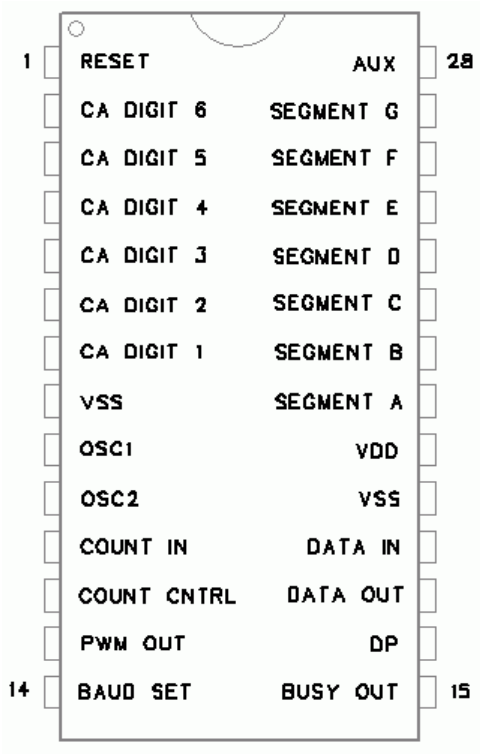
SLED-C6

Serial 6-Digit LED Display Controller IC With Built-In Animations



The SLED-C6 seven-segment LED controller handles up to 6 common anode LED displays, and has advanced built-in features for 7 animations, a 16-bit counter, non-volatile EEPROM, and more. A single I/O-pin is all that's required to control up to 6 common anode type seven-segment LED displays.

Features

- Includes 7 unique built-in display animations for printing, scrolling, clearing digits, and special effects.
- Flicker free multiplexed LED display controller with fast response times.
- Controls up to 6 right hand decimal points.
- Two command modes for total control of individual LED segments or high-speed counting.
- 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 six-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 multiplexed display digit.
- Low power sleep mode current draw <100uA typical, with automatic display restore on wake-up.
- Flexible operating voltage range from 3.0 to 5.5 VDC.
- 2kHz PWM brightness control with 126 levels. 0 = off, 125 = max display brightness.
- Operates with multiplexed display digits for reduced power consumption.
- Built-in 16-bit, high-speed hardware counter with continuous updates of count on display.
- Transmits stored display brightness value in hex format to host controller on request.

Operation:

ASCII command bytes are used to set the SLED-C6 display IC operating modes. Available commands are shown below in table 1.

ASCII COMMAND	MODE / ACTION
A	Select spin animation. Builds or erases characters. Spins from top to bottom, left to right, clockwise, from segments A to G. (the A command must be followed by 6 data bytes for animation.
B	Set display brightness / serially transmit stored brightness setting in hex format to host controller.
C	Custom character display mode (power on default).
D	Select decimal display mode.
E	Store display brightness setting (when after B command) or store 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.
M	Activate built-in 16-bit hardware counter monitor 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	Place display controller in low-power 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. (the U command must be followed by 6 data bytes for animation).
u	Select custom character un-build animation. Erases current display contents from segments G to A. (the u command should be followed immediately by the "~" termination character).
X	Select string pint/scroll animation. Display controller accepts a string of up to 17 characters, and then scrolls characters from right to left across display. (Characters must be in C mode format).
Z	Select cyclone animation. Builds or erases characters on all digits. Spins from left to right, bottom to top, counter clockwise. (the Z command must be followed by 6 data bytes for animation).
~	Serial packet termination character. Forces display controller out of serial input loop, causing immediate execution of last valid command.

Table 1

Display IC Operation

A single I/O-pin on the host controller is all that's required to control the SLED-C6 display IC. Serial data should be sent from the host controller to the SLED-C6 IC in non-inverted N, 8, 1 format, LSB first. During idle or non-transmit periods, the host controller serial output pin should idle at Vcc or logic 1.

Data Rate Selection

Pin #14, marked Baud Set, is the baud select pin. Connecting the Baud Set pin to Vcc or logic 1 selects 9600. Connecting the Baud Set pin to ground selects 19200. The Baud Set 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 #18, marked Data In is the serial data input connection. This pin receives serial commands and data packets from the host controller.

Busy Out Pin

Pin #15, marked Busy Out, will transition to logic 1 while the display controller is busy. The Busy Out pin will immediately return to ground once the SLED-C6 display controller is ready to receive new serial data. The host controller should allow a minimum of 1 millisecond after issuing a command for the Busy Out pin to change state, then wait for the Busy Out pin to transition to logic 0 before sending new data.

The host controller should not attempt to send data to the display controller while the Busy Out pin is at logic 1. Doing so will result in the loss of data. If the Busy Out pin is not used, it should be left unconnected.

Count In & Count Control Pins

The SLED-C6 has a built-in 16-bit hardware counter. When in counter mode, the count will be displayed on the 5 right-most display digits. The following steps must be taken to enter count mode.

1. Take pin #12 Count Cntrl to ground.
2. Send "M" followed by the "~" termination character to the controller.

The display controller is now in counter mode until the Count Cntrl pin is returned to Vcc. The hardware counter will increment on every rising edge present on pin #11 Count In.

Note that a falling edge must be received on pin #11 before the count will increment on the next rising edge. An external pull-up resistor may be used to hold the Count In pin at Vcc, and the first low-to-high transition on the Count In pin will then increment the count. Returning the Count Control pin #12 to Vcc will exit counter mode, and clear the display. The count will automatically rollover to 0 once the count exceeds 65,535. If counter mode will not be used, wire pins #11 and #12 directly to Vcc.

Count mode is dedicated to displaying the external count input. While in counter mode, the display controller will ignore all serial data sent to it. To return to normal operation, pin #12 must be returned to Vcc to exit counter mode.

Power Input Pins

Pins #8 and #19, marked VSS connect to ground. Pin #20, marked VDD, is the + voltage input. The SLED-C6 can operate from DC voltages ranging from 3 to 5.5 VDC. A well-regulated DC power supply should be used, and not exceed +5.5VDC MAX.

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 six seven-segment display digits.

Each LED segment A through G corresponds to a bit position in the data byte received. Segment A is the least significant bit #1. Segment G is bit #7 just before the most significant bit.

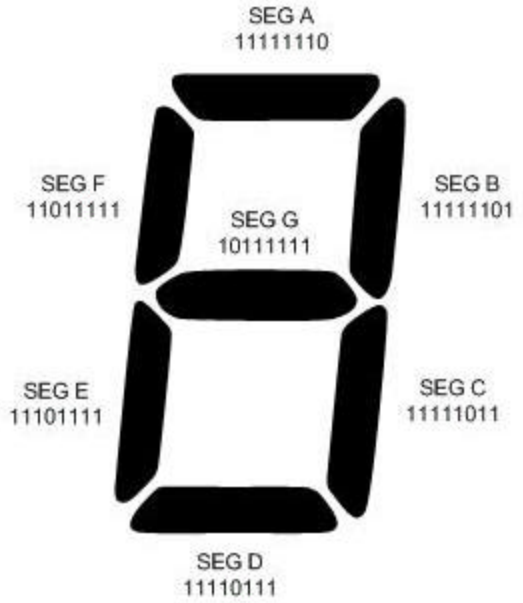


Figure 1

The SLED-C6 controls common anode type 7-segment displays. As shown in Figure 1, a zero in a bit position for individual segments will light a segment. Logic 1 will turn off a segment. The most significant bit in each 8-bit data byte will be placed on the AUX pin #28.

Example: Sending "C", 254,254,254,254,254,254 will light segment A on all six display digits leaving the AUX pin at Vcc since 254 = %11111110 binary. Sending "C", 126,126,126,126,126,126 would also light segment A on all digits, but this value would place logic 0 on the AUX output since 126 = %01111110 binary.

The most significant bit #8 in each data byte is placed on the AUX pin. Control of the AUX output pin is available only in C mode. In D mode, the AUX pin will remain at logic 1. Note that C mode animations will also affect the AUX output pin.

Clearing The Display

Sending "C", "C", "~" will clear all six digits on the display in any mode. In D mode sending 6 bytes with a value greater than 9 will clear the display. The C mode method of clearing this display is recommended to flush segment buffers to prevent ghosting.

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.

Sending "D",0,1,2,3,4,5 would print 0 1 2 3 4 5 on the display.

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 0 1 2 3 4 5. If leading 0 blanking is required, simply send a value greater than 9 in the digit position to blank.

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. To change the default brightness, send four bytes of data to the display IC 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. Each time the B command is received, the display controller will automatically read the brightness level value stored in EEPROM, and transmit this value in 2-digit hex format out on the Data Out pin.

Changing The Default Splash Screen

The factory default display value at power-up is 888888. To change this, use the E command followed by the six characters to be displayed when power is first applied.

Sending "E", 255, 255, 255, 255, 255, 255 would blank all six digits on power-up. The host controller should monitor the Busy Out pin following all command strings that initiate EEPROM writes to ensure the display controller IC has completed the write to EEPROM before sending more serial data.

The SLED-C6 IC 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.

Using The Built-In Animations

The SLED-C6 display IC has 7 built-in animations allowing the host controller to manage other tasks while the display controller handles the animation sequence. The SLED-C6 also allows the host controller to adjust the speed at which each animation is run. Note that all data sent to the display controller for animations must be formatted for C mode.

The T Command

The visual effect of each different animation will vary a great deal depending on the speed at which the animation is executed. The T command is used to set the animation speed. The range of animation speeds is from 0 to 255 with 0 being no delay, and 255 being the maximum delay. Sending "T", 30, "~" would set the animation speed to 30, which is appealing for the A and Z animations. Sending "T", 255, "~" would set the maximum delay, which is good for scrolling messages. The T command must always be followed by the speed value and the terminating "~" character. Experimentation is the easiest approach to finding the best speed for various animations.

The A Animation

This animation builds or erases characters in a spinning motion from top to bottom, left to right, clockwise, from segments A to G. T he A command must be followed by 6 data bytes to animate onto the display, or clear the display. Sending "A", 0, 0, 0, 0, 0, 0 would animate and print 888888 on the display. Sending the "A" followed by 6 bytes consisting of 255 would clear the display with the same spinning animation.

Note that the most significant bit is not used since there are only 7-segments per digit, so a 1 or 0 in the most significant bit does not affect what is displayed. This bit will be placed on the AUX pin.

The L Animation

Sending "L", %01111001, %00100100, %00110000, %00011001, %00010010, %00000010 would scroll 123456 from left-to-right across the display. Sending "L","~" would scroll 123456 off the display to the right leaving the display blank.

The R Animation

Sending "R", %01111001, %00100100, %00110000, %00011001, %00010010, %00000010 would scroll 123456 from right-to-left across the display. Sending "R","~" would scroll 123456 off the display to the left leaving the display blank.

The U Animation

This animation builds each character one segment at a time from segments A to G. The U command must always be followed by 6 data bytes for animation.

Sending "U", 0, 0, 0, 0, 0, 0 would print 888888 on the display building each 8 in a top down fashion from segments A to G.

The u Animation

This animation compliments the U animation, and will un-build characters present on the display by erasing them one segment at a time from segment G to A. Sending "u","~" is all that's required. Not data should be sent for this character un-build animation.

The X Animation

This animation accepts a string of up to 17 characters, and will scroll the string of characters in a marquee fashion across the display from right-to-left leaving the display clear once the string has scrolled completely off.

Note: The X animation requires data for the number 8 to have the most significant bit set. A value of 0 indicates the end of a string for the X animation, so 8 must have the MSB set. A binary value of %10000000 is required to display the number 8 correctly with the X animation.

A string of up to 17 characters may be sent. If there are less than 17 characters, the end of the string must be terminated with the "~" character. The "~" character must also follow directly after the X command.

Example: Sending "X","~", %10000000, %10000000, %10000000, %10000000,"~" would scroll numbers 8888 from right to left across the display. The first terminating "~" character instructs the display controller to switch to the much larger X animation buffer. The second terminating "~" character instructs the display controller to take immediate action and process the character string for the animation.

If 17 characters follow the "X","~" the end termination "~" character is not required. The buffer will automatically be closed, and the animation will start following receipt of the 17th character.

The Z Animation

This animation will build or erase characters by spinning from left to right, bottom to top, counter clockwise. The Z command must always be followed by 6 data bytes for animation or erasing.

Sending "Z", 0, 0, 0, 0, 0, 0 would animate 888888 onto the display. Sending "Z",255,255,255,255,255,255 would clear all digits with the same animation.

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 Busy Out pin is provided to signal the host controller when the animation sequence is complete, or when the display controller is performing other built-in tasks.

Decimal Point Control

The SLED-C6 will control up to six right hand decimal points. The P command is used for decimal point control. A single decimal byte value from 0 (all DPs off) to 63 (all DPs on) follows the P command byte, followed by the terminating character ~.

For example, sending "P", 4, "~" would turn on the decimal point at the 3rd digit from the right as shown above. Sending "P", 0, "~" would turn all six decimal points off. "P", 32, "~" would light the left-most decimal point.

Any combination of decimal point 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. "P", 63, "~" would turn on all decimal points.

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

Data Out

The Data Out pin #17 will transmit the current value stored in the SLED-C6 internal EEPROM for display brightness to the host controller. Data is transmitted in non-inverted format, LSB first, at the baud rate set by the Baud Set pin. The value stored in EEPROM will be read & transmitted each time the B command is received by the display controller. Data is sent HEX format as two bytes. No other information will be transmitted by the Data Out pin.

Low-Power Sleep Mode

Sending "S","~" to the SLED-C6 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 IC draws minimum current (typically <100uA @5VDC) until the host controller wakes the display controller.

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-C6 IC is ready for normal use again.

Operational Notes:

The SLED-C6 IC serial input and counter in pins are Schmitt trigger type inputs. Data and signal levels on these pins should be 0.8 x Vdd for proper operation. Example: With a 5-volt power supply, serial data & count input signal levels should be from 0 to 0.8 x 5 volts or 0-4 volts.

The SLED-C6 IC should never be connected directly to a PC serial port, or any RS232 level signal. Connection to a PC serial port should be made only through a MAX232 RS232 level converter or equivalent IC.

The SLED-C6 IC has a timeout period of 5mS. Data to be displayed should be sent within 5mS from the time the command byte is sent. Breaks in communications longer than 5mS between any characters sent to the display should be avoided to ensure proper operation. After any break in communications exceeding 5mS, the SLED-C6 display controller IC will assume the next byte received is a command byte.

At power on, the SLED-C6 IC will read onboard EEPROM to load default configuration settings such as display brightness, and splash screen. The host controller should monitor the Busy Out pin at power up, and add an additional delay period of at least 10mS before attempting to communicate with the display controller.

The Reset Pin

Pin #1 is the display controller reset pin. This pin should be held at VCC for normal operation. Toggling from VCC to ground, then back to VCC will force a hardware reset of the display controller.

Disclaimer of Liability

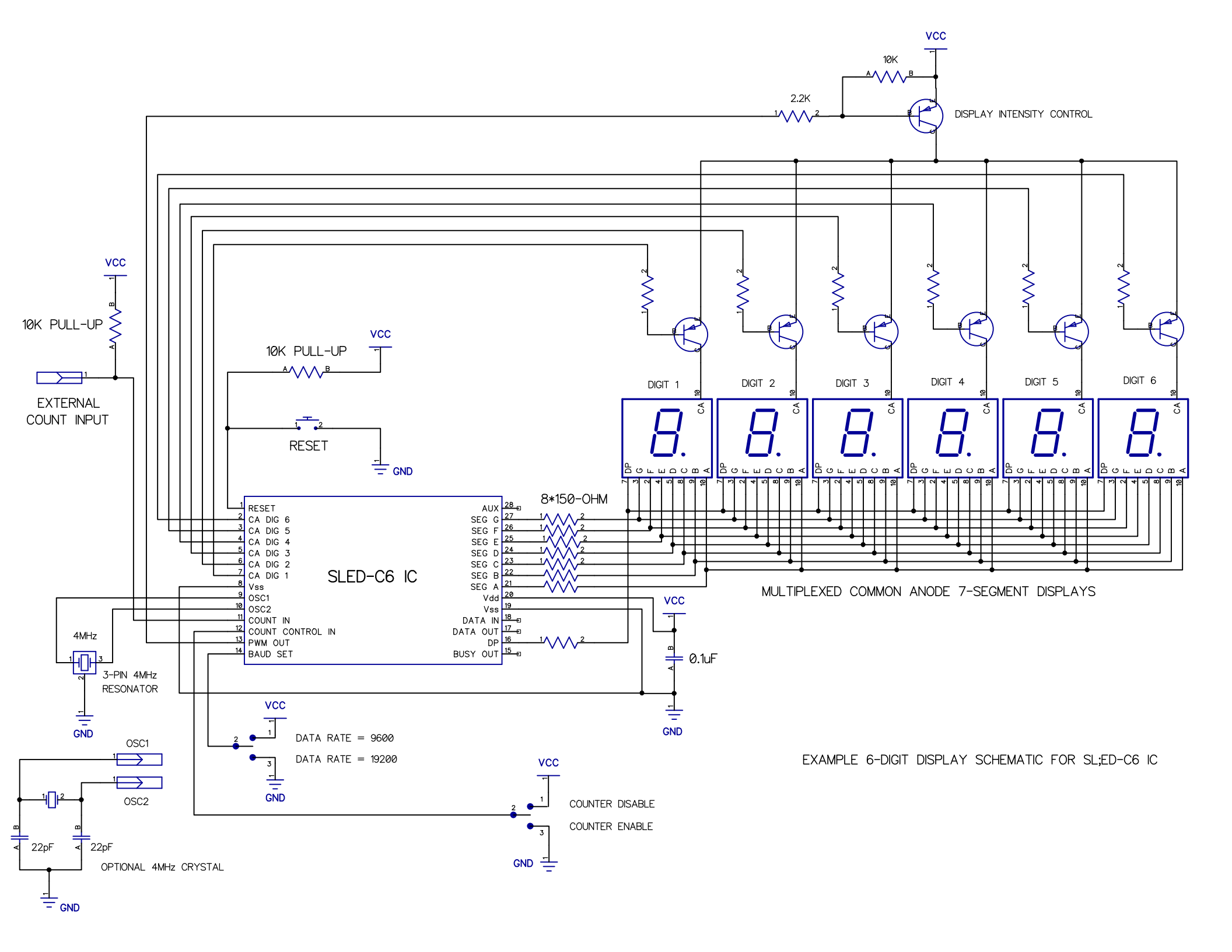
Reynolds Electronics is not responsible for any special, incidental, or consequential damages resulting from any breach of warranty, or under any legal theory, including lost profits, downtime, goodwill, damage to or replacement of equipment or property, and any costs or recovering, reprogramming, or reproducing of data associated with the use of the product described herein.

Warranty

Reynolds Electronics 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. Physical damage to, or direct soldering of the IC to a circuit board voids this warranty.

Absolute Maximum Ratings

Operating voltage.....3.0 to 5.5VDC
Ambient temperature under bias.....-40° to +125°C
Storage temperature ..... -65°C to +150°C
Voltage on VDD with respect to VSS..... -0.3V to +5.5VDC
Maximum output current sunk by any I/O ..... 25 mA
Maximum output current sourced by any I/O pin ..... 25 mA
Maximum current sunk by all ports combined..... 200 mA
Maximum current sourced by all ports combined..... 200 mA


VCC
10K
2.2K
DISPLAY INTENSITY CONTROL
10K PULL-UP
EXTERNAL
COUNT INPUT
RESET
GND
DIGIT 1
DIGIT 2
DIGIT 3
DIGIT 4
DIGIT 5
DIGIT 6
8*150-OHM
SLED-C6 IC
RESET
CA DIG 6
CA DIG 5
CA DIG 4
CA DIG 3
CA DIG 2
CA DIG 1
Vss
OSC1
OSC2
COUNT IN
COUNT CONTROL IN
PWM OUT
BAUD SET
AUX
SEG G
SEG F
SEG E
SEG D
SEG C
SEG B
SEG A
Vdd
Vss
DATA IN
DATA OUT
DP
BUSY OUT
MULTIPLEXED COMMON ANODE 7-SEGMENT DISPLAYS
0.1uF
4MHz
3-PIN 4MHz
RESONATOR
DATA RATE = 9600
DATA RATE = 19200
COUNTER DISABLE
COUNTER ENABLE
OSC1
OSC2
22pF
22pF
OPTIONAL 4MHz CRYSTAL
EXAMPLE 6-DIGIT DISPLAY SCHEMATIC FOR SL;ED-C6 IC