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RTL8231-GR

SMI SLAVE/MIIM/SHIFT REGISTER LED DISPLAY CONTROLLER

DATASHEET

(CONFIDENTIAL: Development Partners Only)

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USING THIS DOCUMENT

This document is intended for the hardware engineer's general information on the Realtek RTL8231 chip.

Though every effort has been made to ensure that this document is current and accurate, more information may have become available subsequent to the production of this guide.

REVISION HISTORY

Revision	Release Date	Summary
1.0	2011/03/01	First release.
1.1	2012/01/16	Revised Table 5 SMI Slave/MIIM Mode Bi-Color Scan LED Power/Ground Pins, page 16. Revised Table 9 SMI Slave/MIIM Mode Single Color Scan LED Power/Ground Pins, page 19. Revised Table 13 SMI Slave/MIIM Mode GPIO Power/Ground Pins, page 22. Revised Table 16 Shift Register Mode Power/Ground Pins, page 25. Revised Table 20 LED Function Register (Address: 0x0001), page 47. Revised Table 49 GPIO Control Register (Address: 0x001E), page 85.
1.2	2012/03/01	Added Figure 36 Shift Register Data Output Timing, page 93. Revised Table 59 SMI Slave Mode Timing Characteristics, page 91. Revised Table 61 Shift Register Data Input/Output Timing, page 93.

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1. General Description

The RTL8231 is an SMI (Serial Management Interface) Slave, MIIM (Media Independent Interface Management), and Shift Register LED display controller that transmits:

- SMI Slave/MIIM Data to Scan LED
- SMI Slave/MIIM Data to GPIO
- Parallel LED output via Shift Register Mode

SMI Slave/MIIM Data to Scan LED

In this mode, the RTL8231 supports SMI Slave and MIIM bus data formats. In SMI Slave mode, 8-bit and 16-bit data accesses are both supported. The SMI Slave or MIIM interface can set the address from 0 to 7 (SMI Slave) or from 0 to 31 (MIIM). The RTL8231 controls Scan LEDs and GPIOs via LED and GPIO status registers.

Single-Color Scan LED supports two configurations:

- 24-port*3-LED=72 LEDs (max)
- 24-port*2-LED+8-port*(1 bi-color+1 single-color LED)=64 LEDs
  (for 24-port Fast Ethernet + 8-port Gigabit Ethernet)

Bi-Color Scan LED supports maximal 24-port applications:

- 24-port*(1 bi-color+1 single-color LED)=48pcs LEDs (max)

SMI Slave/MIIM Data to GPIO

The RTL8231 provides 37 GPIOs. Any unused Single-color or Bi-color LED pin can be switched to become a GPIO pin

Shift Register Mode

In Shift Register Mode, the RTL8231 supports 36 LEDs. The RTL8231 receives serial data and serial clock, and via the shift register changes it to parallel output. The SO (Serial Out) pin outputs any serial data input that exceeds 36 bits for cascading to another RTL8231. The Reset pin clears the shift register data, and the strapping pin sets the initial values when the RTL8231 is reset.

2. Features

Controller Interfaces

- Shift Register
  - CLK_IN and SI provide clock and data to enable the internal shift register
- SMI Slave
  - Supports 8-bit and 16-bit data access
  - Device ID can be set from 0~7
- MIIM
  - Supports the IEEE compliant Management Data Input/Output (MDIO) Interface
  - Slave mode MIIM
  - PHY addresses can be set from 0~31

Functions Support

- Shift Register Mode
  - Supports 36 parallel data outputs
  - The SO (Serial Out) pin outputs any Shift Register data input that exceeds 36 bits (for cascading to another RTL8231)
- Single-Color Scan LED via SMI Slave/ MIIM
  - Supports 24-port Single-Color scanning LEDs; each port includes 3 single-color LEDs
  - Provides 8 bi-color LEDs for 24 FE+8G applications
  - Each LED has a respective status register that is controlled by the SMI Slave/ MIIM
- Bi-Color Scan LED via SMI Slave/MIIM
  - Supports 24-port Bi-color scanning LED; each port includes one bi-color and one single-color LED
  - Each LED has a respective status register that is controlled by the SMI Slave/ MIIM
- GPIO via SMI Slave/MIIM
  - Provides 37 GPIOs
  - Any unused Single-color or Bi-color LED pin can be switched to become a GPIO pin
  - Any GPIO can be controlled by GPI or GPO (except for the 8 strapping pins)
  - Strapping pins only use GPO in GPIO applications
  - Each GPO output default driving current is 8mA (can be changed to 4mA via register setting)
  - Each GPIO has a respective status register that is controlled by the SMI Slave/MIIM

- Buzzer Single Output
  - GPIO[35] can be set to Buzzer output mode
  - The buzzer output frequency can be set to: 1.2K, 1.6K, 2K, 2.4K, 2.8K, 3.2K, 4K, and 4.8K square waveform
- Push Button De-Bouncing
  - The GPIO[31:36] supports input de-bouncing function
  - The GPI pin can be latched only if the same input signal continues for 100ms
- LED Output Synchronization
  - All LEDs (Single-color mode 72+8 LEDs, Bi-color mode 48 LEDs) can change synchronization status via register commands
- GPIO Output Synchronization
  - All 37 GPIO's output synchronization status can be changed via register commands
- LED Blinking Speed Change
  - Each LED's blinking speed can be changed via LED status registers
  - Each LED's status register has 3-bits that control LED speed (40ms to 1280ms)
- LQFP-48 package

3. Block Diagram

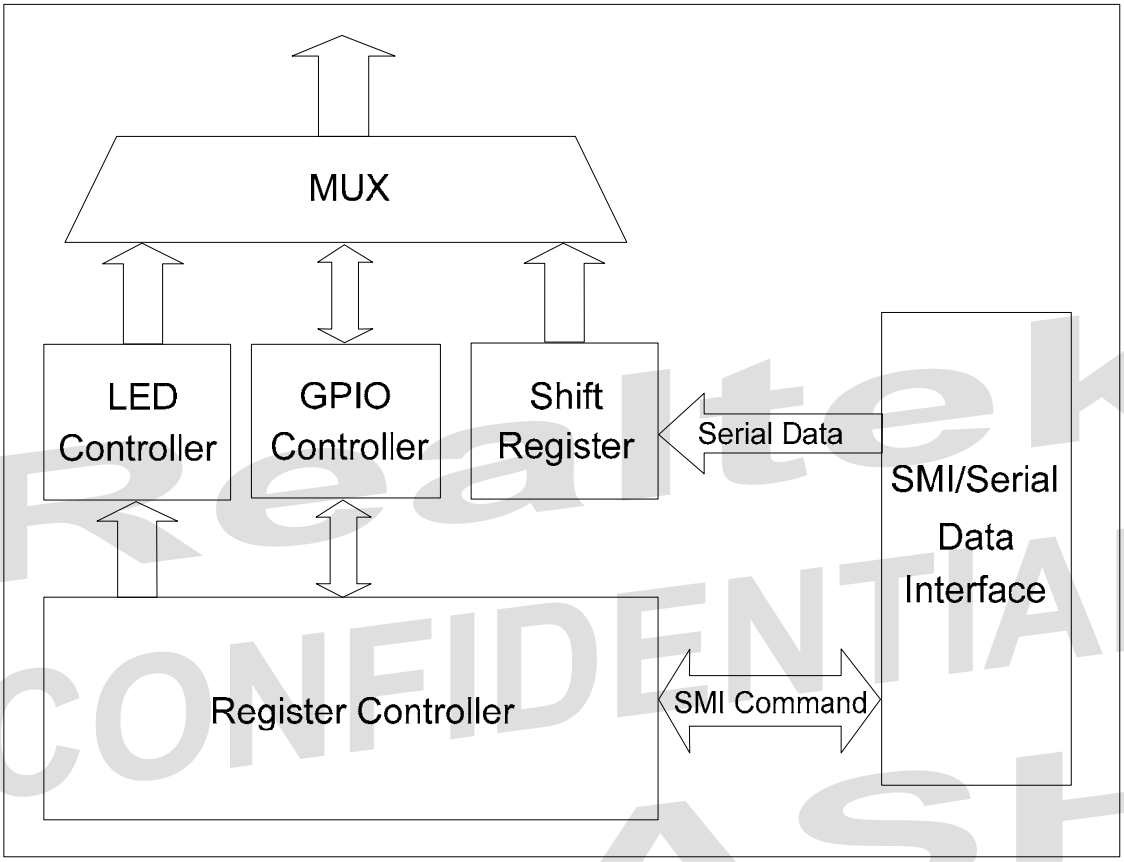


Figure 1. Block Diagram

4. LED Applications

4.1. Scan LED in High-Port-Count Switch

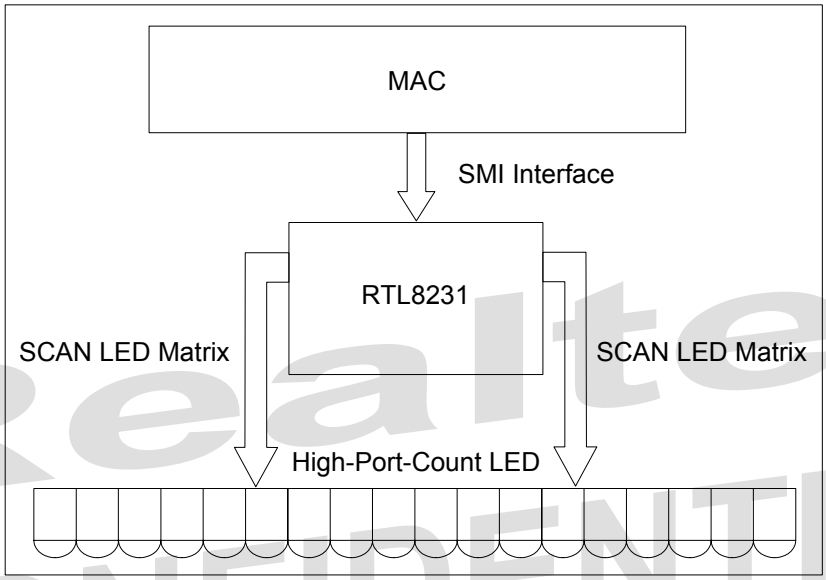


Figure 2. Scan LED in High-Port-Count Switch

4.2. Scan LED and GPIO in Low-Port-Count Switch

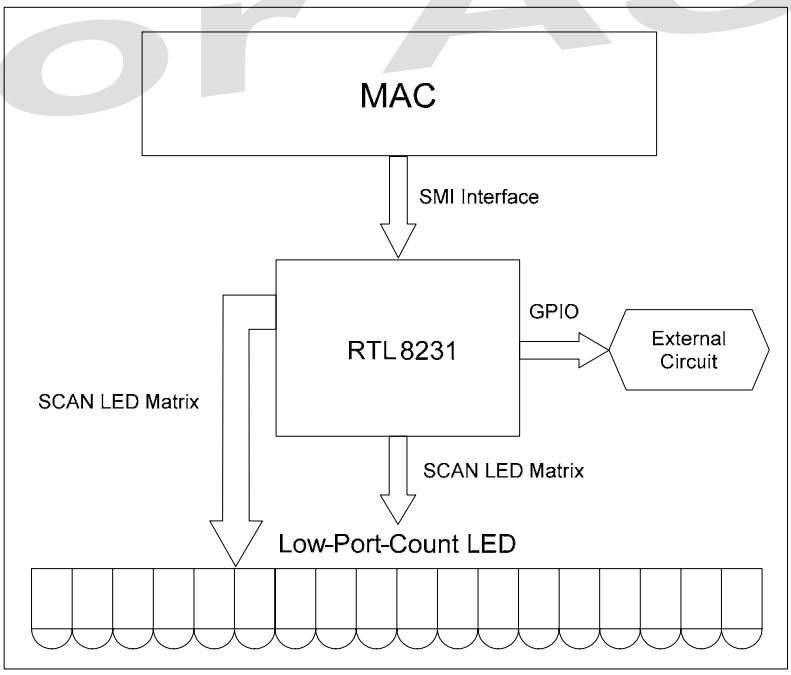


Figure 3. Scan LED and GPIO in Low-Port-Count Switch

4.3. Shift Register Mode LED

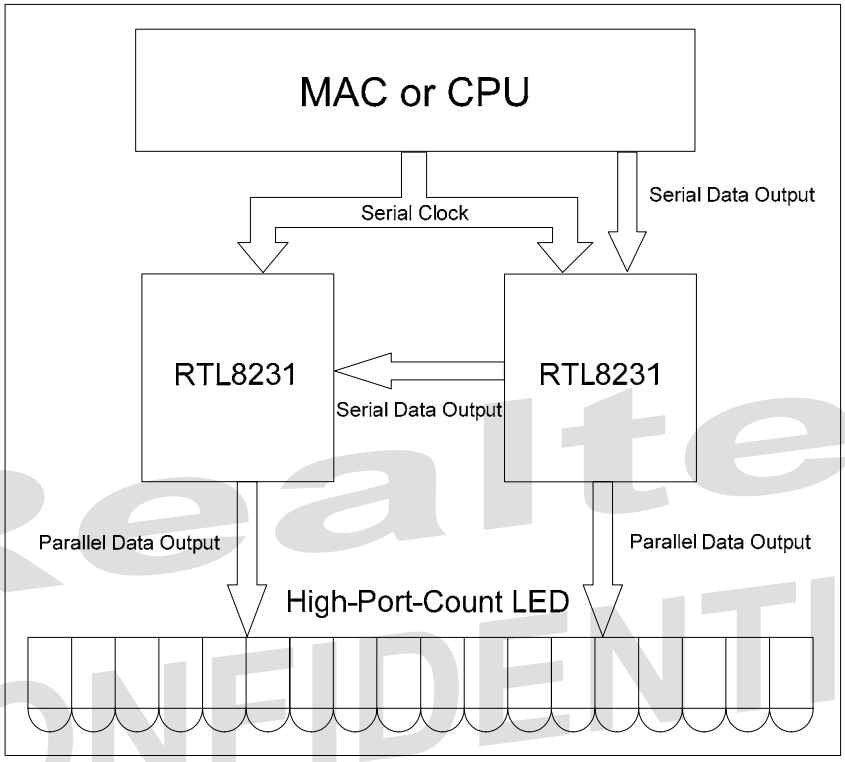


Figure 4. Shift Register Mode LED

5. Pin Assignments

5.1. SMI Slave/MIIM Mode Bi-Color Scan LED Pin Assignments

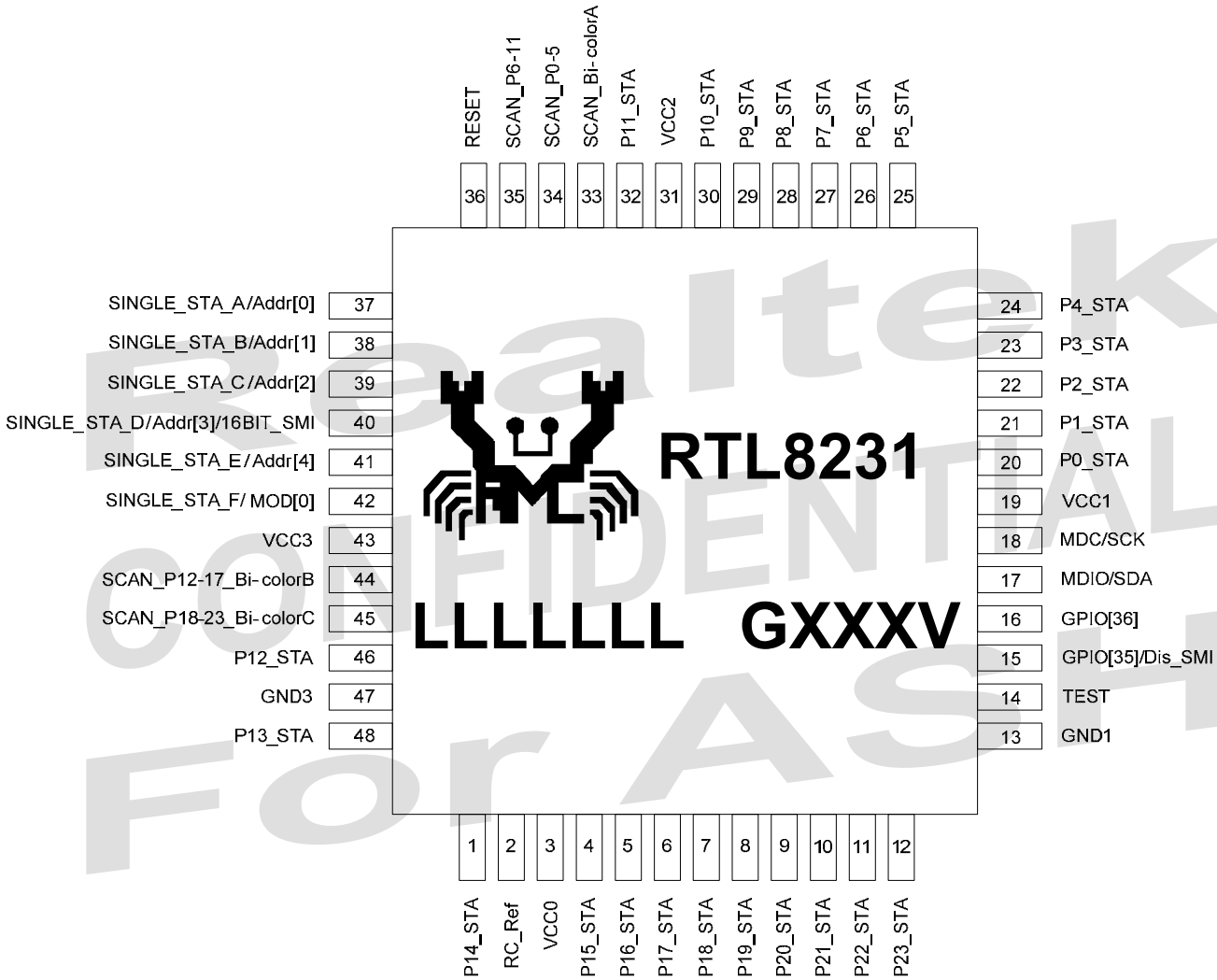


Figure 5. SMI Slave/MIIM Mode Bi-Color Scan LED Pin Assignments

5.2. Green Package and Version Identification

Green package is indicated by the 'G' in GXXXV (Figure 5).

5.3. SMI Slave/MIIM Mode Single-Color Scan LED Pin Assignments

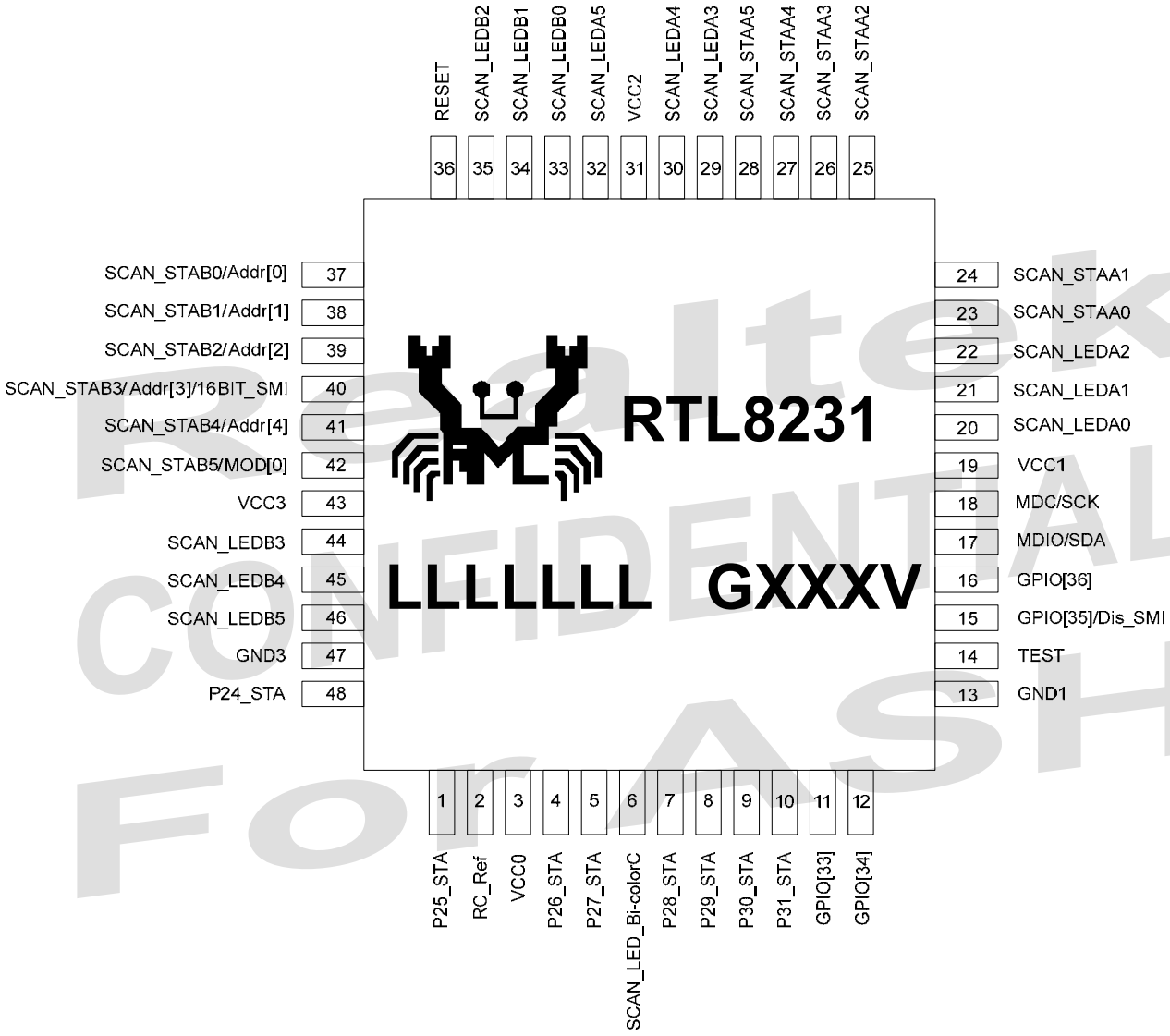


Figure 6. SMI Slave/MIIM Mode Single-Color Scan LED Pin Assignments

5.4. Green Package and Version Identification

Green package is indicated by the 'G' in GXXXV (Figure 6).

5.5. SMI Slave/MIIM Mode GPIO Pin Assignments

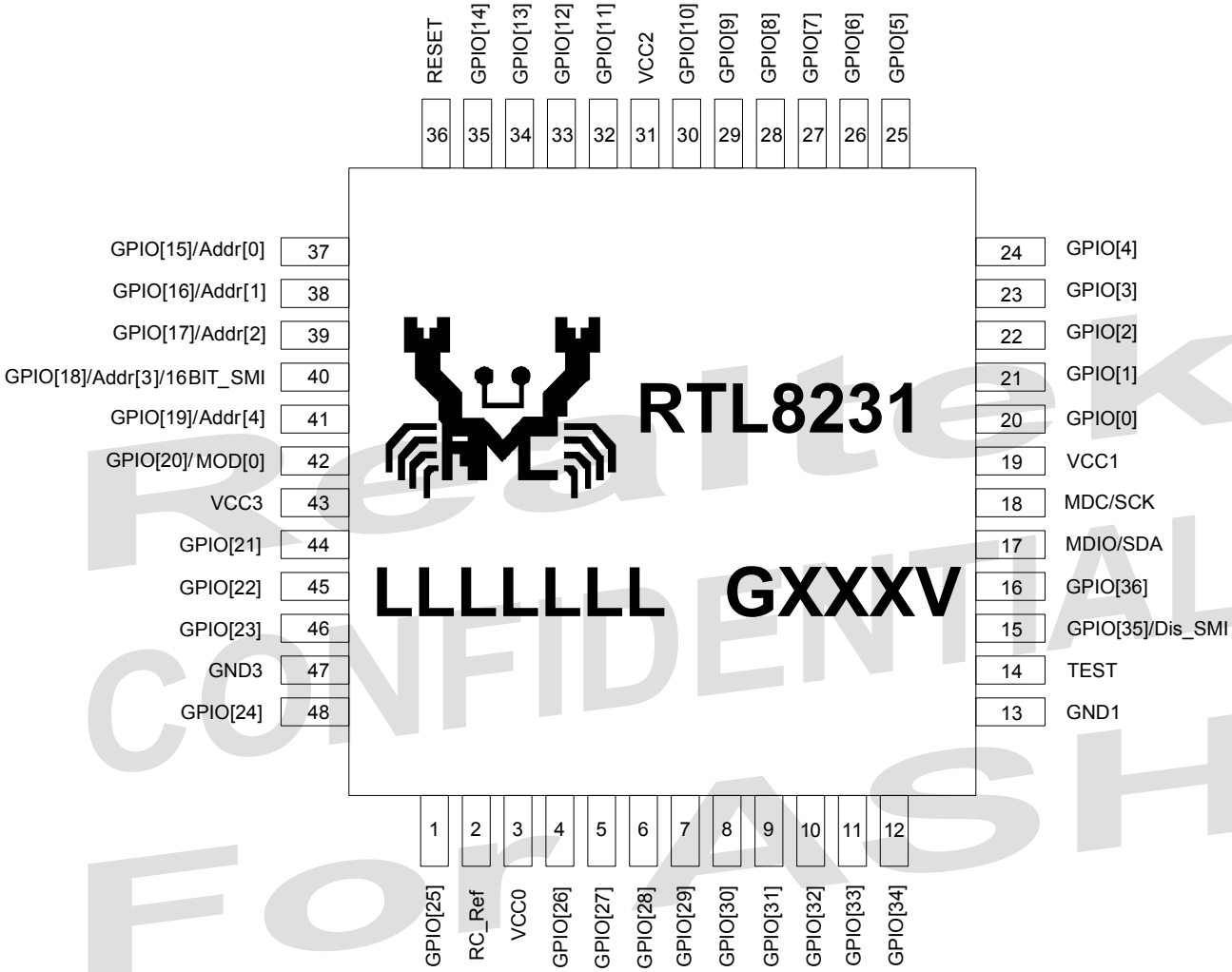


Figure 7. SMI Slave/MIIM Mode GPIO Pin Assignments

5.6. Green Package and Version Identification

Green package is indicated by the 'G' in GXXXV (Figure 7).

5.7. Shift Register Mode Pin Assignments

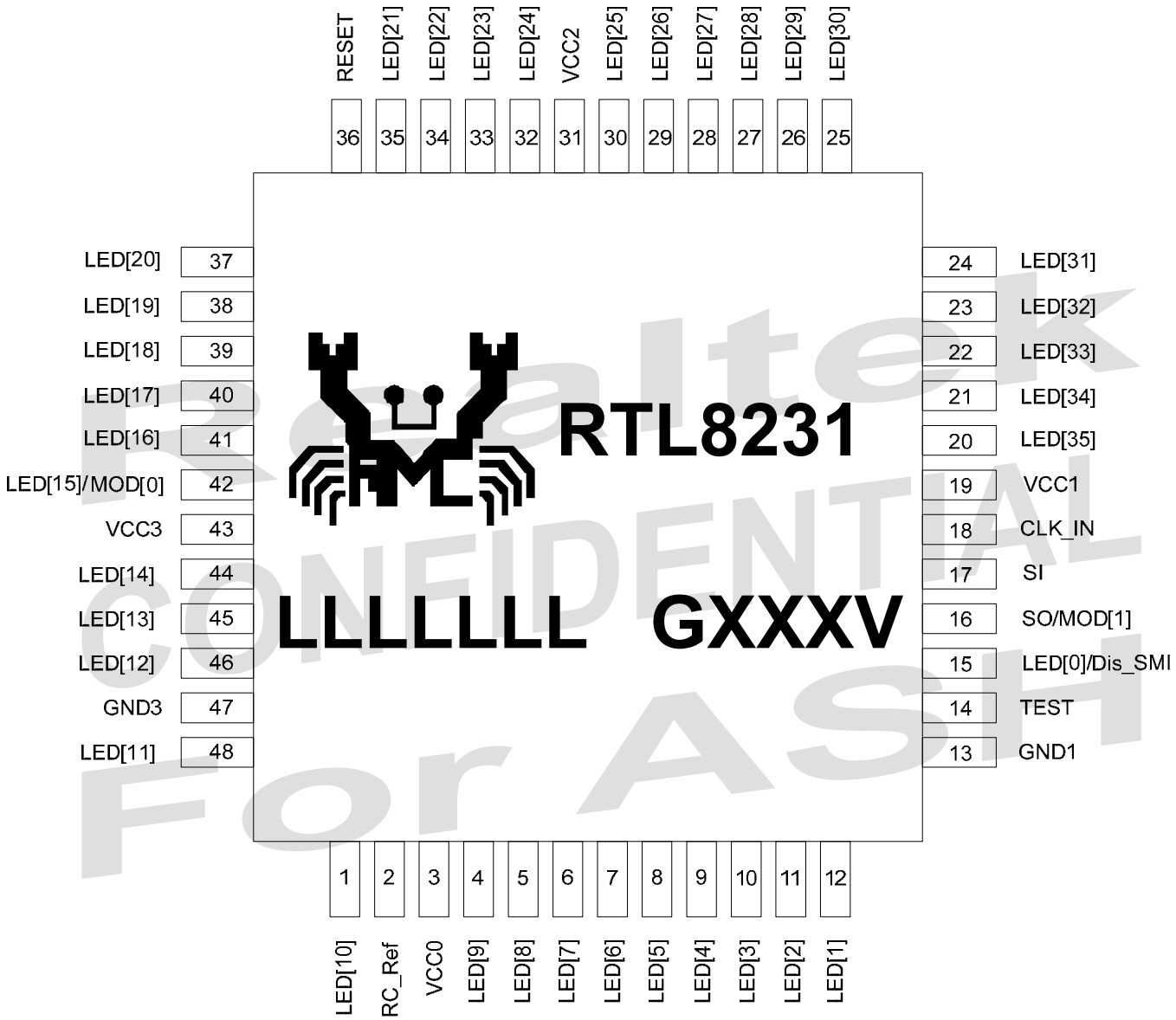


Figure 8. Shift Register Mode Pin Assignments

5.8. Green Package and Version Identification

Green package is indicated by the 'G' in GXXXV (Figure 8).

5.9. Pin Assignments Table

Upon Reset: Defined as a short time after the end of a hardware reset.

After Reset: Defined as the time after the specified 'Upon Reset' time.

I: Input Pin

O: Output Pin

I/O: Bi-Directional Input/Output Pin

O_{PU}: Output Pin With Pull-Up Resistor; (Typical Value = 75K ohm)

P: Digital Power Pin

G: Digital Ground Pin

I_{PU}: Input Pin With Pull-Up Resistor; (Typical Value = 75K ohm)

O_{PD} Output Pin With Pull-Down Resistor; (Typical Value = 75K ohm)

Table 1. Pin Assignments Table

Pin No.	Type	SMI Slave/MIIM Mode Pin Name			Shift Register Mode Pin Name
		Bi-Color Scan LED	Single-Color Scan LED	GPIO	
1	I/O	P14_STA	P25_STA	GPIO[25]	LED[10]
2	O	RC_Ref	RC_Ref	RC_Ref	RC_Ref
3	P	VCC0	VCC0	VCC0	VCC0
4	I/O	P15_STA	P26_STA	GPIO[26]	LED[9]
5	I/O	P16_STA	P27_STA	GPIO[27]	LED[8]
6	I/O	P17_STA	SCAN_LED_Bi-colorC	GPIO[28]	LED[7]
7	I/O	P18_STA	P28_STA	GPIO[29]	LED[6]
8	I/O	P19_STA	P29_STA	GPIO[30]	LED[5]
9	I/O	P20_STA	P30_STA	GPIO[31]	LED[4]
10	I/O	P21_STA	P31_STA	GPIO[32]	LED[3]
11	I/O	P22_STA	GPIO[33]	GPIO[33]	LED[2]
12	I/O	P23_STA	GPIO[34]	GPIO[34]	LED[1]
13	G	GND1	GND1	GND1	GND1
14	I_{PD}	TEST	TEST	TEST	TEST
15	I/O_{PD}	GPIO[35]/Dis_SMI	GPIO[35]/Dis_SMI	GPIO[35]/Dis_SMI	LED[0]/Dis_SMI
16	I/O	GPIO[36]	GPIO[36]	GPIO[36]	SO/MOD[1]*

Pin No.	Type	SMI Slave/MIIM Mode Pin Name			Shift Register Mode Pin Name
		Bi-Color Scan LED	Single-Color Scan LED	GPIO	
17	I/O_{PU}	MDIO/SDA	MDIO/SDA	MDIO/SDA	SI
18	I	MDC/SCK	MDC/SCK	MDC/SCK	CLK_IN
19	P	VCC1	VCC1	VCC1	VCC1
20	I/O	P0_STA	SCAN_LEDA0	GPIO[0]	LED[35]
21	I/O	P1_STA	SCAN_LEDA1	GPIO[1]	LED[34]
22	I/O	P2_STA	SCAN_LEDA2	GPIO[2]	LED[33]
23	I/O	P3_STA	SCAN_STAA0	GPIO[3]	LED[32]
24	I/O	P4_STA	SCAN_STAA1	GPIO[4]	LED[31]
25	I/O	P5_STA	SCAN_STAA2	GPIO[5]	LED[30]
26	I/O	P6_STA	SCAN_STAA3	GPIO[6]	LED[29]
27	I/O	P7_STA	SCAN_STAA4	GPIO[7]	LED[28]
28	I/O	P8_STA	SCAN_STAA5	GPIO[8]	LED[27]
29	I/O	P9_STA	SCAN_LEDA3	GPIO[9]	LED[26]
30	I/O	P10_STA	SCAN_LEDA4	GPIO[10]	LED[25]
31	P	VCC2	VCC2	VCC2	VCC2
32	I/O	P11_STA	SCAN_LEDA5	GPIO[11]	LED[24]
33	I/O	SCAN_Bi-colorA	SCAN_LEDB0	GPIO[12]	LED[23]
34	I/O	SCAN_P0-5	SCAN_LEDB1	GPIO[13]	LED[22]
35	I/O	SCAN_P6-11	SCAN_LEDB2	GPIO[14]	LED[21]
36	I_{PU}	RESET	RESET	RESET	RESET
37	I/O_{PU}	SINGLE_STA_A/ Addr[0]	SCAN_STAB0/Addr[0]	GPIO[15]/Addr[0]	LED[20]
38	I/O_{PU}	SINGLE_STA_B/ Addr[1]	SCAN_STAB1/Addr[1]	GPIO[16]/Addr[1]	LED[19]
39	I/O_{PU}	SINGLE_STA_C/ Addr[2]	SCAN_STAB2/Addr[2]	GPIO[17]/Addr[2]	LED[18]
40	I/O_{PU}	SINGLE_STA_D/ Addr[3]/16BIT_SMI	SCAN_STAB3/ Addr[3]/16BIT_SMI	GPIO[18]/Addr[3]/ 16BIT_SMI	LED[17]

Pin No.	Type	SMI Slave/MIIM Mode Pin Name			Shift Register Mode Pin Name
		Bi-Color Scan LED	Single-Color Scan LED	GPIO	
41	I/O_{PU}	SINGLE_STA_E/ Addr[4]	SCAN_STAB4/Addr[4]	GPIO[19]/Addr[4]	LED[16]
42	I/O_{PU}	SINGLE_STA_E/ MOD[0]	SCAN_STAB5/MOD[0]	GPIO[20]/MOD[0]	LED[15]/MOD[0]
43	P	VCC3	VCC3	VCC3	VCC3
44	I/O	SCAN_P12-17_ Bi-colorB	SCAN_LEDB3	GPIO[21]	LED[14]
45	I/O	SCAN_P18-23_ Bi-colorC	SCAN_LEDB4	GPIO[22]	LED[13]
46	I/O	P12_STA	SCAN_LEDB5	GPIO[23]	LED[12]
47	G	GND3	GND3	GND3	GND3
48	I/O	P13_STA	P24_STA	GPIO[24]	LED[11]

Note 1: Pin16 (SO/MOD[1]) in the Shift Register Mode is initially floating. It must be pulled high/low to select the active high/low application.

Note 2: I/O pin type is dependent on mode configuration.

6. Pin Descriptions

I: Input Pin

O: Output Pin

I/O: Bi-Directional Input/Output Pin

I_{PU}: Input Pin With Pull-Up Resistor; (Typical Value = 75K ohm)

O_{PU}: Output Pin With Pull-Up Resistor; (Typical Value = 75K ohm)

O_{PD} Output Pin With Pull-Down Resistor; (Typical Value = 75K ohm)

6.1. SMI Slave/MIIM Mode Bi-Color Scan LED Pin Descriptions

6.1.1. SMI Slave/MIIM Mode Bi-Color Scan LED I/O Pins

Table 2. SMI Slave/MIIM Mode Bi-Color Scan LED I/O Pins

Pin Name	Pin No.	Type	Drive (mA)	Description
Port 0~11				
P0_STA~P11_STA	20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 32	O	8	Scan LED Bi-Color Status Pins for Ports 0~11.
SCAN_Bi-colorA	33	O	24	Scan LED Bi-Color Scan Pins for Ports 0~11.
Port 12~23				
P12_STA~P23_STA	46, 48, 1, 4, 5, 6, 7, 8, 9, 10, 11, 12	O	8	Scan LED Bi-Color Status Pins for Ports 12~23.
SCAN_P12-17_Bi-colorB	44	O	24	Scan LED Bi-Color Scan Pins for Ports 12~17.
SCAN_P18-23_Bi-colorC	45	O	24	Scan LED Bi-Color Scan Pins for Ports 18~23.
SINGLE_STA_A~D	37, 38, 39, 40	O	4	Scan LED per Port Single-Color LED Status Pins for Ports 0~23.
SCAN_P0-5	34	O	24	Scan LED Scan Pin for per Port LED2 Single-Color LED. These include Ports 0~23.
SCAN_P6-11	35	O	24	
SCAN_P12-17_Bi-colorB	44	O	24	
SCAN_P18-23_Bi-colorC	45	O	24	

Pin Name	Pin No.	Type	Drive (mA)	Description
GPIO[35]	15	I/O_{PD}	8	GPIO Pin.
GPIO[36]	16	I/O	8	GPIO Pin.

Note: I/O pin type is dependent on mode configuration.

6.1.2. SMI Slave/MIIM Mode Bi-Color Scan LED Miscellaneous Pins

Table 3. SMI Slave/MIIM Mode Bi-Color Scan LED Miscellaneous Pins

Pin Name	Pin No.	Type	Description
RC_Ref	2	O	RC (Resistance-Capacitance) Oscillator Circuit. Should be connected to a 249ohm (±1%) resistor and 1nF (±1%) capacitor in parallel when operating in SMI Slave/MIIM Mode. Place the resistor and capacitor on the same PCB layer as the RTL8231, and as near to the RTL8231 RC_Ref pin as possible. *Note: The layout trace inductance must be under 10nH.*
MDC/SCK	18	I	SMI Slave/MIIM Input Clock. MDC operating speed is 0~25MHz. SCK operating speed is 0~800KHz. *Note: SCK maximum operating speed is 800KHz (this requires an 8MHz RC clock).*
MDIO/SDA	17	I/O_{PU}	SMI Slave/MIIM Data Input/Output.
RESET	36	I_{PU}	System Pin Reset Input. When low active will reset the RTL8231.
TEST	14	I_{PD}	Internal Test Pin. Must be pulled-down.

6.1.3. SMI Slave/MIIM Mode Bi-Color Scan LED Configuration Strapping Pins

Table 4. SMI Slave/MIIM Mode Bi-Color Scan LED Configuration Strapping Pins

Pin Name	Pin No.	Type	Description
SINGLE_STA_A/Addr[0]	37	O_{PU}	When MIIM is selected, Addr[4:0] is PHY Address. When SMI Slave is selected (MOD[0] is pulled-down), Addr[2:0] is Device ID, and the strapping Addr[3] changes to 16BIT_SMI. 16BIT_SMI defines the SMI Slave format to a 16-bit word address when 16BIT_SMI is set high. When SMI Slave interface is selected, Addr[4] is reserved.
SINGLE_STA_B/Addr[1]	38	O_{PU}	
SINGLE_STA_C/Addr[2]	39	O_{PU}	
SINGLE_STA_D/Addr[3]/ 16BIT_SMI	40	O_{PU}	
SINGLE_STA_E/Addr[4]	41	O_{PU}	
SINGLE_STA_F/MOD[0]	42	O_{PU}	Selects the MIIM mode when this strapping pin is pulled-high and Dis_SMI is pulled-down. MIIM: Dis_SMI=0 and MOD[0]=1 SMI Slave: Dis_SMI=0 and MOD[0]=0
GPIO[35]/Dis_SMI	15	O_{PD}	Sets the RTL8231 to SMI Slave/MIIM or Shift Register Mode. Pull-up for shift register mode. Pull-down for SMI Slave/MIIM mode. Dis_SMI=1 (pull-high) for shift register mode. Dis_SMI=0 (pull-down) for SMI Slave/MIIM mode (initial value is pulled-down).

Note: I/O pin type is dependent on mode configuration.

6.1.4. SMI Slave/MIIM Mode Bi-Color Scan LED Power Pin

Table 5. SMI Slave/MIIM Mode Bi-Color Scan LED Power/Ground Pins

Pin Name	Pin No.	Type	Description
VCC0	3	P	Power Pin 3.3V Input. Place the decoupling capacitor on the same PCB layer as the RTL8231, and as near to the RTL8231 power pin as possible.
VCC1	19	P	Power Pin 3.3V Input. Place the decoupling capacitor on the same PCB layer as the RTL8231, and as near to the RTL8231 power pin as possible.

Pin Name	Pin No.	Type	Description
VCC2	31	P	Power Pin 3.3V Input. Place the decoupling capacitor on the same PCB layer as the RTL8231, and as near to the RTL8231 power pin as possible.
VCC3	43	P	Power Pin 3.3V Input. Place the decoupling capacitor on the same PCB layer as the RTL8231, and as near to the RTL8231 power pin as possible.
GND1	13	G	Ground Pin.
GND3	47	G	Ground Pin.

6.2. SMI Slave/MIIM Mode Single-Color Scan LED Pin Descriptions

6.2.1. SMI Slave/MIIM Mode Single-Color Scan LED I/O Pins

Table 6. SMI Slave/MIIM Mode Single-Color Scan LED Output Pins

Pin Name	Pin No.	Type	Drive (mA)	Description
Port 0~11				
SCAN_STAA0~5	23, 24, 25, 26, 27, 28	O	4	Scan LED Status Pins for Ports 0~11.
SCAN_LEDA0~5	20, 21, 22, 29, 30, 32	O	24	Scan LED Scan pin for Ports 0~11.
Port 12~23				
SCAN_STAB0~5	37, 38, 39, 40, 41, 42	O_{PU}	4	Scan LED Status Pins for Ports 12~23.
SCAN_LEDB0~5	33, 34, 35, 44, 45, 46	O	24	Scan LED Scan Pins for Ports 12~23.
Port 24~31 Bi-Color				
P24_STA~P31_STA	1, 4, 5, 7, 8, 9, 10, 48	O	8	Scan LED Bi-Color Status Pins for Ports 24~31.
SCAN_LED_Bi-colorC	6	O	24	Scan LED Bi-Color Scan Pins for Ports 24~31.
GPIO[33]	11	I/O	8	GPIO Pin.
GPIO[34]	12	I/O	8	GPIO Pin.
GPIO[35]	15	I/O_{PD}	8	GPIO Pin.
GPIO[36]	16	I/O	8	GPIO Pin.

Note: I/O pin type is dependent on mode configuration.

6.2.2. SMI Slave/MIIM Mode Single-Color Scan LED Miscellaneous Pins

Table 7. SMI Slave/MIIM Mode Single-Color Scan LED Miscellaneous Pins

Pin Name	Pin No.	Type	Description
RC_Ref	2	O	RC (Resistance-Capacitance) Oscillator Circuit. Should be connected to a 249ohm (±1%) resistor and 1nF (±1%) capacitor in parallel when operating in SMI Slave/MIIM mode. Place the resistor and capacitor on the same PCB layer as the RTL8231, and as near to the RTL8231 RC_Ref pin as possible. *Note: The layout trace inductance must be under 10nH.*
MDC/SCK	18	I	SMI Slave/MIIM Input Clock. MDC operating speed is 0~25MHz. SCK operating speed is 0~800KHz. *Note: SCK maximum operating speed is 800KHz (this Requires an 8MHz RC clock).*
MDIO/SDA	17	I/O_{PU}	SMI Slave/MIIM Data Input/Output.
RESET	36	I_{PU}	System Pin Reset Input. When low active will reset the RTL8231.
TEST	14	I_{PD}	Internal Test Pin. Must be pulled-down.

6.2.3. SMI Slave/MIIM Mode Single-Color Scan LED Configuration Strapping Pins

Table 8. SMI Slave/MIIM Mode Single-Color Scan LED Configuration Strapping Pins

Pin Name	Pin No.	Type	Description
SCAN_STA_B0/Addr[0]	37	O_{PU}	When MIIM is selected, Addr[4:0] is PHY Address. When SMI Slave is selected (MOD[0] is pulled-down), Addr[2:0] is Device ID, and the strapping Addr[3] changes to 16BIT_SMI. 16BIT_SMI defines the SMI Slave format to a 16-bit word address when 16BIT_SMI is set high. When SMI Slave interface is selected, Addr[4] is reserved.
SCAN_STA_B1/Addr[1]	38	O_{PU}	
SCAN_STA_B2/Addr[2]	39	O_{PU}	
SCAN_STA_B3/Addr[3]/ 16BIT_SMI	40	O_{PU}	
SCAN_STA_B4/Addr[4]	41	O_{PU}	

Pin Name	Pin No.	Type	Description
SCAN_STA_B5/MOD[0]	42	O_{PU}	Selects the MIIM mode when this strapping pin is pulled-high and Dis_SMI is pulled-down. MIIM: Dis_SMI=0 and MOD[0]=1 SMI Slave: Dis_SMI=0 and MOD[0]=0
GPIO[35]/Dis_SMI	15	I/O_{PD}	Sets the RTL8231 to SMI Slave/MIIM or Shift Register Mode. Pull-up for shift register mode. Pull-down for SMI Slave/MIIM mode. Dis_SMI=1 (pull-high) for shift register mode. Dis_SMI=0 (pull-down) for SMI Slave/MIIM mode (initial value is pulled-down).

6.2.4. SMI Slave/MIIM Mode Single Color Scan LED Power Pin

Table 9. SMI Slave/MIIM Mode Single Color Scan LED Power/Ground Pins

Pin Name	Pin No.	Type	Description
VCC0	3	P	Power Pin 3.3V Input. Place the decoupling capacitor on the same PCB layer as the RTL8231, and as near to the RTL8231 power pin as possible.
VCC1	19	P	Power Pin 3.3V Input. Place the decoupling capacitor on the same PCB layer as the RTL8231, and as near to the RTL8231 power pin as possible.
VCC2	31	P	Power Pin 3.3V Input. Place the decoupling capacitor on the same PCB layer as the RTL8231, and as near to the RTL8231 power pin as possible.
VCC3	43	P	Power Pin 3.3V Input. Place the decoupling capacitor on the same PCB layer as the RTL8231, and as near to the RTL8231 power pin as possible.
GND1	13	G	Ground Pin.
GND3	47	G	Ground Pin.

6.3. SMI Slave/MIIM Mode GPIO Pin Descriptions

Table 10. SMI Slave/MIIM Mode GPIO Pins

Pin Name	Pin No.	Type	Drive (mA)	Description
GPIO[0]~GPIO[36]	20~30, 32~35, 44~46, 48, 1, 4, 5, 6~12, 16	I/O	8	GPIO Pins.
GPIO[15]~GPIO[20]	37~42	I/O_{PU}	8	GPIO Pins.
GPIO[35]	15	I/O_{PD}	8	GPIO Pins.

Note: I/O pin type is dependent on mode configuration.

6.3.1. SMI Slave/MIIM Mode GPIO Miscellaneous Pins

Table 11. SMI Slave/MIIM Mode GPIO Miscellaneous Pins

Pin Name	Pin No.	Type	Description
RC_Ref	2	O	RC (Resistance-Capacitance) Oscillator Circuit. Should be connected to a 249ohm (±1%) resistor and 1nF (±1%) capacitor in parallel when operating in SMI Slave/MIIM mode. Place the resistor and capacitor on the same PCB layer as the RTL8231, and as near to the RTL8231 RC_Ref pin as possible. *Note: The layout trace inductance must be under 10nH.*
MDC/SCK	18	I	SMI Slave/MIIM Input Clock. MDC operating speed is 0~25MHz. SCK operating speed is 0~800KHz. *Note: SCK maximum operating speed is 800KHz (this Requires an 8MHz RC clock).*
MDIO/SDA	17	I/O_{PU}	SMI Slave/MIIM Data Input/Output.
RESET	36	I_{PU}	System Pin Reset Input. When low active will reset the RTL8231.
TEST	14	I_{PD}	Internal Test Pin. Must be pulled-down.

6.3.2. SMI Slave/MIIM Mode GPIO Configuration Strapping Pins

Table 12. SMI Slave/MIIM Mode GPIO Configuration Strapping Pins

Pin Name	Pin No.	Type	Description
GPIO[15]/Addr[0]	37	I/O_{PU}	When MIIM is Selected, Addr[4:0] is PHY Address. When SMI Slave is selected (MOD[0] is pulled-down), Addr[2:0] is Device ID, and the strapping Addr[3] changes to 16BIT_SMI. 16BIT_SMI defines the SMI Slave format to a 16-bit word address when 16BIT_SMI is set high. When SMI Slave interface is selected, Addr[4] is reserved.
GPIO[16]/Addr[1]	38	I/O_{PU}	
GPIO[17]/Addr[2]	39	I/O_{PU}	
GPIO[18]/Addr[3]/16BIT_SMI	40	I/O_{PU}	
GPIO[19]/Addr[4]	41	I/O_{PU}	
GPIO[20]/MOD[0]	42	I/O_{PU}	Selects the MIIM mode when This Strapping Pin is Pulled-High and Dis_SMI is Pulled-Down. MIIM: Dis_SMI=0 and MOD[0]=1 SMI Slave: Dis_SMI=0 and MOD[0]=0
GPIO[35]/Dis_SMI	15	I/O_{PD}	Sets the RTL8231 to SMI Slave/MIIM or Shift Register Mode. Pull-up for shift register mode. Pull-down for SMI Slave/MIIM mode. Dis_SMI=1 (pull-high) for shift register mode. Dis_SMI=0 (pull-down) for SMI Slave/MIIM mode (initial value is pulled-down).

Note: I/O pin type is dependent on mode configuration.

6.3.3. SMI Slave/MIIM Mode GPIO Power Pin

Table 13. SMI Slave/MIIM Mode GPIO Power/Ground Pins

Pin Name	Pin No.	Type	Description
VCC0	3	P	Power Pin 3.3V Input. Place the decoupling capacitor on the same PCB layer as the RTL8231, and as near to the RTL8231 power pin as possible.
VCC1	19	P	Power Pin 3.3V Input. Place the decoupling capacitor on the same PCB layer as the RTL8231, and as near to the RTL8231 power pin as possible.
VCC2	31	P	Power Pin 3.3V Input. Place the decoupling capacitor on the same PCB layer as the RTL8231, and as near to the RTL8231 power pin as possible.
VCC3	43	P	Power Pin 3.3V Input. Place the decoupling capacitor on the same PCB layer as the RTL8231, and as near to the RTL8231 power pin as possible.
GND1	13	G	Ground Pin.
GND3	47	G	Ground Pin.

6.4. Shift Register Mode Pin Descriptions

6.4.1. Shift Register Mode Miscellaneous Pins

Table 14. Shift Register Mode Miscellaneous Pins

Pin Name	Pin No.	Type	Description
RC_Ref	2	O	RC (Resistance-Capacitance) Oscillator Circuit. Should be connected to a 249ohm resistor and 1nF capacitor in parallel when operating in Shift Register mode. Place the resistor and capacitor on the same PCB layer as the RTL8231, and as near to the RTL8231 RC_Ref pin as possible. *Note: The layout trace inductance must be under 10nH.*
CLK_IN	18	I	Shift Register Clock. CLK_IN operating speed is 0~25MHz.
SI	17	I/O_{PU}	Shift Register Data Input.
RESET	36	I_{PU}	System Pin Reset Input. When low active will reset the RTL8231.
TEST	14	I_{PD}	Internal Test Pin. Must be pulled-down.

6.4.2. Shift Register Mode Function Pins and Configuration Strapping Pins

Table 15. Shift Register Mode Function Pins and Configuration Strapping Pins

Pin Name	Pin No.	Type	Drive (mA)	Description
LED[0]/Dis_SMI	15	I/O_{PD}	4	First Output of the Shift Register Data Output Pin. When MOD[1:0] (strapping Pin16 and 42) is configured to 2'b10 or 2'b11, the LED[0] output pin will be inversed. The LED[0] pin must be pulled-high when in Shift Register mode. Strapping Description: Sets the RTL8231 to SMI Slave/MIIM or Shift Register mode. Dis_SMI=1 (pull-high) for shift register mode. Dis_SMI=0 (pull-down) for SMI Slave/MIIM mode (initial value is pulled-down).

Pin Name	Pin No.	Type	Drive (mA)	Description
LED[15]/MOD[0]	42	O_{PU}	4	Sixteenth Output of the Shift Register Data Output Pin. When MOD[1:0] (strapping Pin16 and 42) is configured to 2'b10 or 2'b11, the LED[0] output pin will be inversed.
SO/MOD[1]	16	O	4	Cascades to the Next Stage RTL8231. Always outputs the same data as the LED[35] pin. Never outputs data inversely. Strapping Description: Defines the shift register initial vale after a power on or reset. MOD[1:0]: Defines four modes: [active high, initial low], [active high, initial high], [active low, initial low], and [active low, initial high]. MOD[1] defines the application circuit is active high/low. MOD[0] defines the initial value is output high/low. 00: Active low and initial value is low. In this mode, LED[15]/MOD[0] (pin42) outputs inverse data. 01: Active low and initial value is high. 10: Active high and initial value is low. In this mode, LED[0]/Dis_SMI (pin15) outputs inverse data. 11: Active high and initial value is high. In this mode, LED[0]/Dis_SMI (pin15) and LED[15]/MOD[0] (pin42) outputs inverse data always.
LED[1]~LED[35]	12~4, 1, 48, 46~44, 42, 41~37, 35~32, 30~20	O	4	Shift Register Data Output Pin.

6.4.3. Shift Register Mode Power/Ground Pins

Table 16. Shift Register Mode Power/Ground Pins

Pin Name	Pin No.	Type	Description
VCC0	3	P	Power Pin 3.3V Input. Place the decoupling capacitor on the same PCB layer as the RTL8231, and as near to the RTL8231 power pin as possible.
VCC1	19	P	Power Pin 3.3V Input. Place the decoupling capacitor on the same PCB layer as the RTL8231, and as near to the RTL8231 power pin as possible.
VCC2	31	P	Power Pin 3.3V Input. Place the decoupling capacitor on the same PCB layer as the RTL8231, and as near to the RTL8231 power pin as possible.
VCC3	43	P	Power Pin 3.3V Input. Place the decoupling capacitor on the same PCB layer as the RTL8231, and as near to the RTL8231 power pin as possible.
GND1	13	G	Ground Pin.
GND3	47	G	Ground Pin.

7. Control Interfaces

The Dis_SMI strapping pin sets the chip to GPIO mode or shift register mode:

- Dis_SMI pin pulled low: GPIO mode in SMI Slave/MIIM mode
- Dis_SMI pin pulled high: Shift Register mode

7.1. SMI Slave Interface

The strapping Pin MOD[0] can decide between SMI_Slave and MIIM interface. The switch MAC can access the RTL8231 via SDA and SCK. Figure 9 shows the SMI cycle of the MAC access ASIC Start and Stop state.

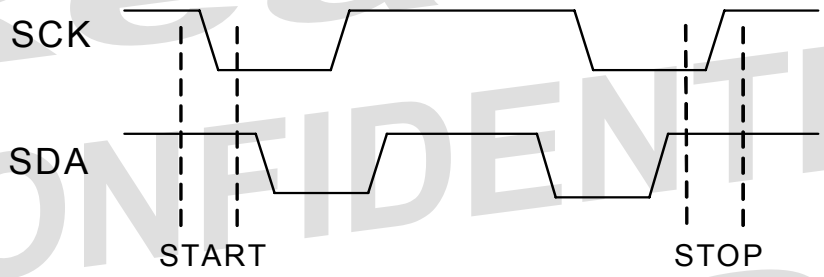


Figure 9. SMI Start and Stop Command

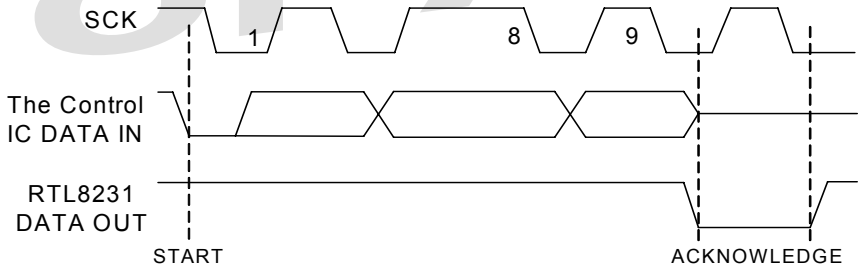


Figure 10. SMI Host to SMI Slave

SMI Slave supports sequential 16 bits or 8 bits Read/Write. Strapping pin 16BIT_SMI (pin40) determines support for 16 bits or 8 bits support.

7.1.1. 16-Bit Read/Write

When 16 bits is enabled, its data format should be:

Control byte (1) + Address bytes (2) + Data bytes (2N, N: Integer, N≠0)

See the format in Figure 11 below.

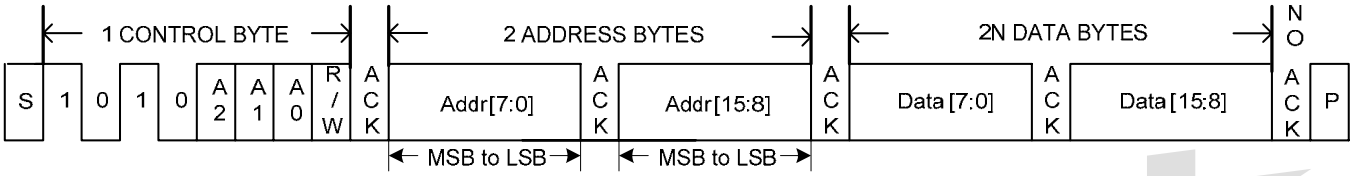


Figure 11. 16-Bit Word Address Access Sequence

When the CPU Read/Writes 16-bit data to the ASIC, the first control byte of the LSB will be set to 1(R)/0(W) for every eight bits of sent data (ACK from the CPU informs the ASIC that it has received 8 bits of data).

7.1.2. 8-Bit Read/Write

When the word address is 8 bits, its data format should be:

Control byte (1) + Address byte (1) + Data bytes (2N, N: Integer, N≠0)

See the format in Figure 12 below.

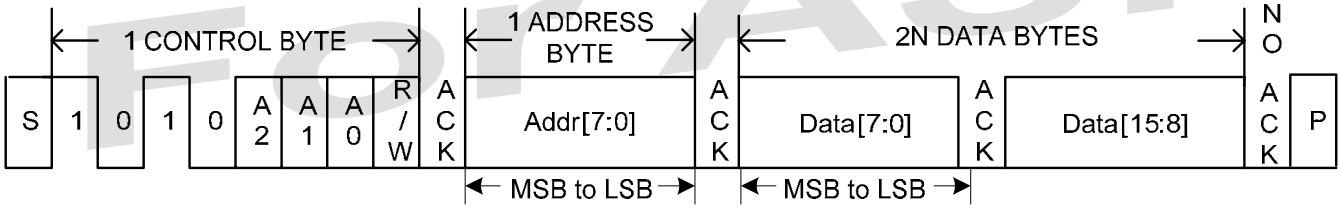


Figure 12. 8-Bit Word Address Access Sequence

Note: The fast frequency of SCK supports up to 800KHz at the SMI Slave interface.

7.2. MIIM (Media Independent Interface Management) Interface (MDC, MDIO)

MIIM Packet Format

Table 17. MIIM Packet Format

	Management Frame Fields							IDLE
	PRE	ST	OP	PHYAD	REGAD	TA	DATA	
Read	1…1	01	10	AAAAA	RRRRR	Z0	DDDDDDDDDDDDDDDD	Z
Write	1…1	01	01	AAAAA	RRRRR	10	DDDDDDDDDDDDDDDD	Z

PRE (Preamble)

When each transaction begins, the station management entity shall send a sequence of 32 or 8 contiguous logical ‘1’ bits on MDIO with 32 or 8 corresponding cycles on MDC.

Note: If the 8-bit preamble MDIO format is used, the MDC must be a free running clock.

PHYAD (PHY Address)

The RTL8231 PHY default address is 5b’11111 (supports PHY addresses from 0 to 31).

REGAD (Register Address)

The register address is 5 bits.

Data

The data field is 16 bits. The first transmitted and received data bit shall be register bit15.

Note: As the RTL8231 clock is independent of the system clock, the MIIM circuit needs the first two clock cycles to start the RTL8231. This means the first command may fail if it is transmitted in the first MDC clock cycle.

8. Function Description

8.1. Reset

8.1.1. Hardware Reset

In a power-on reset, an internal power-on reset pulse is generated and the RTL8231 will start the reset initialization procedures. These are:

- Determine various default settings via the hardware strap pins at the end of the nRESET signal
- Initialize the internal registers

8.1.2. Software Reset

When Software Reset is set to1'b1 (write and self-clear), the chip will take the following step:

- Initialize the internal registers

8.2. Shift Register Mode

Shift register mode receives serial data and outputs it to the LED pin. There are 36 shift registers in the RTL8231 (Figure 13). The SI pin inputs data to the first D Flip Flop. Once the clock is received by the CLK_IN pin, the received data is output from Q (LED[0] pin) to the next D Flip Flop and so on. At the last shift register, the serial data is output to the LED[35] pin and SO pin at the same time.

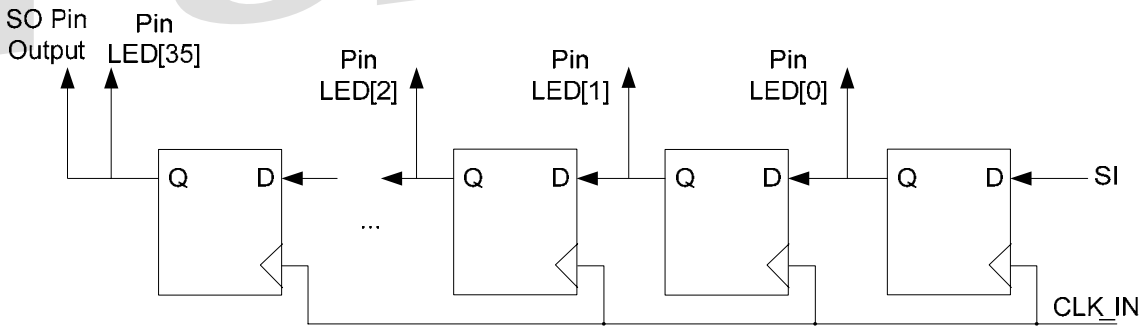


Figure 13. Start/Stop State Waveform

8.2.1. Shift Register Mode System Application

The RTL8231 shift register mode is designed for LED circuits with four individual statuses ([active low, initial low], [active low, initial high], [active high, initial low], [active high, initial high]) that correspond to different LED status circuits.

Active high/low means the external serial LED is lit by a high/low signal output from the LED pins. Initial high/low means the shift register initial output is high/low after power on or a hardware pin reset.

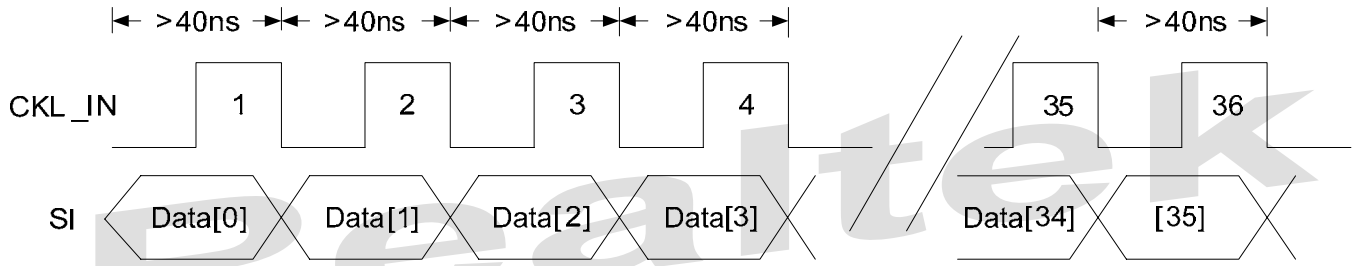


Figure 14. Serial Stream

The active low external serial to parallel LED circuit is shown below.

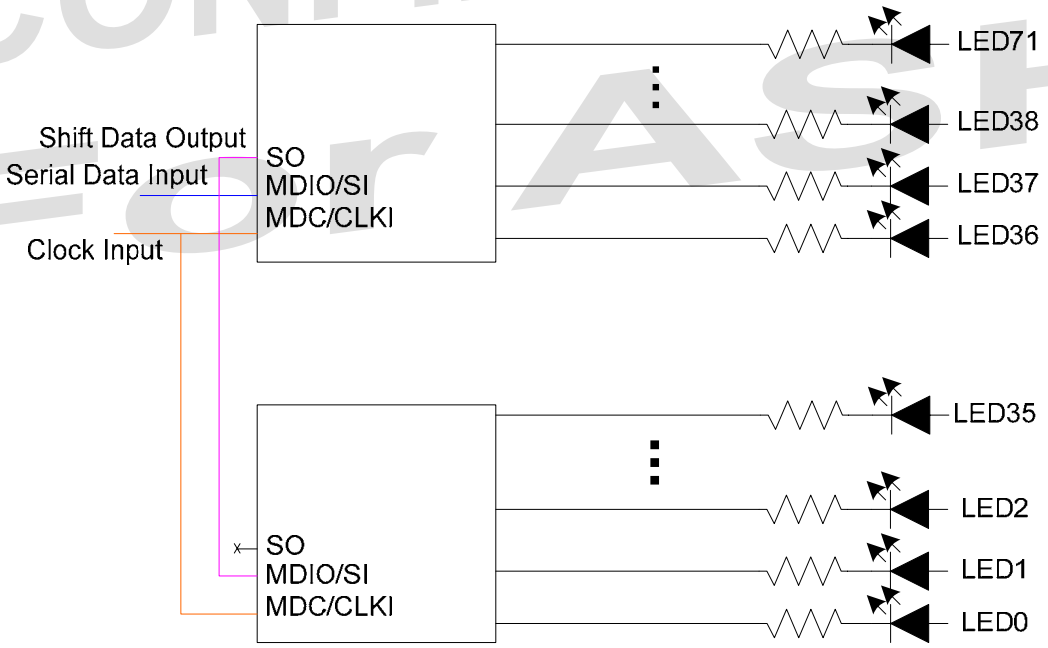


Figure 15. Application Circuit for Shift Register LED

As the parallel data output pin and the strapping pin can coexist, the strapping pin value may have unwanted inverse values (see section 8.2.1 Shift Register Mode System Application, page 30 for details).

Table 18. Inverse Data by Different LED Application Mode

LED[0]/Dis_SMI (Pin15)		LED[15]/MOD[0] (Pin42)		SO/MOD[1] (Pin16)		Status Mode
Initially Pulled-Down		Initially Pulled-High		Initially Floating		
Strapping Value	Shift Register Mode Output Value	Strapping Value	Shift Register Mode Output Value	Strapping Value	Shift Register Mode Output Value	
1 Pull-High	D Non-Inverse	0 Pull-Down	$\overline{D}$ (Shift Register Output Data will be Inversed)	0 Pull-Down	D Non-Inverse	External LED circuit active low and initial output low after power on and or pin reset.
1 Pull-High	D Non-Inverse	1 Pull-High	D Non-Inverse	0 Pull-Down	D Non-Inverse	External LED circuit active low and initial output high after power on and or pin reset.
1 Pull-High	$\overline{D}$ (Shift Register Output Data will be Inversed)	0 Pull-Down	D Non-Inverse	1 Pull-High	D Non-Inverse	External LED circuit active high and initial output low after power on and or pin reset.
1 Pull-High	$\overline{D}$ (Shift Register Output Data will be Inversed)	1 Pull-High	$\overline{D}$ (Shift Register Output Data will be Inversed)	1 Pull-High	D Non-Inverse	External LED circuit active high and initial output high after power on and or pin reset.

8.3. Single-Color Scan LED Mode

LEDs are controlled by registers. Each LED has a 3-bit register to determine OFF, lit, or blinking 40ms, 80ms, 160ms, 320ms, 640ms, and 1280ms. The MAC can control the LED status register via the SMI Slave/MIIM interface.

Note: Blinking times depend on an 8MHz RC (Resistance-Capacitance) clock.

The single-color scan LED mode circuit is composed in a 6x6 matrix. The external circuit is shown in Figure 16.

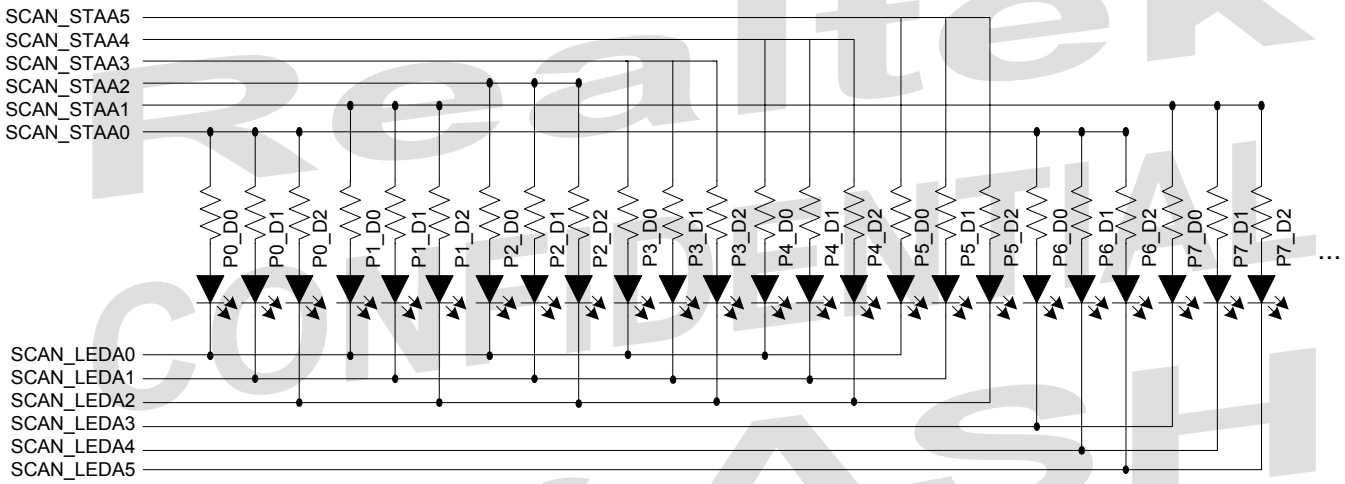


Figure 16. Application Circuit for Single-Color Scan Mode

The single-color scan LED mode timing diagram is shown in Figure 17.

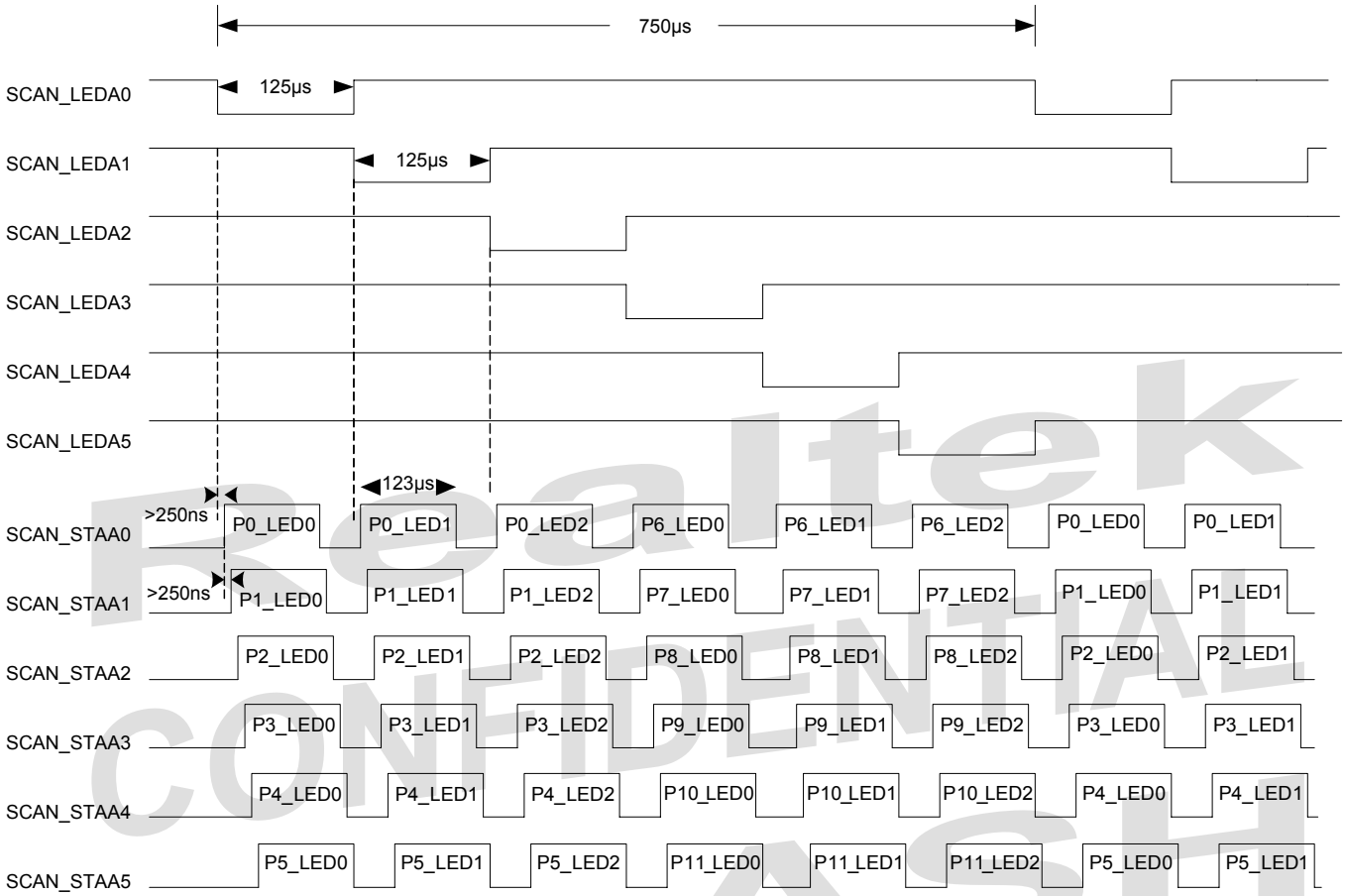


Figure 17. Scan LED Timing Diagram for Single-Color Mode

Note 1: The Scan LED timing requires an 8MHz RC (Resistance-Capacitance) clock.

Note 2: In all Scan LED modes, each LED is turned on every 0.25µs to avoid inrush current.

8.3.1. Scan Single-Color Mode with RTL8328S Application

The Realtek RTL8328S is a 24-port 10/100 Ethernet + 4-port 1000Base-T/1000Base-X Switch.

In 24-port 10/100 Ethernet applications, each port's LED status can be indicated using two single-color LEDs (this uses 48 LEDs in the 6x6 scan circuit matrix). The remaining single-color LEDs can be used to display the 1000M Ethernet ports single-color status.

In the RTL8328S, the 1000Base-T and 1000Base-X bi-color LED status's are divided. As 1000Base-T/1000Base-X must be simultaneously supported, the RTL8231 provides 8 bi-color LEDs in the Scan single-color mode.

In Scan single-color LED mode, the 8-port bi-color LED timing is as shown below.

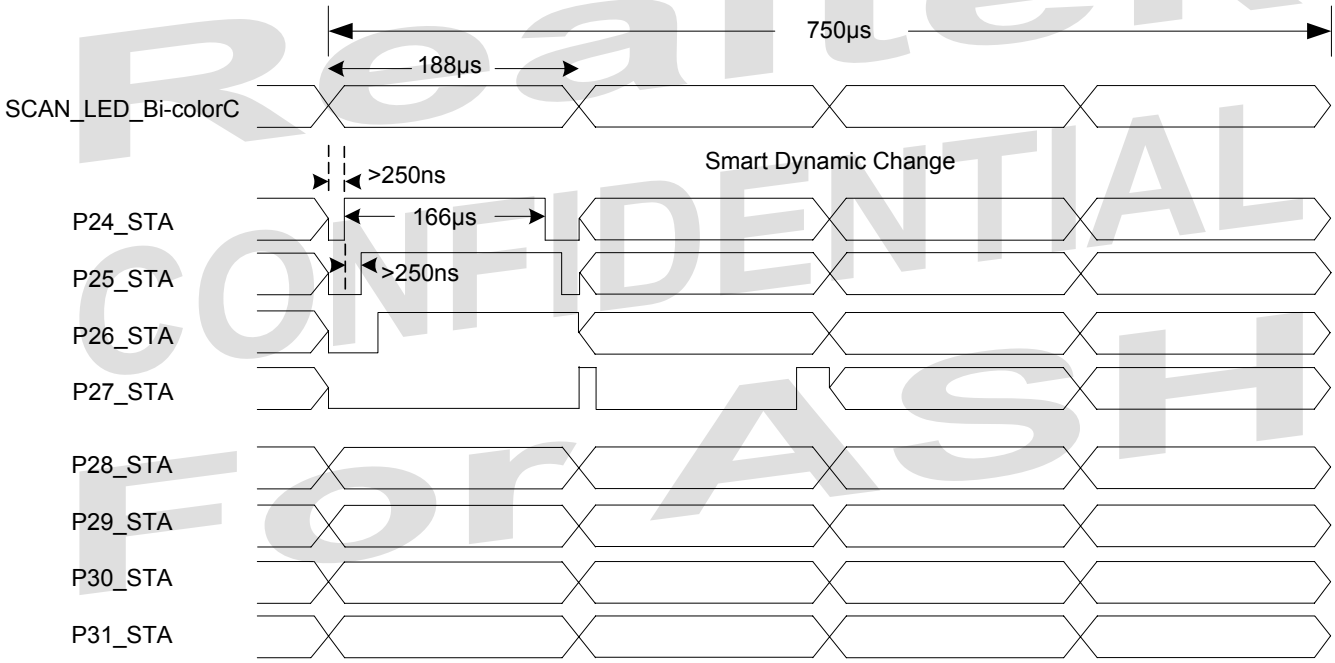


Figure 18. Scan LED Timing Diagram for Single-Color Mode with RTL8328S Bi-Color LEDs

8.3.2. Scan Single-Color Output Matrix Mapped to Control Register

The scan single-color output pins constitute the scan matrix. Each cross line in the scan matrix maps to the LED control registers (see the following figures).

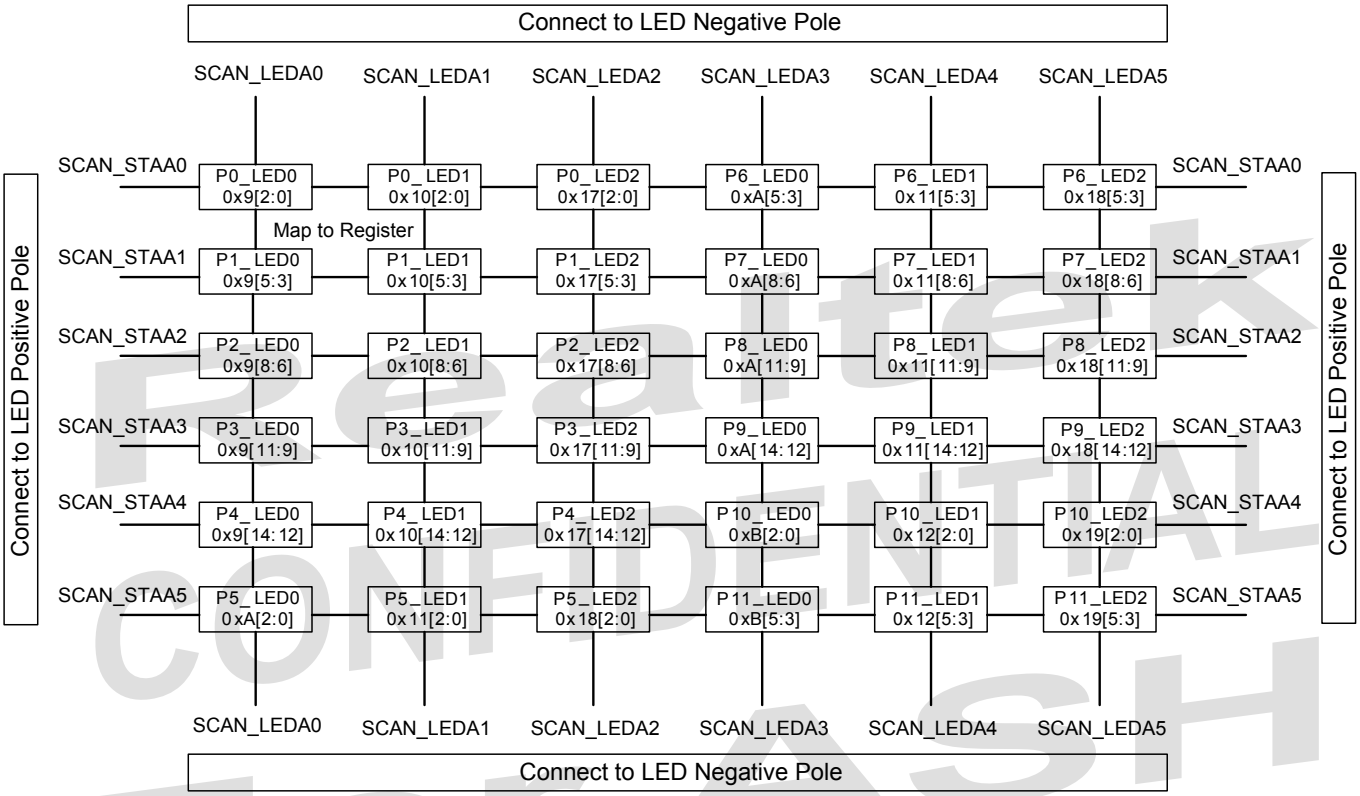


Figure 19. Scan Single-Color LED Circuit Mapped to Control Register at Group A

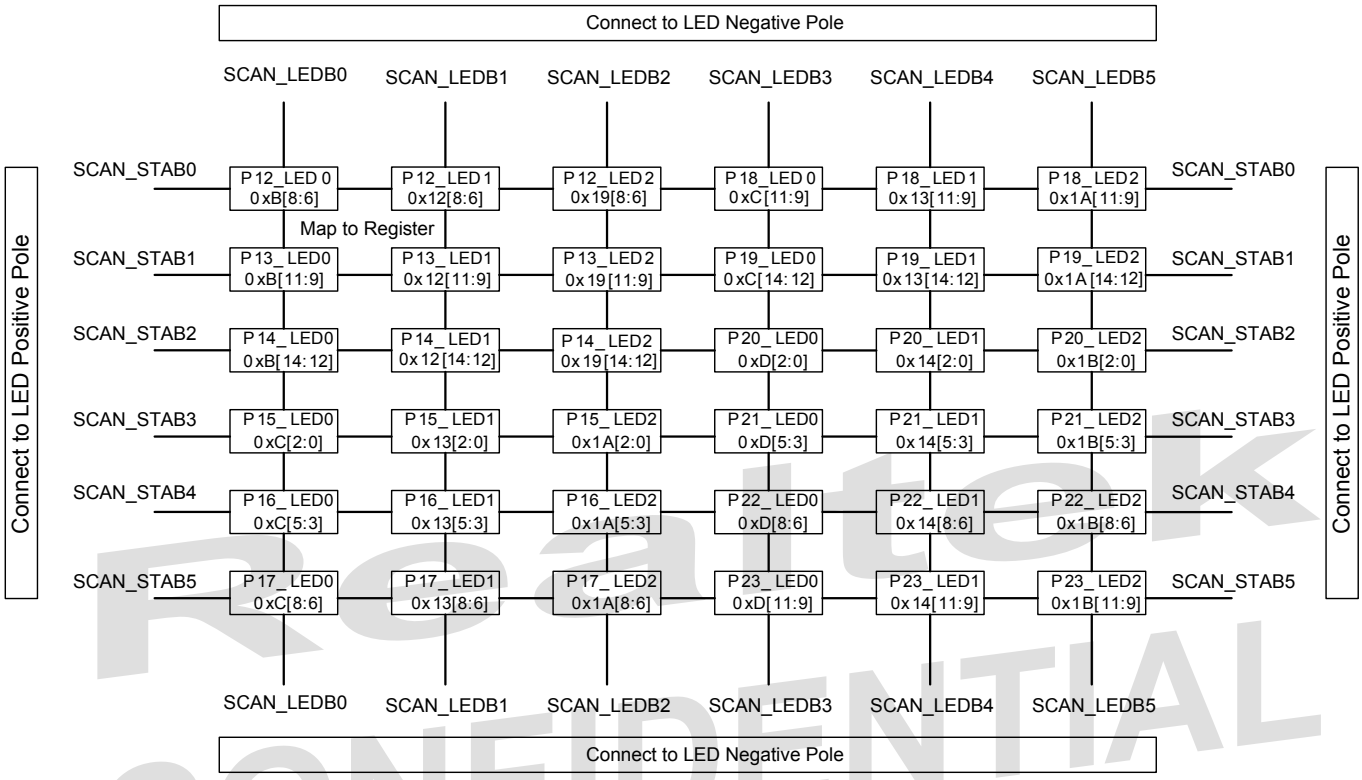


Figure 20. Scan Single-Color LED Circuit Mapped to Control Register at Group B

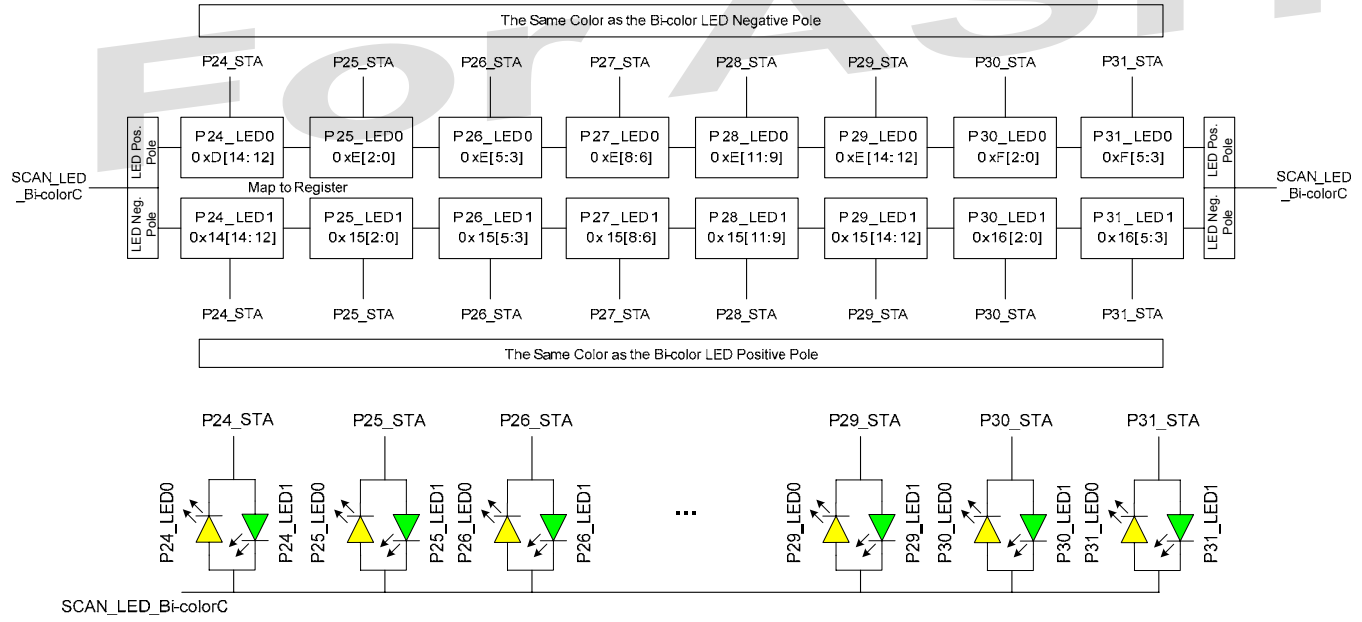


Figure 21. Scan Single-Color LED Circuit Mapped to Control Register at Group C

8.4. Bi-Color Scan LED Mode

The RTL8231 supports 24-port Bi-color scan LEDs. Each port includes one bi-color and one single-color LED. The Scan Bi-color mode is composed of one 4×6 single-color LED circuit matrix, one 1×12 bi-color LED circuit matrix, and two 1×6 scan bi-color LED circuit matrixes.

SCAN_P12-17_Bi-colorB and SCAN_P18-23_Bi-colorC output pins are responsible for lighting the bi-color LEDs (LED0 and LED1) and single-color LED (LED2). To combine bi-color and single color LEDs at the same output pin, the RTL8231 uses a smart dynamic change mechanism (see the following section for details).

In bi-color Scan LED mode, pin SCAN_Bi-colorA, SCAN_P12-17_Bi-colorB, and SCAN_P18-23_Bi-colorC are responsible for lighting LED0 (active high); the SCAN_LED pin is responsible for lighting LED1 (active low).

8.4.1. Smart Dynamic Change

In Scan Bi-color LED mode, SCEN_STA determines which Port needs the LED indication, and SCAN_LED determines which LED to light and which color to light. As the Bi-color LED will not have the situation of light-on both colors on each port, the SCAN_LED is divided to four time slots for color determination. Each time slot can simultaneously light LEDs up to 4 ports, and color combinations are decided by LED_S2P. E.g., if we need Port 0, 2, 4, 5, 11 to light up bi-color Green, and the others are bi-color Yellow, set SCAN_LED high on the 1st and 2nd time slots, set SCEN_STA low for Port 0, 2, 4, 5 (the 1st time slot) and port 11 (the 2nd time slot) so the Ports 0, 2, 4, 5, 11 will be lit up in bi-color Green. Set SCAN_LED low on the 3rd and 4th time slots to light in bi-color Yellow.

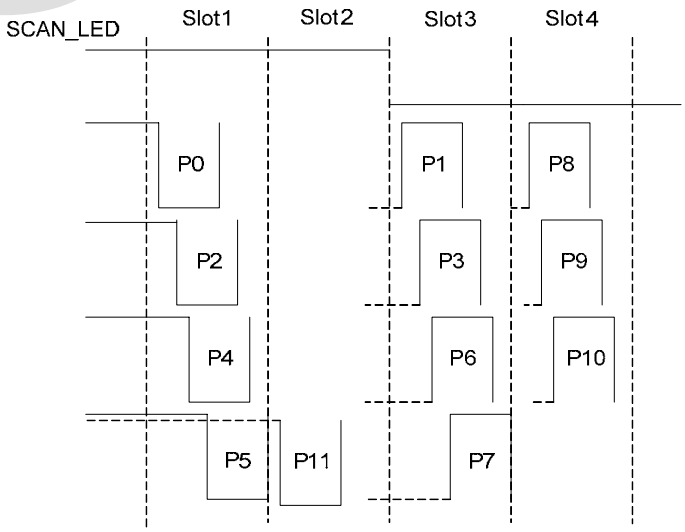


Figure 22. Smart Dynamic Change Timing Diagram

8.4.2. Scan Bi-Color LED Mode Timing

Figure 23 shows the first group Scan Bi-color LED is in a 1x12 matrix group. The LED is used by the Smart Dynamic Change mechanism, so it can increase the Bi-color LED ON time in order to increase the Bi-color LED brightness.

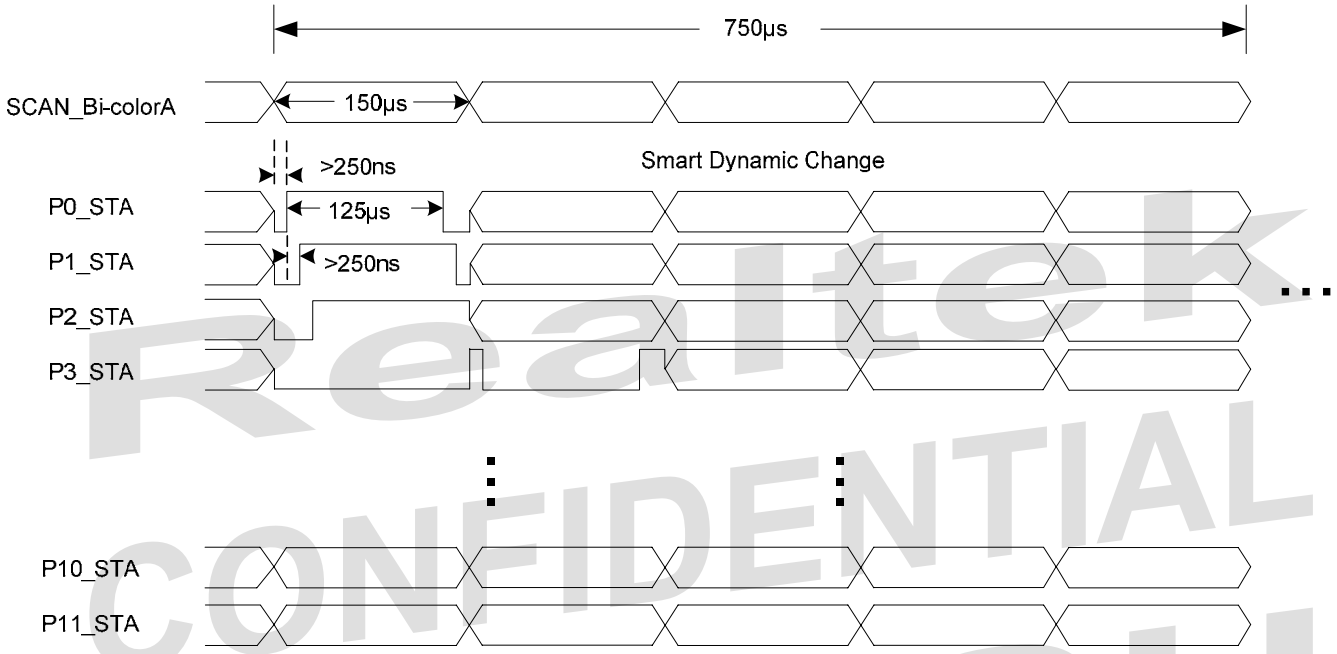


Figure 23. Scan LED Timing Diagram for Bi-Color Mode, Bi-Color

The other groups of bi-color LEDs in Bi-color LED Mode are two 1x6 matrixes, where 1 is the matrix of the SCAN_bi-color pin, and with the single-color pin of the SCAN_LED shared. Figure 24 shows the Bi-color SCAN_LED into single-color LED's SCAN_LED timing diagram. As can be seen from the diagram, for a single-color the time slot P12_STA, P13_STA, ..., P17_STA will follow SCAN_P12-17_Bi-colorB change, and P18_STA, ..., P23_STA will follow SCAN_P18-23_Bi-colorC change, in order to avoid stealing Bi-color LED light.

Figure 24. Scan LED Timing Diagram for Bi-Color Mode, Single-Color Operation

The single-color LED is a 4x6=24 single-color connection. When a Bi-color LED is lit, SCAN_P12-17_Bi-colorB and SCAN_P18-23_Bi-colorC sharing pins will be transformed to Smart Dynamic Change status, and all single-color SCAN_STA pins (SCAN_STA_A, ..., SCAN_STA_F) will be kept Low to ensure the single-color LED will not light.

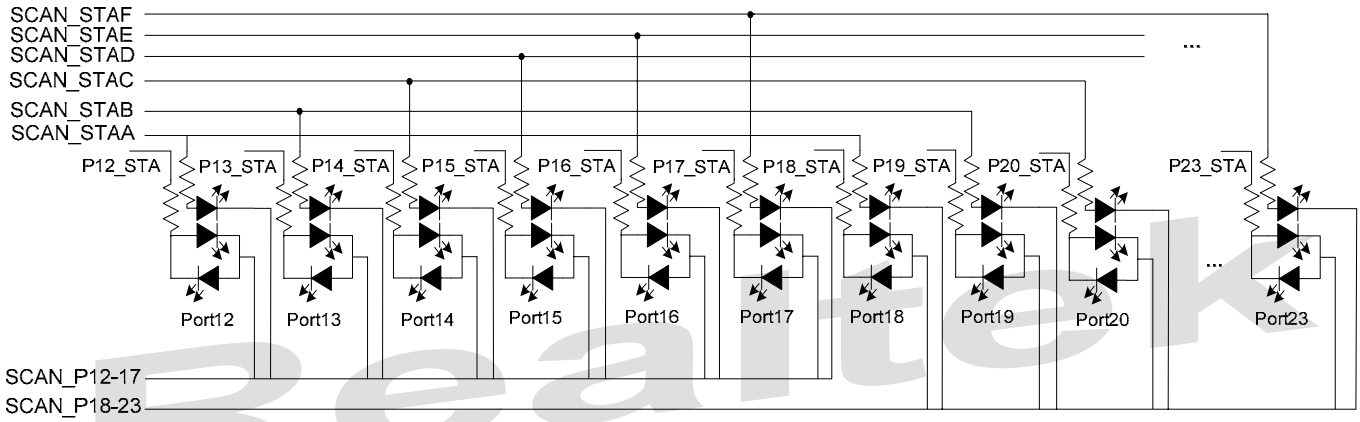


Figure 25. Application Circuit for Bi-Color Scan Mode

8.4.3. Scan Bi-Color Output Matrix Mapped to Control Register

The scan Bi-color output pins constitute the scan matrix. Each cross line in the scan matrix maps to the LED control register, as show in the figures below:

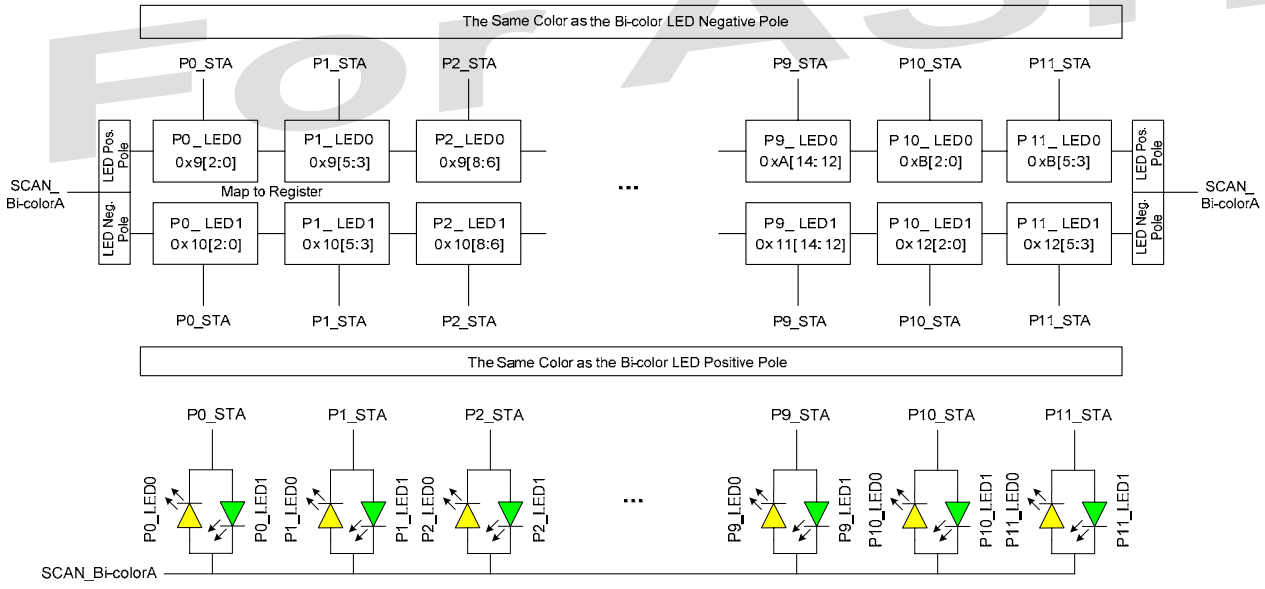


Figure 26. Scan Bi-Color LED Matrix Mapped to Control Register at Bi-Color Group A

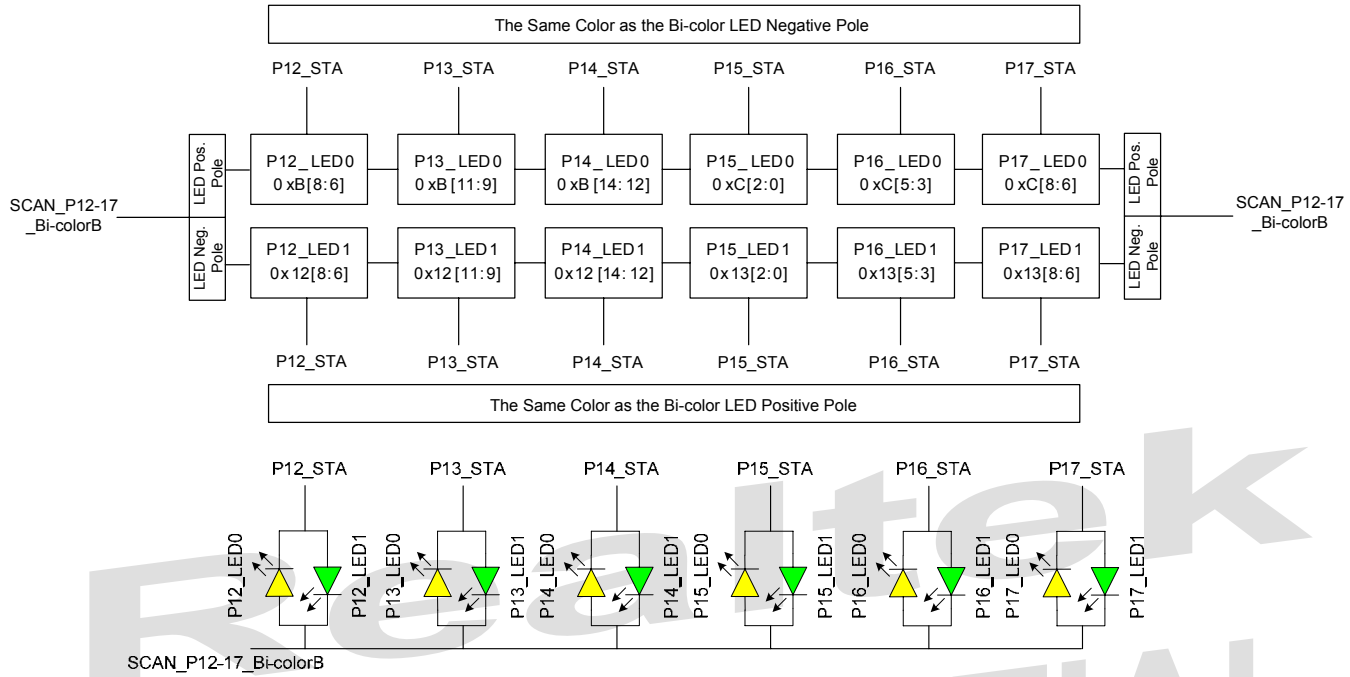


Figure 27. Scan Bi-Color LED Matrix Mapped to Control Register at Bi-Color Group B

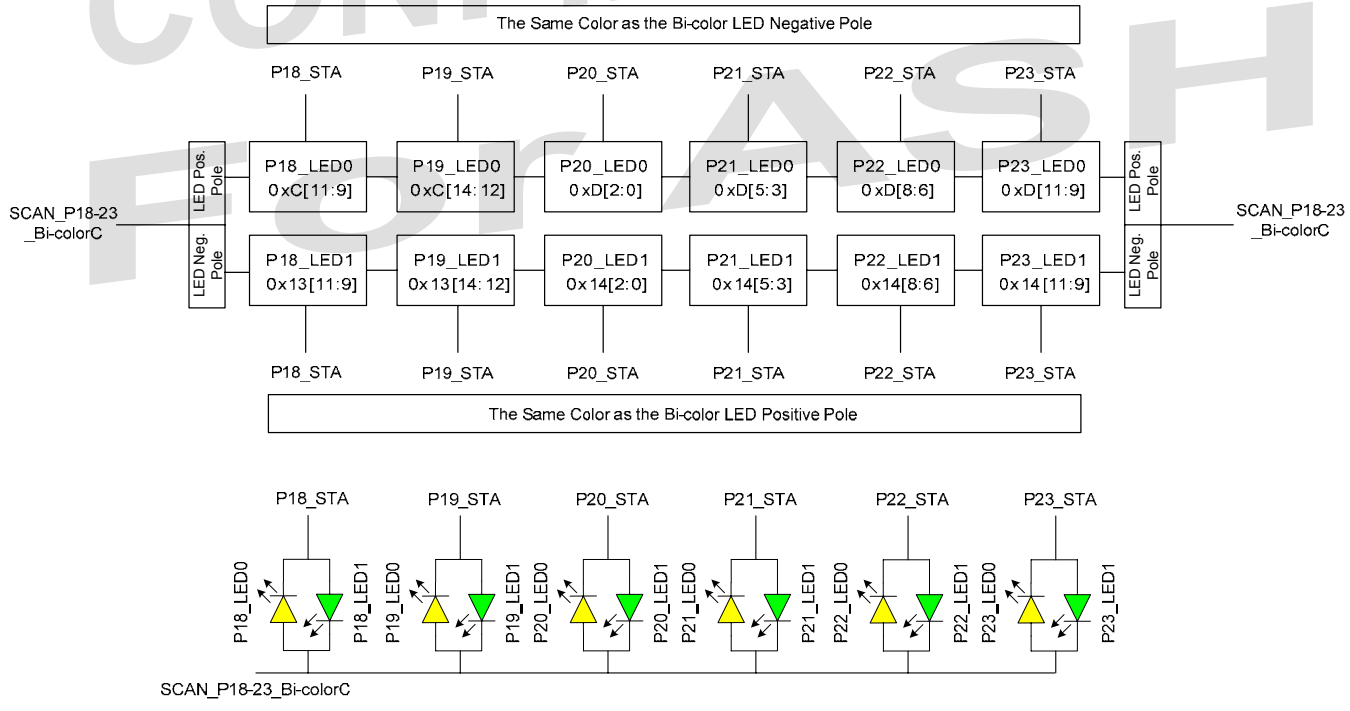


Figure 28. Scan Bi-Color LED Matrix Mapped to Control Register at Bi-Color Group C

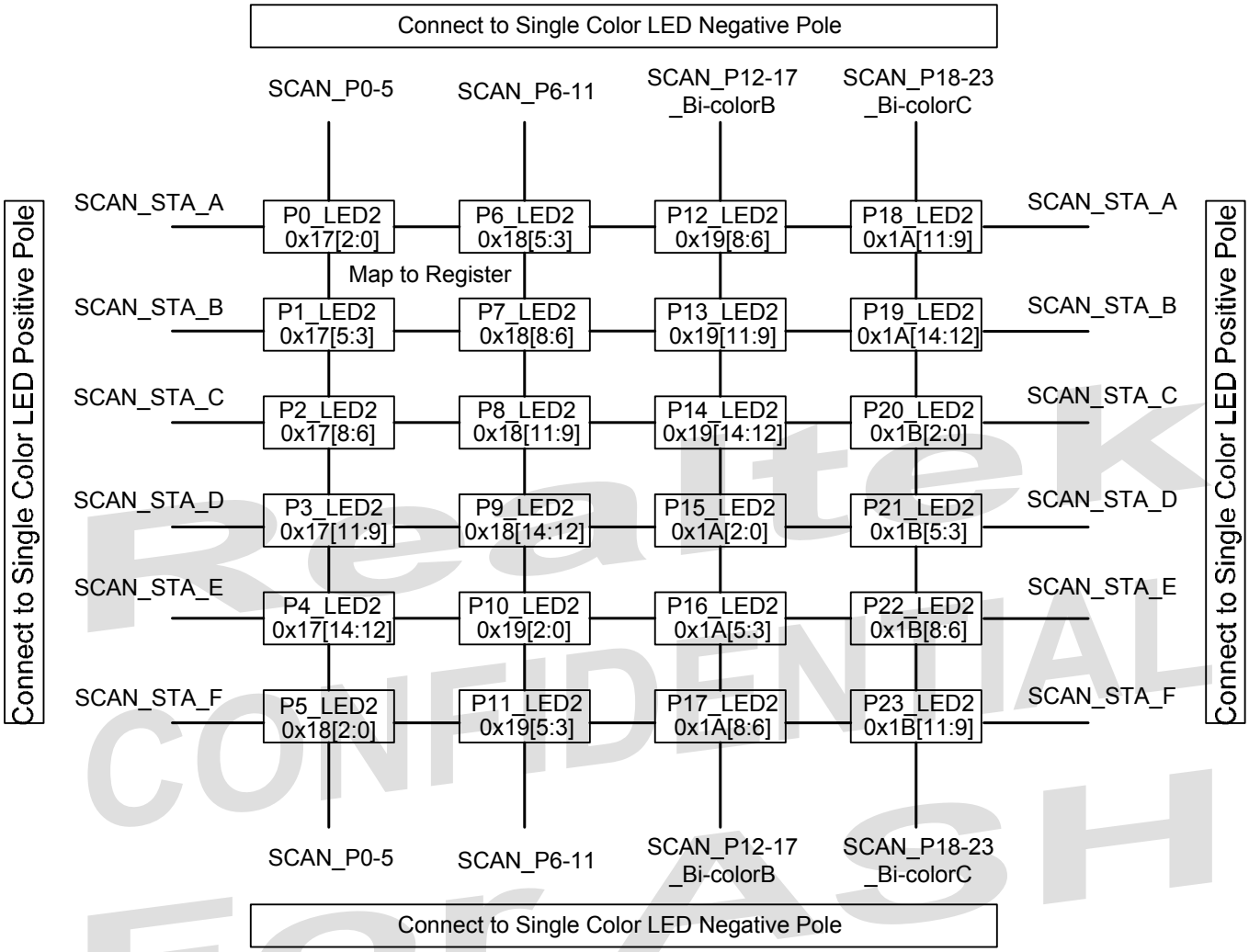


Figure 29. Scan Bi-Color LED Matrix Mapped to Control Register at Single Color Group

8.5. GPIO Mode

In SMI Slave/MIIM mode, except for VCC/GND, Clock input, and MDIO/SDA, any of the RTL8231's pins can become a GPIO pin (up to 37 GPIO pins, which are set by register). Registers 0x0002~0x0004 can set the I/O pins to operate in either SCAN_LED mode or GPIO mode. Registers 0x0004~0x0006 can set the GPIO pins to operate as GPI or GPO.

Register settings are as follows:

SEL_GPIO Register

When this Register value is 1'b0 it indicates that the pin is in SCAN_LED mode. When the Register value is 1'b1, this is a GPIO pin.

IO_GPIO Register

When this Register value is 1'b0, and the mapped SEL_GPIO value is 1'b1 (see section 9 Inter-Register Descriptions, page 45), this GPIO pin is set as Output. When the Register value is 1'b1, and the mapped SEL_GPIO value is 1'b1, this GPIO pin is set as Input.

INV_GPIO Register

When this Register value is 1'b1, and the mapped SEL_GPIO value is 1'b1 (see section 9 Inter-Register Descriptions, page 45), the output data is inversely written. The GPI (Input) is not affected by INV_GPIO.

Buzzer_on Register

This register only used for setting GPIO[35] pin (Pin 15). It is a general GPIO when Buzzer_on (0x0001 bit[3]) is set to 1'b0. When Buzzer_on is 1'b1, GPIO[35] becomes an output pin and sends a frequency beeper for a Buzzer. The frequency is configured by the register Buzzer_Freq[2:0] (0x0001 bits[2:0]).

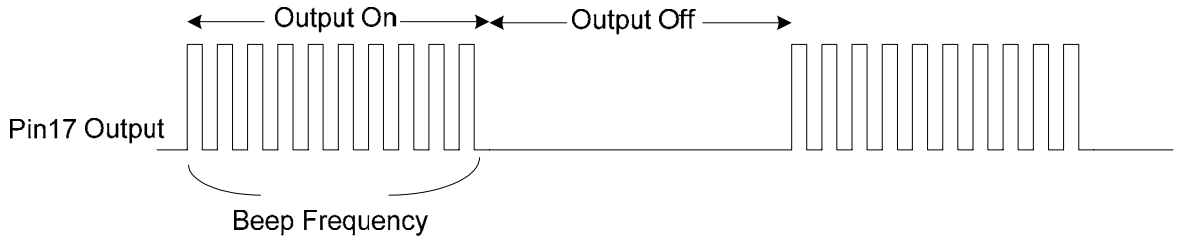


Figure 30. Buzzer Signal Output

En_Debouncing Register

When a pin is set as GPI state (see section 9 Inter-Register Descriptions, page 45), the input signal must continuously maintain the same status for 100ms in order to be latched so the input data can write into DATA_GPIO. In the LED_S2P, only some pins support the En_Debouncing function. When En_Debouncing is enabled, the corresponding pin will become GPI (input), and SEL_GPIO[x] and IO_GPIO[x] registers will be set as 1'b1.

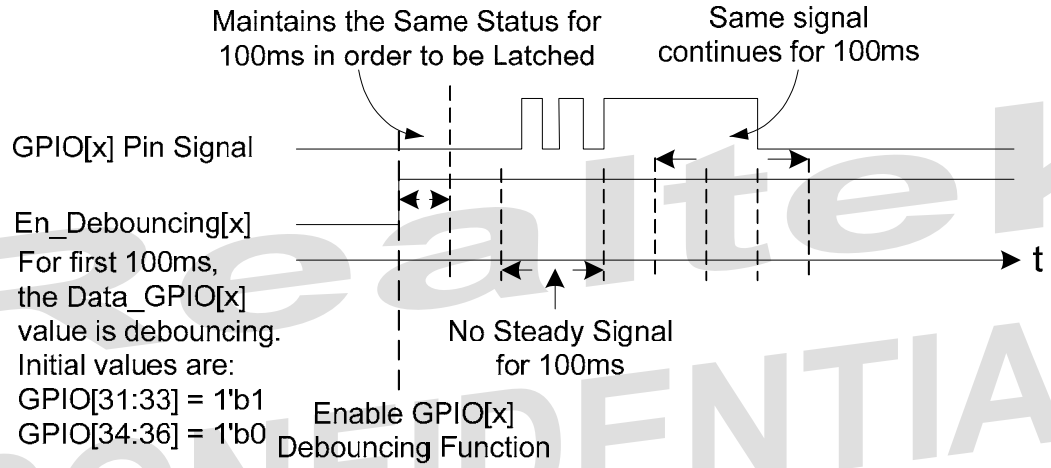


Figure 31. Dip Switch Debouncing

4mA_Driving

Each GPIO's default driving output current is 8mA. To change this to 4mA, set the 4mA_Driving (0x0000 bit[7]) register to 1'b1. This is a global register, all GPIOs pin output driving current will be set to 4mA.

DATA_GPIO

This register is used to store the output contents or input latched value when the corresponding pin is set as GPIO.

9. Inter-Register Descriptions

The following tables are register tables in SMI Slave/MIIM mode.

R: Read RW: Read/Write

W: Write SC: Self-Clearing

9.1. LED Function Register (Address: 0x0000)

Table 19. LED Function Register (Address: 0x0000)

Offset	Description	RW	Default	Pin
0	En_bicolor 1'b0: Uses single-color LED when in Scan LED mode 1'b1: Uses bi-color LED when in Scan LED mode	RW	1	-
1	LED_Start When the RTL8231 has previously been configured by the SMI Master side Chip, this bit should already have been written to 1'b1 (by the SMI Master side Chip).	RW	0	-
2	PHY Address[0]/Device ID[0]	R	1	37
3	PHY Address[1]/Device ID[1]	R	1	38
4	PHY Address[2]/Device ID[2]	R	1	39
5	PHY Address[3]/16BIT_SMI	R	1	40
6	PHY Address[4]	R	1	41
7	4mA_Driving 1'b0: GPIO output driving is 8mA (default) 1'b1: GPIO output driving is 4mA	RW	0	-
8	All_light_LED0 In Scan LED Bi-color, the SCAN_Bi-color pin pulled high will light LED0. 1'b0: All LED0 off (default) 1'b1: All LED0 light	RW	0	-
9	All_light_LED1 In the Scan LED Bi-color, the SCAN_Bi-color pin pulled low will light LED1. 1'b0: All LED1 off (default) 1'b1: All LED1 light	RW	0	-

Offset	Description	RW	Default	Pin
10	All_light_LED2 In Scan LED Bi-color, the SCAN_P[1:23] pin pulled low will light LED2. 1'b0: All LED2 off (default) 1'b1: All LED2 light	RW	0	-
11	All_blinking_LED0 1'b0: All LED0 off (default) 1'b1: All LED0 blinking	RW	0	-
12	All_blinking_LED1 1'b0: All LED1 off (default) 1'b1: All LED1 blinking	RW	0	-
13	All_blinking_LED2 1'b0: All LED2 off (default) 1'b1: All LED2 blinking	RW	0	-
14	En_Sync_LED 1'b0: Provides Scan LED output update status in real-time when LED status register value is changed (default value) 1'b1: Provides Scan LED output status update only when 0x001B[15] (Sync_LED) is written to 1'b1	RW	0	-
15	En_Sync_GPIO 1'b0: Provides GPIO output update status in real-time when DATA_GPIO register value is changed (default value) 1'b1: Provides GPIO output status update only when 0x001E[15] (Sync_GPIO) is written to 1'b1	RW	0	-

9.2. LED Function Register (Address: 0x0001)

Table 20. LED Function Register (Address: 0x0001)

Offset	Description	RW	Default	Pin
0	Buzzer_Freq[2:0] 000: 1.2K 001: 1.6K (default) 010: 2.0K 011: 2.4K 100: 2.8K 101: 3.2K 110: 4.0K 111: 4.8K *Note: The frequency depends on an 8MHz RC (Resistance-Capacitance) clock.*	RW	1	15
1:2		RW	0	
3	Buzzer_on (GPIO[35]) Only used for setting GPIO[35] pin (pin 15). When Buzzer_on is 1'b1, GPIO[35] becomes an output pin, and should set Data_GPIO[35]=1'b1 (Address 30 bit.3) to send a frequency beeper out to a Buzzer. When Buzzer_on is enabled, Data_GPIO[35] (Address 30 bit.3) can control GPIO[35] output frequency turn on/turn off. 1'b0: Off Buzzer function (default) 1'b1: Enable Buzzer function *Note:* *Data_GPIO[35]=1'b1 (Address 30 bit.3) for control frequency turn on when Buzzer_on=1'b1 (Address 1 bit.3 = 1'b1).* *Data_GPIO[35]=1'b0 (Address 30 bit.3) for control frequency turn off when Buzzer_on=1'b1 (Address 1 bit.3 = 1'b1).* *The Buzzer Frequency can be configured via Address 0 bit[2:0].*	RW	0	15
4	Ready_Code[0] The MAC can read the bit Ready_Code[5:0] value when LED_S2P is ready.	R	1	-
5	Ready_Code[1]	R	1	-
6	Ready_Code[2]	R	1	-
7	Ready_Code[3]	R	0	-
8	Ready_Code[4]	R	1	-
9	Ready_Code[5]	R	1	-

Offset	Description	RW	Default	Pin
10	En_Debouncing[31] 1'b0: Disable GPIO input de-bouncing function (default) 1'b1: Enable GPIO input de-bouncing function	RW	0	9
11	En_Debouncing[32] 1'b0: Disable GPIO input de-bouncing function (default) 1'b1: Enable GPIO input de-bouncing function	RW	0	10
12	En_Debouncing[33] 1'b0: Disable GPIO input de-bouncing function (default) 1'b1: Enable GPIO input de-bouncing function	RW	0	11
13	En_Debouncing[34] 1'b0: Disable GPIO input de-bouncing function (default) 1'b1: Enable GPIO input de-bouncing function	RW	0	12
14	En_Debouncing[35] 1'b0: Disable GPIO input de-bouncing function (default) 1'b1: Enable GPIO input de-bouncing function	RW	0	15
15	En_Debouncing[36] 1'b0: Disable GPIO input de-bouncing function (default) 1'b1: Enable GPIO input de-bouncing function	RW	0	16

9.3. GPIO Pin Select Register (Address: 0x0002)

Table 21. GPIO Pin Select Register (Address: 0x0002)

Offset	Name	RW	Default	Pin
0	SEL_GPIO[0] The SEL_GPIO[15:0] is defined as: 1'b0: GPIO pin operates in Scan LED mode 1'b1: GPIO pin operates in GPIO mode	RW	0	20
1	SEL_GPIO[1]	RW	0	21
2	SEL_GPIO[2]	RW	0	22
3	SEL_GPIO[3]	RW	0	23
4	SEL_GPIO[4]	RW	0	24
5	SEL_GPIO[5]	RW	0	25
6	SEL_GPIO[6]	RW	0	26
7	SEL_GPIO[7]	RW	0	27
8	SEL_GPIO[8]	RW	0	28
9	SEL_GPIO[9]	RW	0	29
10	SEL_GPIO[10]	RW	0	30
11	SEL_GPIO[11]	RW	0	32
12	SEL_GPIO[12]	RW	0	33
13	SEL_GPIO[13]	RW	0	34
14	SEL_GPIO[14]	RW	0	35
15	SEL_GPIO[15]	RW	0	37

9.4. GPIO Pin Select Register (Address: 0x0003)

Table 22. GPIO Pin Select Register (Address: 0x0003)

Offset	Name	RW	Default	Pin
0	SEL_GPIO[16] The SEL_GPIO[31:16] is defined as: 1'b0: GPIO pin operates in Scan LED mode 1'b1: GPIO pin operates in GPIO mode	RW	0	38
1	SEL_GPIO[17]	RW	0	39
2	SEL_GPIO[18]	RW	0	40
3	SEL_GPIO[19]	RW	0	41
4	SEL_GPIO[20]	RW	0	42
5	SEL_GPIO[21]	RW	0	44
6	SEL_GPIO[22]	RW	1	45
7	SEL_GPIO[23]	RW	0	46
8	SEL_GPIO[24]	RW	0	48
9	SEL_GPIO[25]	RW	0	1
10	SEL_GPIO[26]	RW	0	4
11	SEL_GPIO[27]	RW	1	5
12	SEL_GPIO[28]	RW	1	6
13	SEL_GPIO[29]	RW	1	7
14	SEL_GPIO[30]	RW	1	8
15	SEL_GPIO[31]	RW	1	9

9.5. GPIO Pin Select Register (Address: 0x0004)

Table 23. GPIO Pin Select Register (Address: 0x0004)

Offset	Name	RW	Default	Pin
0:2	SEL_GPIO[32:34] 1'b0: GPIO pin operates in Scan LED mode 1'b1: GPIO pin operates in GPIO mode	RW	1	10~12
3:4	Reserved	RW	1	-
5:9	IO_GPIO[32:36] I/O Mask 1'b0: GPIO pin operates in output mode 1'b1: GPIO pin operates in input mode	RW	0	10~16
10:14	INV_GPIO[32:36] 1'b0: The GPO output value is normal 1'b1: Inverse the GPO output value	RW	0	10~16
15	Software Reset	RW/SC	0	-

9.6. GPIO I/O Select Register (Address: 0x0005)

Table 24. GPIO I/O Select Register (Address: 0x0005)

Offset	Description	RW	Default	Pin
0	IO_GPIO[0] I/O Mask The IO_GPIO[15:0] is defined as: 1'b0: GPIO pin operates in output mode 1'b1: GPIO pin operates in input mode	RW	0	20
1	IO_GPIO[1] I/O Mask	RW	0	21
2	IO_GPIO[2] I/O Mask	RW	0	22
3	IO_GPIO[3] I/O Mask	RW	0	23
4	IO_GPIO[4] I/O Mask	RW	0	24
5	IO_GPIO[5] I/O Mask	RW	0	25
6	IO_GPIO[6] I/O Mask	RW	0	26
7	IO_GPIO[7] I/O Mask	RW	0	27
8	IO_GPIO[8] I/O Mask	RW	0	28
9	IO_GPIO[9] I/O Mask	RW	0	29

Offset	Description	RW	Default	Pin
10	IO_GPIO[10] I/O Mask	RW	0	30
11	IO_GPIO[11] I/O Mask	RW	0	32
12	IO_GPIO[12] I/O Mask	RW	0	33
13	IO_GPIO[13] I/O Mask	RW	0	34
14	IO_GPIO[14] I/O Mask	RW	0	35
15	IO_GPIO[15] I/O Mask	RW	0	37

9.7. GPIO I/O Select Register (Address: 0x0006)

Table 25. GPIO I/O Select Register (Address: 0x0006)

Offset	Description	RW	Default	Pin
0	IO_GPIO[16] I/O Mask The IO_GPIO[31:16] is defined as: 1'b0: GPIO pin operates in output mode 1'b1: GPIO pin operates in input mode	RW	0	38
1	IO_GPIO[17] I/O Mask	RW	0	39
2	IO_GPIO[18] I/O Mask	RW	0	40
3	IO_GPIO[19] I/O Mask	RW	0	41
4	IO_GPIO[20] I/O Mask	RW	0	42
5	IO_GPIO[21] I/O Mask	RW	0	44
6	IO_GPIO[22] I/O Mask	RW	0	45
7	IO_GPIO[23] I/O Mask	RW	0	46
8	IO_GPIO[24] I/O Mask	RW	0	48
9	IO_GPIO[25] I/O Mask	R	0	1
10	IO_GPIO[26] I/O Mask	R	0	4
11	IO_GPIO[27] I/O Mask	R	0	5
12	IO_GPIO[28] I/O Mask	R	0	6
13	IO_GPIO[29] I/O Mask	R	0	7
14	IO_GPIO[30] I/O Mask	R	0	8
15	IO_GPIO[31] I/O Mask	R	0	9

9.8. GPIO I/O Inverter Register (Address: 0x0007)

Table 26. GPIO I/O Inverter Register (Address: 0x0007)

Offset	Description	RW	Default	Pin
0	INV_GPIO[0] Inverter Mask The INV_GPIO[15:0] is defined as: 1'b0: The GPO output value is normal 1'b1: Inverse the GPO output value	RW	0	20
1	INV_GPIO[1] Inverter Mask	RW	0	21
2	INV_GPIO[2] Inverter Mask	RW	0	22
3	INV_GPIO[3] Inverter Mask	RW	0	23
4	INV_GPIO[4] Inverter Mask	RW	0	24
5	INV_GPIO[5] Inverter Mask	RW	0	25
6	INV_GPIO[6] Inverter Mask	RW	0	26
7	INV_GPIO[7] Inverter Mask	RW	0	27
8	INV_GPIO[8] Inverter Mask	RW	0	28
9	INV_GPIO[9] Inverter Mask	RW	0	29
10	INV_GPIO[10] Inverter Mask	RW	0	30
11	INV_GPIO[11] Inverter Mask	RW	0	32
12	INV_GPIO[12] Inverter Mask	RW	0	33
13	INV_GPIO[13] Inverter Mask	RW	0	34
14	INV_GPIO[14] Inverter Mask	RW	0	35
15	INV_GPIO[15] Inverter Mask	RW	0	37

9.9. GPIO I/O Inverter Register (Address: 0x0008)

Table 27. GPIO I/O Inverter Register (Address: 0x0008)

Offset	Description	RW	Default	Pin
0	INV_GPIO[16] Inverter Mask The INV_GPIO[31:16] is defined as: 1'b0: The GPO output value is normal 1'b1: Inverse the GPO output value	RW	0	38
1	INV_GPIO[17] Inverter Mask	RW	0	39
2	INV_GPIO[18] Inverter Mask	RW	0	40
3	INV_GPIO[19] Inverter Mask	RW	0	41
4	INV_GPIO[20] Inverter Mask	RW	0	42
5	INV_GPIO[21] Inverter Mask	RW	0	44
6	INV_GPIO[22] Inverter Mask	RW	0	45
7	INV_GPIO[23] Inverter Mask	RW	0	46
8	INV_GPIO[24] Inverter Mask	RW	0	48
9	INV_GPIO[25] Inverter Mask	RW	0	1
10	INV_GPIO[26] Inverter Mask	RW	0	4
11	INV_GPIO[27] Inverter Mask	RW	0	5
12	INV_GPIO[28] Inverter Mask	RW	0	6
13	INV_GPIO[29] Inverter Mask	RW	0	7
14	INV_GPIO[30] Inverter Mask	RW	0	8
15	INV_GPIO[31] Inverter Mask	RW	0	9

9.10. LED0 Control Register (Address: 0x0009)

Note: In this table Single-color pins are prefixed with 'S' (e.g., S20, S25), and Bi-color pins with 'B' (e.g., B22, B33). LEDs without supporting Scan Bi-color LED are prefixed with 'B (NA)'.

Table 28. LED0 Control Register (Address: 0x0009)

Offset	Description	RW	Default	Pin
2:0	Port0_LED0_[2:0] 000: Off 001: Blinking 40ms 010: Blinking 80ms 011: Blinking 160ms 100: Blinking 320ms 101: Blinking 640ms 110: Blinking 1280ms 111: Lit	RW	0	S20, S23 B20, B33
3	Port1_LED0_[0] In Scan LED Bi-color, the SCAN_Bi-colorA pin pulled high will light LED0	RW	0	S20, S24 B21, B33
4	Port1_LED0_[1] In Scan LED Bi-color, the SCAN_Bi-colorA pin pulled high will light LED0	RW	0	
5	Port1_LED0_[2] In Scan LED Bi-color, the SCAN_Bi-colorA pin pulled high will light LED0	RW	0	
6	Port2_LED0_[0] In Scan LED Bi-color, the SCAN_Bi-colorA pin pulled high will light LED0	RW	0	S20, S25 B22, B33
7	Port2_LED0_[1] In Scan LED Bi-color, the SCAN_Bi-colorA pin pulled high will light LED0	RW	0	
8	Port2_LED0_[2] In Scan LED Bi-color, the SCAN_Bi-colorA pin pulled high will light LED0	RW	0	
9	Port3_LED0_[0] In Scan LED Bi-color, the SCAN_Bi-colorA pin pulled high will light LED0	RW	0	S20, S26 B23, B33
10	Port3_LED0_[1] In Scan LED Bi-color, the SCAN_Bi-colorA pin pulled high will light LED0	RW	0	
11	Port3_LED0_[2] In Scan LED Bi-color, the SCAN_Bi-colorA pin pulled high will light LED0	RW	0	

Offset	Description	RW	Default	Pin
12	Port4_LED0_[0] In Scan LED Bi-color, the SCAN_Bi-colorA pin pulled high will light LED0	RW	0	S20, S27 B24, B33
13	Port4_LED0_[1] In Scan LED Bi-color, the SCAN_Bi-colorA pin pulled high will light LED0	RW	0	
14	Port4_LED0_[2] In Scan LED Bi-color, the SCAN_Bi-colorA pin pulled high will light LED0	RW	0	
15	Reserved	RW	0	-

9.11. LED0 Control Register (Address: 0x000A)

Table 29. LED0 Control Register (Address: 0x000A)

Offset	Description	RW	Default	Pin
0	Port5_LED0_[0] In Scan LED Bi-color, the SCAN_Bi-colorA pin pulled high will light LED0	RW	0	S20, S28 B25, B33
1	Port5_LED0_[1] In Scan LED Bi-color, the SCAN_Bi-colorA pin pulled high will light LED0	RW	0	
2	Port5_LED0_[2] In Scan LED Bi-color, the SCAN_Bi-colorA pin pulled high will light LED0	RW	0	
3	Port6_LED0_[0] In Scan LED Bi-color, the SCAN_Bi-colorA pin pulled high will light LED0	RW	0	S29, S23 B26, B33
4	Port6_LED0_[1] In Scan LED Bi-color, the SCAN_Bi-colorA pin pulled high will light LED0	RW	0	
5	Port6_LED0_[2] In Scan LED Bi-color, the SCAN_Bi-colorA pin pulled high will light LED0	RW	0	
6	Port7_LED0_[0] In Scan LED Bi-color, the SCAN_Bi-colorA pin pulled high will light LED0	RW	0	S29, S24 B27, B33
7	Port7_LED0_[1] In Scan LED Bi-color, the SCAN_Bi-colorA pin pulled high will light LED0	RW	0	
8	Port7_LED0_[2] In Scan LED Bi-color, the SCAN_Bi-colorA pin pulled high will light LED0	RW	0	

Offset	Description	RW	Default	Pin
9	Port8_LED0_[0] In Scan LED Bi-color, the SCAN_Bi-colorA pin pulled high will light LED0	RW	0	S29, S25 B28, B33
10	Port8_LED0_[1] In Scan LED Bi-color, the SCAN_Bi-colorA pin pulled high will light LED0	RW	0	
11	Port8_LED0_[2] In Scan LED Bi-color, the SCAN_Bi-colorA pin pulled high will light LED0	RW	0	
12	Port9_LED0_[0] In Scan LED Bi-color, the SCAN_Bi-colorA pin pulled high will light LED0	RW	0	S29, S26 B29, B33
13	Port9_LED0_[1] In Scan LED Bi-color, the SCAN_Bi-colorA pin pulled high will light LED0	RW	0	
14	Port9_LED0_[2] In Scan LED Bi-color, the SCAN_Bi-colorA pin pulled high will light LED0	RW	0	
15	Reserved	RW	0	-

9.12. LED0 Control Register (Address: 0x000B)

Table 30. LED0 Control Register (Address: 0x000B)

Offset	Description	RW	Default	Pin
0	Port10_LED0_[0] In Scan LED Bi-color, the SCAN_Bi-colorA pin pulled high will light LED0	RW	0	S29, S27 B30, B33
1	Port10_LED0_[1] In Scan LED Bi-color, the SCAN_Bi-colorA pin pulled high will light LED0	RW	0	
2	Port10_LED0_[2] In Scan LED Bi-color, the SCAN_Bi-colorA pin pulled high will light LED0	RW	0	
3	Port11_LED0_[0] In Scan LED Bi-color, the SCAN_Bi-colorA pin pulled high will light LED0	RW	0	S29, S28 B32, B33
4	Port11_LED0_[1] In Scan LED Bi-color, the SCAN_Bi-colorA pin pulled high will light LED0	RW	0	
5	Port11_LED0_[2] In Scan LED Bi-color, the SCAN_Bi-colorA pin pulled high will light LED0	RW	0	

Offset	Description	RW	Default	Pin
6	Port12_LED0_[0] In Scan LED Bi-color, the SCAN_P12-17_Bi-colorB pin pulled high will light LED0	RW	0	S33, S37 B46, B44
7	Port12_LED0_[1] In Scan LED Bi-color, the SCAN_P12-17_Bi-colorB pin pulled high will light LED0	RW	0	
8	Port12_LED0_[2] In Scan LED Bi-color, the SCAN_P12-17_Bi-colorB pin pulled high will light LED0	RW	0	
9	Port13_LED0_[0] In Scan LED Bi-color, the SCAN_P12-17_Bi-colorB pin pulled high will light LED0	RW	0	S33, S38 B48, B44
10	Port13_LED0_[1] In Scan LED Bi-color, the SCAN_P12-17_Bi-colorB pin pulled high will light LED0	RW	0	
11	Port13_LED0_[2] In Scan LED Bi-color, the SCAN_P12-17_Bi-colorB pin pulled high will light LED0	RW	0	
12	Port14_LED0_[0] In Scan LED Bi-color, the SCAN_P12-17_Bi-colorB pin pulled high will light LED0	RW	0	S33, S39 B1, B44
13	Port14_LED0_[1] In Scan LED Bi-color, the SCAN_P12-17_Bi-colorB pin pulled high will light LED0	RW	0	
14	Port14_LED0_[2] In Scan LED Bi-color, the SCAN_P12-17_Bi-colorB pin pulled high will light LED0	RW	0	
15	Reserved	RW	0	-

9.13. LED0 Control Register (Address: 0x000C)

Table 31. LED0 Control Register (Address: 0x000C)

Offset	Description	RW	Default	Pin
0	Port15_LED0_[0] In Scan LED Bi-color, the SCAN_P12-17_Bi-colorB pin pulled high will light LED0	RW	0	S33, S40 B4, B44
1	Port15_LED0_[1] In Scan LED Bi-color, the SCAN_P12-17_Bi-colorB pin pulled high will light LED0	RW	0	
2	Port15_LED0_[2] In Scan LED Bi-color, the SCAN_P12-17_Bi-colorB pin pulled high will light LED0	RW	0	
3	Port16_LED0_[0] In Scan LED Bi-color, the SCAN_P12-17_Bi-colorB pin pulled high will light LED0	RW	0	S33, S41 B5, B44
4	Port16_LED0_[1] In Scan LED Bi-color, the SCAN_P12-17_Bi-colorB pin pulled high will light LED0	RW	0	
5	Port16_LED0_[2] In Scan LED Bi-color, the SCAN_P12-17_Bi-colorB pin pulled high will light LED0	RW	0	
6	Port17_LED0_[0] In Scan LED Bi-color, the SCAN_P12-17_Bi-colorB pin pulled high will light LED0	RW	0	S33, S42 B6, B44
7	Port17_LED0_[1] In Scan LED Bi-color, the SCAN_P12-17_Bi-colorB pin pulled high will light LED0	RW	0	
8	Port17_LED0_[2] In Scan LED Bi-color, the SCAN_P12-17_Bi-colorB pin pulled high will light LED0	RW	0	

Offset	Description	RW	Default	Pin
9	Port18_LED0_[0] In Scan LED Bi-color, the SCAN_P18-23_Bi-colorC pin pulled high will light LED0	RW	0	S44, S37 B7, B45
10	Port18_LED0_[1] In Scan LED Bi-color, the SCAN_P18-23_Bi-colorC pin pulled high will light LED0	RW	0	
11	Port18_LED0_[2] In Scan LED Bi-color, the SCAN_P18-23_Bi-colorC pin pulled high will light LED0	RW	0	
12	Port19_LED0_[0] In Scan LED Bi-color, the SCAN_P18-23_Bi-colorC pin pulled high will light LED0	RW	0	S44, S38 B8, B45
13	Port19_LED0_[1] In Scan LED Bi-color, the SCAN_P18-23_Bi-colorC pin pulled high will light LED0	RW	0	
14	Port19_LED0_[2] In Scan LED Bi-color, the SCAN_P18-23_Bi-colorC pin pulled high will light LED0	RW	0	
15	Reserved	RW	0	-

9.14. LED0 Control Register (Address: 0x000D)

Table 32. LED0 Control Register (Address: 0x000D)

Offset	Description	RW	Default	Pin
0	Port20_LED0_[0] In Scan LED Bi-color, the SCAN_P18-23_Bi-colorC pin pulled high will light LED0	RW	0	S44, S39 B9, B45
1	Port20_LED0_[1] In Scan LED Bi-color, the SCAN_P18-23_Bi-colorC pin pulled high will light LED0	RW	0	
2	Port20_LED0_[2] In Scan LED Bi-color, the SCAN_P18-23_Bi-colorC pin pulled high will light LED0	RW	0	
3	Port21_LED0_[0] In Scan LED Bi-color, the SCAN_P18-23_Bi-colorC pin pulled high will light LED0	RW	0	S44, S40 B10, B45
4	Port21_LED0_[1] In Scan LED Bi-color, the SCAN_P18-23_Bi-colorC pin pulled high will light LED0	RW	0	
5	Port21_LED0_[2] In Scan LED Bi-color, the SCAN_P18-23_Bi-colorC pin pulled high will light LED0	RW	0	
6	Port22_LED0_[0] In Scan LED Bi-color, the SCAN_P18-23_Bi-colorC pin pulled high will light LED0	RW	0	S44, S41 B11, B45
7	Port22_LED0_[1] In Scan LED Bi-color, the SCAN_P18-23_Bi-colorC pin pulled high will light LED0	RW	0	
8	Port22_LED0_[2] In Scan LED Bi-color, the SCAN_P18-23_Bi-colorC pin pulled high will light LED0	RW	0	

Offset	Description	RW	Default	Pin
9	Port23_LED0_[0] In Scan LED Bi-color, the SCAN_P18-23_Bi-colorC pin pulled high will light LED0	RW	0	S44, S42 B12, B45
10	Port23_LED0_[1] In Scan LED Bi-color, the SCAN_P18-23_Bi-colorC pin pulled high will light LED0	RW	0	
11	Port23_LED0_[2] In Scan LED Bi-color, the SCAN_P18-23_Bi-colorC pin pulled high will light LED0	RW	0	
12	Port24_LED0_[0] In Scan LED Single-color, the SCAN_LED_Bi-colorC pin pulled high will light LED0	RW	0	S48, S6 B (NA)
13	Port24_LED0_[1] In Scan LED Single-color, the SCAN_LED_Bi-colorC pin pulled high will light LED0	RW	0	
14	Port24_LED0_[2] In Scan LED Single-color, the SCAN_LED_Bi-colorC pin pulled high will light LED0	RW	0	
15	Reserved	RW	0	-

9.15. LED0 Control Register (Address: 0x000E)

Table 33. LED0 Control Register (Address: 0x000E)

Offset	Description	RW	Default	Pin
0	Port25_LED0_[0] In Scan LED Single-color, the SCAN_LED_Bi-colorC pin pulled high will light LED0	RW	0	S1, S6 B (NA)
1	Port25_LED0_[1] In Scan LED Single-color, the SCAN_LED_Bi-colorC pin pulled high will light LED0	RW	0	
2	Port25_LED0_[2] In Scan LED Single-color, the SCAN_LED_Bi-colorC pin pulled high will light LED0	RW	0	
3	Port26_LED0_[0] In Scan LED Single-color, the SCAN_LED_Bi-colorC pin pulled high will light LED0	RW	0	S4, S6 B (NA)
4	Port26_LED0_[1] In Scan LED Single-color, the SCAN_LED_Bi-colorC pin pulled high will light LED0	RW	0	
5	Port26_LED0_[2] In Scan LED Single-color, the SCAN_LED_Bi-colorC pin pulled high will light LED0	RW	0	
6	Port27_LED0_[0] In Scan LED Single-color, the SCAN_LED_Bi-colorC pin pulled high will light LED0	RW	0	S5, S6 B (NA)
7	Port27_LED0_[1] In Scan LED Single-color, the SCAN_LED_Bi-colorC pin pulled high will light LED0	RW	0	
8	Port27_LED0_[2] In Scan LED Single-color, the SCAN_LED_Bi-colorC pin pulled high will light LED0	RW	0	

Offset	Description	RW	Default	Pin
9	Port28_LED0_[0] In Scan LED Single-color, the SCAN_LED_Bi-colorC pin pulled high will light LED0	RW	0	S7, S6 B (NA)
10	Port28_LED0_[1] In Scan LED Single-color, the SCAN_LED_Bi-colorC pin pulled high will light LED0	RW	0	
11	Port28_LED0_[2] In Scan LED Single-color, the SCAN_LED_Bi-colorC pin pulled high will light LED0	RW	0	
12	Port29_LED0_[0] In Scan LED Single-color, the SCAN_LED_Bi-colorC pin pulled high will light LED0	RW	0	S8, S6 B (NA)
13	Port29_LED0_[1] In Scan LED Single-color, the SCAN_LED_Bi-colorC pin pulled high will light LED0	RW	0	
14	Port29_LED0_[2] In Scan LED Single-color, the SCAN_LED_Bi-colorC pin pulled high will light LED0	RW	0	
15	Reserved	RW	0	-

9.16. LED0 Control Register (Address: 0x000F)

Table 34. LED0 Control Register (Address: 0x000F)

Offset	Description	RW	Default	Pin
0	Port30_LED0_[0] In Scan LED Single-color, the SCAN_LED_Bi-colorC pin pulled high will light LED0	RW	0	S9, S6 B (NA)
1	Port30_LED0_[1] In Scan LED Single-color, the SCAN_LED_Bi-colorC pin pulled high will light LED0	RW	0	
2	Port30_LED0_[2] In Scan LED Single-color, the SCAN_LED_Bi-colorC pin pulled high will light LED0	RW	0	
3	Port31_LED0_[0] In Scan LED Single-color, the SCAN_LED_Bi-colorC pin pulled high will light LED0	RW	0	S10, S6 B (NA)
4	Port31_LED0_[1] In Scan LED Single-color, the SCAN_LED_Bi-colorC pin pulled high will light LED0	RW	0	
5	Port31_LED0_[2] In Scan LED Single-color, the SCAN_LED_Bi-colorC pin pulled high will light LED0	RW	0	
6:15	Reserved	RW	0	-

9.17. LED1 Control Register (Address: 0x0010)

Table 35. LED1 Control Register (Address: 0x0010)

Offset	Description	RW	Default	Pin
0	Port0_LED1_[0] In Scan LED Bi-color, the SCAN_Bi-colorA pin pulled low will light LED1	RW	0	S21, S23 B20, B33
1	Port0_LED1_[1] In Scan LED Bi-color, the SCAN_Bi-colorA pin pulled low will light LED1	RW	0	
2	Port0_LED1_[2] In Scan LED Bi-color, the SCAN_Bi-colorA pin pulled low will light LED1	RW	0	
3	Port1_LED1_[0] In Scan LED Bi-color, the SCAN_Bi-colorA pin pulled low will light LED1	RW	0	S21, S24 B21, B33
4	Port1_LED1_[1] In Scan LED Bi-color, the SCAN_Bi-colorA pin pulled low will light LED1	RW	0	
5	Port1_LED1_[2] In Scan LED Bi-color, the SCAN_Bi-colorA pin pulled low will light LED1	RW	0	
6	Port2_LED1_[0] In Scan LED Bi-color, the SCAN_Bi-colorA pin pulled low will light LED1	RW	0	S21, S25 B22, B33
7	Port2_LED1_[1] In Scan LED Bi-color, the SCAN_Bi-colorA pin pulled low will light LED1	RW	0	
8	Port2_LED1_[2] In Scan LED Bi-color, the SCAN_Bi-colorA pin pulled low will light LED1	RW	0	
9	Port3_LED1_[0] In Scan LED Bi-color, the SCAN_Bi-colorA pin pulled low will light LED1	RW	0	S21, S26 B23, B33
10	Port3_LED1_[1] In Scan LED Bi-color, the SCAN_Bi-colorA pin pulled low will light LED1	RW	0	
11	Port3_LED1_[2] In Scan LED Bi-color, the SCAN_Bi-colorA pin pulled low will light LED1	RW	0	

Offset	Description	RW	Default	Pin
12	Port4_LED1_[0] In Scan LED Bi-color, the SCAN_Bi-colorA pin pulled low will light LED1	RW	0	S21, S27 B24, B33
13	Port4_LED1_[1] In Scan LED Bi-color, the SCAN_Bi-colorA pin pulled low will light LED1	RW	0	
14	Port4_LED1_[2] In Scan LED Bi-color, the SCAN_Bi-colorA pin pulled low will light LED1	RW	0	
15	Reserved	RW	0	-

9.18. LED1 Control Register (Address: 0x0011)

Table 36. LED1 Control Register (Address: 0x0011)

Offset	Description	RW	Default	Pin
0	Port5_LED1_[0] In Scan LED Bi-color, the SCAN_Bi-colorA pin pulled low will light LED1	RW	0	S21, S28 B25, B33
1	Port5_LED1_[1] In Scan LED Bi-color, the SCAN_Bi-colorA pin pulled low will light LED1	RW	0	
2	Port5_LED1_[2] In Scan LED Bi-color, the SCAN_Bi-colorA pin pulled low will light LED1	RW	0	
3	Port6_LED1_[0] In Scan LED Bi-color, the SCAN_Bi-colorA pin pulled low will light LED1	RW	0	S30, S23 B26, B33
4	Port6_LED1_[1] In Scan LED Bi-color, the SCAN_Bi-colorA pin pulled low will light LED1	RW	0	
5	Port6_LED1_[2] In Scan LED Bi-color, the SCAN_Bi-colorA pin pulled low will light LED1	RW	0	
6	Port7_LED1_[0] In Scan LED Bi-color, the SCAN_Bi-colorA pin pulled low will light LED1	RW	0	S30, S24 B27, B33
7	Port7_LED1_[1] In Scan LED Bi-color, the SCAN_Bi-colorA pin pulled low will light LED1	RW	0	
8	Port7_LED1_[2] In Scan LED Bi-color, the SCAN_Bi-colorA pin pulled low will light LED1	RW	0	

Offset	Description	RW	Default	Pin
9	Port8_LED1_[0] In Scan LED Bi-color, the SCAN_Bi-colorA pin pulled low will light LED1	RW	0	S30, S25 B28, B33
10	Port8_LED1_[1] In Scan LED Bi-color, the SCAN_Bi-colorA pin pulled low will light LED1	RW	0	
11	Port8_LED1_[2] In Scan LED Bi-color, the SCAN_Bi-colorA pin pulled low will light LED1	RW	0	
12	Port9_LED1_[0] In Scan LED Bi-color, the SCAN_Bi-colorA pin pulled low will light LED1	RW	0	S30, S26 B29, B33
13	Port9_LED1_[1] In Scan LED Bi-color, the SCAN_Bi-colorA pin pulled low will light LED1	RW	0	
14	Port9_LED1_[2] In Scan LED Bi-color, the SCAN_Bi-colorA pin pulled low will light LED1	RW	0	
15	Reserved	RW	0	-

9.19. LED1 Control Register (Address: 0x0012)

Table 37. LED1 Control Register (Address: 0x0012)

Offset	Description	RW	Default	Pin
0	Port10_LED1_[0] In Scan LED Bi-color, the SCAN_Bi-colorA pin pulled low will light LED1	RW	0	S30, S27 B30, B33
1	Port10_LED1_[1] In Scan LED Bi-color, the SCAN_Bi-colorA pin pulled low will light LED1	RW	0	
2	Port10_LED1_[2] In Scan LED Bi-color, the SCAN_Bi-colorA pin pulled low will light LED1	RW	0	
3	Port11_LED1_[0] In Scan LED Bi-color, the SCAN_Bi-colorA pin pulled low will light LED1	RW	0	S30, S28 B32, B33
4	Port11_LED1_[1] In Scan LED Bi-color, the SCAN_Bi-colorA pin pulled low will light LED1	RW	0	
5	Port11_LED1_[2] In Scan LED Bi-color, the SCAN_Bi-colorA pin pulled low will light LED1	RW	0	

Offset	Description	RW	Default	Pin
6	Port12_LED1_[0] In Scan LED Bi-color, the SCAN_P12-17_Bi-colorB pin pulled low will light LED1	RW	0	S34, S37 B46, B44
7	Port12_LED1_[1] In Scan LED Bi-color, the SCAN_P12-17_Bi-colorB pin pulled low will light LED1	RW	0	
8	Port12_LED1_[2] In Scan LED Bi-color, the SCAN_P12-17_Bi-colorB pin pulled low will light LED1	RW	0	
9	Port13_LED1_[0] In Scan LED Bi-color, the SCAN_P12-17_Bi-colorB pin pulled low will light LED1	RW	0	S34, S38 B48, B44
10	Port13_LED1_[1] In Scan LED Bi-color, the SCAN_P12-17_Bi-colorB pin pulled low will light LED1	RW	0	
11	Port13_LED1_[2] In Scan LED Bi-color, the SCAN_P12-17_Bi-colorB pin pulled low will light LED1	RW	0	
12	Port14_LED1_[0] In Scan LED Bi-color, the SCAN_P12-17_Bi-colorB pin pulled low will light LED1	RW	0	S34, S39 B1, B44
13	Port14_LED1_[1] In Scan LED Bi-color, the SCAN_P12-17_Bi-colorB pin pulled low will light LED1	RW	0	
14	Port14_LED1_[2] In Scan LED Bi-color, the SCAN_P12-17_Bi-colorB pin pulled low will light LED1	RW	0	
15	Reserved	RW	0	-

9.20. LED1 Control Register (Address: 0x0013)

Table 38. LED1 Control Register (Address: 0x0013)

Offset	Description	RW	Default	Pin
0	Port15_LED1_[0] In Scan LED Bi-color, the SCAN_P12-17_Bi-colorB pin pulled low will light LED1	RW	0	S34, S40 B4, B44
1	Port15_LED1_[1] In Scan LED Bi-color, the SCAN_P12-17_Bi-colorB pin pulled low will light LED1	RW	0	
2	Port15_LED1_[2] In Scan LED Bi-color, the SCAN_P12-17_Bi-colorB pin pulled low will light LED1	RW	0	
3	Port16_LED1_[0] In Scan LED Bi-color, the SCAN_P12-17_Bi-colorB pin pulled low will light LED1	RW	0	S34, S41 B5, B44
4	Port16_LED1_[1] In Scan LED Bi-color, the SCAN_P12-17_Bi-colorB pin pulled low will light LED1	RW	0	
5	Port16_LED1_[2] In Scan LED Bi-color, the SCAN_P12-17_Bi-colorB pin pulled low will light LED1	RW	0	
6	Port17_LED1_[0] In Scan LED Bi-color, the SCAN_P12-17_Bi-colorB pin pulled low will light LED1	RW	0	S34, S42 B6, B44
7	Port17_LED1_[1] In Scan LED Bi-color, the SCAN_P12-17_Bi-colorB pin pulled low will light LED1	RW	0	
8	Port17_LED1_[2] In Scan LED Bi-color, the SCAN_P12-17_Bi-colorB pin pulled low will light LED1	RW	0	

Offset	Description	RW	Default	Pin
9	Port18_LED1_[0] In Scan LED Bi-color, the SCAN_P18-23_Bi-colorC pin pulled low will light LED1	RW	0	S45, S37 B7, B45
10	Port18_LED1_[1] In Scan LED Bi-color, the SCAN_P18-23_Bi-colorC pin pulled low will light LED1	RW	0	
11	Port18_LED1_[2] In Scan LED Bi-color, the SCAN_P18-23_Bi-colorC pin pulled low will light LED1	RW	0	
12	Port19_LED1_[0] In Scan LED Bi-color, the SCAN_P18-23_Bi-colorC pin pulled low will light LED1	RW	0	S45, S38 B8, B45
13	Port19_LED1_[1] In Scan LED Bi-color, the SCAN_P18-23_Bi-colorC pin pulled low will light LED1	RW	0	
14	Port19_LED1_[2] In Scan LED Bi-color, the SCAN_P18-23_Bi-colorC pin pulled low will light LED1	RW	0	
15	Reserved	RW	0	-

9.21. LED1 Control Register (Address: 0x0014)

Table 39. LED1 Control Register (Address: 0x0014)

Offset	Description	RW	Default	Pin
0	Port20_LED1_[0] In Scan LED Bi-color, the SCAN_P18-23_Bi-colorC pin pulled low will light LED1	RW	0	S45, S39 B9, B45
1	Port20_LED1_[1] In Scan LED Bi-color, the SCAN_P18-23_Bi-colorC pin pulled low will light LED1	RW	0	
2	Port20_LED1_[2] In Scan LED Bi-color, the SCAN_P18-23_Bi-colorC pin pulled low will light LED1	RW	0	
3	Port21_LED1_[0] In Scan LED Bi-color, the SCAN_P18-23_Bi-colorC pin pulled low will light LED1	RW	0	S45, S40 B10, B45
4	Port21_LED1_[1] In Scan LED Bi-color, the SCAN_P18-23_Bi-colorC pin pulled low will light LED1	RW	0	
5	Port21_LED1_[2] In Scan LED Bi-color, the SCAN_P18-23_Bi-colorC pin pulled low will light LED1	RW	0	
6	Port22_LED1_[0] In Scan LED Bi-color, the SCAN_P18-23_Bi-colorC pin pulled low will light LED1	RW	0	S45, S41 B11, B45
7	Port22_LED1_[1] In Scan LED Bi-color, the SCAN_P18-23_Bi-colorC pin pulled low will light LED1	RW	0	
8	Port22_LED1_[2] In Scan LED Bi-color, the SCAN_P18-23_Bi-colorC pin pulled low will light LED1	RW	0	

Offset	Description	RW	Default	Pin
9	Port23_LED1_[0] In Scan LED Bi-color, the SCAN_P18-23_Bi-colorC pin pulled low will light LED1	RW	0	S45, S42 B12, B45
10	Port23_LED1_[1] In Scan LED Bi-color, the SCAN_P18-23_Bi-colorC pin pulled low will light LED1	RW	0	
11	Port23_LED1_[2] In Scan LED Bi-color, the SCAN_P18-23_Bi-colorC pin pulled low will light LED1	RW	0	
12	Port24_LED1_[0] In Scan LED Single-color, the SCAN_LED_Bi-colorC pin pulled low will light LED1	RW	0	S48, S6 B (NA)
13	Port24_LED1_[1] In Scan LED Single-color, the SCAN_LED_Bi-colorC pin pulled low will light LED1	RW	0	
14	Port24_LED1_[2] In Scan LED Single-color, the SCAN_LED_Bi-colorC pin pulled low will light LED1	RW	0	
15	Reserved	RW	0	-

9.22. LED1 Control Register (Address: 0x0015)

Table 40. LED1 Control Register (Address: 0x0015)

Offset	Description	RW	Default	Pin
0	Port25_LED1_[0] In Scan LED Single-color, the SCAN_LED_Bi-colorC pin pulled low will light LED1	RW	0	S1, S6 B (NA)
1	Port25_LED1_[1] In Scan LED Single-color, the SCAN_LED_Bi-colorC pin pulled low will light LED1	RW	0	
2	Port25_LED1_[2] In Scan LED Single-color, the SCAN_LED_Bi-colorC pin pulled low will light LED1	RW	0	
3	Port26_LED1_[0] In Scan LED Single-color, the SCAN_LED_Bi-colorC pin pulled low will light LED1	RW	0	S4, S6 B (NA)
4	Port26_LED1_[1] In Scan LED Single-color, the SCAN_LED_Bi-colorC pin pulled low will light LED1	RW	0	
5	Port26_LED1_[2] In Scan LED Single-color, the SCAN_LED_Bi-colorC pin pulled low will light LED1	RW	0	
6	Port27_LED1_[0] In Scan LED Single-color, the SCAN_LED_Bi-colorC pin pulled low will light LED1	RW	0	S5, S6 B (NA)
7	Port27_LED1_[1] In Scan LED Single-color, the SCAN_LED_Bi-colorC pin pulled low will light LED1	RW	0	
8	Port27_LED1_[2] In Scan LED Single-color, the SCAN_LED_Bi-colorC pin pulled low will light LED1	RW	0	

Offset	Description	RW	Default	Pin
9	Port28_LED1_[0] In Scan LED Single-color, the SCAN_LED_Bi-colorC pin pulled low will light LED1	RW	0	S7, S6 B (NA)
10	Port28_LED1_[1] In Scan LED Single-color, the SCAN_LED_Bi-colorC pin pulled low will light LED1	RW	0	
11	Port28_LED1_[2] In Scan LED Single-color, the SCAN_LED_Bi-colorC pin pulled low will light LED1	RW	0	
12	Port29_LED1_[0] In Scan LED Single-color, the SCAN_LED_Bi-colorC pin pulled low will light LED1	RW	0	S8, S6 B (NA)
13	Port29_LED1_[1] In Scan LED Single-color, the SCAN_LED_Bi-colorC pin pulled low will light LED1	RW	0	
14	Port29_LED1_[2] In Scan LED Single-color, the SCAN_LED_Bi-colorC pin pulled low will light LED1	RW	0	
15	Reserved	RW	0	-

9.23. LED1 Control Register (Address: 0x0016)

Table 41. LED1 Control Register (Address: 0x0016)

Offset	Description	RW	Default	Pin
0	Port30_LED1_[0] In Scan LED Single-color, the SCAN_LED_Bi-colorC pin pulled low will light LED1	RW	0	S9, S6 B (NA)
1	Port30_LED1_[1] In Scan LED Single-color, the SCAN_LED_Bi-colorC pin pulled low will light LED1	RW	0	
2	Port30_LED1_[2] In Scan LED Single-color, the SCAN_LED_Bi-colorC pin pulled low will light LED1	RW	0	
3	Port31_LED1_[0] In Scan LED Single-color, the SCAN_LED_Bi-colorC pin pulled low will light LED1	RW	0	S10, S6 B (NA)
4	Port31_LED1_[1] In Scan LED Single-color, the SCAN_LED_Bi-colorC pin pulled low will light LED1	RW	0	
5	Port31_LED1_[2] In Scan LED Single-color, the SCAN_LED_Bi-colorC pin pulled low will light LED1	RW	0	
6:15	Reserved	RW	0	-

9.24. LED2 Control Register (Address: 0x0017)

Table 42. LED2 Control Register (Address: 0x0017)

Offset	Description	RW	Default	Pin
0	Port0_LED2_[0] In Scan LED Bi-color, the SCAN_P0-5 pin pulled low will light LED2	RW	0	S22, S23 B34, B37
1	Port0_LED2_[1] In Scan LED Bi-color, the SCAN_P0-5 pin pulled low will light LED2	RW	0	
2	Port0_LED2_[2] In Scan LED Bi-color, the SCAN_P0-5 pin pulled low will light LED2	RW	0	
3	Port1_LED2_[0] In Scan LED Bi-color, the SCAN_P0-5 pin pulled low will light LED2	RW	0	S22, S24 B34, B38
4	Port1_LED2_[1] In Scan LED Bi-color, the SCAN_P0-5 pin pulled low will light LED2	RW	0	
5	Port1_LED2_[2] In Scan LED Bi-color, the SCAN_P0-5 pin pulled low will light LED2	RW	0	
6	Port2_LED2_[0] In Scan LED Bi-color, the SCAN_P0-5 pin pulled low will light LED2	RW	0	S22, S25 B34, B39
7	Port2_LED2_[1] In Scan LED Bi-color, the SCAN_P0-5 pin pulled low will light LED2	RW	0	
8	Port2_LED2_[2] In Scan LED Bi-color, the SCAN_P0-5 pin pulled low will light LED2	RW	0	
9	Port3_LED2_[0] In Scan LED Bi-color, the SCAN_P0-5 pin pulled low will light LED2	RW	0	S22, S26 B34, B40
10	Port3_LED2_[1] In Scan LED Bi-color, the SCAN_P0-5 pin pulled low will light LED2	RW	0	
11	Port3_LED2_[2] In Scan LED Bi-color, the SCAN_P0-5 pin pulled low will light LED2	RW	0	

Offset	Description	RW	Default	Pin
12	Port4_LED2_[0] In Scan LED Bi-color, the SCAN_P0-5 pin pulled low will light LED2	RW	0	S22, S27 B34, B41
13	Port4_LED2_[1] In Scan LED Bi-color, the SCAN_P0-5 pin pulled low will light LED2	RW	0	
14	Port4_LED2_[2] In Scan LED Bi-color, the SCAN_P0-5 pin pulled low will light LED2	RW	0	
15	Reserved	RW	0	-

9.25. LED2 Control Register (Address: 0x0018)

Table 43. LED2 Control Register (Address: 0x0018)

Offset	Description	RW	Default	Pin
0	Port5_LED2_[0] In Scan LED Bi-color, the SCAN_P0-5 pin pulled low will light LED2	RW	0	S22, S28 B34, B42
1	Port5_LED2_[1] In Scan LED Bi-color, the SCAN_P0-5 pin pulled low will light LED2	RW	0	
2	Port5_LED2_[2] In Scan LED Bi-color, the SCAN_P0-5 pin pulled low will light LED2	RW	0	
3	Port6_LED2_[0] In Scan LED Bi-color, the SCAN_P6-11 pin pulled low will light LED2	RW	0	S32, S23 B35, B37
4	Port6_LED2_[1] In Scan LED Bi-color, the SCAN_P6-11 pin pulled low will light LED2	RW	0	
5	Port6_LED2_[2] In Scan LED Bi-color, the SCAN_P6-11 pin pulled low will light LED2	RW	0	
6	Port7_LED2_[0] In Scan LED Bi-color, the SCAN_P6-11 pin pulled low will light LED2	RW	0	S32, S24 B35, B38
7	Port7_LED2_[1] In Scan LED Bi-color, the SCAN_P6-11 pin pulled low will light LED2	RW	0	
8	Port7_LED2_[2] In Scan LED Bi-color, the SCAN_P6-11 pin pulled low will light LED2	RW	0	

Offset	Description	RW	Default	Pin
9	Port8_LED2_[0] In Scan LED Bi-color, the SCAN_P6-11 pin pulled low will light LED2	RW	0	S32, S25 B35, B39
10	Port8_LED2_[1] In Scan LED Bi-color, the SCAN_P6-11 pin pulled low will light LED2	RW	0	
11	Port8_LED2_[2] In Scan LED Bi-color, the SCAN_P6-11 pin pulled low will light LED2	RW	0	
12	Port9_LED2_[0] In Scan LED Bi-color, the SCAN_P6-11 pin pulled low will light LED2	RW	0	S32, S26 B35, B40
13	Port9_LED2_[1] In Scan LED Bi-color, the SCAN_P6-11 pin pulled low will light LED2	RW	0	
14	Port9_LED2_[2] In Scan LED Bi-color, the SCAN_P6-11 pin pulled low will light LED2	RW	0	
15	Reserved	RW	0	-

9.26. LED2 Control Register (Address: 0x0019)

Table 44. LED2 Control Register (Address: 0x0019)

Offset	Description	RW	Default	Pin
0	Port10_LED2_[0] In Scan LED Bi-color, the SCAN_P6-11 pin pulled low will light LED2	RW	0	S32, S27 B35, B41
1	Port10_LED2_[1] In Scan LED Bi-color, the SCAN_P6-11 pin pulled low will light LED2	RW	0	
2	Port10_LED2_[2] In Scan LED Bi-color, the SCAN_P6-11 pin pulled low will light LED2	RW	0	
3	Port11_LED2_[0] In Scan LED Bi-color, the SCAN_P6-11 pin pulled low will light LED2	RW	0	S32, S28 B35, B42
4	Port11_LED2_[1] In Scan LED Bi-color, the SCAN_P6-11 pin pulled low will light LED2	RW	0	
5	Port11_LED2_[2] In Scan LED Bi-color, the SCAN_P6-11 pin pulled low will light LED2	RW	0	

Offset	Description	RW	Default	Pin
6	Port12_LED2_[0] In Scan LED Bi-color, the SCAN_P12-17 pin pulled low will light LED2	RW	0	S35, S37 B44, B37
7	Port12_LED2_[1] In Scan LED Bi-color, the SCAN_P12-17 pin pulled low will light LED2	RW	0	
8	Port12_LED2_[2] In Scan LED Bi-color, the SCAN_P12-17 pin pulled low will light LED2	RW	0	
9	Port13_LED2_[0] In Scan LED Bi-color, the SCAN_P12-17 pin pulled low will light LED2	RW	0	S35, S38 B44, B38
10	Port13_LED2_[1] In Scan LED Bi-color, the SCAN_P12-17 pin pulled low will light LED2	RW	0	
11	Port13_LED2_[2] In Scan LED Bi-color, the SCAN_P12-17 pin pulled low will light LED2	RW	0	
12	Port14_LED2_[0] In Scan LED Bi-color, the SCAN_P12-17 pin pulled low will light LED2	RW	0	S35, S39 B44, B39
13	Port14_LED2_[1] In Scan LED Bi-color, the SCAN_P12-17 pin pulled low will light LED2	RW	0	
14	Port14_LED2_[2] In Scan LED Bi-color, the SCAN_P12-17 pin pulled low will light LED2	RW	0	
15	Reserved	RW	0	-

9.27. LED2 Control Register (Address: 0x001A)

Table 45. LED2 Control Register (Address: 0x001A)

Offset	Description	RW	Default	Pin
0	Port15_LED2_[0] In Scan LED Bi-color, the SCAN_P12-17 pin pulled low will light LED2	RW	0	S35, S40 B44, B40
1	Port15_LED2_[1] In Scan LED Bi-color, the SCAN_P12-17 pin pulled low will light LED2	RW	0	
2	Port15_LED2_[2] In Scan LED Bi-color, the SCAN_P12-17 pin pulled low will light LED2	RW	0	

Offset	Description	RW	Default	Pin
3	Port16_LED2_[0] In Scan LED Bi-color, the SCAN_P12-17 pin pulled low will light LED2	RW	0	S35, S41
4	Port16_LED2_[1] In Scan LED Bi-color, the SCAN_P12-17 pin pulled low will light LED2	RW	0	B44, B41
5	Port16_LED2_[2] In Scan LED Bi-color, the SCAN_P12-17 pin pulled low will light LED2	RW	0	
6	Port17_LED2_[0] In Scan LED Bi-color, the SCAN_P12-17 pin pulled low will light LED2	RW	0	S35, S42
7	Port17_LED2_[1] In Scan LED Bi-color, the SCAN_P12-17 pin pulled low will light LED2	RW	0	B44, B42
8	Port17_LED2_[2] In Scan LED Bi-color, the SCAN_P12-17 pin pulled low will light LED2	RW	0	
9	Port18_LED2_[0] In Scan LED Bi-color, the SCAN_P18-23 pin pulled low will light LED2	RW	0	S46, S37
10	Port18_LED2_[1] In Scan LED Bi-color, the SCAN_P18-23 pin pulled low will light LED2	RW	0	B45, B37
11	Port18_LED2_[2] In Scan LED Bi-color, the SCAN_P18-23 pin pulled low will light LED2	RW	0	
12	Port19_LED2_[0] In Scan LED Bi-color, the SCAN_P18-23 pin pulled low will light LED2	RW	0	S46, S38
13	Port19_LED2_[1] In Scan LED Bi-color, the SCAN_P18-23 pin pulled low will light LED2	RW	0	B45, B38
14	Port19_LED2_[2] In Scan LED Bi-color, the SCAN_P18-23 pin pulled low will light LED2	RW	0	
15	Reserved	RW	0	-

9.28. LED2 Control Register (Address: 0x001B)

Table 46. LED2 Control Register (Address: 0x001B)

Offset	Description	RW	Default	Pin
0	Port20_LED2_[0] In Scan LED Bi-color, the SCAN_P18-23 pin pulled low will light LED2	RW	0	S46, S39 B45, B39
1	Port20_LED2_[1] In Scan LED Bi-color, the SCAN_P18-23 pin pulled low will light LED2	RW	0	
2	Port20_LED2_[2] In Scan LED Bi-color, the SCAN_P18-23 pin pulled low will light LED2	RW	0	
3	Port21_LED2_[0] In Scan LED Bi-color, the SCAN_P18-23 pin pulled low will light LED2	RW	0	S46, S40 B45, B40
4	Port21_LED2_[1] In Scan LED Bi-color, the SCAN_P18-23 pin pulled low will light LED2	RW	0	
5	Port21_LED2_[2] In Scan LED Bi-color, the SCAN_P18-23 pin pulled low will light LED2	RW	0	
6	Port22_LED2_[0] In Scan LED Bi-color, the SCAN_P18-23 pin pulled low will light LED2	RW	0	S46, S41 B45, B41
7	Port22_LED2_[1] In Scan LED Bi-color, the SCAN_P18-23 pin pulled low will light LED2	RW	0	
8	Port22_LED2_[2] In Scan LED Bi-color, the SCAN_P18-23 pin pulled low will light LED2	RW	0	
9	Port23_LED2_[0] In Scan LED Bi-color, the SCAN_P18-23 pin pulled low will light LED2	RW	0	S46, S42 B45, B42
10	Port23_LED2_[1] In Scan LED Bi-color, the SCAN_P18-23 pin pulled low will light LED2	RW	0	
11	Port23_LED2_[2] In Scan LED Bi-color, the SCAN_P18-23 pin pulled low will light LED2	RW	0	
12:14	Reserved	RW	0	-
15	Sync_LED LED synchronization status change. 1'b0: All LEDs do not change status when En_Sync_LED is Enabled 1'b1: All LEDs change status when En_Sync_LED is Enabled	RW/SC	0	-

9.29. GPIO Control Register (Address: 0x001C)

Table 47. GPIO Control Register (Address: 0x001C)

Offset	Description	RW	Default	Pin
0	DATA_GPIO[0] Stores the output contents or input latched values when the corresponding pin is set as GPIO.	RW	0	20
1	DATA_GPIO[1]	RW	0	21
2	DATA_GPIO[2]	RW	0	22
3	DATA_GPIO[3]	RW	0	23
4	DATA_GPIO[4]	RW	0	24
5	DATA_GPIO[5]	RW	0	25
6	DATA_GPIO[6]	RW	0	26
7	DATA_GPIO[7]	RW	0	27
8	DATA_GPIO[8]	RW	0	28
9	DATA_GPIO[9]	RW	0	29
10	DATA_GPIO[10]	RW	0	30
11	DATA_GPIO[11]	RW	0	32
12	DATA_GPIO[12]	RW	0	33
13	DATA_GPIO[13]	RW	0	34
14	DATA_GPIO[14]	RW	0	35
15	DATA_GPIO[15]	RW	0	37

9.30. GPIO Control Register (Address: 0x001D)

Table 48. GPIO Control Register (Address: 0x001D)

Offset	Description	RW	Default	Pin
0	DATA_GPIO[16] Stores the output contents or input latched values when the corresponding pin is set as GPIO.	RW	0	38
1	DATA_GPIO[17]	RW	0	39
2	DATA_GPIO[18]	RW	0	40
3	DATA_GPIO[19]	RW	0	41
4	DATA_GPIO[20]	RW	0	42
5	DATA_GPIO[21]	RW	0	44
6	DATA_GPIO[22]	RW	0	45
7	DATA_GPIO[23]	RW	0	46
8	DATA_GPIO[24]	RW	0	48
9	DATA_GPIO[25]	RW	0	1
10	DATA_GPIO[26]	RW	0	4
11	DATA_GPIO[27]	RW	0	5
12	DATA_GPIO[28]	RW	0	6
13	DATA_GPIO[29]	RW	0	7
14	DATA_GPIO[30]	RW	0	8
15	DATA_GPIO[31]	RW	0	9

9.31. GPIO Control Register (Address: 0x001E)

Table 49. GPIO Control Register (Address: 0x001E)

Offset	Description	RW	Default	Pin
0	DATA_GPIO[32] Stores the output contents or input latched values when the corresponding pin is set as GPIO.	RW	0	10
1	DATA_GPIO[33] Stores the output contents or input latched values when the corresponding pin is set as GPIO.	RW	0	11
2	DATA_GPIO[34] Stores the output contents or input latched values when the corresponding pin is set as GPIO.	RW	0	12
3	DATA_GPIO[35] For Address 1 bit.3 (Buzzer_on)=1'b0 Stores the output contents or input latched values when the corresponding pin is set as GPIO. For Address 1 bit.3 (Buzzer_on)=1'b1 Data_GPIO[35]=1'b1 for control Buzzer frequency turn on Data_GPIO[35]=1'b0 for control Buzzer frequency turn off	RW	0	15
4	DATA_GPIO[36] Stores the output contents or input latched values when the corresponding pin is set as GPIO.	RW	0	16
5:14	Reserved	RW	0	-
15	Sync_GPIO LED synchronization status change. 1'b0: All GPIO outputs do not change status when En_Sync_GPIO is Enabled 1'b1: All GPIO outputs change status when En_Sync_GPIO is Enabled	RW/SC	0	-

10. Electrical Characteristics

10.1. Absolute Maximum Ratings

WARNING: Absolute maximum ratings are limits beyond which permanent damage may be caused to the device, or device reliability will be affected. All voltages are specified reference to GND unless otherwise specified.

Table 50. Absolute Maximum Ratings

Parameter	Min	Max	Units
Junction Temperature (Tj)	-	+125	°C
Storage Temperature	-45	+125	°C
VCC Supply Referenced to GND	GND-0.3	+3.63	V
Digital Input Voltage	GND-0.3	VCC+0.3	V

10.2. Recommended Operating Range

Table 51. Recommended Operating Range

Parameter	Min	Typical	Max	Units
Ambient Operating Temperature (Ta)	0	-	70	°C
VCC Supply Voltage Range	3.135	3.3	3.465	V

10.3. Thermal Characteristics

10.3.1. Assembly Description

Table 52. Assembly Description

Package	Type	LQFP-48
	Dimension (L×W)	7×7mm
	Thickness	0.0254mm
PCB	PCB Dimension (L×W)	68×40mm
	PCB Thickness	1.47mm
	Number of Cu Layer-PCB	**2 Layers (2S):** -Top layer: 20% coverage of Cu -Bottom layer: 60% coverage of Cu **4 Layers (2S2P):** -1st layer: 20% coverage of Cu -2nd layer: 100% coverage of Cu -3rd layer: 100% coverage of Cu -4th layer: 60% coverage of Cu

10.3.2. Material Properties

Table 53. Material Properties

Item		**Material**	**Thermal Conductivity K (W/m-k)**
Package	Die	Si	147
	Silver Paste	1033BF	1.0
	Lead Frame	CDA7025	168
	Mold Compound	7372	0.92
PCB		Cu	400
		FR4	0.2

10.3.3. Shift Register Mode

10.3.3.1 Simulation Conditions

Table 54. Simulation Conditions

Input Power	382.8mW
Test Board (PCB)	2L (2S) / 4L (2S2P)
Control Condition	Air Flow = 0, 1, 2, 3 m/s

10.3.3.2 Thermal Performance of LQFP-48 on PCB Under Still Air Convection

Table 55. Thermal Performance of LQFP-48 on PCB Under Still Air Convection

	θ_{JA}	θ_{JB}	θ_{JC}	Ψ_{JT}	Ψ_{JB}
4L PCB	76.5	49.1	35.9	10.6	47.3
2L PCB	89	49.8	36.3	13.4	47.5

Note: θ_{JA}: Junction to ambient thermal resistance.

θ_{JB}: Junction to board thermal resistance.

θ_{JC}: Junction to case thermal resistance.

Ψ_{JT}: Junction to top center of package thermal characterization.

Ψ_{JB}: Junction to bottom surface center of PCB thermal characterization.

10.3.3.3 Thermal Performance of LQFP-48 on PCB Under Forced Convection

Table 56. Thermal Performance of LQFP-48 on PCB Under Forced Convection

	Air Flow (m/s)	**0**	**1**	**2**	**3**
4L PCB	θ_{JA}	76.5	67.8	65	63.5
2L PCB	θ_{JA}	89	77.1	72.9	70.5

Note: θ_{JA}: Junction to ambient thermal resistance.

10.4. DC Characteristics

10.4.1. Power Consumption

Table 57. Power Consumption

Parameter	SYM	Min	Typical	Max	Units
Idle (No Loading)					
Power Supply Current for VCC	I_{VCC}	-	17	-	mA
Total Power Consumption	PS	-	56.1	-	mW
Single-Color Scan LED					
Power Supply Current for VCC	I_{VCC}	-	109	-	mA
Total Power Consumption for 72 LED Application	PS	-	359.7	-	mW
Bi-Color Scan LED					
Power Supply Current for VCC 48 LED Application	I_{VCC}	-	116	-	mA
Total Power Consumption	PS	-	382.8	-	mW
Shift Register Mode					
Power Supply Current for VCC 36 LED Application	I_{VCC}	-	132	-	mA
Total Power Consumption	PS	-	435.6	-	mW
VCC=3.3V					
TTL Input High Voltage	V_{ih}	2.0	-	-	V
TTL Input Low Voltage	V_{il}	-	-	0.8	V
Output High Voltage	V_{oh}	2.7	-	-	V
Output Low Voltage	V_{ol}	-	-	0.6	V

10.4.2. Driving Current Specifications

The RTL8231 maximum driving current depends on the PMOS and NMOS power metal width. The RTL8231 I/O pins are distributed to all four sides of the chip. The driving current limits on each side are shown in Table 58.

Table 58. Driving Current Specifications

Operating Temperature	Modes	Total Maximum Driving Current on Each Side	
		Output High Voltage	Output Low Voltage
80°C	Scan Single-Color Mode	150mA	125mA
100°C	Scan Single-Color Mode	100mA	90mA
80°C	Scan Bi-Color Mode	150mA	125mA
100°C	Scan Bi-Color Mode	100mA	90mA
80°C	GPIO Mode	150mA	125mA
100°C	GPIO Mode	100mA	90mA
80°C	Shift Register	150mA	125mA
100°C	Shift Register	100mA	90mA

Note: Maximum driving current at other operating temperatures can be calculated linearly.

10.5. AC Characteristics

10.5.1. SMI Slave Mode Timing Characteristics

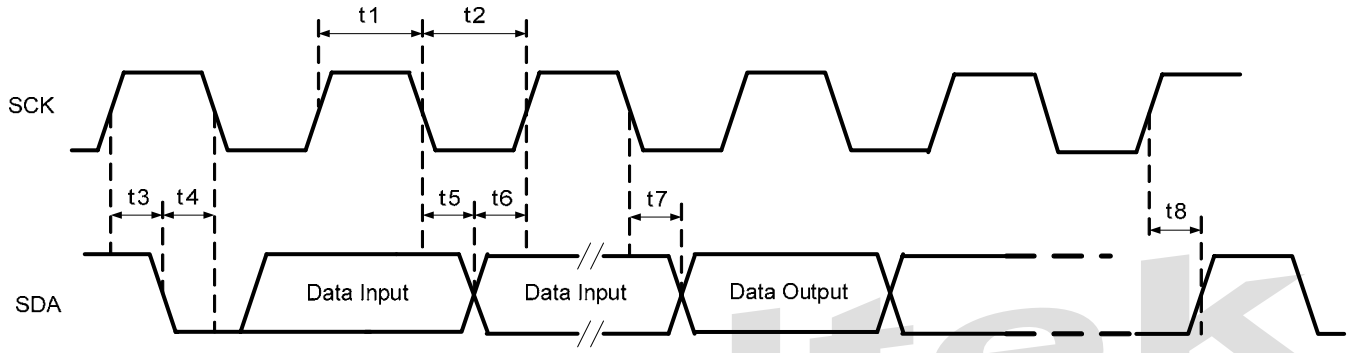


Figure 32. SMI Slave Mode Timing Characteristics

Table 59. SMI Slave Mode Timing Characteristics

Symbol	Description	I/O	Min	Typical	Max	Units
t1	SCK High Time*	I	400	-	-	ns
t2	SCK Low Time*	I	400	-	-	ns
t3	START Condition Setup Time	I	200	-	-	ns
t4	START Condition Hold Time	I	200	-	-	ns
t5	Data Hold Time	I	10	-	-	ns
t6	Data Setup Time	I	10	-	-	ns
t7	Clock to Data Output Delay	O	300	-	800	ns
t8	STOP Condition Setup Time	I	200	-	-	ns

Note: Requires an 8MHz RC (Resistance-Capacitance) clock.

10.5.2. MIIM (Media Independent Interface Management) Timing

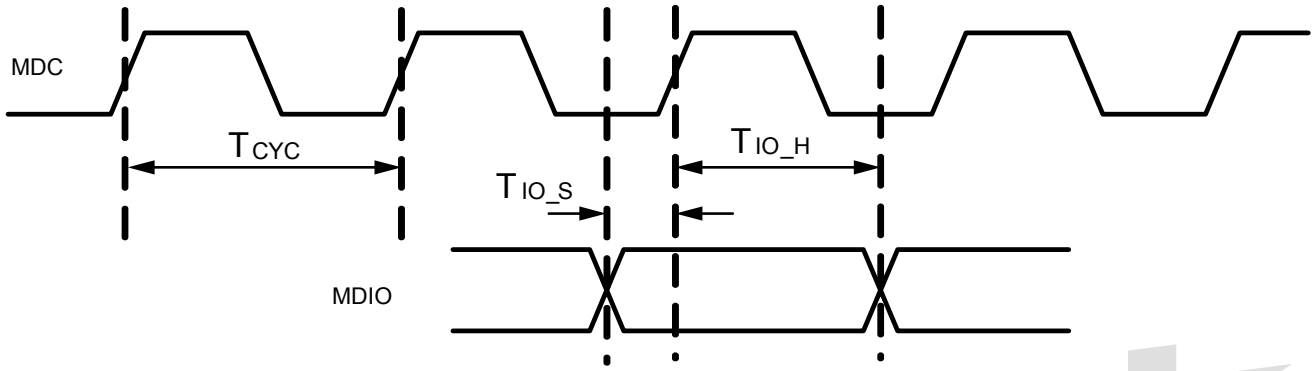


Figure 33. MIIM Write Timing

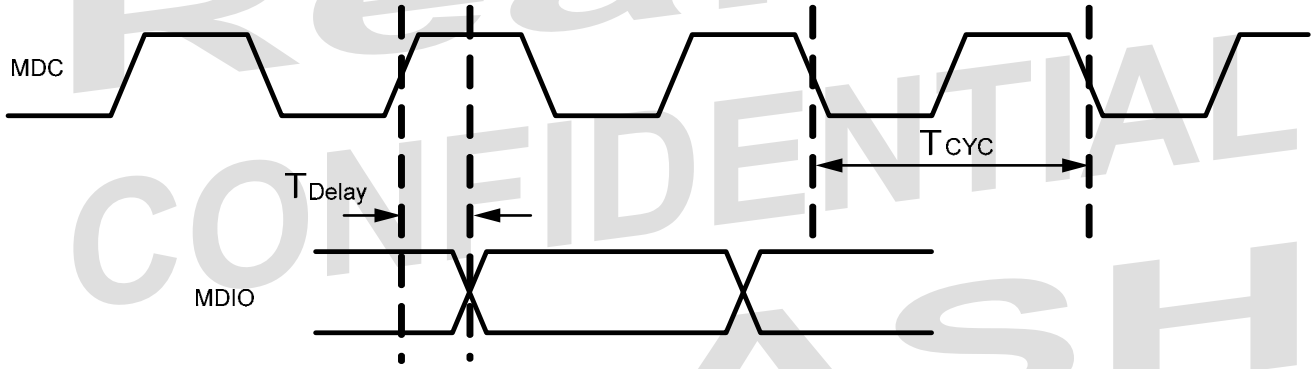


Figure 34. MIIM Read Timing

Table 60. MIIM Timing

Parameter	SYM	Condition	Min	Typical	Max	Units
MDC Clock Input Cycle	T_{CYC}	MDC Clock Input Cycle	50	-	-	ns
MDIO to MDC Rising Input Setup Time	T_{IO_S}	MDIO to MDC Rising Input Setup Time	10	-	-	ns
MDIO to MDC Rising Input Hold Time	T_{IO_H}	MDIO to MDC Rising Input Hold Time	10	-	-	ns
MDIO Output Delay	T_{Delay}	MDC to MDIO Rising Output Delay	-	-	10	ns

10.5.3. Shift Register Input Clock and Data Timing

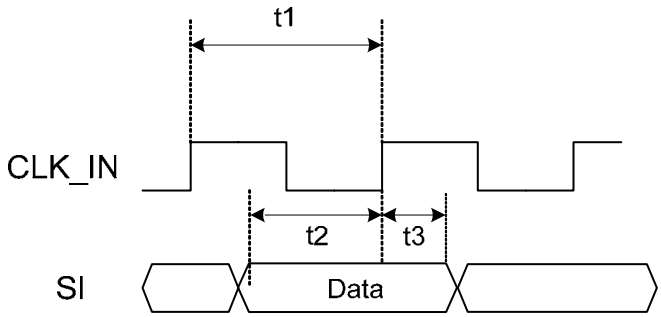


Figure 35. Shift Register Input Clock Timing

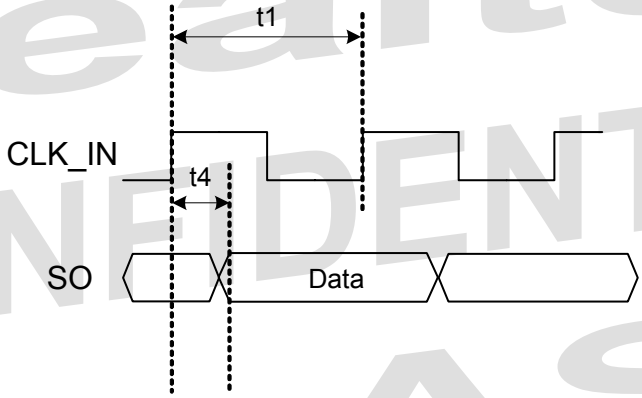


Figure 36. Shift Register Data Output Timing

Table 61. Shift Register Data Input/Output Timing

Symbol	Description	I/O	Min	Typical	Max	Units
t1	Clock Period	I	40	-	-	ns
t2	Input Data Set Time	I	1.5	-	-	ns
t3	Input Data Hold Time	I	1.0	-	-	ns
t4	Clock to Data delay	O	2.3	-	-	ns

10.6. Reset Characteristics

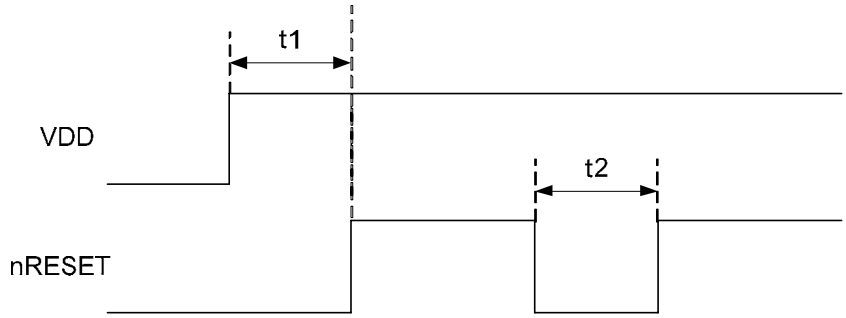
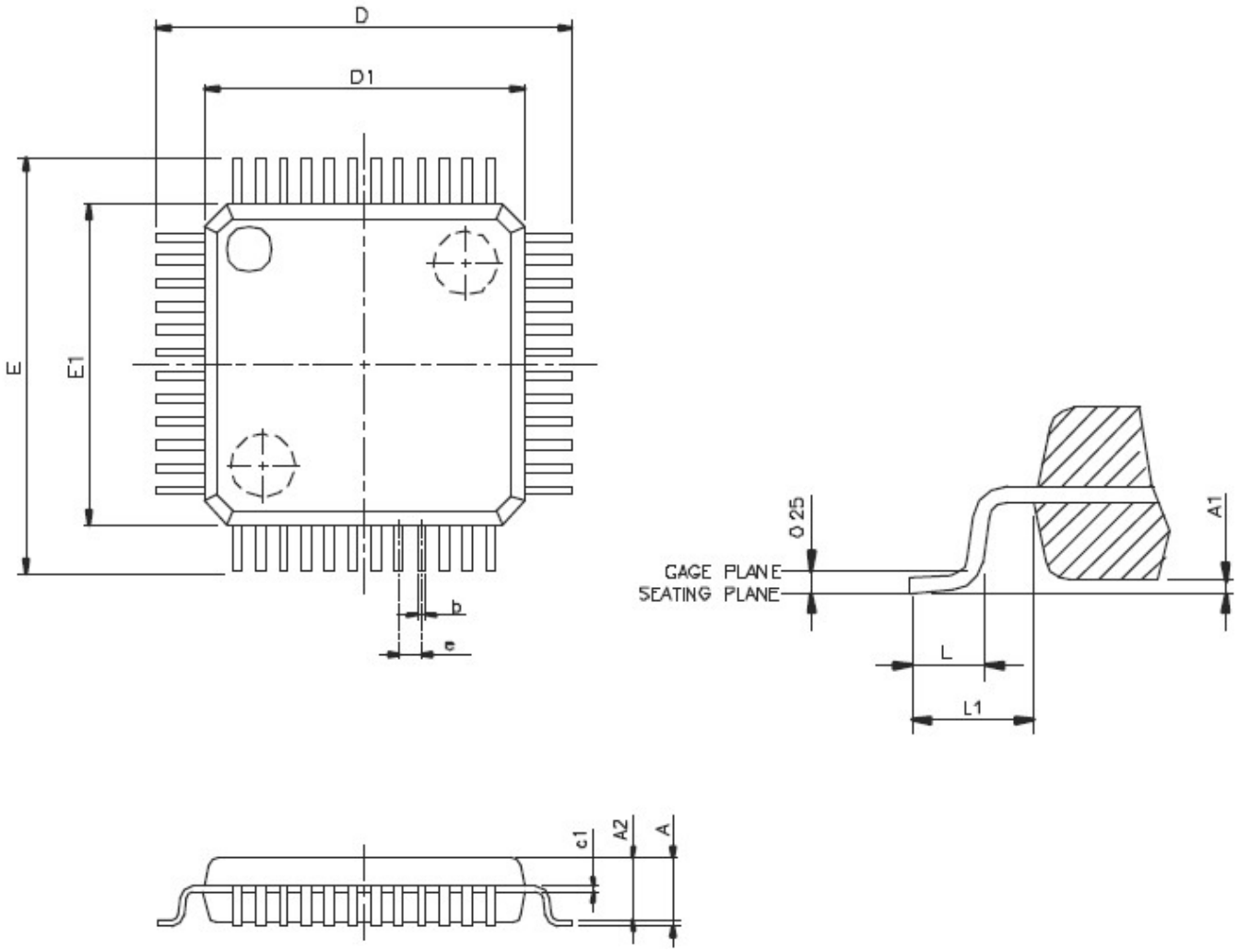


Figure 37. Reset Characteristics

Table 62. Reset Characteristics

Symbol	Description	I/O	Min	Typical	Max	Units
t1	Reset Delay	I	1	-	-	ms
t2	Reset Low	I	1	-	-	ms

11. Mechanical Dimensions



11.1. Mechanical Dimensions Notes (7×7mm)

Symbol	Dimension in mm		Dimension in inch	
	Min	Max	Min	Max
A	-	1.6	-	0.06299
A1	0.05	0.15	0.00196	0.00591
A2	1.35	1.45	0.05315	0.05708
c1	0.09	0.16	0.00354	0.00629
D	9.00 BSC		0.3543 BSC	
D1	7.00 BSC		0.2756 BSC	
E	9.00 BSC		0.3543 BSC	
E1	7.00 BSC		0.2756 BSC	
e	0.5 BSC		0.0197 BSC	
b	0.17	0.27	0.0067	0.0106
L	0.45	0.75	0.0177	0.0295
L1	1		0.0393	

Note 1: JEDEC outline: MS-026 BBC.

Note 2: Dimensions D1 and E1 do not include mold protrusion. Allowable protrusion is 0.25mm per side. D1 and E1 are maximum plastic body size dimensions including mold mismatch.

Note 3: Dimension b does not include dambar protrusion. Allowable dambar protrusion shall not cause the lead width to exceed the maximum b dimension by more than 0.08mm.

12. Ordering Information

Table 63. Ordering Information

Part Number	Package	Status
RTL8231-GR	LQFP 48-Pin 'Green' Package	MP

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