Description

The AL5887Q is comprised of 36 programmable LED current channels, each with internal 12-bit PWM for color and brightness control through I^2C or SPI digital interface. The AL5887Q is ideal for lighting applications and features up to 12 RGB LED modules with 3 programmable banks (A, B, C) for software control of each color. An external resistor can set up the global output current of all 36 channels. Each channel current can be digitally configured up to 70mA under the thermal limitation of the package.

Features of the AL5887Q are controlled via a I^2C/SPI digital interface, which is selectable by the INT_SEL pin. The AL5887Q has a 30kHz, 12-bit PWM generator for each channel, as well as channel/module independent color mixing and brightness control registers to enable vivid LED effects with zero audible noise. Users can benefit from the device's ultra-low shutdown current (I_Q, Power Saving Mode) and easy software programming.

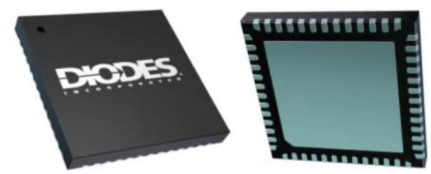
The device operates over the -40°C to +125°C ambient temperature range, and is available in the wettable flank W-QFN6060-52/SWP (Type A1) package.

Features

- AEC-Q100 Grade 1
- Input Voltage: 2.7V to 5.5V
- 36 Precision LED Current Sinks
  - OUT Pins Voltage Max. 5.5V
  - Maximum of 70mA per Channel Current
  - 12-Bit PWM Register with 30kHz Internal PWM Generator
  - PWM Phase Shifting
  - 6-Bit Global Current Dimming
  - Independent Color-Mixing Register per Channel
  - Independent Brightness-Control Register per RGB Module
  - Logarithmic or Linear Scale Brightness Control
  - Three Programmable Banks (A, B, C)
- Hardware-Selectable I^2C or SPI Digital Interface
  - Support 400kHz I^2C Interface and 4MHz SPI
- Diagnosis Protections Configurable Registers
  - Open Drain Fault Pin for Fault Indication
  - Individual Fault Mask Registers & Open/Short Registers
  - Overtemperature Protection (OTP) with Pre-OTP Warning
- Ultra-Low Quiescent Shutdown 1µA:
  - Power-Saving Mode: 15µA (Max.)
- **Totally Lead-Free & Fully RoHS Compliant (Notes 1& 2)**
- **Halogen and Antimony Free. "Green" Device (Note 3)**
- **The AL5887Q is suitable for automotive applications requiring specific change control; this part is AEC-Q100 qualified, PPAP capable, and manufactured in IATF 16949 certified facilities.**
  https://www.diodes.com/quality/product-definitions/

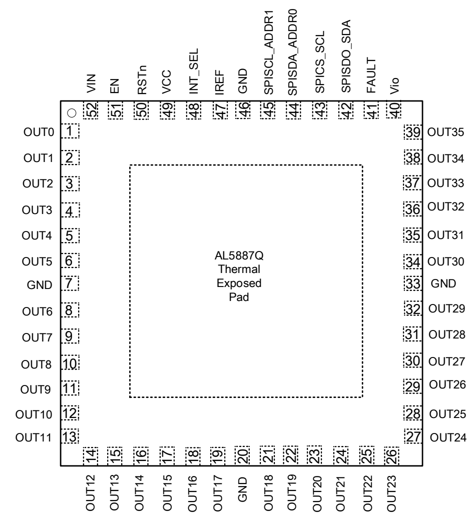
Pin Assignments

W-QFN6060-52/SWP (Type A1)



Top View Bottom View

(Top View – Not to Scale)



W-QFN6060-52/SWP (Type A1)

Applications

- Automotive interior and exterior lighting
- Infotainment displays
- Automotive status indicator lights
- Touch panels and LCD display backlights

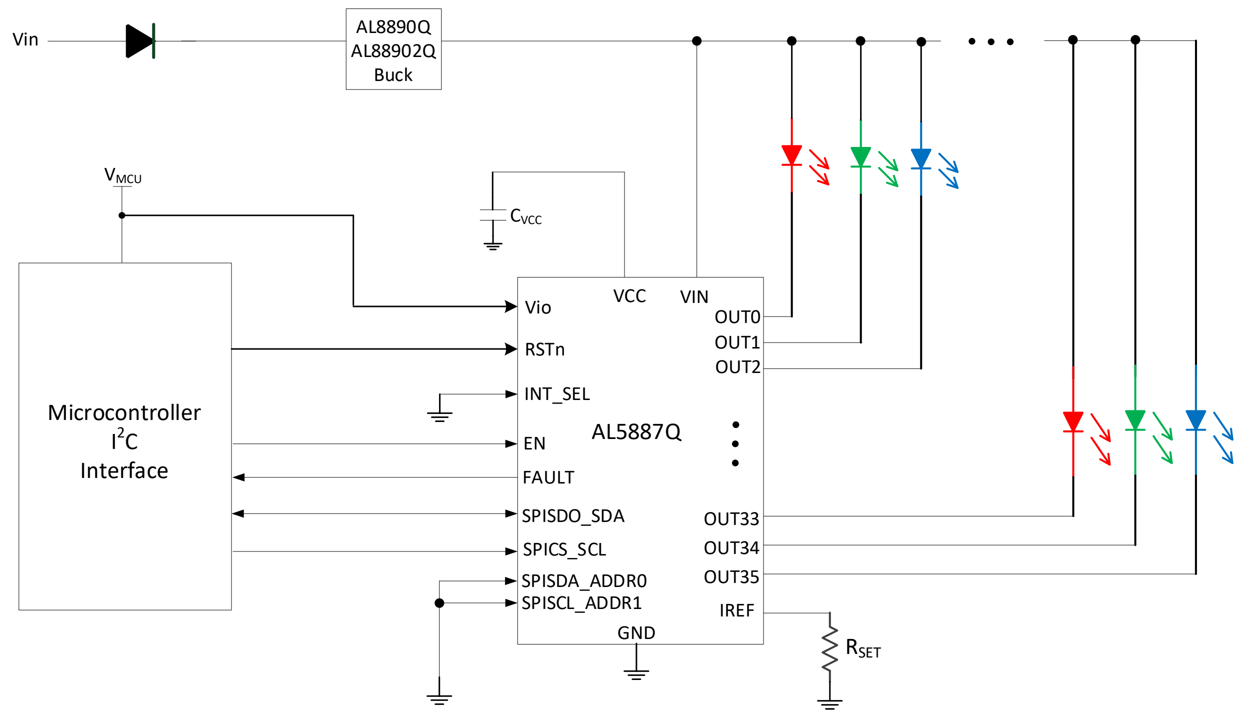
Device Information

Orderable Part Number	Package	Body Size
AL5887QJAZW52-13	W-QFN6060-52/SWP (Type A1)	6mm x 6mm

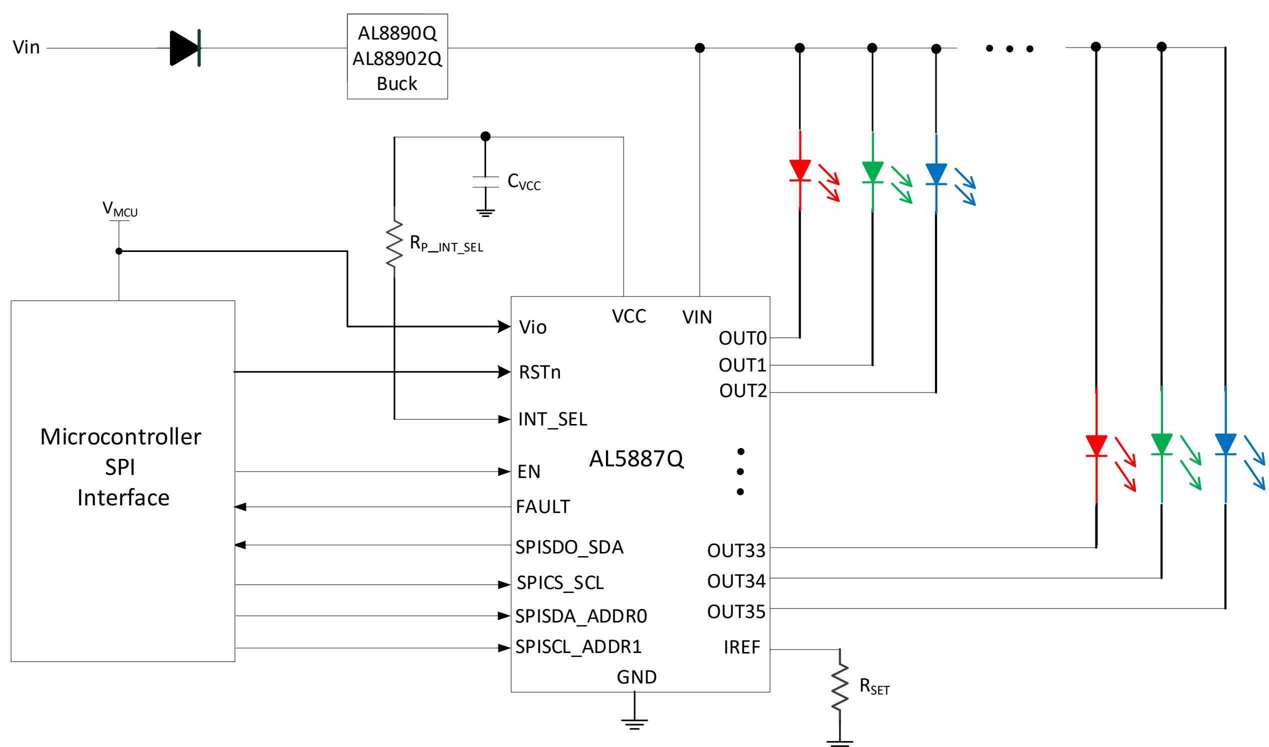
Notes: 1. No purposely added lead. Fully EU Directive 2002/95/EC (RoHS), 2011/65/EU (RoHS 2) & 2015/863/EU (RoHS 3) compliant.
2. See https://www.diodes.com/quality/lead-free/ for more information about Diodes Incorporated's definitions of Halogen- and Antimony-free, "Green" and Lead-free.
3. Halogen- and Antimony-free "Green" products are defined as those which contain <900ppm bromine, <900ppm chlorine (<1500ppm total Br + Cl) and <1000ppm antimony compounds.

Typical Applications Circuit

1) For I²C Interface

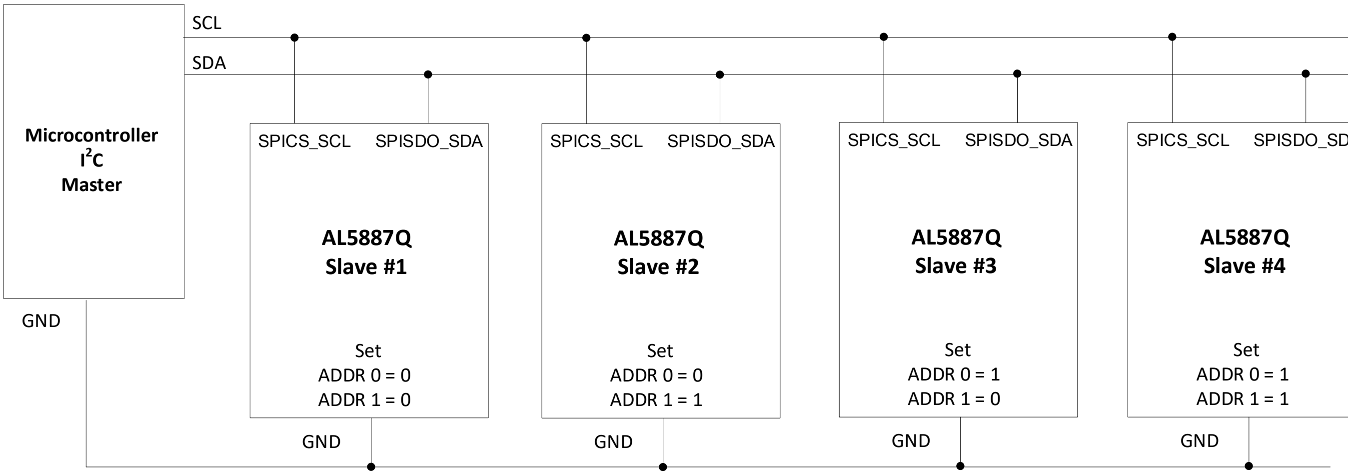


2) For SPI Interface

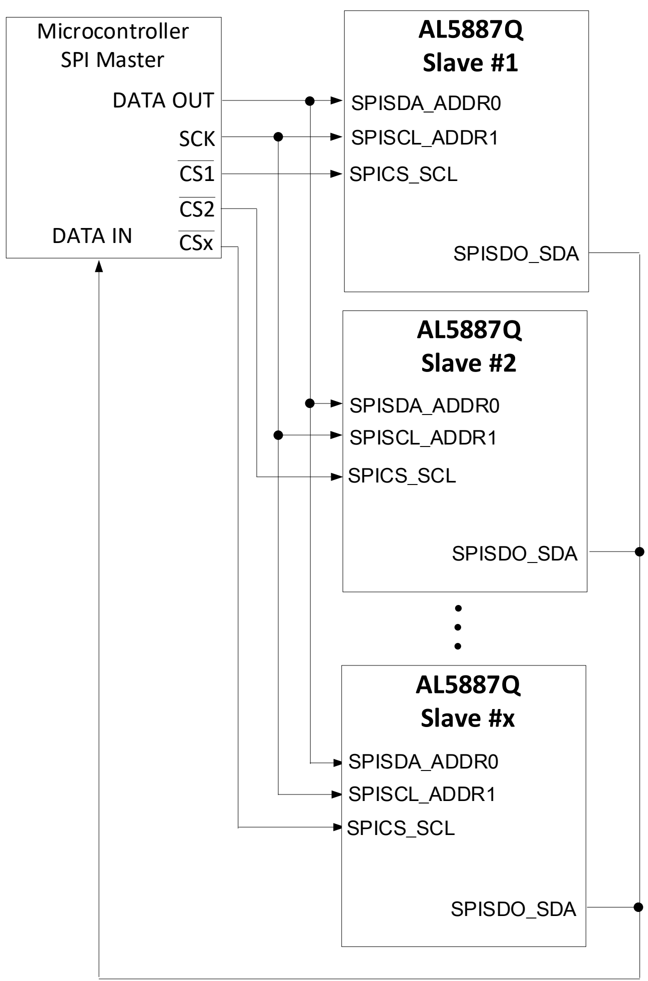


Typical Applications Circuit (continued)

3) Four AL5887Q connected together with external hardware pins setup



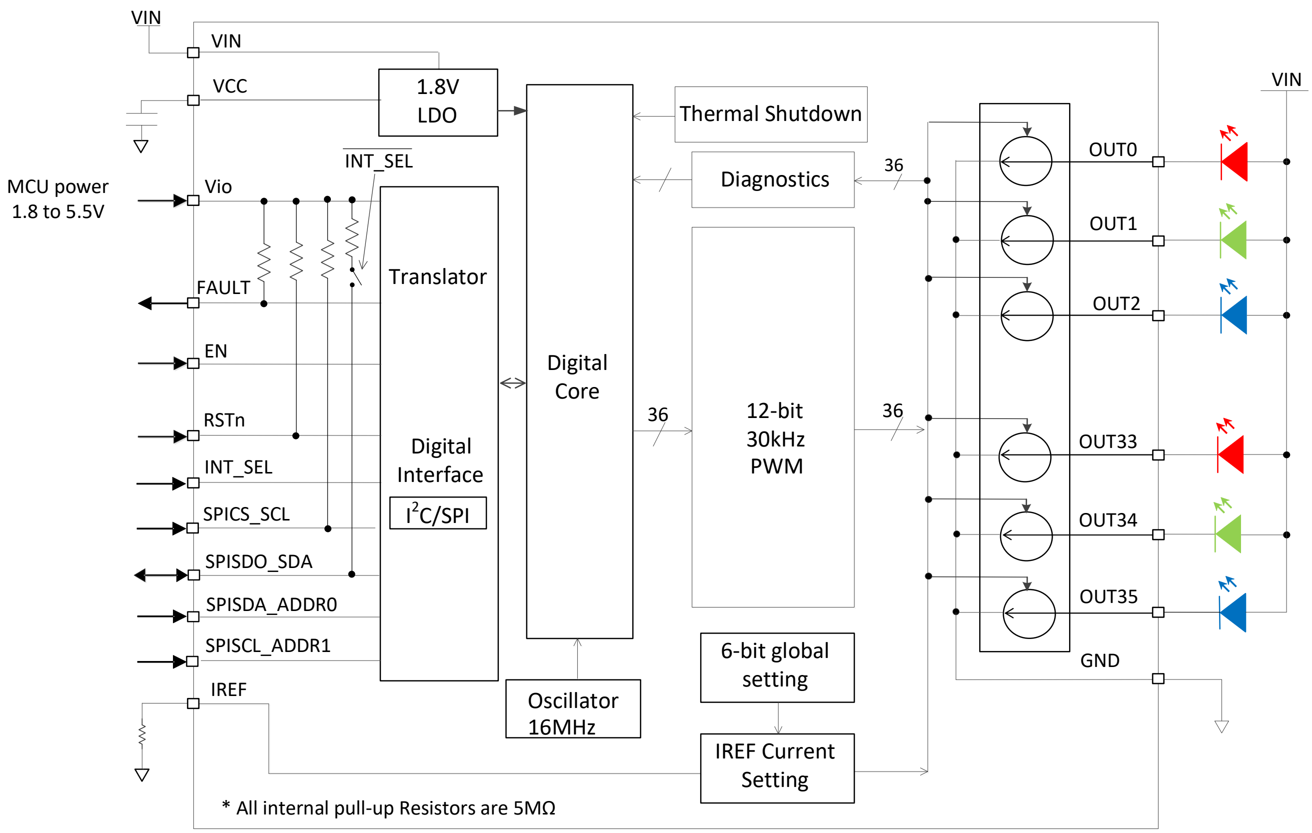
4) AL5887Q (SPI interface) connected in parallel



Pin Descriptions

Pin Name	Pin Number	Type	Function
OUT0 to OUT5	1 to 6	O	Current sink output for LED 0 to LED 5
OUT6 to OUT17	8 to 19	O	Current sink output for LED 6 to LED 17
OUT18 to OUT29	21 to 32	O	Current sink output for LED 18 to LED 29
OUT30 to OUT35	34 to 39	O	Current sink output for LED 30 to LED 35
Vio	40	I	Input power from MCU power rail
FAULT	41	O	Analog output with open drain internal pull up 5MΩ resistor to Vio for fault indication
SPISDO_SDA	42	I/O	INT_SEL = HIGH, SPI master input slave output, serial data line INT_SEL = LOW, I^2C Data line If not used, this pin must be connected to GND or VIN. (Default = HIGH for I^2C)
SPICS_SCL	43	I	INT_SEL = HIGH, SPI active low chip select INT_SEL = LOW, I^2C bus clock line If not used, this pin must be connected to GND or VIN. (Default = HIGH)
SPISDA_ADDR0	44	I	INT_SEL = HIGH, SPI master output slave input, serial data line INT_SEL = LOW, I^2C slave-address selection pin This pin must not be left floating. (Default = LOW)
SPISCL_ADDR1	45	I	INT_SEL = HIGH, SPI serial clock line from SPI master (FPGA) INT_SEL = LOW, I^2C slave-address selection pin This pin must not be left floating. (Default = LOW)
IREF	47	O	Connect an external resistor to regulate all channel output current.
INT_SEL	48	I	Selects the required communication interface. INT_SEL = LOW selects I^2C and INT_SEL = HIGH selects SPI. This pin must not be left floating. (Default = LOW)
VCC	49	O	Internal LDO 1.8V output pin, this pin must be connected to a 1µF capacitor to GND.
RSTn	50	I	Resets digital interface only but retains other register values if pulled down for time between 1ms to 20ms. Resets all register values if pulled down for time more than 20ms. Needs to be pulled high for powering up the internal digital block. (Default = HIGH)
EN	51	I	Active low to shut down the chip. (Default = LOW)
VIN	52	Power	Power supply
GND	7, 20, 33, 46	GND	Ground
—	Thermal Exposed Pad	GND	Thermal exposed pad also serves as a ground for the device.

Functional Block Diagram



Absolute Maximum Ratings (Note 4)

Symbol	Parameter	Rating	Unit
V_{IN}	Input Voltage, Voltage Relative to GND	-0.3 to 6	V
I_{OUTx}	OUTx Output Current	160	mA
V_{OUTx}, EN, FAULT, RSTn, Vio, INT_SEL, SPICS_SCL, SPISDO_SDA, SPISDA_ADDR0, SPISCL_ADDR1, IREF	High-Voltage Pins	-0.3 to 6V	V
VCC	Low-Voltage Pins	-0.3 to 2V	V
T_J	Junction Temperature	-40 to +150	°C
T_{STG}	Storage Temperature	-65 to +150	°C
ESD	HBM	2000	V
	CDM	1000	V

Note: 4. Stresses greater than those listed under *Absolute Maximum Ratings* can cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions* is not implied. Exposure to *Absolute Maximum Ratings* for extended periods can affect device reliability.
Semiconductor devices are ESD sensitive and may be damaged by exposure to ESD events. Suitable ESD precautions should be taken when handling and transporting these devices.

Package Thermal Data (Note 5)

Symbol	Thermal Resistance	W-QFN6060-52/SWP (Type A1)	Unit
$R_{\theta JA}$	Junction-to-ambient thermal resistance	19.23	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	7.76	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	3.58	°C/W
Ψ_{JT}	Junction-to-top characterization parameter	0.07	°C/W
Ψ_{JB}	Junction-to-board characterization parameter	3.36	°C/W
$R_{\theta JC(bot)}$	Junction-to-case (bottom) thermal resistance	0.72	°C/W

Note: 5. Test condition: Device mounted on FR-4 PCB (51mm x 51mm 2oz copper, minimum recommended pad layout on top layer and thermal vias to bottom layer with maximum area ground plane. For better thermal performance, larger copper pad for heat-sink is needed.

Recommended Operating Conditions (@T_A = -40°C to +125°C, unless otherwise specified.)

Symbol	Parameter	Min	Typ	Max	Unit
V_{IN}	Device supply voltage	2.7	—	5.5	V
Vio	Input power from MCU rail	1.8	3.3	5.5	V
I_{OUTx}	OUTx output current (Note 6)	—	39	70	mA
T_A	Ambient temperature (Note 6)	-40	—	+125	°C
T_J	Junction temperature	-40	—	+150	°C

Note: 6. Dependent on ambient temperature, LED voltage, package thermal limitation, and PCB layout.

Electrical Characteristics (V_{IN} = 3.3V, -40°C < T_A < +125°C, unless otherwise specified.)

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
POWER SUPPLY						
V_{IN}	Supply voltage	—	2.7	3.3	5.5	V
VCC	Internal 1.8V LDO output	—	1.75	1.8	1.84	V
I_{VIN}	Shut down supply current	V_{EN} = 0V	—	0.2	6	µA
	Standby supply current	V_{EN} = 3.3V, Chip_EN = 0 (bit)	—	12	33	µA
	Normal-mode supply current	With 39mA LED current per OUTx	—	7	9	mA
	Power-save mode supply current	V_{EN} = 3.3V, Chip_EN = 1 (bit), Power_Save_EN = 1 (bit), All LEDs turned off for time > 30ms	—	12	33	µA
UVLO+	VIN UVLO rising	—	2	2.36	2.6	V
UVLO-	VIN UVLO falling	—	1.8	2.16	2.4	V
UVLO_Hys	—	—	—	0.2	—	V
V_{IREF}	Output voltage of IREF pin	—	0.690	0.7	0.710	V
CURRENT SINK (Note 7), Max_Current_Option set in Device Config 1 Register, G5:G0 set in LED Global Dimming Register (See page 24)						
I_{MAX}	Maximum global output current (Channel average current, Color Register = FF, Brightness Register = FF)	V_{IN} in full range, R_{SET} = 2.1kΩ Max_Current_Option = 0, G5:G0 = 000000	—	29.25	—	mA
		V_{IN} in full range, R_{SET} = 2.1kΩ Max_Current_Option = 1, G5:G0 = 100000 (Note 10)	—	7	—	mA
		V_{IN} in full range, R_{SET} = 2.1kΩ Max_Current_Option = 1 G5:G0 = 000000	—	39	—	mA
		V_{IN} in full range, R_{SET} = 2.1kΩ Max_Current_Option = 1 G5:G0 = 011111 (Note 10)	—	70	—	mA
I_{LIM}	Internal current limit	V_{IN} = 3.3V Max_Current_Option = 1, V_{IREF} = 0V G5:G0 = 011111	—	75	155	mA
I_{D2D} (Note 8)	Device to device (Iavg-Iset)/Iset x 100	V_{IN} = 2.7 – 5.5V. RSET= 2.1K, all channels' current set to 10mA. PWM = 100%. G5:G0=100011 (I_{MAX}=10mA)	—	±3	—	%
I_{C2C} (Note 9)	Channel to channel (Ioutx-Iavg)/Iavg x 100	V_{IN} = 2.7 – 5.5V. RSET= 2.1K, all channels' current set to 10mA. PWM = 100%. G5:G0=100011 (I_{MAX}=10mA)	—	±3	—	%
I_{lkg}	LEDx leakage current	PWM = 0%	—	0.01	2.2	µA
VSAT	Output Saturation Voltage	V_{IN} in full range, Max_Current_Option = 1 (bit), R_{SET} = 2.1kΩ, PWM=100%, the voltage when the LED current has dropped 5%, G5:G0 = 000000	—	0.2	0.6	V
$V_{OPEN\_th\_rising}$	LED open threshold	V_{IN} = 3.3V, V_{OUTx} < $V_{OPEN\_th\_rising}$	0.10	0.2	0.35	V
$V_{SC\_th\_rising}$	LED short threshold (V_{IN} - V_{OUTx})	V_{IN} = 3.3V, V_{IN} - V_{OUTx} < $V_{SC\_th\_rising}$	0.31	0.62	0.9	V

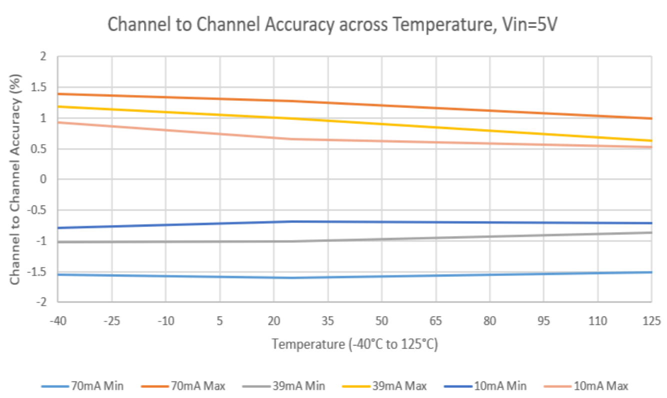
Notes:
7. For understanding of PWM generation process, please refer to Section 2.1.3.
8. I_{D2D}: Accuracy of average of all 36 channels current with respect to design target. Not production tested, guaranteed by design.
9. I_{C2C}: Accuracy of individual channel current with respect to average of all 36 channels current within a device. Channel current: average, or mean current (not RMS current) on a channel. Not production tested, guaranteed by design.
10. Not production tested, guaranteed by design.

Electrical Characteristics (V_{IN} = 3.3V, -40°C < T_A < +125°C, unless otherwise specified.) (continued)

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
PWM GROUP DIMMING						
f_{PWM}	PWM frequency	—	25	30	36	kHz
f_{OSC}	Internal oscillator frequency (Note 10)	—	—	15.5	—	MHz
t_{IOUTx_rise}	IOUTx rise time (Note 10)	Time for 0% to 90% rise of IOUTx	—	8	—	ns
PROTECTION (Note 10)						
$T_{(PRETSD)}$	Pre-thermal warning threshold	—	—	+145	—	°C
$T_{(PRETSD\_HYS)}$	Pre-thermal warning hysteresis	—	—	+20	—	°C
T_{SD}	Thermal shutdown temperature	—	—	+165	—	°C
T_{HYS}	Thermal shutdown temperature hysteresis	—	—	+20	—	°C

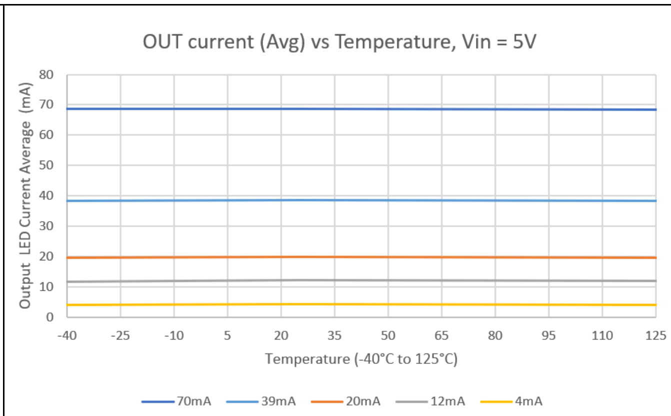
Note: 10. Not production tested, guaranteed by design.

Typical Performance Characteristics (V_{IN} = 5V, -40°C < T_A < +125°C, unless otherwise specified.)



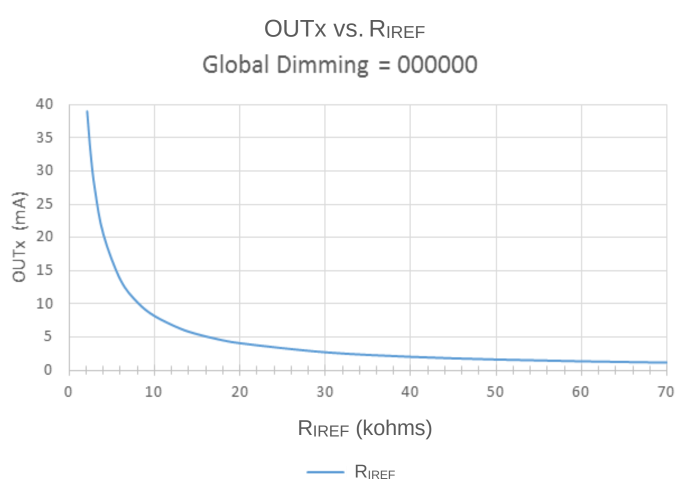
V_{IN} = 5V, I_{OUT} = 70mA, 39mA,10mA

Figure 1. Channel to Channel Accuracy vs. Temperature



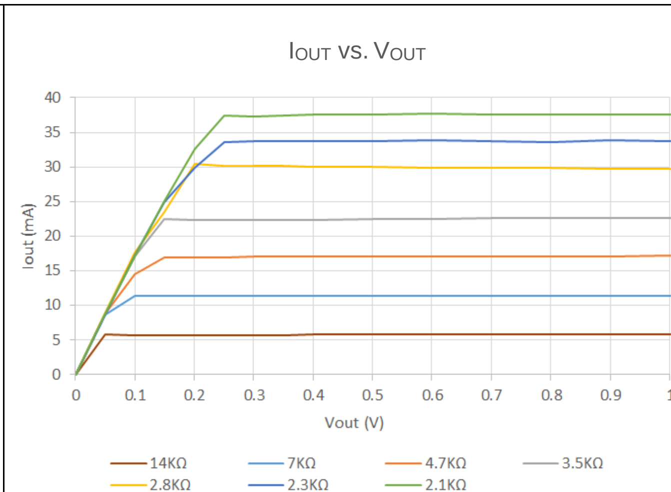
V_{IN} = 5V, I_{OUT} = 70mA, 39mA, 20mA, 12mA, 4mA

Figure 2. OUT Current vs. Temperature



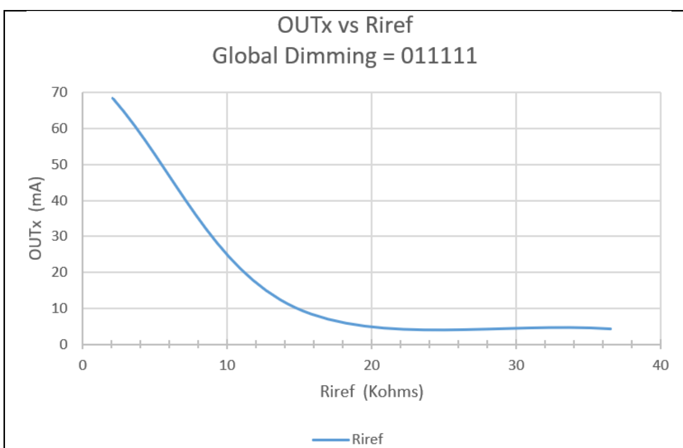
Global Dimming = 000000

Figure 3. OUTx vs. R_{IREF}



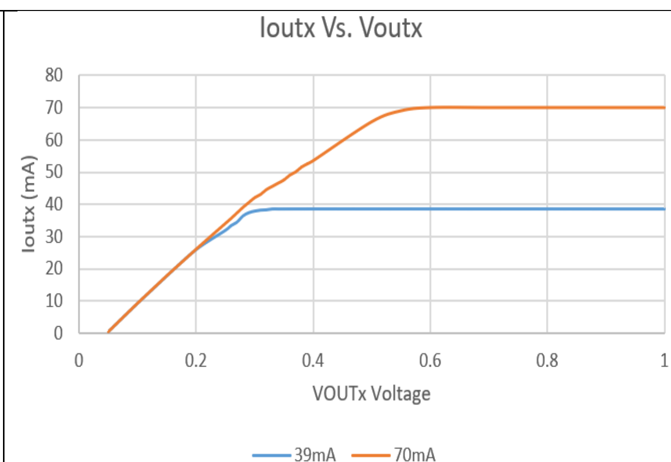
V_{IN} = 5V, R_{SET} = 2.1kΩ to 14kΩ

Figure 4. I_{OUT} vs. V_{OUT}



Global Dimming = 011111

Figure 5. OUTx vs. R_{IREF}



V_{IN} = 5V, R_{SET} = 2.1kΩ

Figure 6. I_{OUT} vs. V_{OUT}

Functional Descriptions

1. General Operation

One of the I²C or SPI protocols can be selected using the INT_SEL pin. Using the I²C/SPI interface, the AL5887Q controls the LED's color and brightness through four primary mechanisms:

1. Use R_{SET} to set full range for LED current I_{MAX} (up to 70mA).
2. Set I_{MAX} by using a 6-bit global dimming register, which is termed as LED GLOBAL DIMMING in the register's map.
3. Set color/brightness registers for LED color and brightness (see *Registers Map Description*).
4. Further select various dimming and protection features as described in *Registers Map Description*.

2. Feature Description

2.1 Each Channel PWM Control

The AL5887Q device is designed with independent color mixing and brightness control, which make it easier to achieve the RGB LED color effects needed. With the inputs of the color-mixing register and the brightness-control register, the final PWM generator output for each channel is a 12-bit resolution and 30kHz dimming frequency, which help achieve a smooth dimming effect and eliminate audible noise. See Figure 7.

For example, yellow color has the red, green, and blue components as 255, 255, and 0 respectively. So, to get the color yellow for the first RGB LED module, the color registers at the addresses 14h, 15h, and 16h—with values 255, 255, and 0 respectively. The brightness register for the first RGB LED module (at the address 8h) can be configured based on the amount of brightness needed, 255 being the maximum brightness.

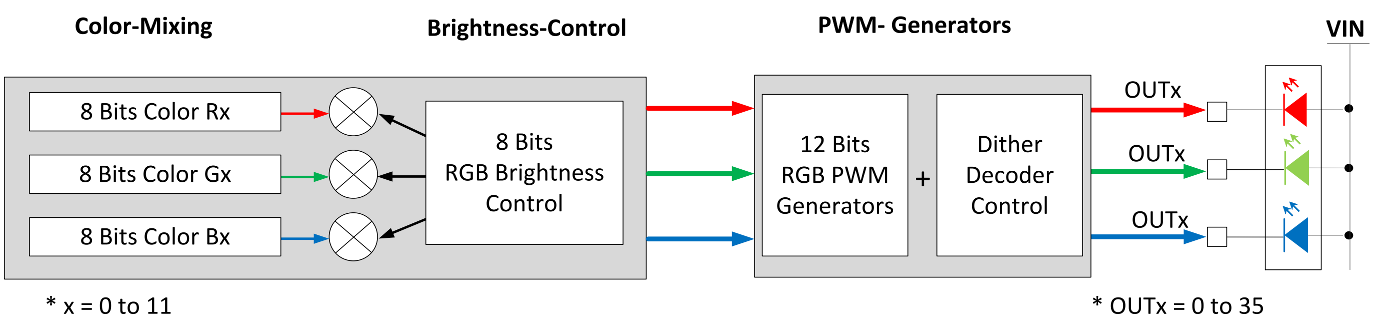


Figure 7. PWM Control Scheme for Each Channel

2.1.1 Independent Color Mixing Per RGB LED Module

Each output channel has its own individual 8-bit color-setting register (OUTx_COLOR). The device allows every RGB LED module to achieve > 16 million (256 × 256 × 256) color mixing.

2.1.2 Independent Brightness Control per RGB LED Module

When color is fixed, the independent brightness control is used to achieve accurate and flexible dimming control for every RGB LED module.

2.1.2.1 Brightness-Control Register Configuration

Every three consecutive output channels are assigned to their respective brightness-control register (RGBx_BRIGHTNESS). For example, LED0, LED1, and LED2 are assigned to RGB0_BRIGHTNESS, so it is recommended to connect the RGB LEDs in the sequence as shown in Table 1. The AL5887Q allows 256-step brightness control for each RGB LED module, which helps achieve a smooth dimming effect.

Keeping FFh (default value) in the RGB0_BRIGHTNESS register results in 100% dimming brightness. With this setting, users can configure the color-mixing register by channel to achieve the target dimming effect in a single-color LED application.

Functional Descriptions (continued)

2.1.2.2 Logarithmic- or Linear-Scale Brightness Control

For human-eye-friendly visual performance, a logarithmic-scale dimming curve is usually implemented in LED drivers. For RGB LEDs and if using a single register to achieve both color mixing and brightness control, color distortion can be observed easily when using a logarithmic scale. The AL5887Q, with independent color-mixing and brightness-control registers, implements the logarithmic scale dimming control inside the brightness-control function, which effectively solves the color distortion issue (See Figure 8). The AL5887Q also allows users to configure the dimming scale either logarithmically or linearly through the global Log_Scale_EN register bit. If a special dimming curve is desired, using the linear scale with software correction is the most flexible approach.

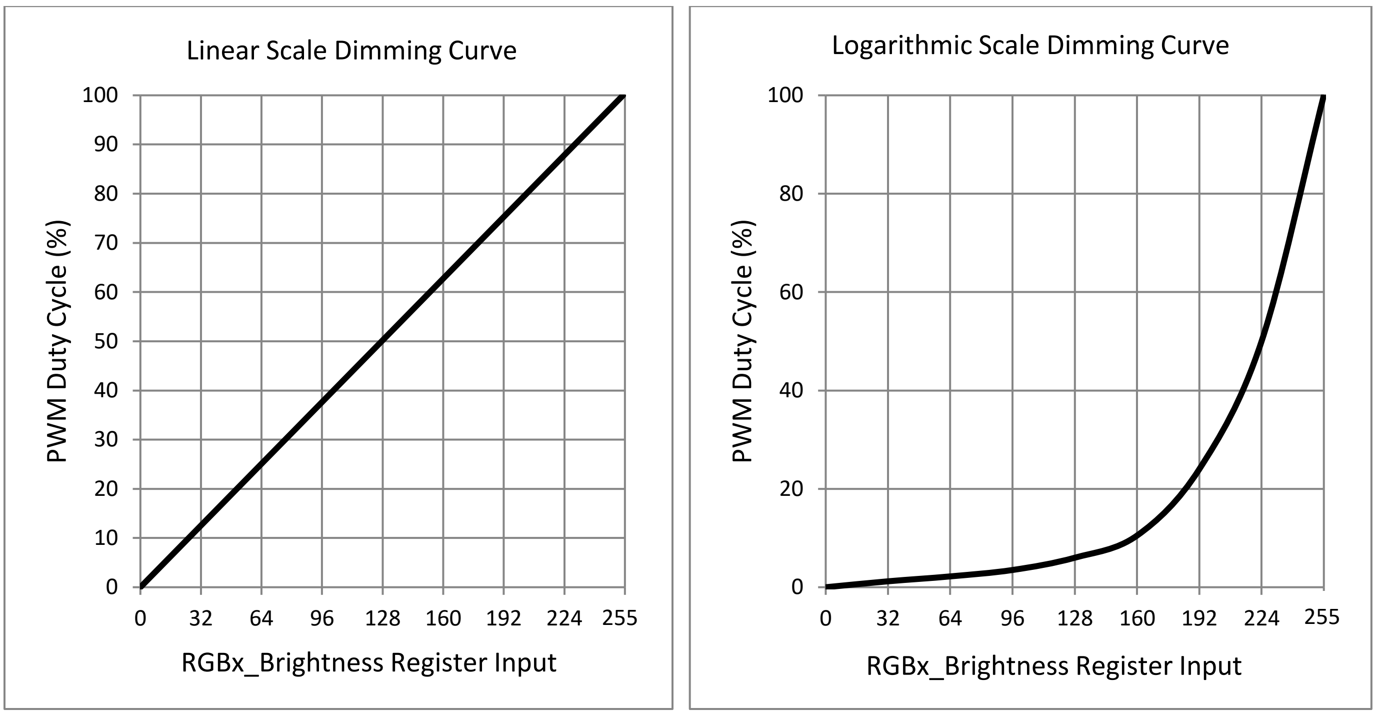


Figure 8. Logarithmic vs Linear Dimming Curve

2.1.3 12-Bit, 30kHz PWM Generator per Channel

With the inputs of the color mixing and the brightness control, the final output PWM duty cycle is defined as the product obtained by multiplying the color-mixing register value by the related brightness-control register value. The final output PWM duty cycle has 12 bits of control resolution, which is achieved by 9 bits of pure PWM resolution and 3 bits of dithering digital control. The AL5887Q allows users to enable or disable the dithering function through the PWM_Dithering_EN register. When enabled (default), the output PWM duty-cycle resolution is 12 bits. When disabled, the output PWM duty-cycle resolution is 9 bits.

When 3-bit dithering is enabled, dither effect is generated with 8 ($2^3 = 8$) possible dither values: “0”, “1”, “2”,…“7”, where 0 means no dithering; “1” means every 8^{th} PWM pulse is made 1 LSB longer to increase the final average duty cycle by 1 LSB/8 (duty cycle is termed as DT); “2” means in every group of 8 PWM pulses, the 7^{th} and 8^{th} PWM pulses are both made 1 LSB longer to increase DT by 2 LSB/8, etc. The AL5887Q uses 512 clocks in a 100% PWM DT period to achieve 9-bit pure PWM resolution ($2^9 = 512$), thus 1 LSB PWM DT is 1/512. Therefore, dither value “1” adds 1/(8 x 512) = 0.0244% additional DT to pure PWM DT. For example, combining with dither value “1”, the pure PWM DT of 25% will generate DT = 25.0244% for LED current regulation; while with dither value “2”, pure PWM DT of 25% will generate DT = 25.05%. Though the AL5887Q’s pure PWM resolution is 1/512 = 0.195%, the 3-bit dither scheme enhances PWM resolution to 0.0244%.

Functional Description (continued)

2.1.4 PWM Phase-Shifting

A PWM phase-shifting scheme allows for a delay in time when each LED driver is active. When the LED drivers are not activated simultaneously, the peak load current from the pre-stage power supply is significantly decreased. The scheme also reduces input-current ripple and ceramic-capacitor audible ringing. LED drivers are grouped into three different phases:

- Phase 1 - The rising edge of the PWM pulse is fixed. The falling edge of the pulse is changed when the duty cycle changes. Phase 1 is applied to LED0, LED3, …, LED[3 × (n – 1)].
- Phase 2 - The middle point of the PWM pulse is fixed. The pulse spreads in both directions when the PWM duty cycle is increased. Phase 2 is applied to LED1, LED4, …, LED[3 × (n – 1) + 1].
- Phase 3 - The falling edge of the PWM pulse is fixed. The rising edge of the pulse is changed when the duty cycle changes. Phase 3 is applied to LED2, LED5, …, LED[3 × (n – 1) + 2].

2.2 LED Bank Control

For most LED-animation effects, like blinking and breathing, all the RGB LEDs have the same lighting pattern. Instead of controlling the individual LED separately, which occupies the microcontroller resources heavily, the AL5887Q device provides an easy coding approach, the LED bank control. Each channel can be configured as either independent control or bank control through the LEDx_Bank_EN register. When LEDx_Bank_EN = 0 (default), the LED is controlled independently by the related color-mixing and brightness-control registers. When LEDx_Bank_EN = 1, the AL5887Q drives the LED in LED bank-control mode. The LED bank has its own independent PWM control scheme, which is the same structure as the PWM scheme of each channel. When a channel is configured in LED bank-control mode, the related color-mixing and brightness control are governed by the bank-control registers (BANK_A_COLOR, BANK_B_COLOR, BANK_C_COLOR, and BANK_BRIGHTNESS), regardless of the inputs on its own color-mixing and brightness-control registers.

Table 1. Bank Number and RGB Number Assignment

Out Number	Bank Number	RGB Module Number		Out Number	Bank Number	RGB Module Number
OUT0	Bank A	RGB0		OUT18	Bank A	RGB6
OUT1	Bank B			OUT19	Bank B	
OUT2	Bank C			OUT20	Bank C	
OUT3	Bank A	RGB1		OUT21	Bank A	RGB7
OUT4	Bank B			OUT22	Bank B	
OUT5	Bank C			OUT23	Bank C	
OUT6	Bank A	RGB2		OUT24	Bank A	RGB8
OUT7	Bank B			OUT25	Bank B	
OUT8	Bank C			OUT26	Bank C	
OUT9	Bank A	RGB3		OUT27	Bank A	RGB9
OUT10	Bank B			OUT28	Bank B	
OUT11	Bank C			OUT29	Bank C	
OUT12	Bank A	RGB4		OUT30	Bank A	RGB10
OUT13	Bank B			OUT31	Bank B	
OUT14	Bank C			OUT32	Bank C	
OUT15	Bank A	RGB5		OUT33	Bank A	RGB11
OUT16	Bank B			OUT34	Bank B	
OUT17	Bank C			OUT35	Bank C	

With the bank-control configuration, the AL5887Q enables users to achieve smooth and live LED effects globally with an ultra-simple software effort.

For example (as shown in Figure 9), if we want to configure RGB0 in independent mode and the rest of RGB1 to RGB11 in BANK mode, we can configure the LED_CONFIG0 register to FEh and LED_CONFIG1 register to 0Fh. By doing this, the RGB0 module operating in independent mode will be using RGB0_BRIGHTNESS for brightness and R0_COLOR, G0_COLOR, and B0_COLOR for R, G, and B colors respectively, while the other RGB modules in bank mode would use BANK_BRIGHTNESS for brightness and BANK A, BANK B, and BANK C for R, G, and B colors respectively.

Functional Description (continued)

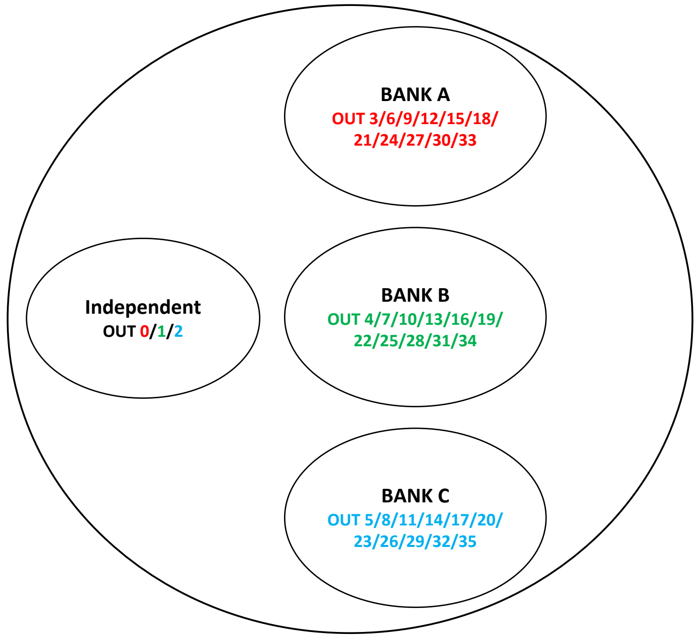


Figure 9. Bank PWM Control Example

2.3 Automatic Power-Save Mode

When all the LED outputs are inactive, the AL5887Q is able to enter power-save mode automatically, thus lowering idle-current consumption down to 25µA (maximum). Automatic power-save mode is enabled when the register bit Power_Save_EN = 1 (default) and all LEDs are off (both color and brightness registers = 00H) for a duration of > 30ms. Almost all analog blocks are powered down in power-save mode. If any I^2C/SPI command to the device occurs, the AL5887Q returns to NORMAL mode.

2.4 Protection Features

2.4.1 LED Open-Circuit Diagnostics

The AL5887Q integrates LED open-circuit diagnostics to allow users to monitor the LED status in real time. The device monitors OUTx voltage to determine if there is any open-circuit failure.

If the voltage V_{OUTx} for any of the channels goes below threshold $V_{OPEN\_th\_rising}$ and if the open persists for more than t_{FAULT_WAIT}, the AL5887Q pulls the FAULT pin low to report the fault, and sets the flag registers OFx and FLAG_OPEN to 1. Once the open-circuit failure is removed, the controller needs to send CLR_FAULT to clear the FLAG_OPEN after fault removal. The fault delay is decided based on the below table.

Table 2. Fault Wait Time

FW1	FW0	t_{FAULT_WAIT}
0	0	8 PWM clock count
0	1	16 PWM clock count
1	0	24 PWM clock count
1	1	32 PWM clock count

2.4.2 LED Short-Circuit Diagnostics

The AL5887Q monitors the voltage difference between supply (VIN) and OUTx to determine if there is any short-circuit failure. If the difference voltage (V_{IN} - V_{OUTx}) for any of the channels falls below the threshold ($V_{SC\_th\_rising}$), and if the short persists for more than t_{FAULT_WAIT}, the AL5887Q pulls the FAULT pin low to report the fault and also sets flag register SFx and FLAG_SHORT to 1. The MCU should turn off the channel that detects a short fault to avoid overstressing the device. Once the short-circuit failure is removed, the controller needs to send CLR_FAULT to clear the FLAG_SHORT after fault removal.

Functional Description (continued)

2.4.3 Pre-OTP Warning & Thermal Shutdown

The AL5887Q has a pre-thermal warning threshold of +145°C (typical) and thermal shutdown threshold of +165°C (typical)

When the AL5887Q's junction temperature rises above the pre-thermal warning threshold of +145°C (typical) and persists for more than 33µs, the device reports a pre-thermal warning by pulling the FAULT pin low and sets the flag register FLAG_PREOTP to 1. The device releases pre-OTP warning once the temperature goes below +125°C. Once the fault is removed, the controller needs to send CLR_FAULT to clear the flag register after fault removal.

The AL5887Q also implements a thermal-shutdown mechanism to protect the device from damage due to overheating when the junction temperature rises further than +165°C (typical). In this mode, the FAULT pin state will change to LOW, Flag register (65h), and the default value of 10h will change to 14h. All the OUTx outputs will be shut down. To return to NORMAL mode, write 02h to Mask and CLR register (68h) and decrease the junction temperature below +150°C (typical). The FAULT pin state will then change to HIGH, and the device will return to NORMAL mode.

2.4.4 Pre-UVLO Warning

The AL5887Q provides a pre-UVLO feature that warns the MCU if the supply (V_{IN}) is low. When V_{IN} goes below the pre-UVLO threshold and persists for more than 33µs, the FAULT pin is pulled low and the flag register FLAG_PREUVLO is set to 1. The device releases pre-UVLO warning once the V_{IN} goes above pre-UVLO+ threshold. Once the fault is cleared, the controller needs to send CLR_FAULT to clear the flag register after fault removal.

2.4.5 UVLO

The AL5887Q has an internal comparator that monitors the voltage at V_{IN} . When V_{IN} is below UVLO-, reset is active and the AL5887Q is in the INITIALIZATION state. When the V_{IN} supply goes below the UVLO- threshold, the FAULT pin is pulled low to indicate the fault.

2.4.6 Digital POR Indicator

The AL5887Q has a digital bit FLAG_POR to indicate the power on reset. The default value of this bit is high to indicate the power on reset of digital block. The controller can set CLR_POR during the start of the operation to reset FLAG_POR so that the next power on reset to digital block can be captured.

2.4.7 Fault Masking

OMx prevents the output open-circuit fault of individual channels from being reported to the FAULT pin, while Open_Mask prevents any of the channels open fault from being reported to the FAULT pin.

SMx prevents the output short-circuit fault of individual channels from being reported to the FAULT pin, while Short_Mask prevents any of the channels short fault from being reported to the FAULT pin.

Pre_OTP_Mask prevents the pre_OTP fault from being reported to the FAULT pin.

Pre_UVLOMask prevents the pre_UVLO fault from being reported to the FAULT pin.

POR_Mask prevents the POR event from being reported to the FAULT pin.

Functional Description (continued)

2.4.8 Output

The FAULT pin is a fault indicator pin. It can be used as an interrupt output to the master controller in case of any fault. The FAULT pin is an NMOS open-drain output with an internal 5MΩ pull-up resistor, pulled to Vio, and additionally this pin can be pulled up externally to the controller supply using a smaller resistor such as 10kΩ, as shown in the figure below. When one or any of the faults are triggered; such as UVLO, OTP, pre-UVLO, pre-OTP, channel open, and channel short; the FAULT pin is pulled low continuously. Once the FAULT pin output is triggered, the controller needs to take necessary action and to deal with the fault and reset the fault flag. The AL5887Q acts only for UVLO and OTP faults. For any other fault, the AL5887Q only reports the fault and the controller must take action.

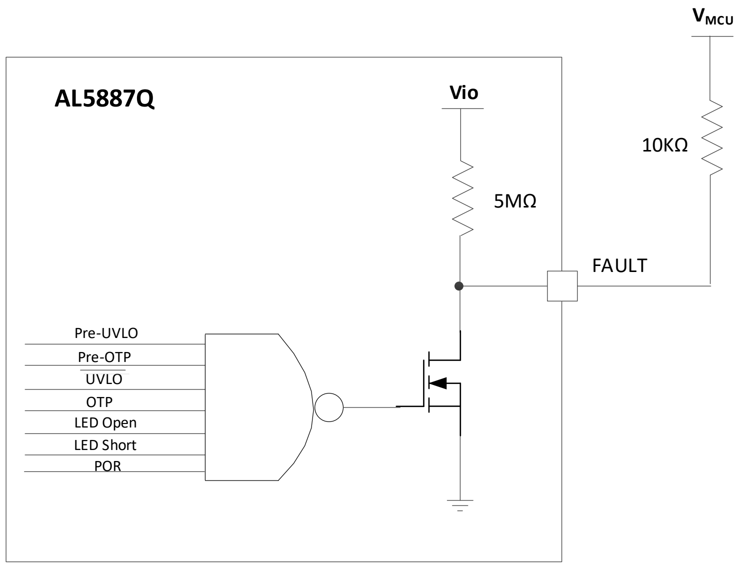


Figure 10. FAULT Internal Block Diagram

2.5 Interface Selection

Interface selection between I^2C or SPI is done using an external pin INT_SEL. When tied low, I^2C is selected. When connected high, SPI is selected.

2.6 Digital Communication Enhancements

Pulling the external pin RSTn high enables the internal digital block. Pulling down for a duration between 1ms to 20ms resets only the digital interface and keeps other register values unaltered. Pulling down for a duration of more than 20ms resets all registers. There is an internal pull-up resistor that, by default, pulls up this pin to HIGH.

Functional Description (continued)

2.7 Current Setting for all Channels

The maximum global output current for all 36 channels can be adjusted by the external resistor, R_{SET}, as described below.

$I_{MAX} = K_{IREF} \times V_{IREF} / R_{SET} \times [\, (Max\_Current\_Option/4)+(3/4) \,]$ ……………………………………….(1)

where,

I_{MAX} = Channel average current, Color Register = FF, Brightness Register = FF

V_{IREF} = 0.7 V

R_{SET} = External dimming resistor (2.1kΩ recommended)

Max_Current_Option = 1 (default) or 0, see *Register Map*.

K_{IREF} = 21 + (N x 3), is the current multiplication factor which can be programmed using a 6-bit global dimming register G5:G0 (Address = 66H), which is an analog dimming register and N is the decimal equivalent of $\overline{G5}$ G4 G3 G2 G1 G0.

For example, if all global dimming register bits are 0, the N will be the decimal equivalent of 100000, which is 32. Hence, K_{IREF} = 21 + (32 x 3) = 117.

Using equation (1) above, for R_{SET} = 2.1kΩ and Max_Current_Option = 1, below is the table that shows I_{MAX} variation with respect to the global dimming register bits. From Table 3, we can see that the default value = 39mA, minimum value = 7mA, and maximum value = 70mA.

Table 3. I_{MAX} vs. Global Dimming @ R_{SET} = 2.1kΩ

G5	G4	G3	G2	G1	G0	I_{MAX} (mA)	K_{IREF}
0	0	0	0	0	0	39 (Default)	117 (Default)
0	0	0	0	0	1	40	120
0	0	0	0	1	0	41	123
0	0	0	0	1	1	42	126
		• • •				• • •	• • •
0	1	1	1	0	0	67	201
0	1	1	1	0	1	68	204
0	1	1	1	1	0	69	207
0	1	1	1	1	1	70 (Max)	210 (Max)
1	0	0	0	0	0	7 (Min)	21 (Min)
1	0	0	0	0	1	8	24
1	0	0	0	1	0	9	27
1	0	0	0	1	1	10	30
		• • •				• • •	• • •
1	1	1	1	0	1	36	108
1	1	1	1	1	0	37	111
1	1	1	1	1	1	38	114

Functional Description (continued)

Similarly, using equation (1) above, for global dimming register setting of 000000H and Max_Current_Option = 1, below is the table that shows I_{MAX} variation with respect to the R_{SET}.

Table 4. I_{MAX} vs. R_{SET} @ G5:G0 = 000000

R_{SET} (kΩ)	I_{MAX} (mA)	K_{IREF}
2.1 (Recommended)	39	117
14.7	5.57	117
36.5	2.24	117

Table 5 shows I_{MAX} range using global dimming at different R_{SET} values.

Table 5. I_{MAX} vs. Global Dimming Bits @ Various R_{SET}

R_{SET} (kΩ)	I_{MAX} (mA)		
	Min	Default	Max
2.1 (Recommended)	7	39	70
14.7	1	5.57	10
36.5	0.4	2.24	4

2.7.1 Thermal Considerations

As V_{INMAX} increases to 5.5V, the voltage on the OUTx nodes can go as high as 3V for RED LEDs and 2V for GREEN and BLUE LEDs. In the situation where the user configures G5:G0 or R_{EXT} for higher currents, the device may overheat and hit the thermal shutdown voltage.

Hence, the channels' V_{IN} and I_{OUTx} should be chosen in such a way that the device junction temperature does not exceed its thermal shutdown temperature. Below is the formula relating the power dissipation and θ_{JA} to avoid thermal shutdown.

$$T_J = T_A + (\theta_{JA} \times P_{TOTAL})$$

Where, T_J is the junction temperature.
T_A is the ambient temperature.
θ_{JA} is the junction to ambient thermal resistance.
P_{TOTAL} is the device's total power dissipation.

Example: If all 36 channels are turned on and carry the same current I_{MAX}, then the device total power dissipation is given by,

$$P_{TOTAL} = (12 \times V_{(OUT0)} \times I_{MAX}) + (12 \times V_{(OUT1)} \times I_{MAX}) + (12 \times V_{(OUT2)} \times I_{MAX})$$

2.8 Microcontroller (MCU) Supply

The AL5887Q can recognize interface logic levels from 1.8V to 5.5V. So, an MCU interacting with the AL5887Q can operate in the range 1.8V to 5.5V. However, the information of the supply used by the MCU is required to be shared with the AL5887Q by connecting the MCU supply to the AL5887Q's Vio pin.

Functional Description (continued)

2.9 Device Functional Modes

- **INITIALIZATION**: The device enters INITIALIZATION mode when EN = High. In this mode, all the registers are reset. Entry can also be from any state if the RESET (register) = FFh or UVLO is active.
- **NORMAL**: The device enters NORMAL mode when Chip_EN (register) = 1. I_{VIN} is 7mA (typical).
- **POWER SAVE**: The device automatically enters POWER SAVE mode when Power_Save_EN (register) = 1 and all the LEDs are off for a duration of > 30ms. In POWER SAVE mode, analog blocks are disabled to minimize power consumption, but the registers retain the data and keep it available via I²C/SPI. I_{VIN} is 33µA (max). In the occurrence of any I²C/SPI command, the device goes back to NORMAL mode.
- **SHUTDOWN**: The device enters SHUTDOWN mode from all states on VIN power down or when EN = Low > 25ms. I_{VIN} is < 6µA (max).
- **STANDBY**: The device enters STANDBY mode when Chip_EN (register bit) = 0. In this mode, all OUTx are shut down, but the registers retain data and keep it available via I²C/SPI. STANDBY is the low-power-consumption mode when all circuit functions are disabled. I_{VIN} is 33µA (max).
- **THERMAL SHUTDOWN**: The device automatically enters THERMAL SHUTDOWN mode when the junction temperature exceeds +165°C (typical). In this mode, the FAULT pin state will change to LOW, Flag register (65h), and the default value 10h will change to 14h. All OUTx outputs will shut down.

Addr.	Name	BIT7	BIT6	BIT5	BIT4	BIT3	BIT2	BIT1	BIT0	FDV
65h	FLAG	Reserved			FLAG_POR	FLAG_ PREUVLO	FLAG_ PREOTP	FLAG_ SHORT	FLAG_ OPEN	10h

- **RETURN TO NORMAL MODE**: Write 02h to Mask and CLR register (68h) to clear the Fault bit.

Addr.	Name	BIT7	BIT6	BIT5	BIT4	BIT3	BIT2	BIT1	BIT0	FDV
68h	MASK and CLR	Reserved	POR_Mask	PreUVLO_ Mask	PreOTP_ Mask	Short_Mask	Open_ Mask	CLR_Fault	CLR_POR	00h

Write 40h to DEVICE_CONFIG0 register (00h) to enable the device back to normal mode, then decrease the junction temperature below +145°C (typical). FAULT pin state will change to HIGH, then the device returns to NORMAL mode.

Addr.	Name	BIT7	BIT6	BIT5	BIT4	BIT3	BIT2	BIT1	BIT0	FDV
00h	DEVICE_CONFIG0	Reserved	CHIP_EN	Reserved						00h

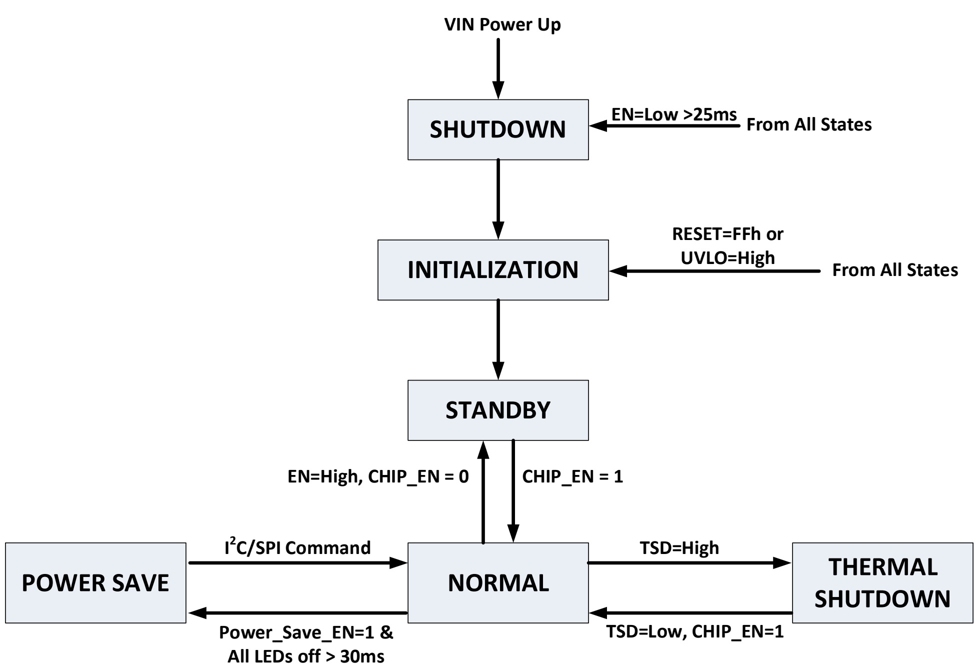


Figure 11. Functional Mode

Functional Description (continued)

3. Programming (SPI)

3.1 SPI-Compatible Interface

The AL5887Q is compatible with SPI serial-bus specification and operates as a slave.

3.1.1 SPI INITIALIZATION

Upon the release of power-on-reset (POR), the SPI peripheral in the Digital Block waits for the chip-selection signal (SPICS_SCL) from the SPI Controller. The output SPISDA_ADDR0 of the AL5887Q is at high impedance until the reception of an active low on the select line.

The duration of the select line (SPICS_SCL) should be compliant with lead- and lag-time requirements.

Lead time: 1) The time from SPICS_SCL low to SPISCL_ADDR1 high.
2) Least lead time is half clock period.

Lag time: 1) The time from SPISCL_ADDR1 low to SPICS_SCL high.
2) Least lag time is one clock period.

The AL5887Q is configured to communicate in Mode 0. Data read on rising edge. Clock Polarity in Idle State is Logic Low.

3.1.2 Write Operation

A '1' on bit (R/W) of the SPI request frame indicates a write request from the SPI Controller. Bits A6 to A0 provide the address of the register to which the data is to be written. The contents of the frame from bit D7 to D0 are written into the respective register, with the last positive edge of the SPISCL_ADDR1 being in the current SPI frame.

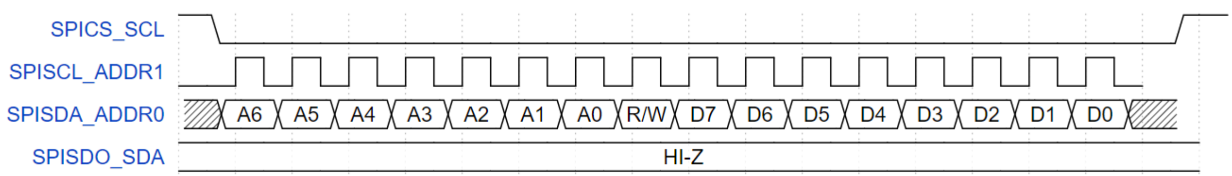


Figure 12. SPI Write Transaction

3.1.3 Read Operation

A read request from the SPI Controller is decoded with the read/write enable bit (R/W). A '0' on bit (R/W) of the frame indicates a read request from the Controller.

Bits A6 to A0 provide the address of the register. For a valid address, the 8-bit contents of the respective register are read out. For invalid addresses (out-of range/unused addresses) the response will be a default value (zero). The peripheral responds to the read request one clock cycle later by setting up data on the falling edge; the Controller reads data on the rising edge.

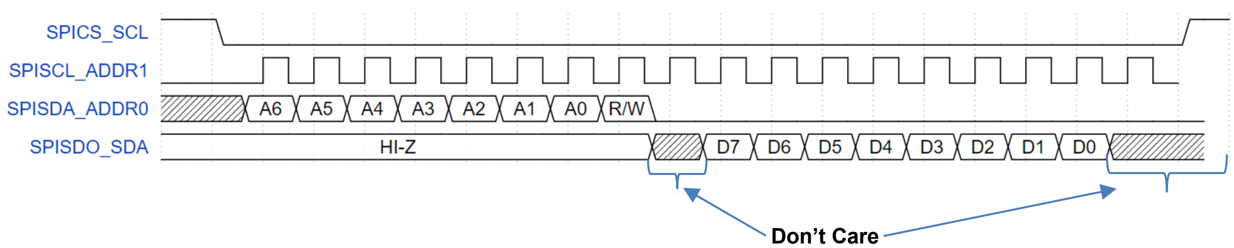


Figure 13. SPI Read Transaction

Functional Description (continued)

4. Programming (I²C)

4.1 I²C Interface

The I²C-compatible two-wire serial interface provides access to the programmable functions and registers on the device. This protocol uses a two-wire interface for bidirectional communications between the devices connected to the bus. The two interface lines are the serial data line (SDA) and the serial clock line (SCL). Every device on the bus is assigned a unique address and acts as either a master or a slave depending on whether it generates or receives the serial clock, SCL. The SCL and SDA lines should each have a pull-up resistor placed somewhere on the line and remain HIGH even when the bus is idle.

4.1.1 Data Validity

The data on the SDA line must be stable during the HIGH period of the clock signal (SCL). In other words, the state of the data line can only be changed when the clock signal is LOW.

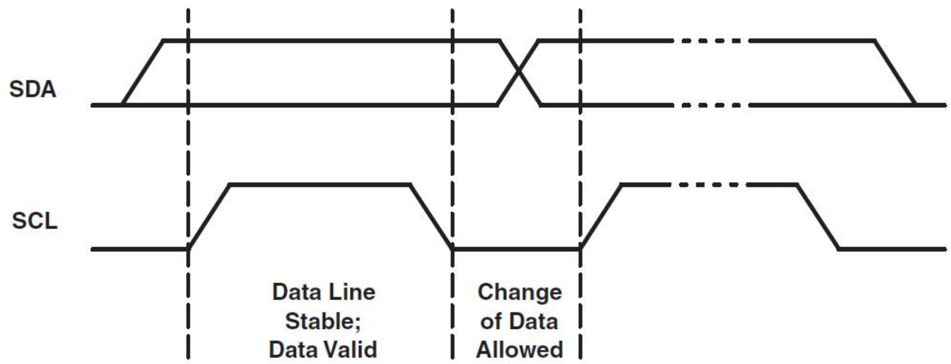


Figure 14. Data Validity

4.1.2 Start and Stop Conditions

START and STOP conditions classify the beginning and the end of the data transfer session. A START condition is defined as the SDA signal transitioning from HIGH to LOW while the SCL line is HIGH. A STOP condition is defined as the SDA transitioning from LOW to HIGH while SCL is HIGH. The bus master always generates START and STOP conditions. The bus is considered to be busy after a START condition, and free after a STOP condition. During data transmission, the bus master can generate repeated START conditions. First START and repeated START conditions are functionally equivalent.

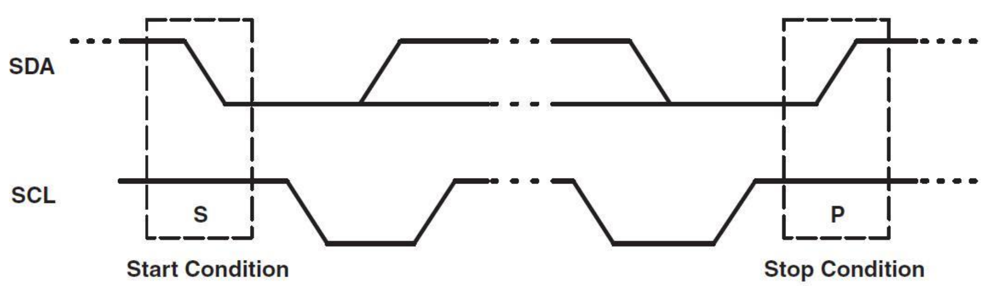


Figure 15. Start and Stop Conditions

Functional Description (continued)

4.1.3 Transferring Data

Every byte put on the SDA line must be eight bits long, with the most significant bit (MSB) being transferred first. Each byte of data must be followed by an acknowledge bit. The acknowledge-related clock pulse is generated by the master. The master releases the SDA line (HIGH) during the acknowledge clock pulse. The device pulls down the SDA line during the 9th clock pulse, signifying an acknowledge. The device generates an acknowledge after each byte has been received.

There is one exception to the acknowledge-after-every-byte rule. When the master is the receiver, it must indicate to the transmitter an end of data by not acknowledging (negative acknowledge) the last byte clocked out of the slave. This negative acknowledge still includes the acknowledge clock pulse (generated by the master), but the SDA line is not pulled down.

After the START condition, the bus master sends a chip address. This address is seven bits long followed by an eighth bit, which is a data direction bit (READ or WRITE). For the eighth bit, a 0 indicates a WRITE, and a 1 indicates a READ. The second byte selects the register to which the data is written. The third byte contains data to write to the selected register.

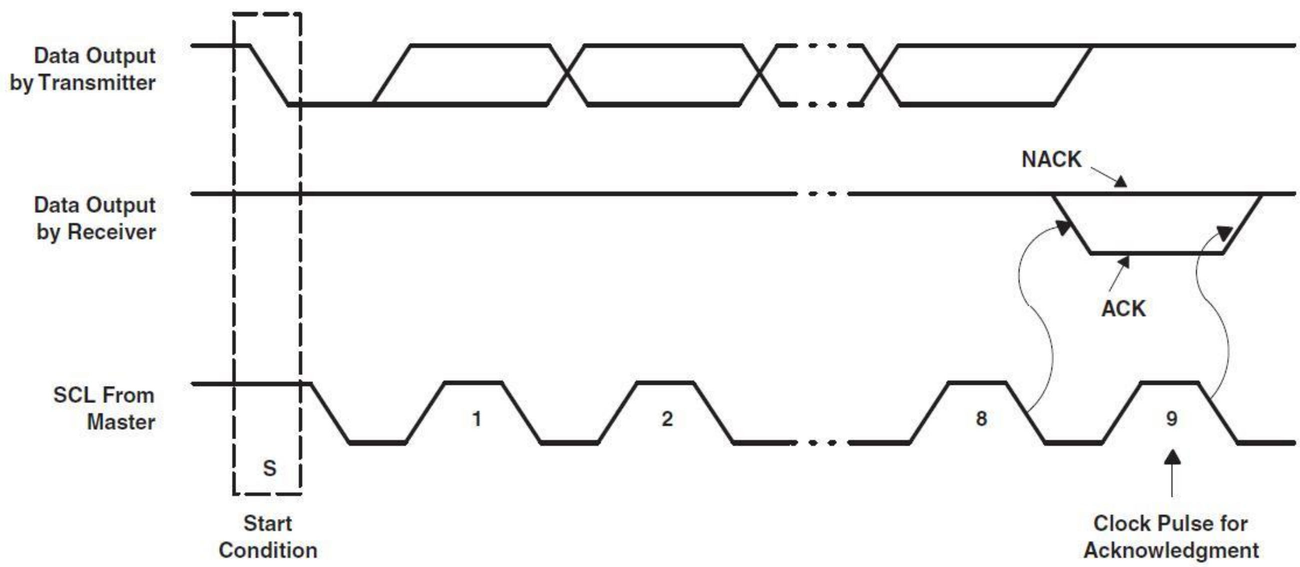


Figure 16. Acknowledge and Not Acknowledge on I^{2}C Bus

Functional Description (continued)

4.1.4 I²C Slave Addressing

The AL5887Q slave address is defined by connecting GND or VIO to the SPISDA_ADDR0 and SPISCL_ADDR1 pins. A total of four independent slave addresses can be realized by combinations when GND or VIO are connected to the SPISDA_ADDR0 and SPISCL_ADDR1 pins (see Table 6 and Table 7).

The device has a slave address for Broadcast Mode which allows MCU to configure multiple AL5887Q devices simultaneously. The device responds to a broadcast slave address regardless of the setting of the SPISDA_ADDR0 and SPISCL_ADDR1 pins. Global writing to the broadcast address can be used for configuring all devices simultaneously. The device supports global read using a broadcast address; however, the data read is only valid if all devices on the I²C bus contain the same value in the addressed register.

Table 6. Slave-Address Combinations

SPISCL_ADDR1	SPISDA_ADDR0	Slave Address	
		Independent	**Broadcast**
GND	GND	011 0000	001 1100
GND	Vio	011 0001	
Vio	GND	011 0010	
Vio	Vio	011 0011	

Table 7. Chip Address

	Slave Address							R/W
	Bit 7	**Bit 6**	**Bit 5**	**Bit 4**	**Bit 3**	**Bit 2**	**Bit 1**	**Bit 0**
Independent	0	1	1	0	0	SPISCL_ADDR1	SPISDA_ADDR0	1 or 0
Broadcast	0	0	1	1	1	0	0	1 or 0

4.1.5 Control-Register Write Cycle

- The master device generates a start condition.
- The master device sends the slave address (7 bits) and the data direction bit (R/W = 0).
- The slave device sends an acknowledge signal if the slave address is correct.
- The master device sends the control register address (8 bits).
- The slave device sends an acknowledge signal.
- The master device sends the data byte to be written to the addressed register.
- The slave device sends an acknowledge signal.
- If the master device sends further data bytes, the control register address of the slave is incremented by 1 after the acknowledge signal. To reduce program load time, the device supports address auto incrementation. The register address is incremented after each 8 data bits. In this Auto Incrementation Mode MCU can write or read consecutive registers within one transmission.
- The write cycle ends when the master device creates a stop condition.

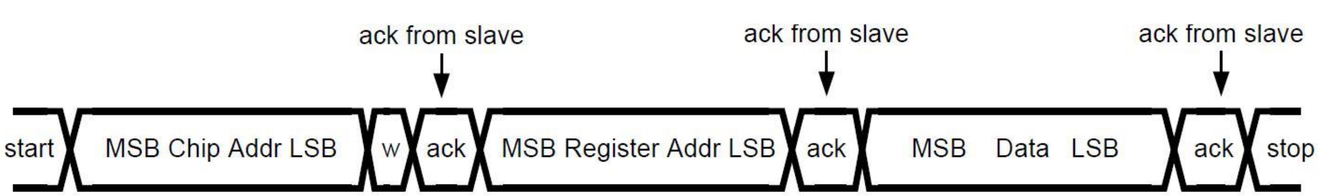


Figure 17. Write Cycle

Functional Description (continued)

4.1.6 Control-Register Read Cycle

- The master device generates a start condition.
- The master device sends the slave address (7 bits) and the data direction bit (R/W = 0).
- The slave device sends an acknowledge signal if the slave address is correct.
- The master device sends the control register address (8 bits).
- The slave device sends an acknowledge signal.
- The master device generates a repeated-start condition.
- The master device sends the slave address (7 bits) and the data direction bit (R/W = 1).
- The slave device sends an acknowledge signal if the slave address is correct.
- The slave device sends the data byte from the addressed register.
- If the master device sends an acknowledge signal, the control-register address is incremented by 1. The slave device sends the data byte from the addressed register. To reduce program load time, the device supports address auto incrementation. The register address is incremented after each 8 data bits.
- The read cycle ends when the master device does not generate an acknowledge signal after a data byte and generates a stop condition.

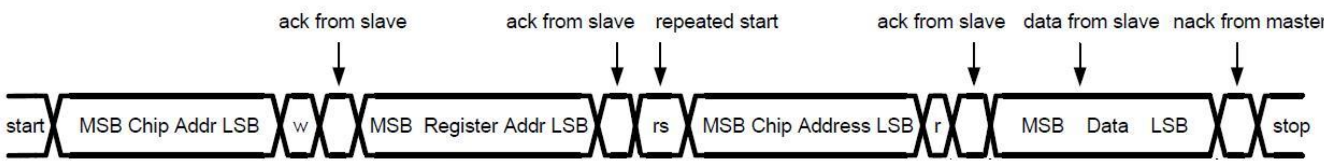


Figure 18. Read Cycle

Register Map Description

5. Registers Map

Addr.	Name	BIT7	BIT6	BIT5	BIT4	BIT3	BIT2	BIT1	BIT0	FDV
00h	DEVICE_CONFIG0	Reserved	CHIP_EN	Reserved						00h
01h	DEVICE_CONFIG1	Phase_Shift_EN	Reserved	Log_Scale_EN	Power_Save_EN	Reserved	Dither_EN	Max_Current_Option	LED_Global_Off	AEh
02h	LED_CONFIG0	LED7_Bank_EN	LED6_Bank_EN	LED5_Bank_EN	LED4_Bank_EN	LED3_Bank_EN	LED2_Bank_EN	LED1_Bank_EN	LED0_Bank_EN	00h
03h	LED_CONFIG1	Reserved				LED11_Bank_EN	LED10_Bank_EN	LED9_Bank_EN	LED8_Bank_EN	00h
04h	BANK_BRIGHTNESS	Bank_Brightness								FFh
05h	BANK_A_COLOR	Bank_A_Color								00h
06h	BANK_B_COLOR	Bank_B_Color								00h
07h	BANK_C_COLOR	Bank_C_Color								00h
08h	RGB0_BRIGHTNESS	RGB0_Brightness								FFh
09h	RGB1_BRIGHTNESS	RGB1_Brightness								FFh
0Ah	RGB2_BRIGHTNESS	RGB2_Brightness								FFh
0Bh	RGB3_BRIGHTNESS	RGB3_Brightness								FFh
0Ch	RGB4_BRIGHTNESS	RGB4_Brightness								FFh
0Dh	RGB5_BRIGHTNESS	RGB5_Brightness								FFh
0Eh	RGB6_BRIGHTNESS	RGB6_Brightness								FFh
0Fh	RGB7_BRIGHTNESS	RGB7_Brightness								FFh
10h	RGB8_BRIGHTNESS	RGB8_Brightness								FFh
11h	RGB9_BRIGHTNESS	RGB9_Brightness								FFh
12h	RGB10_BRIGHTNESS	RGB10_Brightness								FFh
13h	RGB11_BRIGHTNESS	RGB11_Brightness								FFh
14h	R0_COLOR	R0_Color								00h
15h	G0_COLOR	G0_Color								00h
16h	B0_COLOR	B0_Color								00h
17h	R1_COLOR	R1_Color								00h
18h	G1_COLOR	G1_Color								00h
19h	B1_COLOR	B1_Color								00h
1Ah	R2_COLOR	R2_Color								00h
1Bh	G2_COLOR	G2_Color								00h
1Ch	B2_COLOR	B2_Color								00h
1Dh	R3_COLOR	R3_Color								00h
1Eh	G3_COLOR	G3_Color								00h
1Fh	B3_COLOR	B3_Color								00h
20h	R4_COLOR	R4_Color								00h
21h	G4_COLOR	G4_Color								00h
22h	B4_COLOR	B4_Color								00h
23h	R5_COLOR	R5_Color								00h
24h	G5_COLOR	G5_Color								00h
25h	B5_COLOR	B5_Color								00h
26h	R6_COLOR	R6_Color								00h
27h	G6_COLOR	G6_Color								00h
28h	B6_COLOR	B6_Color								00h
29h	R7_COLOR	R7_Color								00h
2Ah	G7_COLOR	G7_Color								00h
2Bh	B7_COLOR	B7_Color								00h
2Ch	R8_COLOR	R8_Color								00h
2Dh	G8_COLOR	G8_Color								00h
2Eh	B8_COLOR	B8_Color								00h
2Fh	R9_COLOR	R9_Color								00h
30h	G9_COLOR	G9_Color								00h
31h	B9_COLOR	B9_Color								00h
32h	R10_COLOR	R10_Color								00h
33h	G10_COLOR	G10_Color								00h
34h	B10_COLOR	B10_Color								00h
35h	R11_COLOR	R11_Color								00h
36h	G11_COLOR	G11_Color								00h
37h	B11_COLOR	B11_Color								00h
38h	RESET	RESET								00h
65h	FLAG	Reserved			FLAG_POR	FLAG_PREUVLO	FLAG_PREOTP	FLAG_SHORT	FLAG_OPEN	10h
66h	LED_GLOBAL_DIMMING	Reserved		G5	G4	G3	G2	G1	G0	00h
67h	FAULT WAIT	Reserved						FW1	FW0	00h
68h	MASK and CLR	Reserved	POR_Mask	PreUVLO_Mask	PreOTP_Mask	Short_Mask	Open_Mask	CLR_Fault	CLR_POR	00h

* FDV = Factory Default Value

Register Map Description (continued)

Addr.	Name	BIT7	BIT6	BIT5	BIT4	BIT3	BIT2	BIT1	BIT0	FDV
6Ah	OM0	OM_OUT7	OM_OUT6	OM_OUT5	OM_OUT4	OM_OUT3	OM_OUT2	OM_OUT1	OM_OUT0	00h
6Bh	OM1	OM_OUT15	OM_OUT14	OM_OUT13	OM_OUT12	OM_OUT11	OM_OUT10	OM_OUT9	OM_OUT8	00h
6Ch	OM2	OM_OUT23	OM_OUT22	OM_OUT21	OM_OUT20	OM_OUT19	OM_OUT18	OM_OUT17	OM_OUT16	00h
6Dh	OM3	OM_OUT31	OM_OUT30	OM_OUT29	OM_OUT28	OM_OUT27	OM_OUT26	OM_OUT25	OM_OUT24	00h
6Eh	OM4	Reserved				OM_OUT35	OM_OUT34	OM_OUT33	OM_OUT32	00h
6Fh	SM0	SM_OUT7	SM_OUT6	SM_OUT5	SM_OUT4	SM_OUT3	SM_OUT2	SM_OUT1	SM_OUT0	00h
70h	SM1	SM_OUT15	SM_OUT14	SM_OUT13	SM_OUT12	SM_OUT11	SM_OUT10	SM_OUT9	SM_OUT8	00h
71h	SM2	SM_OUT23	SM_OUT22	SM_OUT21	SM_OUT20	SM_OUT19	SM_OUT18	SM_OUT17	SM_OUT16	00h
74h	SM3	SM_OUT31	SM_OUT30	SM_OUT29	SM_OUT28	SM_OUT27	SM_OUT26	SM_OUT25	SM_OUT24	00h
75h	SM4	Reserved				SM_OUT35	SM_OUT34	SM_OUT33	SM_OUT32	00h
76h	OF0	OF_OUT7	OF_OUT6	OF_OUT5	OF_OUT4	OF_OUT3	OF_OUT2	OF_OUT1	OF_OUT0	00h
77h	OF1	OF_OUT15	OF_OUT14	OF_OUT13	OF_OUT12	OF_OUT11	OF_OUT10	OF_OUT9	OF_OUT8	00h
78h	OF2	OF_OUT23	OF_OUT22	OF_OUT21	OF_OUT20	OF_OUT19	OF_OUT18	OF_OUT17	OF_OUT16	00h
79h	OF3	OF_OUT31	OF_OUT30	OF_OUT29	OF_OUT28	OF_OUT27	OF_OUT26	OF_OUT25	OF_OUT24	00h
7Ah	OF4	Reserved				OF_OUT35	OF_OUT34	OF_OUT33	OF_OUT32	00h
7Bh	SF0	SF_OUT7	SF_OUT6	SF_OUT5	SF_OUT4	SF_OUT3	SF_OUT2	SF_OUT1	SF_OUT0	00h
7Ch	SF1	SF_OUT15	SF_OUT14	SF_OUT13	SF_OUT12	SF_OUT11	SF_OUT10	SF_OUT9	SF_OUT8	00h
7Dh	SF2	SF_OUT23	SF_OUT22	SF_OUT21	SF_OUT20	SF_OUT19	SF_OUT18	SF_OUT17	SF_OUT16	00h
7Eh	SF3	SF_OUT31	SF_OUT30	SF_OUT29	SF_OUT28	SF_OUT27	SF_OUT26	SF_OUT25	SF_OUT24	00h
7Fh	SF4	Reserved				SF_OUT35	SF_OUT34	SF_OUT33	SF_OUT32	00h

* OMx = Open Maskx
* SMx = Short Maskx
* OFx = Open Faultx
* SFx = Short Faultx
* FDV = Factory Default Value

Table 8. Access Type Codes

Access Type	Code	Description
Read Type		
R	R	Read
Write Type		
$\overline{W}$	$\overline{W}$	Write
Power On Reset or Default value		
(xxh)	(xxh)	Value after POR or default value

5.1 DEVICE_CONFIG0 (Address = 00h) [default = 00h]

Table 9. DEVICE_CONFIG0 Register

7	6	5	4	3	2	1	0
Reserved	Chip_EN	Reserved					
Reserved	R/$\overline{W}$-(00h)	Reserved					
Reserved	0 = AL5887Q Disabled 1 = AL5887Q Enabled	Reserved					

Register Map Description (continued)

5.2 DEVICE_CONFIG1 (Address = 01h) [default = AEh]

Table 10. DEVICE_CONFIG1 Register

7	6	5	4	3	2	1	0
Phase_Shift_EN	Reserved	Log_Scale_EN	Power_Save_EN	Reserved	Dither_EN	Max_Current_Option	LED_Global_Off
R/$\overline{W}$-(01h)	R/$\overline{W}$-(00h)	R/$\overline{W}$-(01h)	R/$\overline{W}$-(00h)	R/$\overline{W}$-(01h)	R/$\overline{W}$-(01h)	R/$\overline{W}$-(01h)	R/$\overline{W}$-(00h)
0 = Disabled 1 = Enabled	—	0 = Linear curve Enabled 1 = Logarithmic curve Enabled	0 = Power Save Mode Disabled 1 = Power Save Mode Enabled	—	0 = Disabled 1 = Enabled	0 = 29.25mA 1 = 39mA	0 = Normal Operation 1 = Shutdown all LEDs

5.3 LED_CONFIG0 (Address = 02h) [default = 00h]

Table 11. LED_CONFIG0 Register

7	6	5	4	3	2	1	0
LED7_Bank_ EN	LED6_Bank_ EN	LED5_Bank_ EN	LED4_Bank_ EN	LED3_Bank_ EN	LED2_Bank_ EN	LED1_Bank_EN	LED0_Bank_EN
R/$\overline{W}$-(00h)							
0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1

* 0 = Independent Mode Enabled
* 1 = Bank Mode Enabled

5.4 LED_CONFIG1 (Address = 03h) [default = 00h]

Table 12. LED_CONFIG1 Register

7	6	5	4	3	2	1	0
Reserved				LED11_Bank_ EN	LED10_Bank_ EN	LED9_Bank_ EN	LED8_Bank_ EN
R/$\overline{W}$-(00h)							
Reserved				0/1	0/1	0/1	0/1

* 0 = Independent Mode Enabled
* 1 = Bank Mode Enabled

5.5 BANK_BRIGHTNESS (Address = 04h) [default = FFh]

Table 13. BANK_BRIGTHNESS Register

7	6	5	4	3	2	1	0
BANK_BRIGHTNESS							
R/$\overline{W}$-(FFh)							
00h = 0% of full brightness ... 80h = 50% of full brightness ... FFh = 100 % of full brightness							

5.6 BANK_A_COLOR (Address = 05h) [default = 00h]

Table 14. BANK_A_COLOR Register

7	6	5	4	3	2	1	0
BANK_A_COLOR							
R/$\overline{W}$-(00h)							
00h = The color mixing percentage is 0% ... 80h = The color mixing percentage is 50% ... FFh = The color mixing percentage is 100%							

Register Map Description (continued)

5.7 BANK_B_COLOR (Address = 06h) [default = 00h]

Table 15. BANK_B_COLOR Register

7	6	5	4	3	2	1	0
BANK_B_COLOR							
R/$\overline{W}$-(00h)							
00h = The color mixing percentage is 0% ... 80h = The color mixing percentage is 50% ... FFh = The color mixing percentage is 100%							

5.8 BANK_C_COLOR (Address = 07h) [default = 00h]

Table 16. BANK_C_COLOR Register

7	6	5	4	3	2	1	0
BANK_C_COLOR							
R/$\overline{W}$-(00h)							
00h = The color mixing percentage is 0% ... 80h = The color mixing percentage is 50% ... FFh = The color mixing percentage is 100%							

5.9 RGB0 to RGB11_BRIGHTNESS (Address = 08h to 13h) [default = FFh]

Table 17. RGB0 to RGB11_BRIGHTNESS Register

7	6	5	4	3	2	1	0
RGB0 to RGB11_BRIGHTNESS							
R/$\overline{W}$-(FFh)							
00h = 0% of full brightness ... 80h = 50% of full brightness ... FFh = 100 % of full brightness							

5.10 Rx_COLORx = 0 to 11 (Address = 14h to 1Eh) [default = 00h]

Table 18. Rx_COLOR Register

7	6	5	4	3	2	1	0
Rx_COLOR							
R/$\overline{W}$-(00h)							
00h = The color mixing percentage is 0% ... 80h = The color mixing percentage is 50% ... FFh = The color mixing percentage is 100%							

Register Map Description (continued)

5.11 Gx_COLORx = 0 to 11 (Address = 1Fh to 2Ah) [default = 00h]

Table 19. Gx_COLOR Register

7	6	5	4	3	2	1	0
Gx_COLOR							
R/$\overline{W}$-(00h)							
00h = The color mixing percentage is 0% ... 80h = The color mixing percentage is 50% ... FFh = The color mixing percentage is 100%							

5.12 Bx_COLORx = 0 to 11 (Address = 2Bh to 37h) [default = 00h]

Table 20. Bx_COLOR Register

7	6	5	4	3	2	1	0
Bx_COLOR							
R/$\overline{W}$-(00h)							
00h = The color mixing percentage is 0% ... 80h = The color mixing percentage is 50% ... FFh = The color mixing percentage is 100%							

5.13 RESET (Address = 38h) [default = 00h]

Table 21. RESET Register

7	6	5	4	3	2	1	0
RESET							
$\overline{W}$-(00h)							
FFh = Resets all the registers to default value.							

5.14 FLAG (Address = 65h) [default = 00h]

Table 22. FLAG Register

7	6	5	4	3	2	1	0
Reserved			FLAG_POR	FLAG_PREUVLO	FLAG_PREOTP	FLAG_SHORT	FLAG_OPEN
R/$\overline{W}$-(00h)							
Reserved			0 = No POR fault reported. 1 = POR fault reported.	0 = No Pre_UVLO fault reported. 1 = Pre_UVLO fault reported.	0 = No Pre_OTP fault reported. 1 = Pre_OTP fault reported.	0 = No short fault reported on any channel. 1 = Short fault reported on any of the channels.	0 = No open fault reported on any channel. 1 = Open fault reported on any of the channels.

5.15 LED_GLOBAL_DIMMING (Address = 66h) [default = 00h]

Table 23. LED_GLOBAL_DIMMING Register

7	6	5	4	3	2	1	0
Reserved		G5	G4	G3	G2	G1	G0
R/$\overline{W}$-(00h)							
Reserved		6-bit LED Global current setting. See Table 3 for details.					

Register Map Description (continued)

5.16 FAULT_WAIT (Address = 67h) [default = 00h]

Table 24. FAULT_WAIT Register

7	6	5	4	3	2	1	0
Reserved						FW1	FW0
R/W̅-(00h)							
Reserved						0 = as per Table 2 1 = as per Table 2	0 = as per Table 2 1 = as per Table 2

5.17 MASK and CLR (Address = 68h) [default = 00h]

Table 25. MASK and CLR Register

7	6	5	4	3	2	1	0
Reserved	POR_Mask	PreUVLOMask	PreOTP_Mask	Short_Mask	Open_Mask	CLR_Fault	CLR_POR
R/W̅-(00h)							
Reserved	0 = POR mask turned off 1 = POR mask turned on	0 = Pre-UVLO mask turned off 1 = Pre-UVLO mask turned on	0 = Pre-OTP mask turned off 1 = Pre-OTP mask turned on	0 = Short Detection Mask off 1 = Short Detection Mask on	0 = Open Detection Mask off 1 = Open Detection Mask on	0 = Clearing faults turned off 1 = Clears the faults	0 = Clearing POR turned off 1 = Clears the POR faults

5.18 OM0 (Address = 6Ah) [default = 00h]

Table 26. OM0 Register

7	6	5	4	3	2	1	0
*OM_OUT7	OM_OUT6	OM_OUT5	OM_OUT4	OM_OUT3	OM_OUT2	OM_OUT1	OM_OUT0
R/W̅-(00h)							
0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1

* OM = Open Maskx
* 0 = Open Detection Mask Off
* 1 = Open Detection Mask On

5.19 OM1 (Address = 6Bh) [default = 00h]

Table 27. OM1 Register

7	6	5	4	3	2	1	0
*OM_OUT15	OM_OUT14	OM_OUT13	OM_OUT12	OM_OUT11	OM_OUT10	OM_OUT9	OM_OUT8
R/W̅-(00h)							
0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1

* OM = Open Maskx
* 0 = Open Detection Mask Off
* 1 = Open Detection Mask On

5.20 OM2 (Address = 6Ch) [default = 00h]

Table 28. OM2 Register

7	6	5	4	3	2	1	0
*OM_OUT23	OM_OUT22	OM_OUT21	OM_OUT20	OM_OUT19	OM_OUT18	OM_OUT17	OM_OUT16
R/W̅-(00h)							
0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1

* OM = Open Maskx
* 0 = Open Detection Mask Off
* 1 = Open Detection Mask On

Register Map Description (continued)

5.21 OM3 (Address = 6Dh) [default = 00h]

Table 29. OM3 Register

7	6	5	4	3	2	1	0
OM_OUT31	OM_OUT30	OM_OUT29	OM_OUT28	OM_OUT27	OM_OUT26	OM_OUT25	OM_OUT24
R/W̄-(00h)							
0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1

* OM = Open Maskx
* 0 = Open Detection Mask Off
* 1 = Open Detection Mask On

5.22 OM4 (Address = 6Eh) [default = 00h]

Table 30. OM4 Register

7	6	5	4	3	2	1	0
Reserved				OM_OUT35	OM_OUT34	OM_OUT33	OM_OUT32
R/W̄-(00h)							
Reserved				0/1	0/1	0/1	0/1

* OM = Open Maskx
* 0 = Open Detection Mask Off
* 1 = Open Detection Mask On

5.23 SM0 (Address = 6Fh) [default = 00h]

Table 31. SM0 Register

7	6	5	4	3	2	1	0
SM_OUT7	SM_OUT6	SM_OUT5	SM_OUT4	SM_OUT3	SM_OUT2	SM_OUT1	SM_OUT0
R/W̄-(00h)							
0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1

* SM = Short Maskx
* 0 = Short Detection Mask Off
* 1 = Short Detection Mask On

5.24 SM1 (Address = 70h) [default = 00h]

Table 32. SM1 Register

7	6	5	4	3	2	1	0
SM_OUT15	SM_OUT14	SM_OUT13	SM_OUT12	SM_OUT11	SM_OUT10	SM_OUT9	SM_OUT8
R/W̄-(00h)							
0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1

* SM = Short Maskx
* 0 = Short Detection Mask Off
* 1 = Short Detection Mask On

Register Map Description (continued)

5.25 SM2 (Address = 71h) [default = 00h]

Table 33. SM2 Register

7	6	5	4	3	2	1	0
SM_OUT23	SM_OUT22	SM_OUT21	SM_OUT20	SM_OUT19	SM_OUT18	SM_OUT17	SM_OUT16
R/$\overline{W}$-(00h)							
0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1

* SM = Short Maskx

* 0 = Short Detection Mask Off

* 1 = Short Detection Mask On

5.26 SM3 (Address = 74h) [default = 00h]

Table 34. SM3 Register

7	6	5	4	3	2	1	0
SM_OUT31	SM_OUT30	SM_OUT29	SM_OUT28	SM_OUT27	SM_OUT26	SM_OUT25	SM_OUT24
R/$\overline{W}$-(00h)							
0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1

* SM = Short Maskx

* 0 = Short Detection Mask Off

* 1 = Short Detection Mask On

5.27 SM4 (Address = 75h) [default = 00h]

Table 35. SM4 Register

7	6	5	4	3	2	1	0
Reserved				SM_OUT35	SM_OUT34	SM_OUT33	SM_OUT32
R/$\overline{W}$-(00h)							
Reserved				0/1	0/1	0/1	0/1

* SM = Short Maskx

* 0 = Short Detection Mask Off

* 1 = Short Detection Mask On

5.28 OF0 (Address = 76h) [default = 00h]

Table 36. OF0 Register

7	6	5	4	3	2	1	0
OF_OUT7	OF_OUT6	OF_OUT5	OF_OUT4	OF_OUT3	OF_OUT2	OF_OUT1	OF_OUT0
R/$\overline{W}$-(00h)							
0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1

* OF = Open Faultx

* 0 = Open Fault Not Detected

* 1 = Open Fault Detected

Register Map Description (continued)

5.29 OF1 (Address = 77h) [default = 00h]

Table 37. OF1 Register

7	6	5	4	3	2	1	0
OF_OUT15	OF_OUT14	OF_OUT13	OF_OUT12	OF_OUT11	OF_OUT10	OF_OUT9	OF_OUT8
R/$\overline{W}$-(00h)							
0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1

* OF = Open Faultx
* 0 = Open Fault Not Detected
* 1 = Open Fault Detected

5.30 OF2 (Address = 78h) [default = 00h]

Table 38. OF2 Register

7	6	5	4	3	2	1	0
OF_OUT23	OF_OUT22	OF_OUT21	OF_OUT20	OF_OUT19	OF_OUT18	OF_OUT17	OF_OUT16
R/$\overline{W}$-(00h)							
0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1

* OF = Open Faultx
* 0 = Open Fault Not Detected
* 1 = Open Fault Detected

5.31 OF3 (Address = 79h) [default = 00h]

Table 39. OF3 Register

7	6	5	4	3	2	1	0
OF_OUT31	OF_OUT30	OF_OUT29	OF_OUT28	OF_OUT27	OF_OUT26	OF_OUT25	OF_OUT24
R/$\overline{W}$-(00h)							
0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1

* OF = Open Faultx
* 0 = Open Fault Not Detected
* 1 = Open Fault Detected

5.32 OF4 (Address = 7Ah) [default = 00h]

Table 40. OF4 Register

7	6	5	4	3	2	1	0
Reserved				OF_OUT35	OF_OUT34	OF_OUT33	OF_OUT32
R/$\overline{W}$-(00h)							
Reserved				0/1	0/1	0/1	0/1

* OF = Open Faultx
* 0 = Open Fault Not Detected
* 1 = Open Fault Detected

Register Map Description (continued)

5.33 SF0 (Address = 7Bh) [default = 00h]

Table 41. SF0 Register

7	6	5	4	3	2	1	0
SF_OUT7	SF_OUT6	SF_OUT5	SF_OUT4	SF_OUT3	SF_OUT2	SF_OUT1	SF_OUT0
R/$\overline{W}$-(00h)							
0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1

* SF = Short Faultx
* 0 = Short Fault Not Detected
* 1 = Short Fault Detected

5.34 SF1 (Address = 7Ch) [default = 00h]

Table 42. SF1 Register

7	6	5	4	3	2	1	0
SF_OUT15	SF_OUT14	SF_OUT13	SF_OUT12	SF_OUT11	SF_OUT10	SF_OUT9	SF_OUT8
R/$\overline{W}$-(00h)							
0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1

* SF = Short Faultx
* 0 = Short Fault Not Detected
* 1 = Short Fault Detected

5.35 SF2 (Address = 7Dh) [default = 00h]

Table 43. SF2 Register

7	6	5	4	3	2	1	0
SF_OUT23	SF_OUT22	SF_OUT21	SF_OUT20	SF_OUT19	SF_OUT18	SF_OUT17	SF_OUT16
R/$\overline{W}$-(00h)							
0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1

* SF = Short Faultx
* 0 = Short Fault Not Detected
* 1 = Short Fault Detected

5.36 SF3 (Address = 7Eh) [default = 00h]

Table 44. SF3 Register

7	6	5	4	3	2	1	0
SF_OUT31	SF_OUT30	SF_OUT29	SF_OUT28	SF_OUT27	SF_OUT26	SF_OUT25	SF_OUT24
R/$\overline{W}$-(00h)							
0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1

* SF = Short Faultx
* 0 = Short Fault Not Detected
* 1 = Short Fault Detected

Register Map Description (continued)

5.37 SF4 (Address = 7Fh) [default = 00h]

Table 45. SF4 Register

7	6	5	4	3	2	1	0
Reserved				SF_OUT35	SF_OUT34	SF_OUT33	SF_OUT32
R/$\overline{W}$-(00h)							
Reserved				0/1	0/1	0/1	0/1

* SF = Short Faultx

* 0 = Short Fault Not Detected

* 1 = Short Fault Detected

Application Information

Timing Requirements for I²C interface (Note 11)

Symbol	Parameter	Min	Typ	Max	Unit
f_{SCL}	I²C clock frequency	—	—	400	kHz
t_{EN_H}	EN first rising edge until first I²C access	—	—	500	µs
t_{EN_L}	EN first falling edge until first I²C reset	—	—	3	µs
1	Hold time (repeated) START condition	0.6	—	—	µs
2	Clock low time	1.3	—	—	µs
3	Clock high time	600	—	—	ns
4	Setup time for a repeated START condition	600	—	—	ns
5	Data hold time	0	—	—	ns
6	Data setup time	100	—	—	ns
7	Rise time of SDA and SCL	20 + 0.1 Cb	—	300	ns
8	Fall time of SDA and SCL	15 + 0.1 Cb	—	300	ns
9	Setup time for STOP condition	600	—	—	ns
10	Bus free time between a STOP and a START condition	1.3	—	—	ns
Cb	Capacitive load parameter for each bus line. Load of 1pF corresponds to one nanosecond.	—	—	200	pF

Note: 11. Specified by design & ATE characterized.

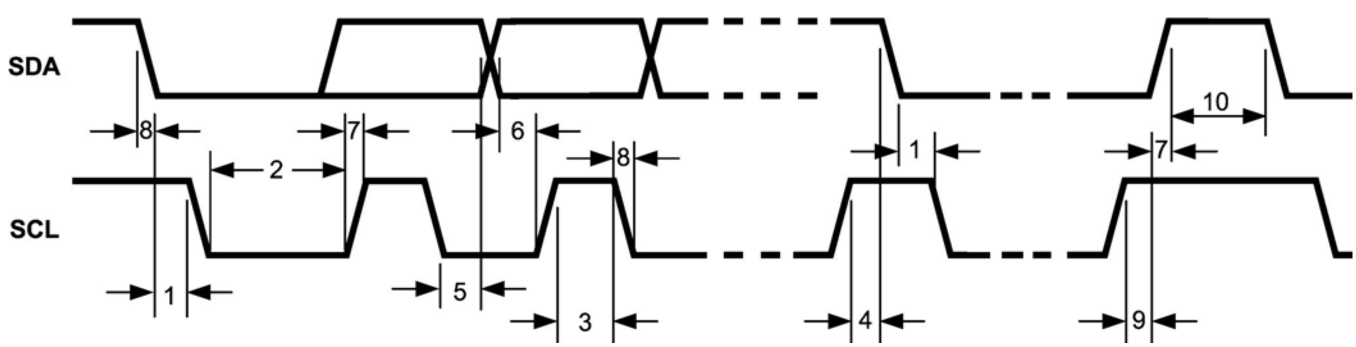


Figure 19. I²C Timing Parameters

Table 46. Input and Output Logic Levels

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
DIGITAL INPUT LOGIC LEVELS (EN, RSTn, INT_SEL)						
V_{IL}	Input logic low	Vio = 1.8V	—	—	0.35	V
V_{IH}	Input logic high		1.4	—	—	V
DIGITAL INTERFACE LOGIC LEVELS (SPICS_SCL, SPISDO_SDA, SPISDA_ADDR0, SPISCL_ADDR1)						
V_{IL}	Input logic low	Vio = 1.8V	—	—	0.4	V
V_{IH}	Input logic high		1.4	—	—	V
V_{SDA}	SDA output low level	I_{PULLUP} = 5mA	—	—	0.4	V

Application Information (continued)

Timing Requirements for SPI interface (Note 12)

Symbol	Parameter	Condition	Min	Typ	Max	Unit
f_{SCLK}	SPI clock frequency	—	—	—	4	MHz
t_{CSS}	The time from SPICS_SCL low to SPISCL_ADDR1 high	—	250	—	—	ns
t_{CSH}	The time from SPISCL_ADDR1 low to SPICS_SCL high	—	250	—	—	ns
t_{DS}	Data set-up time	—	10	—	—	ns
t_{DH}	Data hold time	—	0	—	—	ns
t_{CS_HI}	Minimum chip select de-asserted HIGH time	—	250	—	—	ns
$t_{D(SDO)}$	SDO delay time	C_L = 50pF	—	—	20	ns
t_{LOW}	LOW period of SCLK clock	—	125	—	—	ns
t_{HIGH}	HIGH period of SCLK clock	—	125	—	—	ns

Note: 12. Specified by design & ATE characterized.

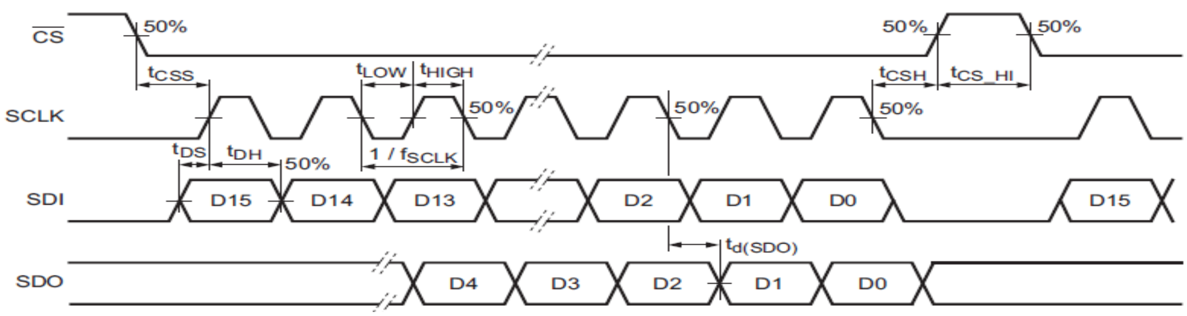


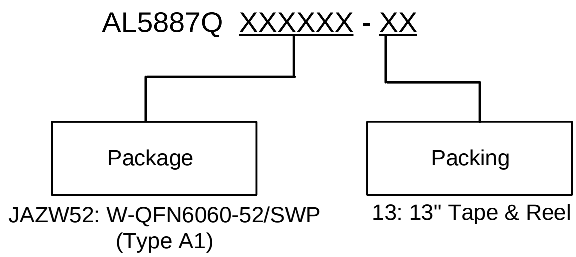
Figure 20. SPI Timing Parameters

Design Tools (Note 13)

- AL5887QEV1 Demo Board
- Labview Emulator for EV1
- AL5887QEV2 Demo Board
- Arduino Sample Code for EV2
- Demo Board Gerber File for PCB Layout Reference
- PSPICE available

Note: 13. Diodes' design tools can be found on our website at https://www.diodes.com/design/tools/.

Ordering Information

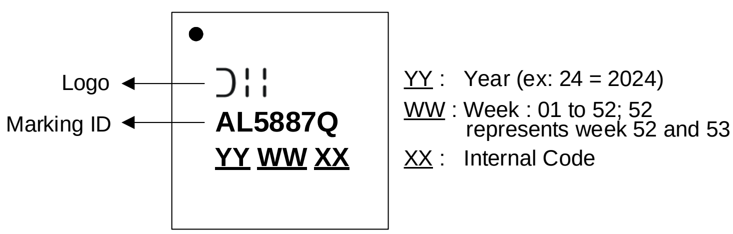


Orderable Part Number	Part Number Suffix	Package Code	Package (Note 13)	Packing	
				Qty.	Carrier
AL5887QJAZW52-13	-13	JAZW52	W-QFN6060-52/SWP (Type A1)	4,000	Tape & Reel

Marking Information

W-QFN6060-52/SWP (Type A1)

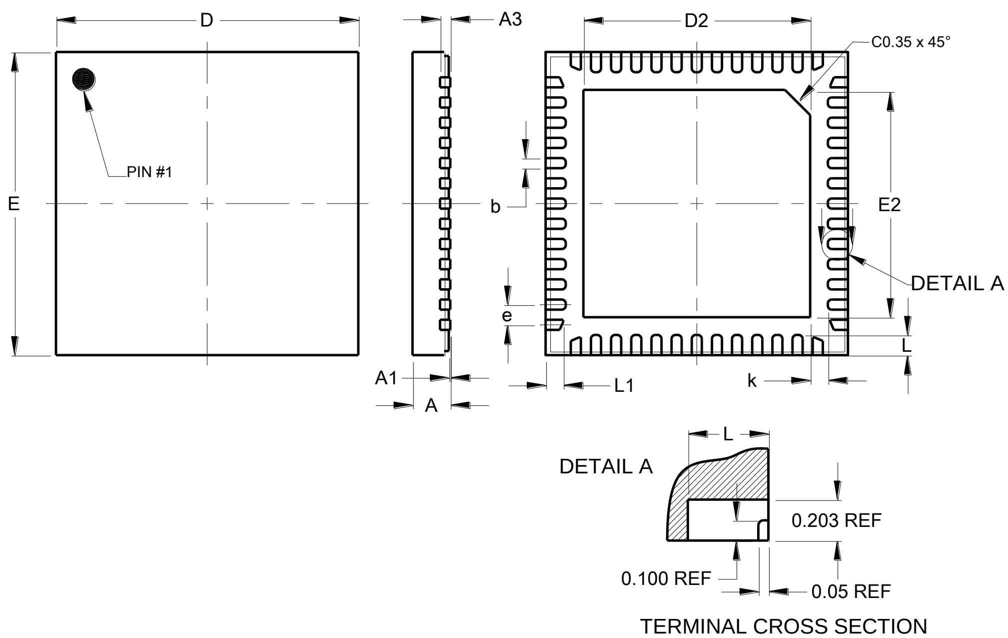
(Top View)



Package Outline Dimensions

Please see http://www.diodes.com/package-outlines.html for the latest version.

W-QFN6060-52/SWP (Type A1)

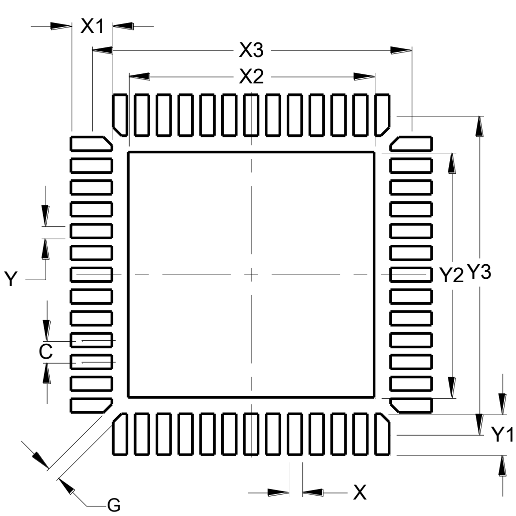


W-QFN6060-52/SWP (Type A1)			
Dim	**Min**	**Max**	**Typ**
A	0.700	0.800	0.750
A1	0.00	0.05	0.02
A3	0.203 REF		
b	0.15	0.25	0.20
D	6.00 BSC		
D2	4.45	4.55	4.50
E	6.00 BSC		
E2	4.45	4.55	4.50
e	0.40 BSC		
k	0.20	--	--
L	0.35	0.45	0.40
L1	0.30	0.40	0.35
All Dimensions in mm			

Suggested Pad Layout

Please see http://www.diodes.com/package-outlines.html for the latest version.

W-QFN6060-52/SWP (Type A1)



Dimensions	Value (in mm)
C	0.400
G	0.250
X	0.250
X1	0.750
X2	4.500
X3	5.850
Y	0.250
Y1	0.750
Y2	4.500
Y3	5.850

Tape and Reel Information

Please see https://www.diodes.com/assets/Packaging-Support-Docs/AP02007.pdf for tape and reel details.

Mechanical Data

Package W-QFN6060-52/SWP (Type A1)

- Moisture Sensitivity: Level 1 per J-STD-020
- Terminals: Finish – Matte Tin Plated Leads, Solderable per JESD22-B102 (e3)
- Weight: 0.0091 grams (Approximate)

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