MIC2860-D

High Efficiency 2 Channel WLED Driver with Single Wire Digital Control

General Description

The MIC2860-2D is a high efficiency White LED (WLED) driver designed to drive two WLEDs and greatly extend battery life for portable display backlighting, and keypad backlighting in low cost mobile devices. The MIC2860-2D architecture provides the highest possible efficiency by eliminating switching losses present in traditional charge pumps or inductive boost circuits. It features a typical dropout of 52mV at 30.2mA per channel. This allows the WLEDs to be driven directly from the battery eliminating switching noise and losses present with the use of boost circuitry.

The two channels have better than ±0.5% matching, which ensures uniform display illumination under all conditions. The WLEDs brightness is externally preset by a resistor and dimmed using a single wire digital control signal. The MIC2860-2D single wire digital interface accepts digital programming pulses providing 32 dimming steps.

The MIC2860-2D is available in Thin SOT-23 and SC-70 six pin packages with a junction temperature range of -40°C to +125°C.

Datasheets and support documentation can be found on Micrel's web site at: www.micrel.com.

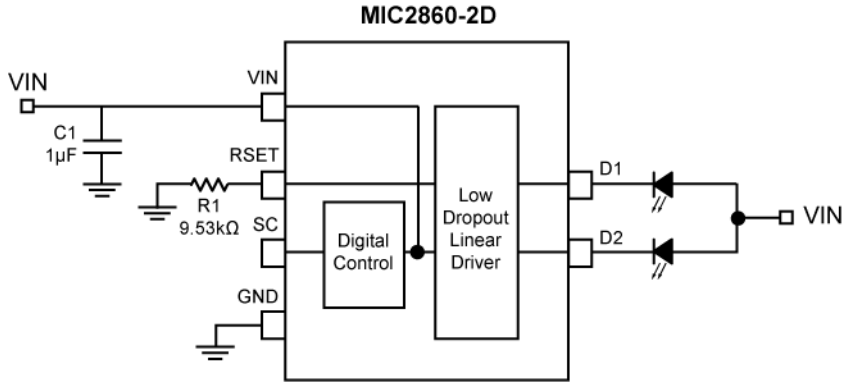
Features

- High Efficiency (no switching losses)
- No charge pumps
- 2 WLED driver channels
- Single wire digital control
- Input voltage range: 3.0V to 5.5V
- WLED driver dropout of 52mV at 30.2mA
- Matching better than ±0.5% (typical)
- Current Accuracy better than ±1.0% (typical)
- Available in Thin SOT-23 and SC-70 6 pin packages

Applications

- Mobile handsets
- Digital cameras
- Portable media/MP3 players
- Portable navigation devices (GPS)
- Portable applications

Typical Application



LCD Display Backlight with 2 WLEDs

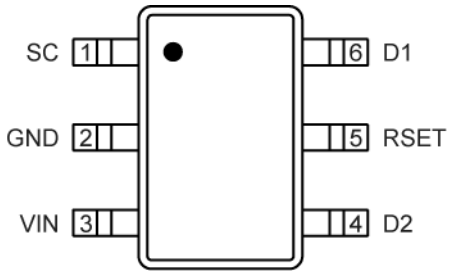
Ordering Information

Part Number	Mark Code[1]	Temperature Range	Package[2]
MIC2860-2DYC6	62D	–40°C to +85°C	6-Pin SC-70
MIC2860-2DYD6	602D	–40°C to +85°C	6-Pin Thin SOT-23

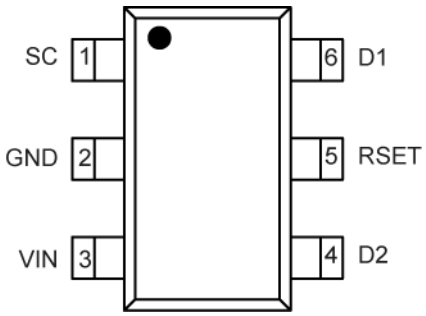
Note:

1. Under bar symbol (_) may not be to scale.
2. Package is GREEN RoHS compliant. Lead finish is NiPdAu. Mold compound is halogen free.

Pin Configuration



6-Pin SC-70 (C6)
(Top View)



6-Pin Thin SOT-23 (D6)
(Top View)

Pin Description

Pin Number MIC2860-2D	Pin Name	Pin Function
1	SC	Serial Control Digital input. Do not leave floating.
2	GND	Ground.
3	VIN	Voltage Input. Connect at least 1µF ceramic capacitor between VIN and GND.
4	D2	LED2 driver. Connect LED anode to VIN and cathode to this pin. Do not leave floating.[1]
5	RSET	Connect an external resistor from this pin to GND to set the maximum LED current. Example, apply a 9.53kΩ resistor between RSET and GND to set LED current to 30mA at 100% duty cycle.
6	D1	LED1 driver. Connect LED anode to VIN and cathode to this pin. Do not leave floating. [1]

Note 1. When driving only 1 LED, connect D1 and D2 in parallel to the LED cathode and adjust the RSET resistor for half the desired output.

Absolute Maximum Ratings[1]

Main Input Voltage (V_{IN}) ..... -0.3V to +6V
Enable Input Voltage (V_{SC}) ..... -0.3V to V_{IN}
LED Driver Voltage ($V_{D1, D2}$) ..... -0.3V to V_{IN}
Power Dissipation ..... Internally Limited
Lead Temperature (soldering, 10sec.) ..... 260°C
Storage Temperature (T_s) ..... -65°C to +150°C
ESD Rating[3] ..... ESD Sensitive

Operating Ratings[2]

Supply Voltage (V_{IN}) ..... +3.0V to +5.5V
Enable Input Voltage (V_{SC}) ..... 0V to V_{IN}
LED Driver Voltage ($V_{D1, D2}$) ..... 0V to V_{IN}
Junction Temperature (T_J) ..... –40°C to +125°C
Junction Thermal Resistance
SC-70 (θ_{JA}) ..... 256 °C /W
SOT-23 (θ_{JA}) ..... 177 °C /W

Electrical Characteristics

$V_{IN} = V_{SC} = 3.6V$, $C_{IN} = 1\mu F$, $R_{SET} = 9.53k\Omega$; $V_{D1, D2} = 0.6V$; $T_J = 25°C$, **bold** values indicate $–40°C \le T_J \le 85°C$; unless noted.

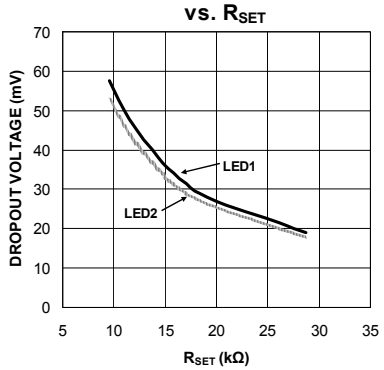
Parameter	Conditions	Min	Typ	Max	Units
Current Accuracy[4]		**27.18**	30.2	**33.22**	mA
Matching[5]			±0.5	±3	%
Drop-out ($V_{D1, D2}$)	Where I_{LED} = 90% of LED current seen at $V_{DROPNOM}$ = 0.6V, 100% brightness level		52	**125**	mV
Ground/Supply Bias Current	I_{OUT} = 30.2mA		0.7	**1.5**	mA
Shutdown Current (current source leakage)	V_{SC} = 0V > 500µs		0.01	1	µA
Digital Dimming					
V_{SC} Input Voltage	Logic Low			**0.4**	V
	Logic High	**1.4**			V
V_{SC} Enable Input Current	V_{SC} = 1.2V		0.01	1	µA
$t_{SHUTDOWN}$	Time SC pin is low to put into shutdown		100	**500**	µs
t_{PROG_HIGH}, t_{PROG_LOW}	Time for valid SC edge; Ignored if outside limit range	**0.3**		**75**	µs
t_{START_UP}	Delay from SC is high to start up		33		µs

Notes:

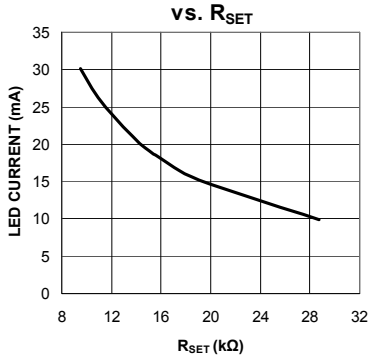
1. Exceeding the absolute maximum rating may damage the device.
2. The device is not guaranteed to function outside its operating rating.
3. Devices are ESD sensitive. Handling precautions recommended. Human body model, 1.5kΩ in series with 100pF.
4. As determined by average current of all channels in use and all channels loaded.
5. The current through each LED meets the stated limits from the average current of all LEDs.

Typical Characteristics

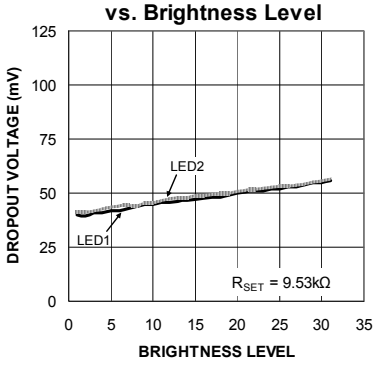
Dropout Voltage vs. R_{SET}



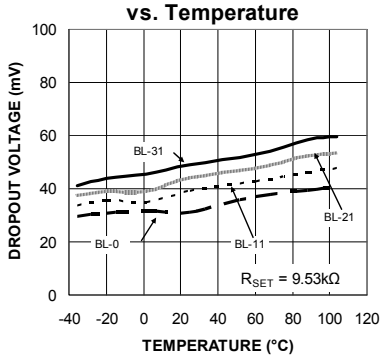
Peak LED Current vs. R_{SET}



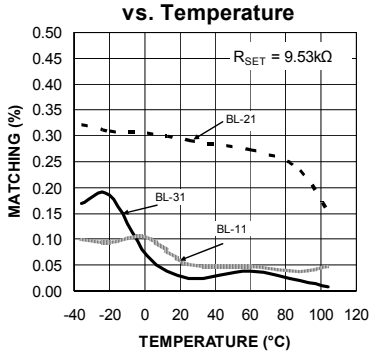
Dropout Voltage vs. Brightness Level



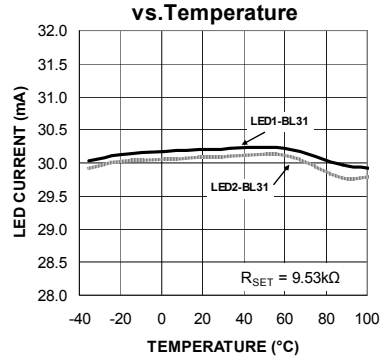
Dropout Voltage vs. Temperature



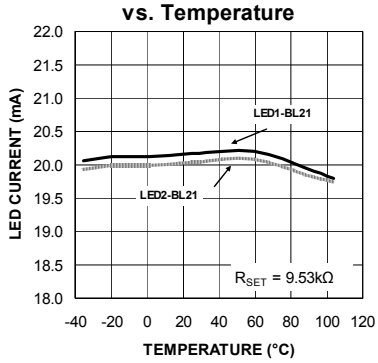
Matching vs. Temperature



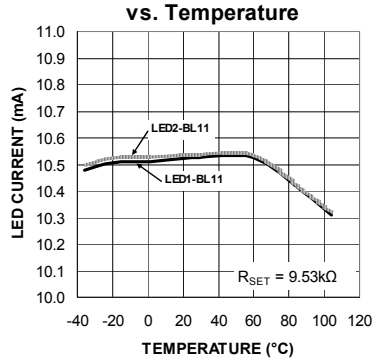
LED Current vs.Temperature



LED Current vs. Temperature



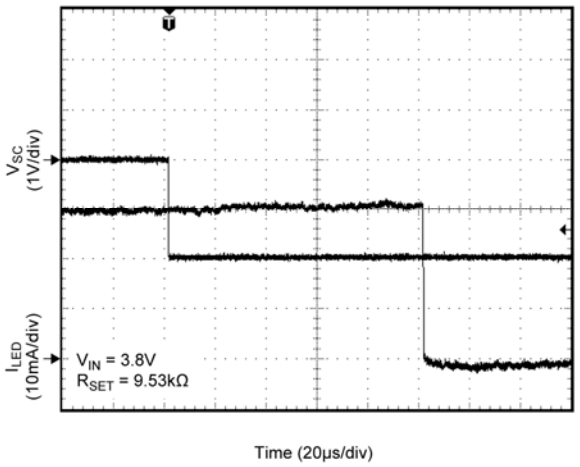
LED Current vs. Temperature



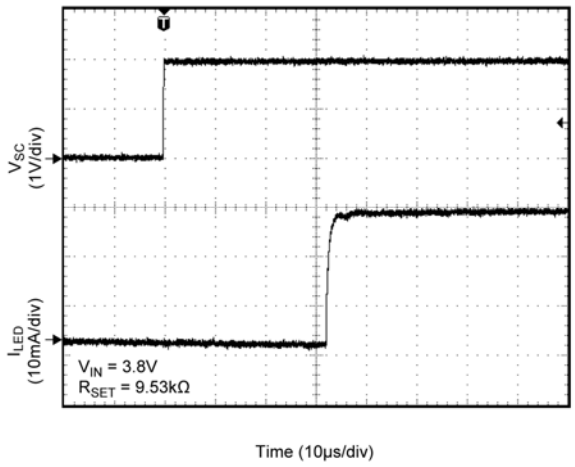
Note: BL = Brightness Level

Functional Characteristics

ILED Response to SC Signal Turn-Off Time



ILED Response to SC Signal Turn-On Time



Functional Diagram

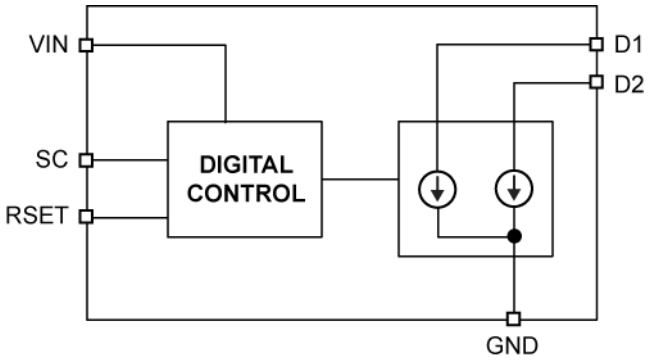


Figure 1. MIC2860-2D Functional Block Diagram

Functional Description

The MIC2860-2D is a 2 channel WLED driver. The WLED driver is designed to maintain proper current regulation with LED current accuracy of 1.0% while the typical matching between the 2 channels is 0.5% at room temperature. The WLEDs are driven independently from the input supply and will maintain regulation with a dropout of 52mV at 30.2mA. The low dropout of the linear drivers allows the WLEDs to be driven directly from the battery voltage and eliminates the need for large and inefficient charge pumps. The maximum WLED current for each channel is set via an external resistor.

Block Diagram

As shown in Figure 1, the MIC2860-2D consists of 2 current mirrors set to copy a master current determined by R_{SET}. The linear drivers have a designated control block for enabling and dimming of the WLEDs. The MIC2860-2D dimming is controlled by an internal Digital Control Interface.

V_{IN}

The input supply (V_{IN}) provides power to the linear drivers and the control circuitry. The V_{IN} operating range is 3V to 5.5V. Due to wire inductance a minimum bypass capacitor of 1µF should be placed close to the input (V_{IN}) pin and the ground (GND) pin. Refer to the layout recommendations section for details on placing the input capacitor (C1).

SC

The SC pin is equivalent to the enable pin for the linear drivers on the MIC2860-2D. It can also be used for dimming using a single wire digital interface. See the MIC2860-2D Digital Dimming Interface in the Application Information section for details. Do not leave control pins floating.

R_{SET}

The R_{SET} pin is used by connecting an R_{SET} resistor to ground to set the peak current of the linear drivers. The maximum LED current set by the R_{SET} resistor is shown in the table below:

R_{SET} (kΩ)	I_{LED} (mA)
9.53	30.2
11.5	25.0
14.3	20.1
15.8	18.2
19.1	15.1
28.7	10.0

Table 1. Maximum LED Current vs. R_{SET} Resistor Values

A plot of maximum I_{LED} versus R_{SET} is shown in Figure 2.

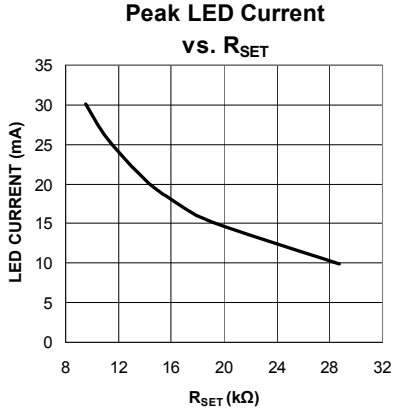


Figure 2. Peak LED current vs. R_{SET}

D1, D2

The D1 and D2 pins are the linear driver inputs for WLED 1 and 2 respectively. Connect the anodes of the WLEDs to V_{IN} and each cathode of the WLEDs to D1 and D2. When operating with a single WLED, D1 and D2 should be connected to the WLED cathode to parallel the outputs for improved dropout performance. Paralleling these pins can also be done to drive a higher current through a single WLED. Do not leave these pins floating

GND

The ground pin is the ground path for the linear drivers. The current loop for the ground should be as small as possible. The ground of the input capacitor should be routed with low impedance traces to the GND pin and made as short as possible. Refer to the layout recommendations for more details.

Application Information

Digital Dimming Interface

Brightness Level (0 - 31)	I_{LED} (mA) R_{SET}=14.3kΩ	I_{LED} (mA) R_{SET}=19.1kΩ	% of Max. Current
31	20.1	15.1	100
30	19.4	14.6	96.7
29	18.8	14.1	93.7
28	18.2	13.6	90.4
27	17.5	13.1	87.1
26	16.8	12.6	83.8
25	16.2	12.2	80.8
24	15.6	11.7	77.5
23	14.9	11.2	74.2
22	14.2	10.7	70.9
21	13.6	10.2	67.9
20	13.0	9.7	64.6
19	12.3	9.2	61.3
18	11.6	8.7	57.9
17	11.0	8.3	55.0
16	10.4	7.8	51.7
15	9.7	7.3	48.3
14	9.1	6.8	45.0
13	8.5	6.4	42.1
12	7.8	5.8	38.7
11	7.1	5.3	35.4
10	6.5	4.8	32.1
9	5.9	4.4	29.1
8	5.2	3.9	25.8
7	4.5	3.4	22.5
6	3.9	2.9	19.2
5	3.3	2.4	16.2
4	2.6	1.9	12.9
3	1.9	1.4	9.6
2	1.3	0.9	6.3
1	0.7	0.5	3.3
0	0.3	0.2	1.7

Table 2. Digital Interface Brightness Level Table

The MIC2860-2D incorporates an easy to use single wire, serial programming interface that allows users to set WLED brightness up to 32 different levels as shown in Table 2. To calculate the brightness level for other R_{SET} values, multiply the percentage of max current values by the maximum LED current set by the R_{SET} resistor value from table 1.

For example with R_{SET} = 19.1kΩ, the max current (brightness level = 31) is 15.1mA and brightness level 20 would equate to 15.1mA x 0.646 = 9.7mA.

Brightness levels are linearly spaced with a maximum current equal to 100% of the current set by R_{SET}. The MIC2860-2D is designed to receive programming pulses to decrease brightness from the initial start up default (level 1 maximum current). Once the brightness change signal is received, the SC pin is simply pulled high to maintain the brightness. This “set and forget” feature relieves processor computing power by eliminating the need to constantly send a PWM signal to the dimming pin.

Start Up

Assuming the MIC2860-2D has been off for a long time, the MIC2860-2D will start-up in its default mode approximately 33µs (t_{START_UP}) after a logic level high is applied to the SC pin. In the default mode the WLEDs are turned on at the maximum brightness (level 31). Each falling edge will cause the default brightness level to decrease by one.

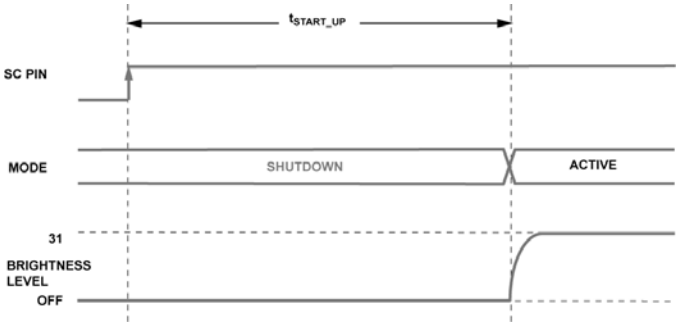


Figure 3. Typical Start-Up Timing

Shutdown

When the SC input pin is pulled low for a period greater than or equal to $t_{SHUTDOWN}$ (500µs), the MIC2860-2D will turn off the current sinks as shown in Figure 4.

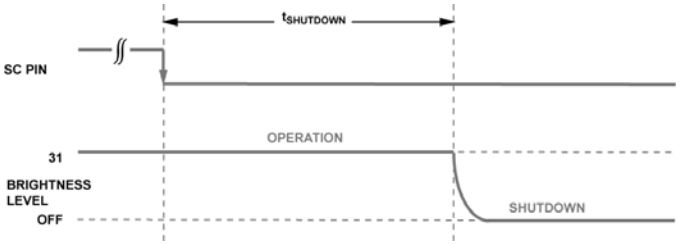


Figure 4. Shutdown Timing

Once the device is shutdown, the control circuit supply is disabled and the WLEDs are turned off drawing only 0.01µA. Brightness level information stored in the MIC2860-2D prior to shutdown will be erased and upon a following startup signal the WLEDs will be turned on at maximum brightness (level 31).

Programming the Brightness Level

MIC2860-2D is designed to start driving the WLEDs

33µs (t_{START_UP}) after the SC pin is first pulled high at the maximum brightness level 1. After start up, the internal control logic is ready to decrease the WLED brightness upon receiving programming pulses (positive edges applied to SC pin). The brightness level can be decreased one level by applying a single programming pulse as shown in Figure 5. Brightness settings can be quickly changed by sending programming pulses one after each other. Each programming pulse has a high (t_{PROG_HIGH}) and a low (t_{PROG_LOW}) pulse width that must be between 0.3µs to 75µs.

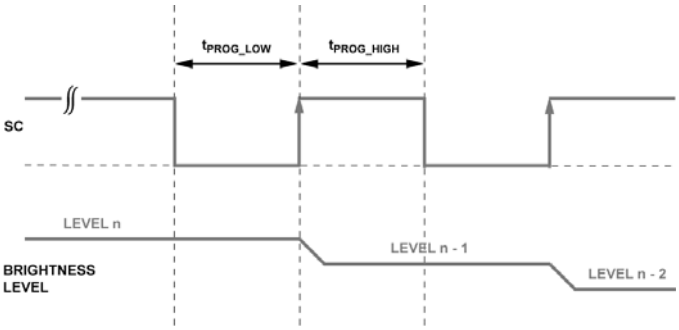


Figure 5. Brightness Programming Pulses

Multiple brightness levels can be changed as shown in Figure 6. When issuing multiple brightness level adjustments to the SC pin, ensure both t_{PROG_LOW} and t_{PROG_HIGH} are within 0.3µs and 75µs.

To maintain operation at the current brightness level simply maintain a logic level high at the SC pin.

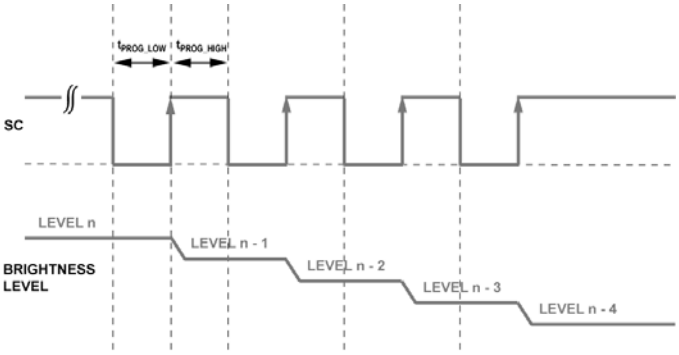


Figure 6. Consecutive Brightness Level Commands

The MIC2860-2D can be programmed to set WLED drive current to produce one of 32 distinct brightness levels. The following section explains how the brightness counter functions with continued programming edges.

Counter Roll-Over

The MIC2860-2D internal counter contains registers from 0 to 31 (32 levels). When the brightness level is at 32 (minimum brightness) and a programming pulse forces the brightness to step down, the counter will roll-over to level 31 (maximum brightness). This is illustrated in Figure 7.

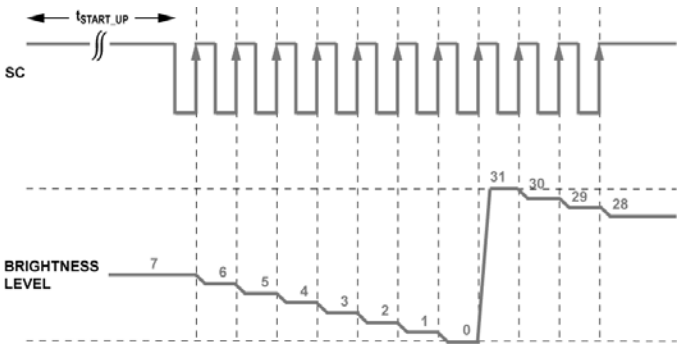
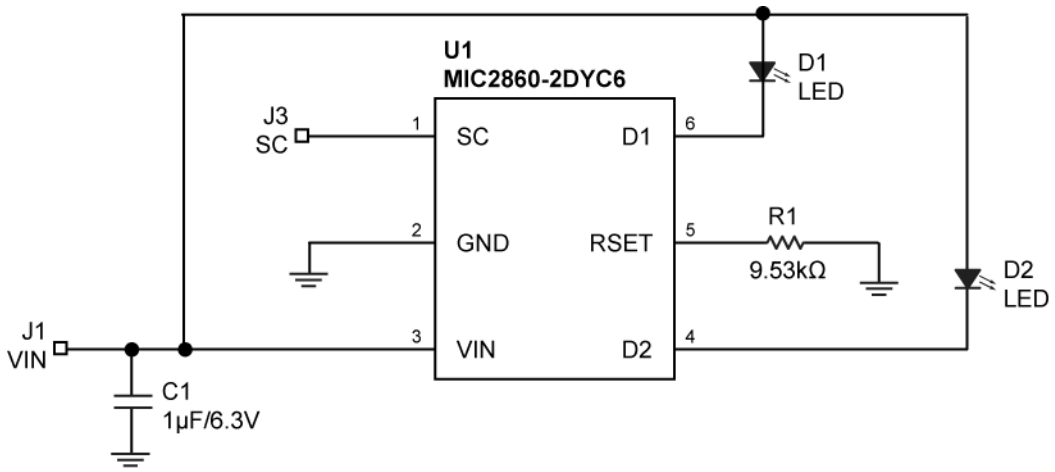


Figure 7. Down Counter Roll-Over

Input Capacitor

The MIC2860-2D is a high performance, high bandwidth device. Stability can be maintained using a ceramic input capacitor of 1µF. Low ESR ceramic capacitors provide optimal performance at a minimum amount of space. Additional high-frequency capacitors, such as small valued NPO dielectric type capacitors, help filter out high frequency noise and are good practice in any noise sensitive circuit. X5R or X7R dielectrics are recommended for the input capacitor. Y5V dielectrics lose most of their capacitance over temperature and are therefore not recommended.

MIC2860-2D Typical Application Circuit



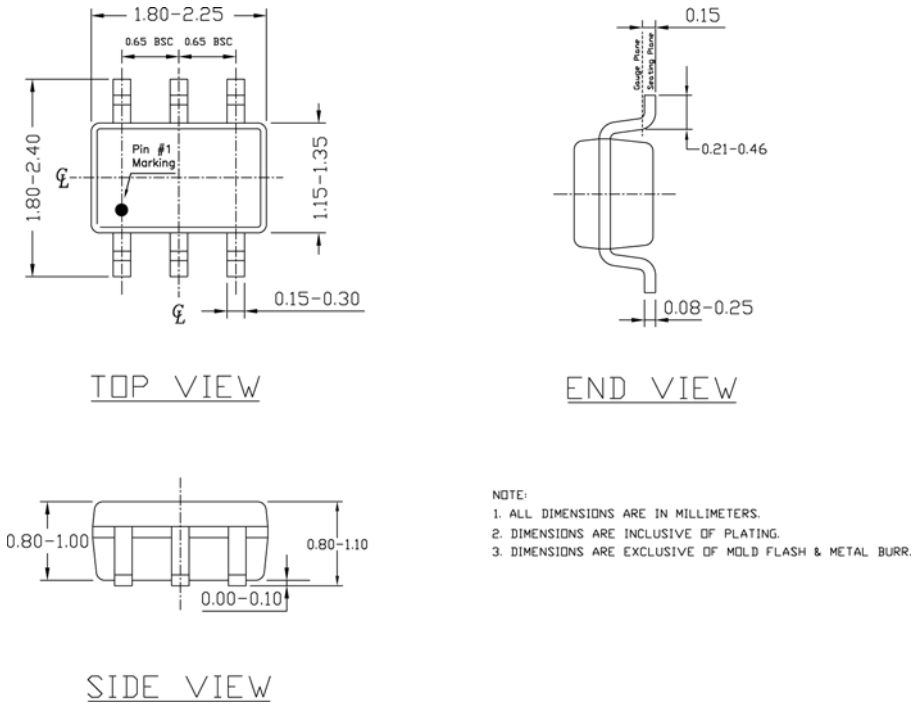
Bill of Materials

Item	Part Number	Manufacturer	Description	Qty.
C1	C1608X5R0J105K	TDK[1]	1µF Ceramic Capacitor, 6.3V, X5R, Size 0603	1
R1	CRCW06032052FT1	Vishay[2]	9.53kΩ, 1%, Size 0603	1
U1	**MIC2860-2DYC6**	**Micrel, Inc.[3]**	**2 Channel Digital Control Linear WLED Driver**	**1**

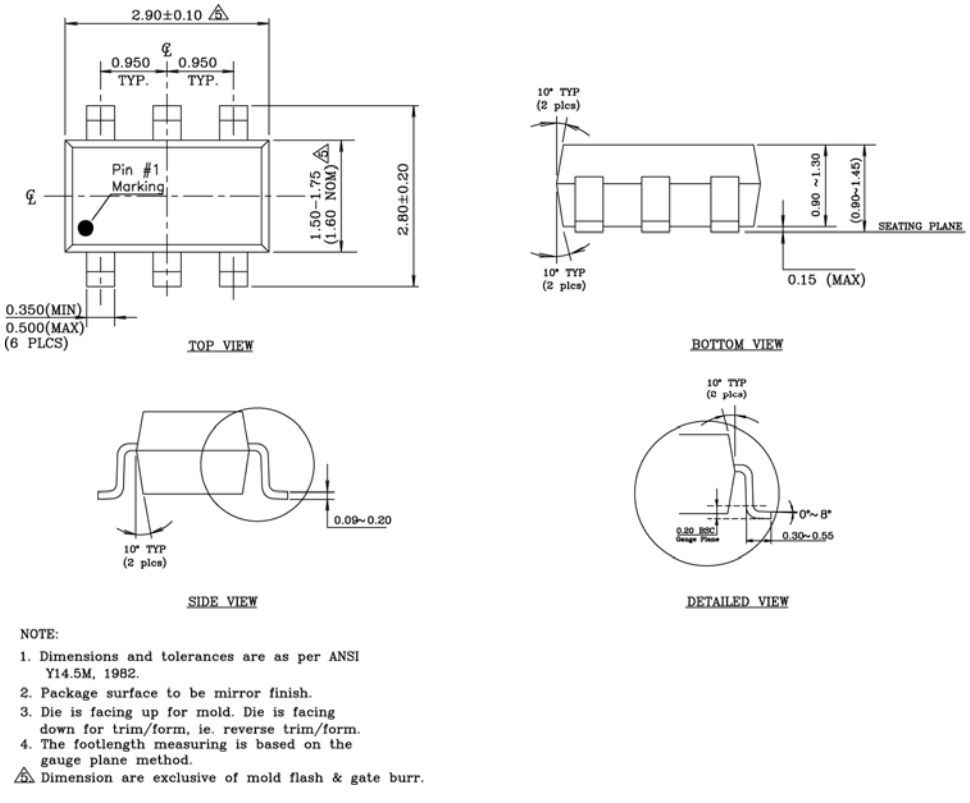
Notes:

1. TDK: www.tdk.com
2. Vishay: www.vishay.com
3. **Micrel, Inc.: www.micrel.com**

Package Information



6-Pin SC-70 (C6)



6-Pin Thin SOT-23 (D6)

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