Contrast Control Circuits for the PIC16F91X

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INTRODUCTION

The PIC16F91X is a low-cost flash-based PICmicro® microcontroller that has the ability to drive LCD glass. This device also has a wide operational voltage range and low power, making it an ideal candidate for many battery powered applications. To get the most use from the battery, the device must operate over a wide voltage range. The wide voltage range can cause contrast problems with the LCD glass, so a solution is needed that will maintain constant LCD voltage and be very cost effective. In this technical brief we will discuss three different contrast control systems; external voltage regulator, comparator buck regulator and comparator buck/boost regulator.

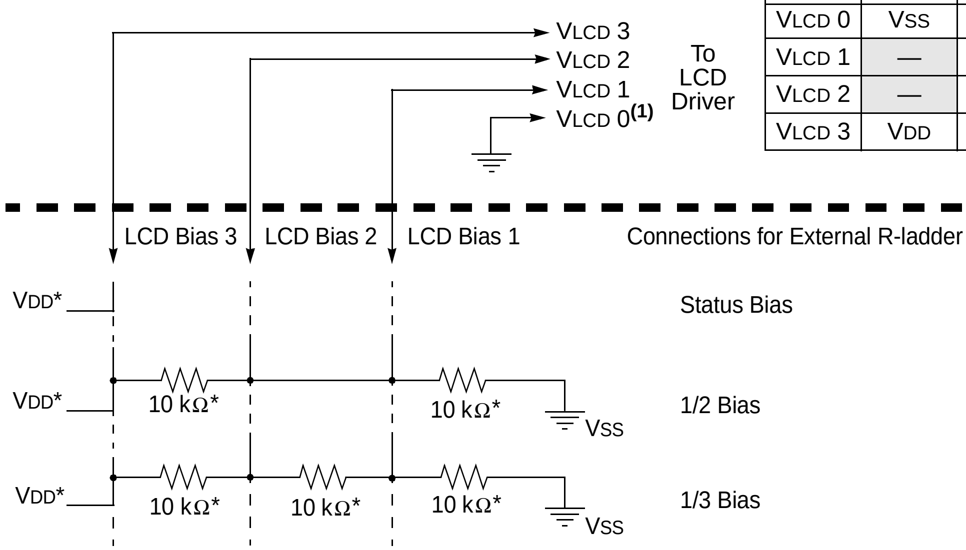
SYSTEM REQUIREMENTS

LCD glass requires a specific RMS voltage applied between a segment and a common to create the required polarization shift. Different pieces of glass are designed for different voltages with the most common type of glass being 5.0V glass. Lower voltage glass is available, though as the voltage gets below 3V, it is more difficult to create large panels with acceptable contrast.

The PIC16F91X has a series of analog switches to connect the segment and common pins to 4 voltages. Three of the voltages are applied to the VLCD<3:0> pins. The fourth voltage is internally connected to VSS. To operate the LCD module, correct voltages must be applied to these pins. The voltages applied depend upon the type of LCD drive and the type of glass.

FIGURE 1: VOLTAGE APPLICATION

	Static Bias	1/2 Bias	1/3 Bias
VLCD 0	VSS	VSS	VSS
VLCD 1	—	VDD	VDD
VLCD 2	—	VDD	VDD
VLCD 3	VDD	VDD	VDD



* These values are provided for design guidance only and should be optimized for the application by the designer.

Note 1: Internal connection.

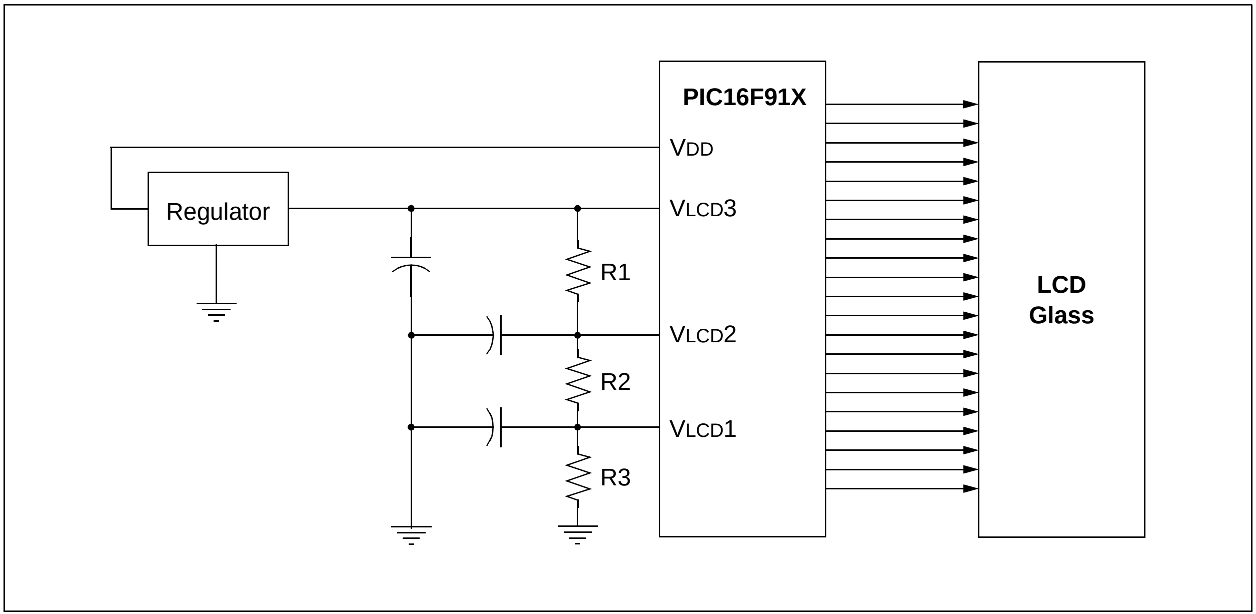
EXTERNAL VOLTAGE REGULATOR

A simple solution for contrast control is to use an external voltage regulator to generate the required glass voltage. If low voltage glass is used, the voltage regulator simply steps the power supply down to the required glass voltage.

Circuit Description

The basic format for the external regulator voltage generator is as shown in Figure 2. The regulator must be chosen to satisfy the requirements of glass voltage and power usage.

FIGURE 2: EXTERNAL VOLTAGE REGULATOR GENERATOR



COMPARATOR BUCK REGULATOR

The external comparator solution is a simple one, but not without its issues. The first issue is that most battery applications are cost sensitive, so the addition of a regulator IC may not be practical. Another one is the regulator's dropout voltage. Linear regulators require a higher input voltage than their output. This difference may be very small, but it will limit the useful battery life of a product. The last issue is power consumption. The linear regulator will burn a small amount of current to provide its function. These problems can be solved with a PFM switched capacitor regulator, if it can use features already present in the microcontroller. Fortunately, the comparator in the PIC16F91X devices is designed to accommodate this function.

When Comparator mode 5 (CMCON<2:0> = 101) is used, it is possible to use an internal 0.6V band gap as the voltage reference. With this mode, creating a PFM buck regulator is simple.

Circuit Description

The circuit in Figure 4 uses the internal comparator to create a PFM buck power supply. The voltage between R4 and R5 is compared to the internal 0.6V reference. The comparator output is filtered by the capacitors and R6. R1-R3 divide the output voltage to an appropriate value for the VLCD inputs.

Software Description

No software is required for running this system, but the comparator must be initialized into the correct mode. The following code can be used to initialize this circuit.

EXAMPLE 1: INITIALIZATION CODE

```
banksel     CMCON0
    MOVLW   0x0D
    MOVWF   CMCON0    ;enter the contrast
                      ;control mode
```

FIGURE 3: COMPARATOR MODE 5 DETAIL

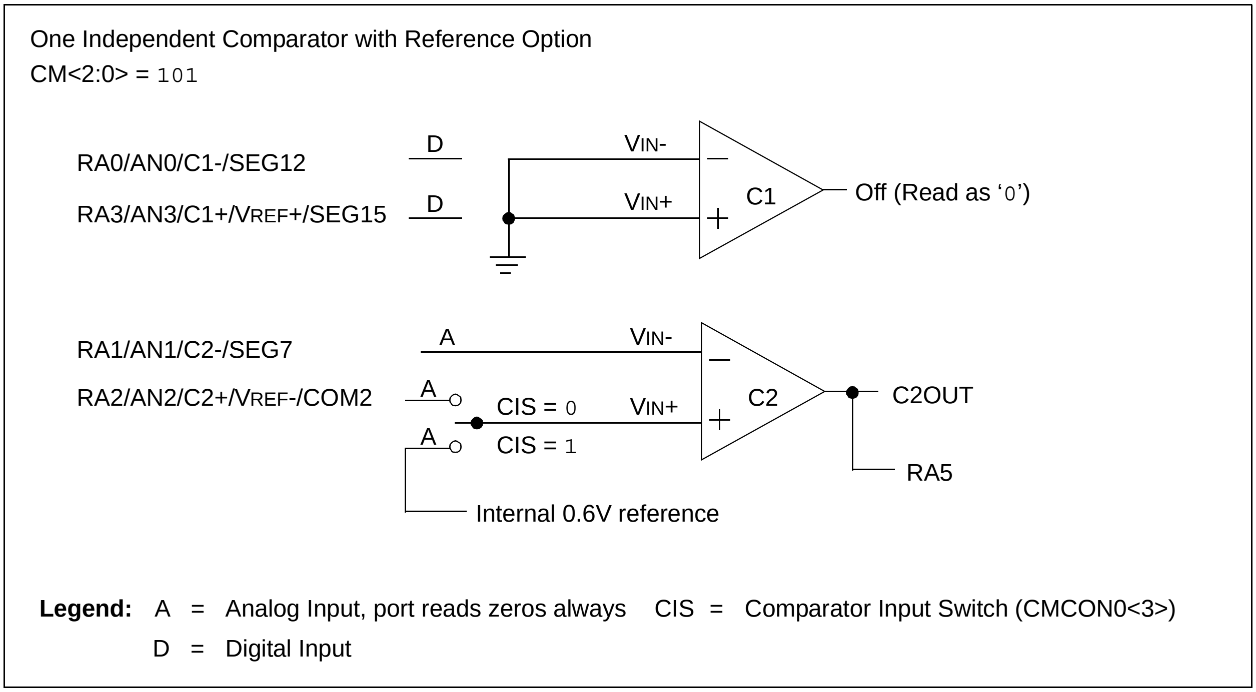
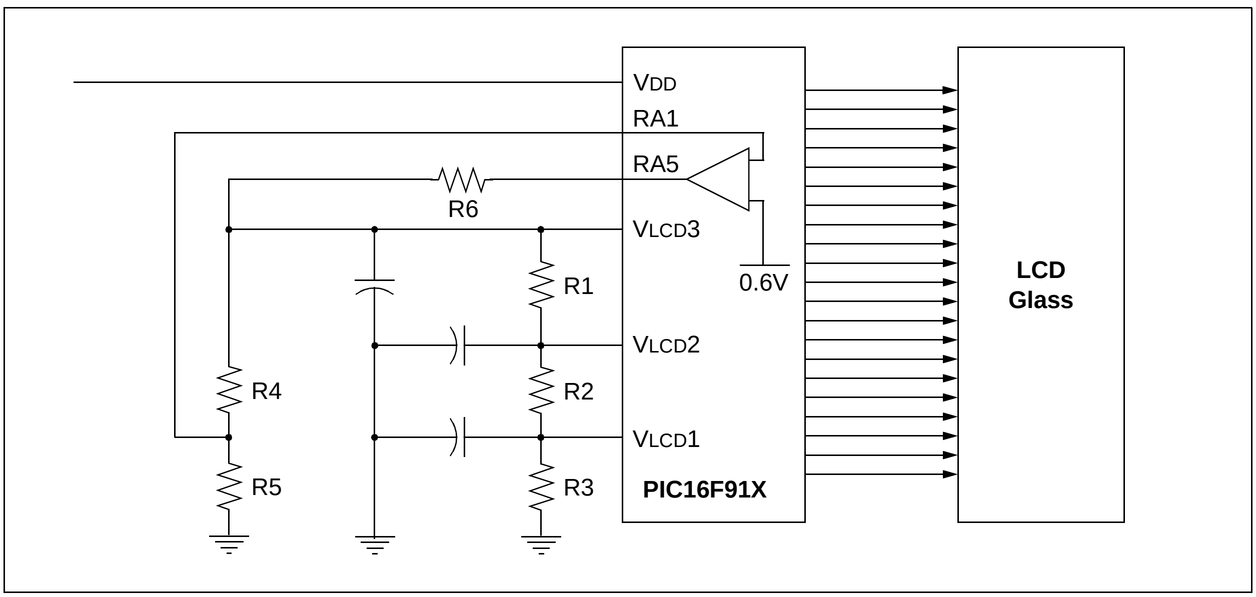


FIGURE 4: COMPARATOR BUCK REGULATOR



COMPARATOR BUCK/BOOST REGULATOR

A comparator buck circuit is beneficial for many applications, but if the V_{DD} is too low for the glass, a boost converter may be a better option. Fortunately, it is possible to use the internal comparators to build a simple buck/boost.

There are many trade-offs with a boost circuit, but the primary issue is the voltage limits of the I/O pins. The data sheet specifies that the input range of the V_{LCD} pins is V_{SS} to V_{DD}. Therefore, if the voltage to the LCD is to be boosted, then that boosted voltage must also be applied to V_{DD}. With an increase in V_{DD} comes an increase in current consumption so software must be used to control when the boosted voltage is to be used. Also, the device must be powered before the boost is active so the minimum battery voltage is still 2.0V.

Circuit Description

There are two basic methods to boost a voltage. Fortunately, it is easy to use the on-board comparators to regulate both methods of boosting voltage. The basic architecture of the circuit is shown in Figure 5. Comparator C1 is used to build an oscillator that drives the boost circuit. Comparator C2 is used to regulate the activity of C1 by shutting off the oscillator when the voltage exceeds the limit programmed by R6 and R7. R5 and D3 create a simple voltage reference for the entire system. C2 is a bulk capacitor that is maintained at the desired voltage level by the entire regulator. D1 allows the rise and fall time of the oscillator to be tuned independently by adjusting R2 and R4.

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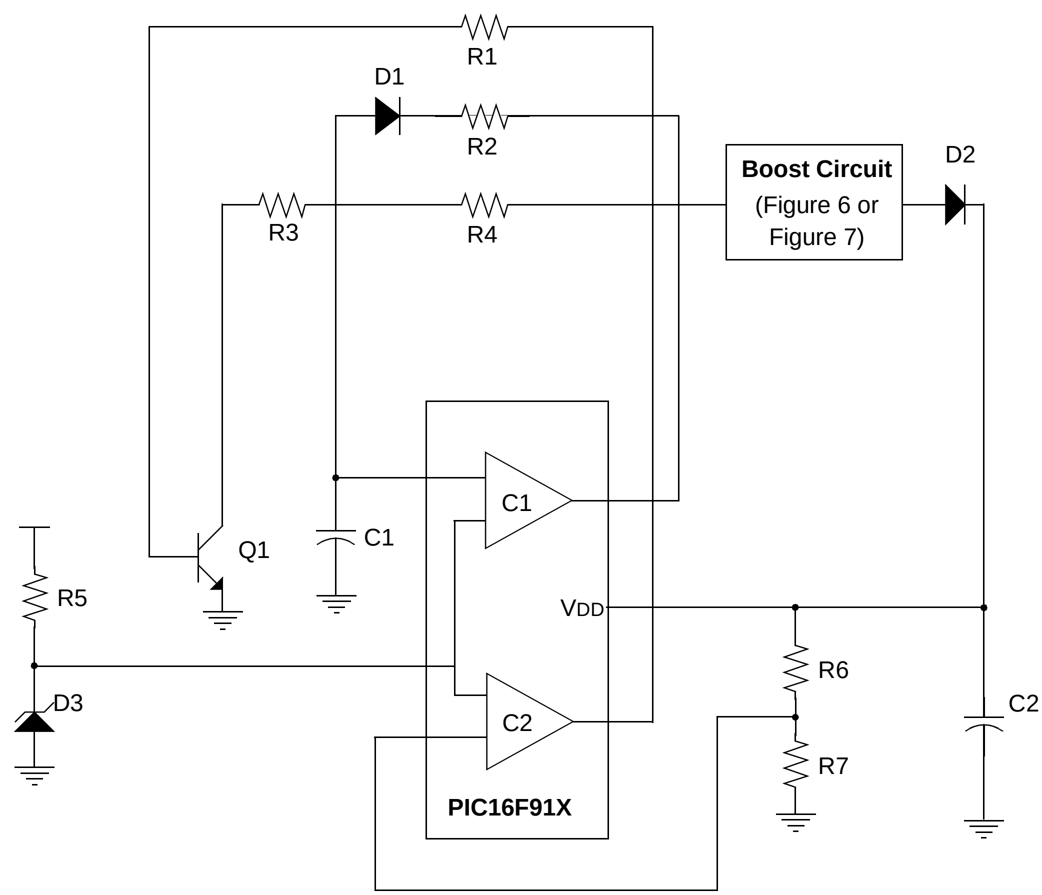
FIGURE 5: COMPARATOR BUCK/BOOST REGULATOR



There are two boost circuits that can be easily inserted into the boost block as shown in Figure 5. The first circuit is a simple switched capacitor doubler.

The capacitor and diode work with the circuit as drawn in Figure 6 to produce a doubler. This circuit works best with a 50% duty cycle. Therefore, a few components can be removed from the first schematic. To meet the start-up requirement, the minimum V_{BAT} is 2 diode drops over 2.0V. Assuming schottky diodes, this circuit will convert 2.6V to any voltage from 2.6-5.2V. If a slightly lower minimum voltage is required, then an inductor-based switcher is required (Figure 7).

To adjust the amount of energy transferred to the output capacitor, the duty cycle of Q2 must be tuned. This is done by adjusting the values of R2 and R4 in the first schematic.

FIGURE 6: SIMPLE SWITCHED CAPACITOR DOUBLER

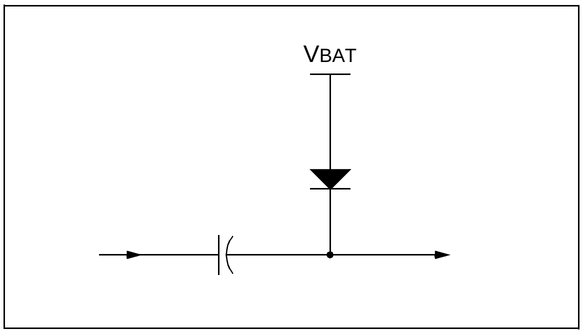
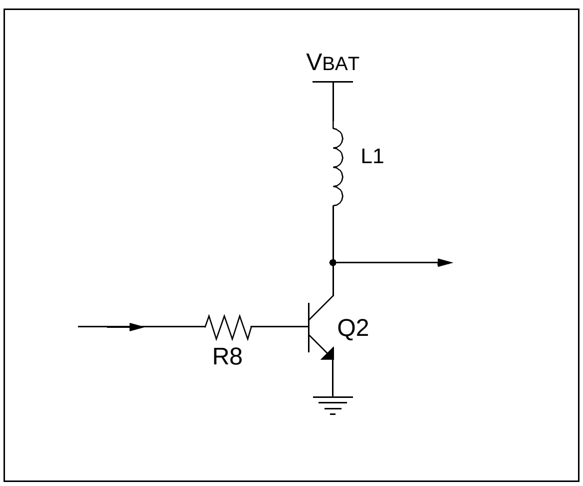


FIGURE 7: INDUCTOR BASED SWITCHER



Software Description

There is no special software required for this application. Simply initialize the comparators by writing 0x06 to the CMCON0 register.

CONCLUSION

Managing the contrast of an LCD in an environment with a wide range of voltages can be challenging. The designs presented in this technical brief provide a good basis to start designing low-cost, low-voltage systems. The PIC16F91X device provides all the features necessary to ensure excellent low-power performance.

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