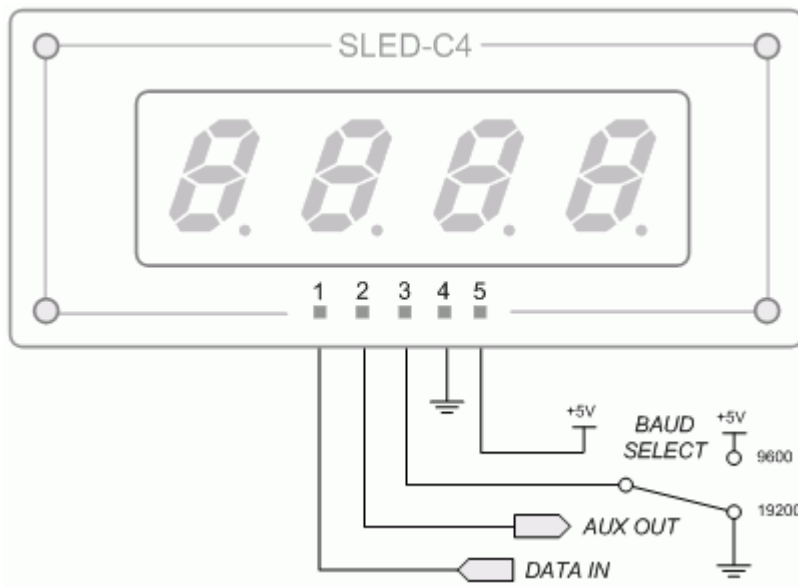# SLED-C4
Serial 4-Digit LED Display Module With Built-In Animations

The SLED-C4 is a serially controlled seven-segment red LED display module with advanced built-in features. With the SLED-C4, a single I/O-pin is all that's required to add an eye-catching, animated, 4-digit LED display to any product.

Features

- Includes 6 unique built-in display animations for printing, scrolling, clearing digits, and other special effects.
- Flicker free multiplexed LED display with fast response times.
- Available with 4 right hand decimal points, or clock type display with 2 colon LED's.
- Two command modes for total control of individual LED segments.
- Animation speed control for enhanced creative freedom and custom effects.
- Stores display brightness setting in onboard non-volatile memory for automatic power-up brightness setting.
- Stores a four-digit splash screen in onboard non-volatile memory for automatic display at power-up.
- Eliminates the need for continuous display updates and refresh loops in the host controller's firmware.
- Simple single wire asynchronous serial control with pin selectable data rates of 9600 or 19200 bps.
- Automatically refreshes and updates each display digit at ~1.2kHz.
- Low power sleep mode current draw <100uA typical, with automatic display restore on wake-up.
- Flexible operating voltage range from 4.5 to 5.5 VDC.
- Small footprint PCB measuring only 2.4″ x 1.2″.
- 2kHz PWM brightness control with 126 levels. 0 = off, 125 = max display brightness.
- Multiplexed display digits for reduced power consumption.
- Auxiliary digital output pin signals end of onboard animation sequence, or may be used as digital output when built-in animations are not used.

Operation:

Single ASCII command bytes are used to set the SLED-C4 display operating modes. Available command bytes are shown below in table 1.

ASCII COMMAND	MODE / ACTION
A	Select spin animation. Builds or erases characters on all digits. Spins from top to bottom, left to right, clockwise.
B	Set display brightness
C	Custom character display mode (power on default)
D	Decimal display mode
E	Record display brightness or splash screen to display controller onboard EEPROM
L	Select left to right scroll animation. Scroll new digits onto display – or scroll current digits off of display.
O	AUX digital output control (not available in animation mode)
P	Decimal point control
R	Select right to left scroll animation. Scroll new digits onto display – or scroll current digits off of display.
S	Enter sleep mode
T	Set built-in animation speed
U	Select custom character build animation. Builds each character one segment at a time from segments A to G.
u	Select custom character un-build animation. Erases current display contents from segments G to A.
Z	Select cyclone animation. Builds or erases characters on all digits. Spins from left to right, bottom to top, counter clockwise.
~	Serial packet termination character. Forces display controller out of serial input loop, causing immediate execution of last valid command.

Table 1

Display Operation

A single I/O-pin on the host controller is all that's required to control the SLED-C4 display. Serial data should be sent from the host controller to the SLED-C4 display in standard non-inverted N, 8, 1 format. During idle or non-transmit periods, the host controller serial output pin should idle at Vcc or logic 1.

Data Rate Selection

Pin #3, marked BAUD, is the baud select pin. Connecting the BAUD pin to Vcc or logic 1 selects 9600. Connecting the BAUD pin to ground selects 19200. The BAUD pin should be hard-wired directly to Vcc or ground before power is applied. The baud rate cannot be changed on the fly. It is sampled and set only at power-up.

Data Input Pin

Pin #1, marked DIN, is the serial data input connection. This pin receives serial commands and data packets from the host controller.

AUX Output Pin

Pin #2, marked AUX, serves two purposes. When using the built-in display animations, the AUX pin will transition to logic 1 while the display controller is busy with an animation sequence. The AUX pin will immediately return to ground once the animation is complete, signaling to the host controller the display is ready to receive new data.

The host controller should sample the AUX pin to determine when the display controller is available to receive data, and should never attempt to send data to the display controller while the AUX pin is at ground. Sending data to the display controller during an animation sequence will result in the loss of data.

If built-in animations are not used, the host controller has the option of software control of the AUX digital output. The command for controlling the AUX digital output is the capital letter O as shown in table 1. Sending a serial command string of "O", 1, "~" will toggle the AUX output pin high. Sending "O", 0, "~" will toggle the AUX output low.

Note that the AUX pin is an output, and should never be connected directly to Vcc or ground. It may be used to drive an LED, transistors, etc with a series resistor limiting sink/source current to 25mA absolute maximum. When used for handshaking, and connected to a host controller high impedance input pin, a series current limiting resistor should not be necessary. If the AUX pin is not used, it should be left unconnected.

Power Input Pins

Pin #4, marked GND, is the power supply ground input pin. Pin #5, marked VCC, is the regulated +4.5 to +5.5 VDC input pin. A well-regulated DC power supply should be used, and not exceed +5.5VDC MAX on the power inputs.

C Mode Display Operation

Operating in C or custom mode offers the greatest flexibility. This mode does not use a fixed character set, and allows the host controller to control individual LED segments on each of the four seven-segment display digits.

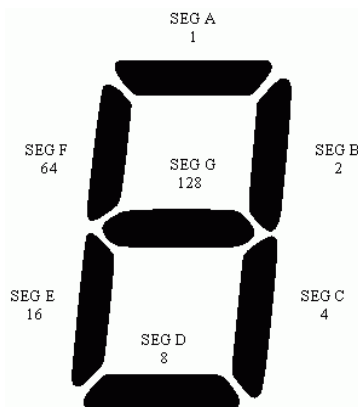As shown below in Figure 1, each LED segment A through G is assigned a control number.

Figure 1

Sending "C", 1, 1, 1, 1 to the SLED-C4 display would light segments A on all 4 display digits. The ASCII C selects custom character mode. The 4 bytes of decimal 1 data following the ASCII C represent the custom characters to be displayed. On the SLED-C4 display module, Digit 1 is the left-most digit. Digit 4 is the right-most digit.

To create custom characters, simply add segment control numbers together to form custom characters to display on each of the 4 digits.

For example: Sending "C", 143, 95, 195, 89 would display 30°C on the SLED-C4 display module The number 3 is formed by simply adding control numbers for segments A, B, C, D and G together. 1+2+4+8+128 = 143. The number 0 is formed by segments A, B, C, D, E and F. 1+2+4+8+16+64 = 95. The degree symbol is formed by segments A, B, G and F, or 1+2+128+64 = 195, and so on. With no fixed character set, you're in complete control of what will be displayed when using the custom "C" display mode.

D Mode Display Operation

Operating in D or "decimal" mode allows simple loop counter programs to control the display without the use of lookup tables or pre-defined constants for custom characters.

Below is a BASIC example.

```
CountIt:
    ' 4-digit counter from 0 to 1000 using "D"ecimal mode
    FOR Counter = 0 TO 1000
    '                  left digit                                right digit
    DEBUG "D", Counter DIG 3, Counter DIG 2, Counter DIG 1, Counter DIG 0
    PAUSE 20
    NEXT Counter
    PAUSE 500
    DEBUG "C","~" ' Clear display
```

D mode offers the least amount of flexibility, but simplifies host side firmware for simple counter applications as shown above, where custom characters or animations are not necessary.

Note that D mode expects to receive decimal digits 0 through 9. Any value greater than 9 decimal will clear the display digit position it is in. In the above example, D mode will not provide automatic leading zero blanking. The display will show a count of 0000 through to 1000.

To blank a digit position on the display in D mode, you would send a decimal value greater than 9 in the position to blank. One example would be;

```
CountIt:
    ' 4-digit counter from 0 to 100 using "D"ecimal mode with leading zero blanked
    FOR Counter = 0 TO 100
    '            left digit                          right digit
    DEBUG "D",  10, Counter DIG 2, Counter DIG 1, Counter DIG 0
    PAUSE 20
    NEXT Counter
    PAUSE 500
    DEBUG "C","~" ' Clear display
```

This would display a count of 000 to 100 with the left-most LED digit blank through the entire count sequence.

Display Brightness Control

As shown in table 1, the ASCII letter B is the command byte for brightness control. Sending "B", 0, "~" would set the display brightness level to zero, effectively turning off all display digits. Sending "B", 125, "~" would set the display to max brightness.

In B mode, decimal values between 0 and 125 provide 126 levels of display brightness control. The ASCII tilde ~ character is required in the 3rd byte position to terminate the data packet, and instruct the display controller to immediately execute the command.

The B command may also be used together with the E command to change & save the default power-up display brightness settings. The default display brightness setting of the SLED-C4 from the factory is 30. This is roughly 23% full brightness. To change the default brightness, send four bytes of data to the display as follows

"B", 10, "E", "~" ' Select brightness control mode, set brightness level 10, store the new value in "E" EEPROM, and "~" terminate the command string, and execute the command.

Changing The Default Splash Screen

The factory default display value at power-up is 8888. To change this, use the E command followed by the four characters to be displayed when power is first applied.

Sending "E", 0, 0, 0, 0 would blank all four digits on power-up. The host controller should pause for at least 10mS following all command strings that initiate EEPROM writes to allow the display controller time to complete the write cycle.

The SLED-C4 default power-up display mode is C. All characters to be displayed at power-up should be selected as appropriate for the C display mode.

Important Note: Using the E command to store default display configuration settings in the display controllers onboard non-volatile EEPROM memory should be used sparingly. The onboard EEPROM allows up to ~1,000,000 write cycles before it becomes unreliable, however, the host controller can potentially exceed this number if running in a continuous loop executing either of the previous code examples. In general practice, the host controller should change & store new default settings only when necessary, and then the command lines to write to EEPROM should be removed or commented out of the source firmware.

Using The Built-In Animations

The SLED-C4 display module has 6 built-in animations allowing the host controller to manage other tasks while the display controller handles the animation sequence. The SLED-C4 even allows the host controller to adjust the speed at which each animation is run. This is a powerful feature not commonly found on serial LED display controllers, and it can really make your product stand out in the crowd.

Depending on the animation selected, and the animation speed setting, it can take the display controller several seconds to run the complete animation sequence from start to finish.

The AUX pin is provided to signal the host controller when the animation sequence is complete. Below is an example of running an animation that will print SLED on the display using the built-in Cyclone animation while monitoring the AUX pin to signal the animation is complete.

```
' Define C mode constants
S  CON 205        ' Capital letter S
L  CON 88         ' Capital letter L
E  CON 217        ' Capital letter E
D  CON 158        ' Lower case letter d

DEBUG "T",20,"~"  ' Set animation speed to 20
PAUSE 1           ' Short delay time for change

DEBUG "Z",S,L,E,D ' Print SLED to display with Cyclone animation
PAUSE 1           ' Short delay time for change
WHILE BusyPin = 1 ' Wait for animation to complete
WEND
```

```
PAUSE 1000          ' Pause 1 second before changing display
DEBUG "Z","~"       ' Erase SLED from the display using the same animation
PAUSE 1             ' Short delay time for change
WHILE BusyPin = 1   ' Wait for animation to complete
WEND
```

Note how the animation command Z may be followed by up to 4 characters to animate onto the display, or the ~ termination character. All animation commands work in a similar fashion. Four bytes of data following the command will be used for the animation. If the termination character follows the animation command byte, then the animation effect will be used to clear the display VS animate four characters onto the display.

The ASCII T command followed by a decimal value of 0 to 255 sets the animation frame speed. Note that all animation modes expect character data formatted for C display mode.

The Z or Cyclone animation prints or erases characters on the display from right to left in an anti clockwise circular spinning motion from bottom to top. The A spinning animation works just the opposite. Spinning clockwise, from top to bottom, in a circular motion.

The L and R animations will slide characters from left to right, or right to left, onto or off of the display for a scrolling display effect.

The U animation builds each character, one segment at a time, starting with segment A, then B, C, D, E, F and G. The lower case u command will un-build the display characters in a reverse action, clearing segments G, then F, E, D, C, B and finally A.

Decimal Point / Colon Control

The SLED-C4 is available with standard or clock type 7-segment display modules. One has 4 right hand decimal points. The other has a clock type display with a two LED colon. The P command is used for decimal point & colon control. A single decimal byte value from 0 to 15 follows the P command byte, followed by the terminating character ~.

For example, with the standard display module, sending "P", 15, "~" would turn on all four decimal points. Sending "P", 0, "~" would turn all four off. Sending "P","~" would also turn off all decimal points or colon LED's since the byte value between the P and ~ characters is cleared if it is not received before the command terminator character.

As shown below in Figure 2, each decimal point or colon LED is assigned a control number. On the SLED-C4 standard display module, a value of 1 corresponds to decimal point number 1, which is on the left most display digit. A decimal value of 8 corresponds to the right most decimal point.

Figure 2   Standard LED display module   Clock display module with colon LED's

Any combination of decimal points, or colon LED's may be turned on or off using the single decimal value sent after the P command. Simply add together the control numbers for each decimal point or colon LED.

For example, sending "P", 9, "~" to the SLED-C4 with a standard LED display would turn on decimal points 1 and 4, leaving the two inside decimal points off. With the clock display module, sending "P", 12, "~" would turn on both LED's in the clock colon position. Note that only the 2 colon LED's are available on the clock display module, so only 4, 8 or 0 following the P command byte are valid.

Note that only the P command mode will affect the status of any decimal point or clock colon LEDs'. All decimal point or colon LED's that have been previously turned on of off, will remain that way until the P command is issued again to change their state.

Low-Power Sleep Mode

Sending "S","~" to the SLED-C4 display will place the module in low-power sleep mode. While in sleep mode, the display driver oscillator is turned off, all LED digits are extinguished, and the display module draws minimum current (typically <100uA @5VDC) until the host controller wakes the display.

The host controller should hold the serial output pin at logic 1 while the display is in sleep mode. To wake the display, simply toggle the serial output pin from logic 1 to ground, and then back to logic 1.

On wake-up, the contents of the display prior to entering sleep mode will be restored, and the SLED-C4 is ready for normal use again. Below is an example of placing the display in sleep mode for a period of 1 second, then waking it back up.

```
Sleepy:                    ' Routine for placing display in low-power sleep mode
    DEBUG "S","~"          ' Put display to sleep
    PAUSE 1000             ' Let it sleep for 1 second
    LOW PORTC.0            ' Force wake-up
    HIGH PORTC.0           ' Return pin to non-inverted serial idle logic state
    PAUSE 100              ' Wait 100mS after wakeup, then carry on
```

Example Source Code & Videos

Code examples for the BASIC Stamp, and PIC microcontrollers written in PicBasic Pro, assembly, and Swordfish BASIC, are available for download on our website at http://www.rentron.com/SLED-C4.htm.

The firmware examples show how to build your own complex display animations, and how to use the SLED-C4 built-in animations.

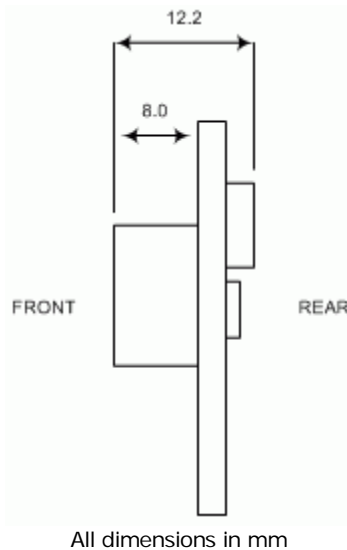Along with the source code examples, we have a video showing various animation sequences in action.
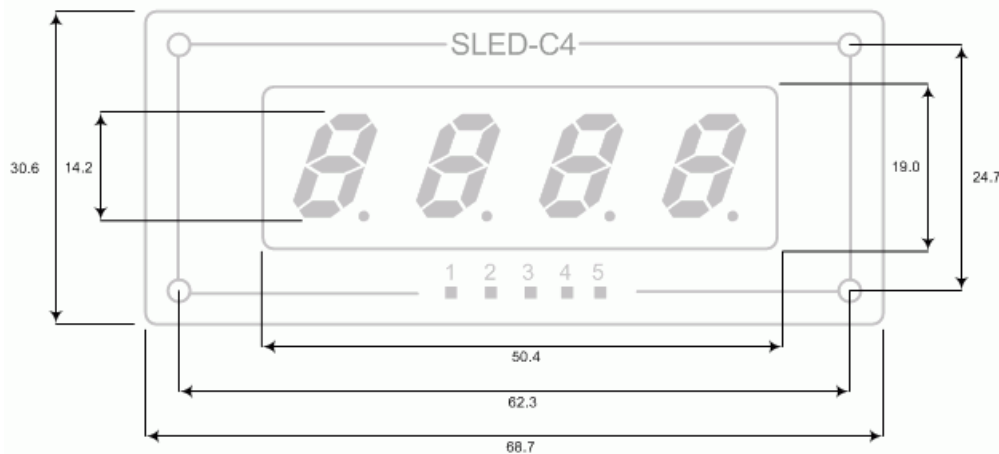
SLED-C4 Dimensions

All dimensions in mm

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Warranty

microEngineering Labs, Inc. warrants this product against defects in materials and workmanship for a period of 90 days. If you discover a defect, we will, at our option, repair, replace, or refund the purchase price. Return the product with a description of the problem. We will return your product or its replacement via standard shipping. Expedited shipping is available at the customer's expense.

• Note: Physically abusing the module, or attempting to repair or modify it, voids this warranty.

With Standard Display   With Clock Display

Rear View