbb	-	-	0.10
ccc	-	-	0.08
ddd	-	-	0.10

14 Ordering Information

Device ID	Part Number	Package Type	Delivery Form*	Description
AS3683-*PD*	AS3683-EA	QFN 24	Tape and Reel	4x4mm, Pitch = 0.5mm
	AS3683-EB		Tube	

Where:

P = **Package Type**:

E = QFN 4x4x0.85mm

D = **Delivery Form**:

A = Tape and Reel

B = Tube

* Dry-pack sensitivity level = 3 in accordance with *IPC/JEDEC J-STD-033A.*

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