Application Report
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LP8863-Q1 Automatic String Detection Deep Dive

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ABSTRACT

The LP8863-Q1 device has a LED string configuration auto-detection feature. Every time powered on, the device automatically detects the number of connected LED strings so as to select the correct phase shift.

This application report firstly introduces the mechanism of LP8863-Q1 string auto-detection, gives the detection flow step by step. Then, it analyzes two common application issues: the first case is using invalid LED string configuration, the second case is powering off then powering on quickly, both could affect the proper string configuration auto-detection, leading to a wrong phase shift and fault misreporting. Lastly the article gives a software method to solve the problem.

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Trademarks

1 Introduction

The LP8863-Q1 device is an automotive 6-channel backlighting LED driver, which defaults to phase shift mode. When the device is powered on, the string configuration is automatically detected and the phases of each channel configured. For example, if four strings are connected, the LED outputs are phase shifted by 90° (= 360 / 4); if 6 strings are connected, the LED outputs are phase shifted by 60° (=360/6). The LED strings are always appropriately phase shifted for their string configuration. This reduces the ripple of the boost output, and increases the load frequency which can move potential capacitor noise above the audible band.

The string configurations in Table 1 are valid configurations for auto detection. Any invalid configurations are NOT allowed to be used. The detected configuration can be read from AUTO_LED_STRING_CFG in AUTO_DETECT_DIAGNOSTICS register.

Table 1. LP8863-Q1 Valid LED String Configurations

Configuration	LED0	LED1	LED2	LED3	LED4	LED5	Detected LED String Configuration (AUTO_LED_STRING_CFG)	Phase Shift
6 channels	150 mA	150 mA	150 mA	150 mA	150 mA	150 mA	0h = 6 separate strings	60°
5 channels	150 mA	150 mA	150 mA	150 mA	150 mA	GND	1h = 5 separate strings	72°
4 channels	150 mA	150 mA	150 mA	150 mA	GND	GND	2h = 4 separate strings	90°
3 channels	150 mA	150 mA	150 mA	GND	GND	GND	3h = 3 separate strings	120°
2 channels	150 mA	150 mA	GND	GND	GND	GND	4h = 2 separate strings	180°
3 channels	300 mA		300 mA		300 mA		5h = outputs connected in groups of 3 to drive 2 strings	120°
2 channels	450 mA			450 mA			6h = outputs connected in groups of 2 to drive 3 strings	180°
1 channel	900 mA						7h = all outputs connected together to drive one string	None

2 LP8863-Q1 LED String Auto-Detection Mechanism

Figure 1 shows the LP8863-Q1 string auto-detection flow.

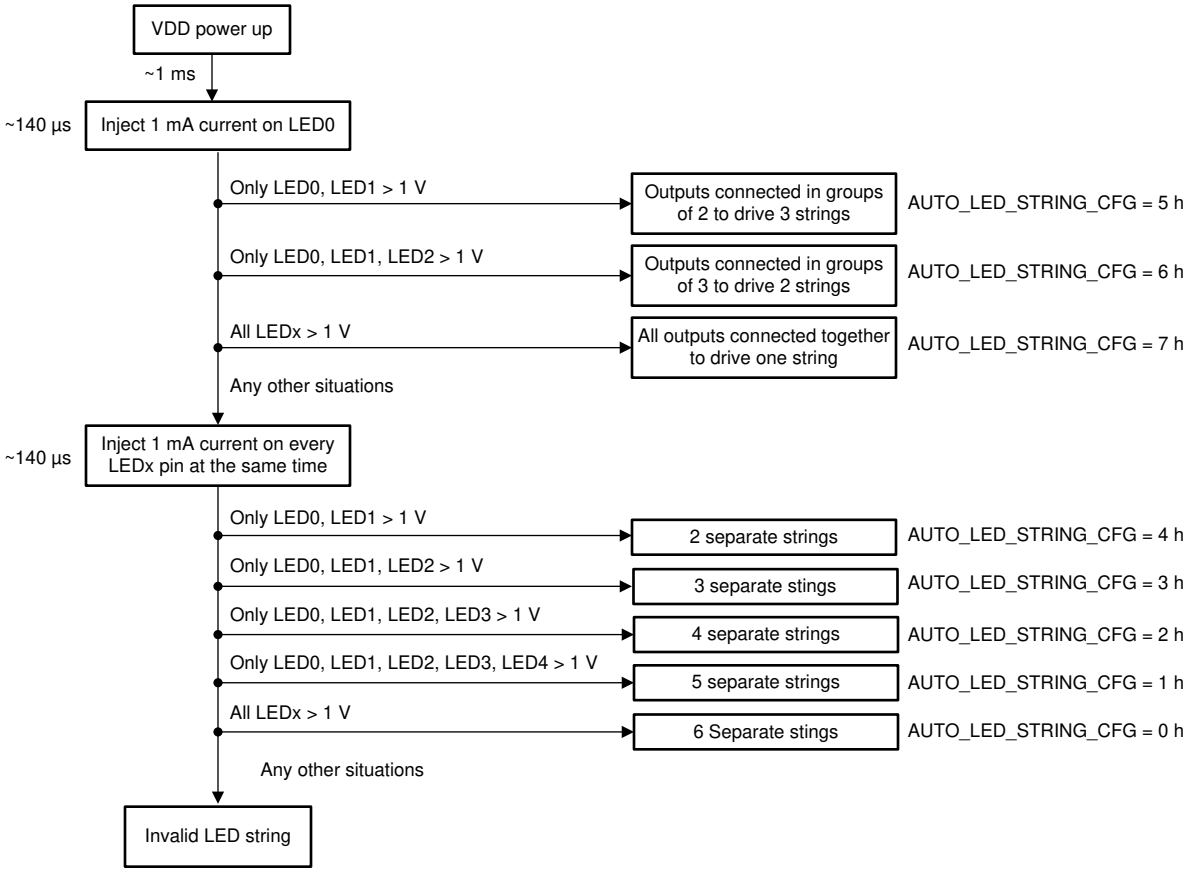


Figure 1. LP8863-Q1 LED String Auto-Detection Flow

When VDD is powered up, the device automatically injects 1 mA current on LED0 pin in order to check whether using multi-string configuration.

- If only LED0 and LED1 are detected beyond 1 V, which indicates LED0 and LED1 pins are tied together, the device will set **AUTO_LED_STRING_CFG = 5h** (outputs connected in groups of 2 to drive 3 strings)
- If only LED0, LED1 and LED2 are detected beyond 1 V, which indicates LED0, LED1 and LED2 pins are tied together, the device will set **AUTO_LED_STRING_CFG = 6h** (outputs connected in groups of 3 to drive 2 strings)
- If all LEDx are detected beyond 1 V, which indicates all LEDx pins are tied together, the device will set **AUTO_LED_STRING_CFG = 7h** (all outputs connected together to drive one string)

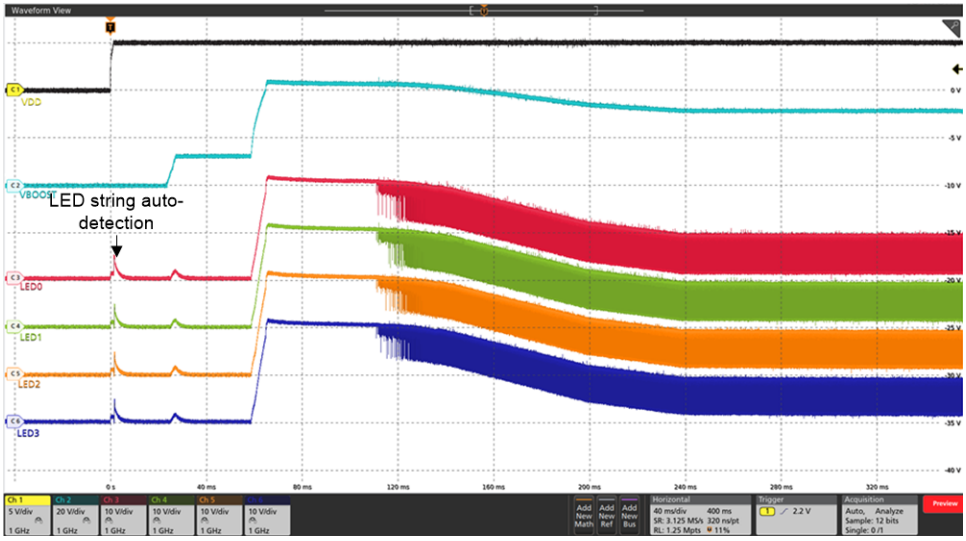
If none of above situations meets, the device automatically injects 1 mA current on every LEDx pin in order to check whether using separate-string configuration.

- If only LED0 and LED1 are detected beyond 1 V, which indicates LED2 to approximately LED5 pins are tied to ground, the device will set **AUTO_LED_STRING_CFG = 4h** (2 separate strings)
- If LED0, LED1 and LED2 are detected beyond 1V, which indicates LED3 ~ LED5 pins are tied to ground, the device will set **AUTO_LED_STRING_CFG = 3h** (3 separate strings)
- If only LED0, LED1, LED2 and LED3 are detected beyond 1 V, which indicates LED4 and LED5 pins are tied to ground, the device will set **AUTO_LED_STRING_CFG = 2h** (4 separate strings)
- If only LED0, LED1, LED2, LED3 and LED4 are detected beyond 1 V, which indicates LED5 pin is tied to ground, the device will set **AUTO_LED_STRING_CFG = 1h** (5 separate strings)

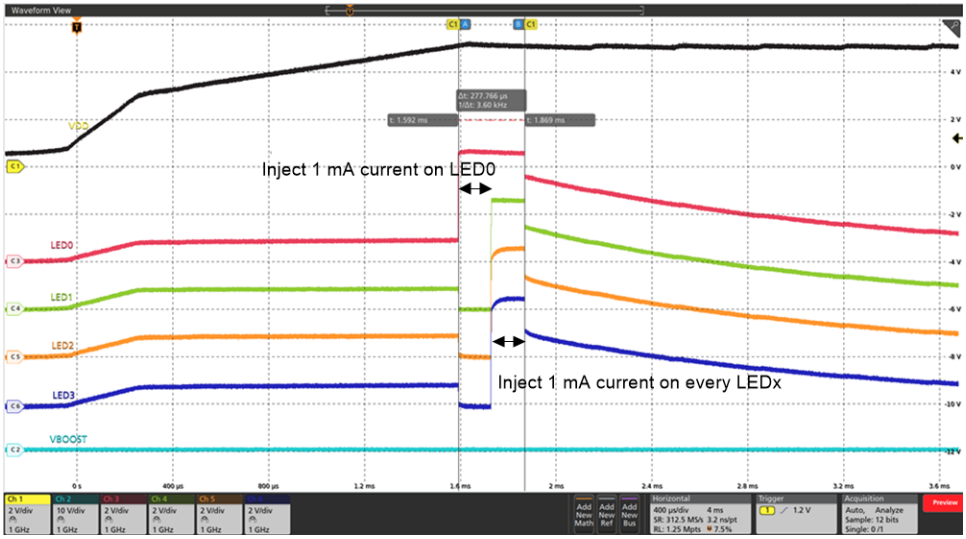
- If all LEDx are detected beyond 1 V, which indicates no LEDx pin is tied to ground, the device will set **AUTO_LED_STRING_CFG = 0h** (6 separate strings)

If none of above situations meets, which means the string detection does not match one of 8 valid configurations, the device automatically defaults to **AUTO_LED_STRING_CFG = 0h** (6 separate strings) and alarms invalid LED string fault.

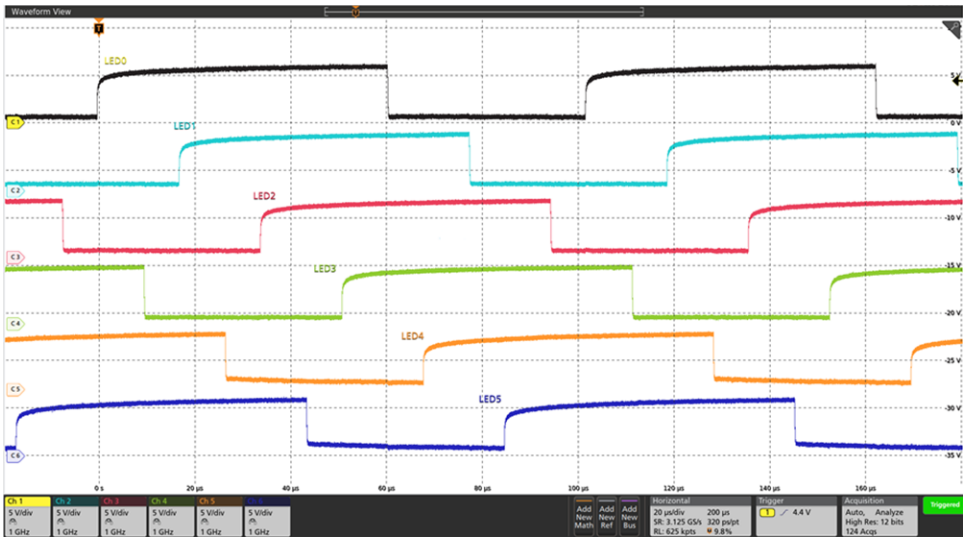
Figure 2(a) demonstrates a normal start-up of LP8863-Q1. Figure 2(b) shows an enlarged portion of LED string detection of Figure 2(a). Figure 2(c) displays the phase shift of each LEDx.



(a) Start-Up



(b) LED String Auto-Detection



(c) 60° Phase Shift

Figure 2. LP8863-Q1 Normal Start-up Using 6 Separate Strings

3 Application Issue

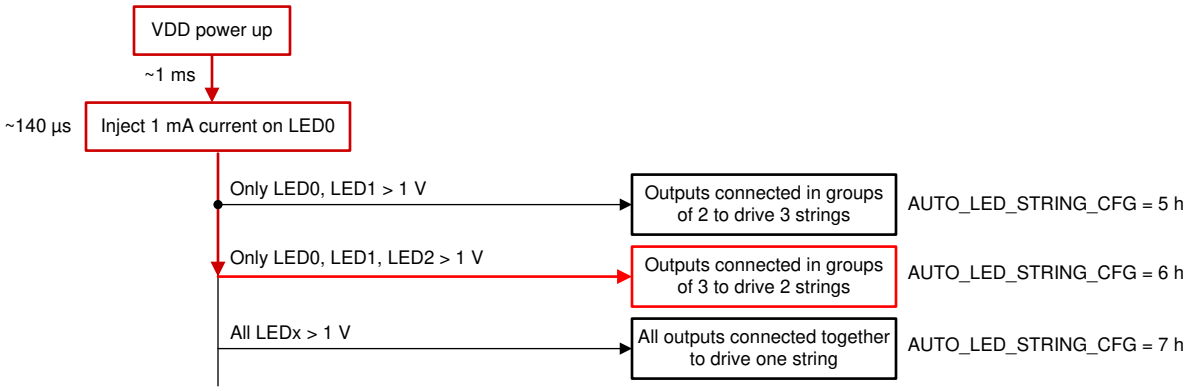
3.1 Misuse Invalid LED String Configuration

The LP8863-Q1 supports eight valid string configurations for auto-detection, as shown in Table 1. The auto-detection could not work properly if using invalid string configuration, which may cause the following problems:

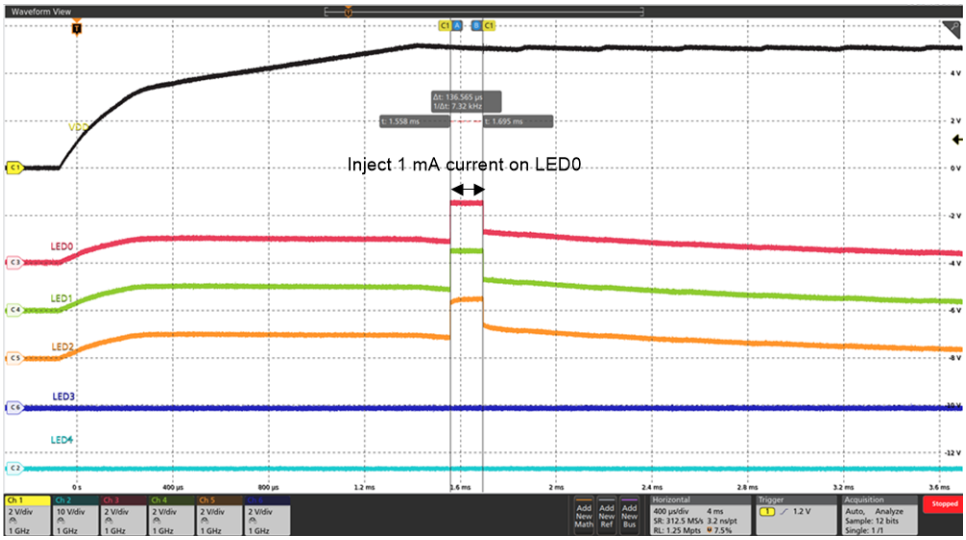
- Wrong phase shift. The device selects the phase shift according to string configuration. The phase shift could be wrong if the detected string configuration is wrong.
- Misreport open LED faults. If the string configuration detection is wrong, unused channels are detected being used, the device may report open LED faults of unused channels.

For example, use an invalid configuration - LED0~2 tied together LED3~5 tied to ground.

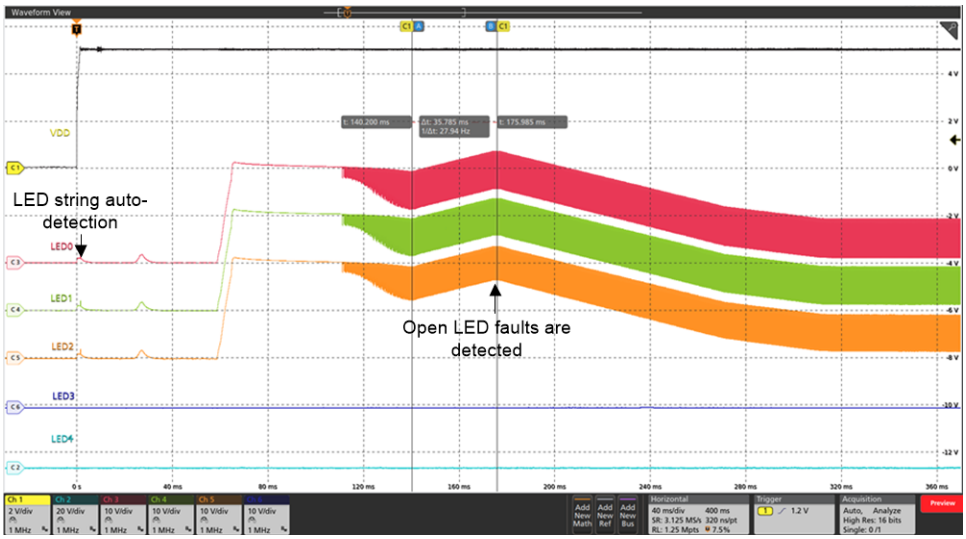
This configuration is automatically detected as LED0~2 tied together LED3~5 tied together mode (**AUTO_LED_STRING_CFG = 6h**), as shown in Figure 3(a) and Figure 3(b). For LP8863-Q1 device, unused channels are automatically disabled and do not generate open/short LED fault. But, LED3~5 are wrongly detected being used here, the device keeps detecting LED3~5 faults. After the boost ramps to maximum level, the headroom voltage on LED3~5 is detected below minimum level (because LED3~5 tied to ground), which triggers LED3~5 open faults. The open detection process can be seen in Figure 3(c).



(a) LED String Auto-Detection Flow



(b) LED String Auto-Detection Waveform



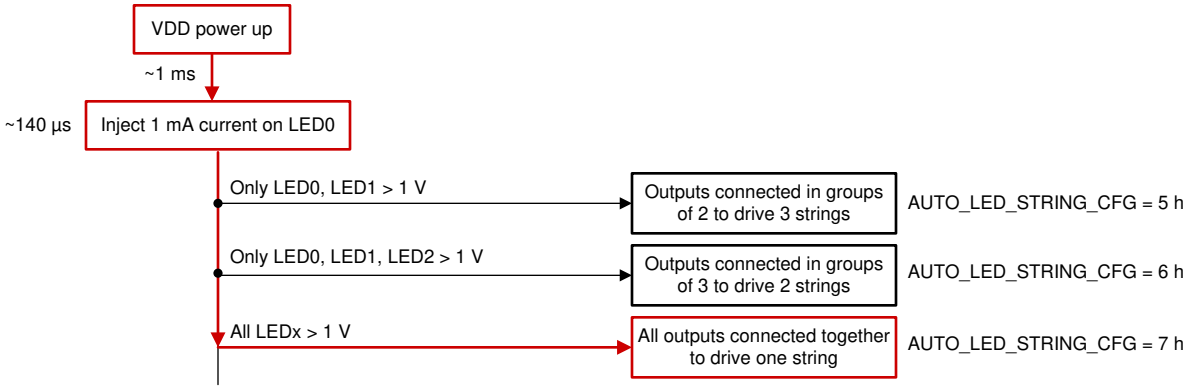
(c) Start-Up Waveform

Figure 3. LP8863-Q1 Start-Up Using Invalid LED String Configuration (LED0~2 tied together LED3~5 tied to ground)

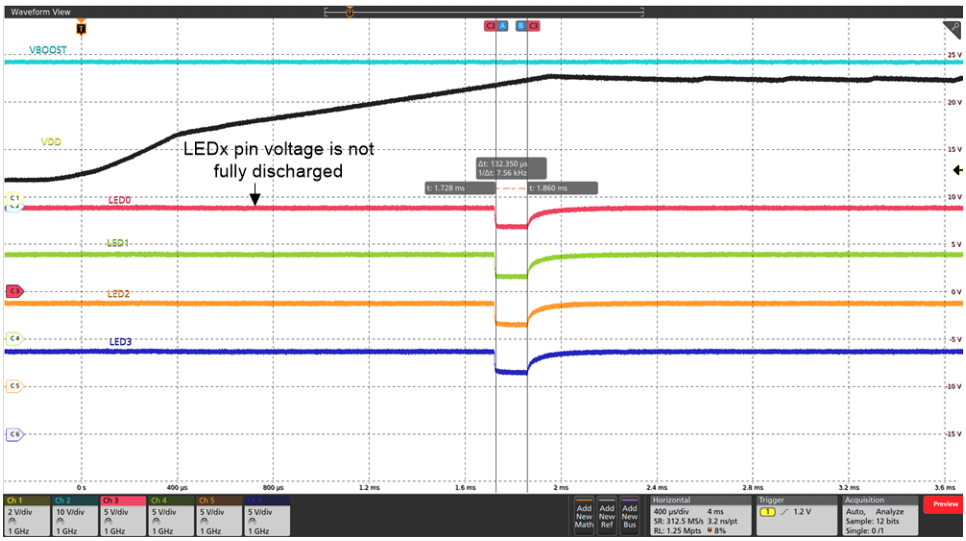
3.2 Power Off Then On Immediately

The LP8863-Q1 device uses the LEDx pin voltage to detect the string configuration. If the device powered off then on immediately, the boost output is not fully discharged, causing LEDx pin is not fully discharged, the string auto-detection may work improperly like Application Issue 1.

For example, if power off then on immediately, the 6 separate strings mode could be detected as all outputs connected together mode (**AUTO_LED_STRING_CFG = 7h**) since all LEDx pin voltage is beyond 1 V, as shown in Figure 4(a) and Figure 4(b). There will be no phase shift but should be 60°. For the solution, see Section 3.3.



(a) LP8863-Q1 String Detection Flow



(b) LED String Detection Waveform

Figure 4. LP8863-Q1 Power Off Then On Immediately (use 6 separate strings)

3.3 Solution: Override String Auto-Detection

To avoid the wrong phase shift or fault misreport caused by string auto-detection, a method to override the string auto-detection is provided. You can access the LED_AUTO_DETECT register (an internal register not specified in datasheet) to override string auto-detection and manually set the string configuration through I2C/SPI. Note that this register needs to be overridden during start-up. Use the following sequence:

1. Power up system with both VDD and VDDIO supplied
2. Wait 2 ms after VDD voltage > 2.8 V
3. Set LED_AUTO_OVERRIDE to 1 and write <new data> to LED_STRING_CONF in 0x28C to override the LED_AUTO_DETECT register (see Table 2)
4. Write other registers for other configuration (if needed)
5. Pull EN high

Table 2. LED_AUTO_DETECT Register: Address: 0x28C

Bit	Field	Description	Type	Reset
15-4	Reserved	Reserved (Don't change)	R/W	810h
3	LED_AUTO_ OVERRIDE	0h = String configuration is auto detected 1h = String configuration is overriden by register bits LED_STRING_CONF	R/W	0h
2-0	LED_STRING_CONF	0h = 6 separate strings 1h = 5 separate strings 2h = 4 separate strings 3h = 3 separate strings 4h = 2 separate strings 5h = outputs connected in groups of 3 to drive 2 strings 6h = outputs connected in groups of 2 to drive 3 strings 7h = all outputs connected together to drive one string	R/W	0h

CAUTION

The LP8863-Q1 device 7-bits I2C slave address is 0x2E for 0x28C register if SS_ADDRSEL pin is connected to GND. Or 7-bits I2C slave address is 0x3E for 0x28C register if SS_ADDRSEL pin is biased by VDDIO.

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