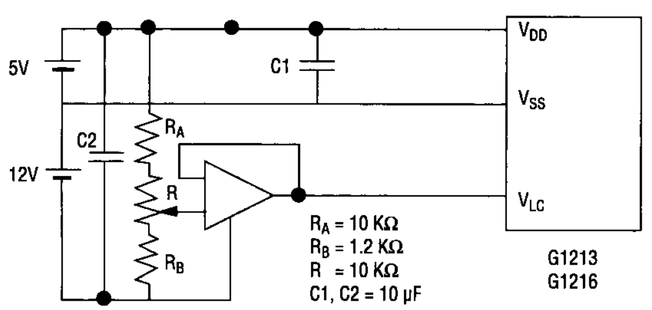
OPERATING VOLTAGE (V_O) VS. TEMPERATURE

				V_O (VOLTS)					
	SIZE	DUTY	BIAS	-20°C	-10°C	0°C	+25°C	+50°C	+70°C
G1213	128 x 32	1/64	1/9	-8.5	-8.3	-8.0	-7.5	-6.5	-5.5
G1216	128 x 64	1/64	1/9	-8.5	-8.3	-8.0	-7.5	-6.5	-5.5
G121C	128 x 128	1/128	1/10	-17.0	-16.5	-16.4	-15.1	-13.7	-12.2
G191C	192 x 128	1/128	1/12			-13.4	-12.4	-11.3	
G2436	240 x 64	1/64	1/9			-8.0	-7.0	-5.5	
G242C	240 x 128	1/128	1/12			-15.0	-12.0	-11.2	
G321D	320 x 200	1/200	1/15			-18.0	-17.0	-15.2	
G321E	320 x 240	1/240	1/13			-17.8	-16.2	-15.3	
G324E	320 x 240	1/240	1/13			-19.0	-18.0	-17.1	
G648D	640 x 200	1/200	1/15			-18.0	-17.5	-15.5	
G649D	640 x 200	1/200	1/15			-18.0	-17.1	-15.3	

CONTRAST ADJUSTMENT CIRCUITS

Display screen contrast and viewing angle are affected by changes in the liquid crystal operating voltage (Vopr) and the ambient temperature. Here are some suggested circuits for maintaining optimum contrast.

G1213, G1216

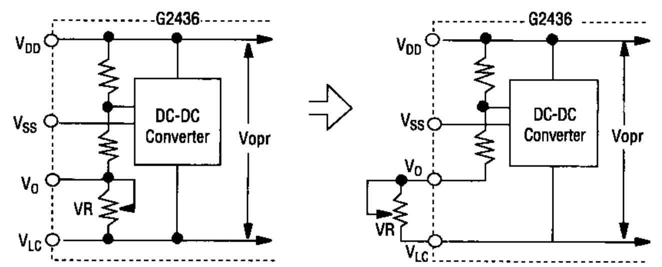


G2436

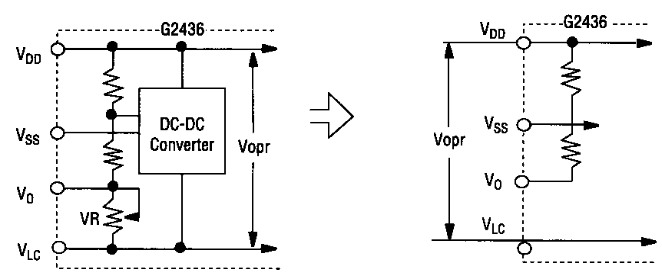
The DC/DC converter internally generates the power supply voltage (V_{LC}). Also, the G2436 has a built-in variable resistor (VR) which controls V_{LC}. When V_{LC} is changed, the liquid crystal operating voltage (V_{opr}) changes. This changes the display screen contrast.

When the VR is supplied external to the G2436, or when the DC/DC converter is not used, the circuit must be changed as follows.

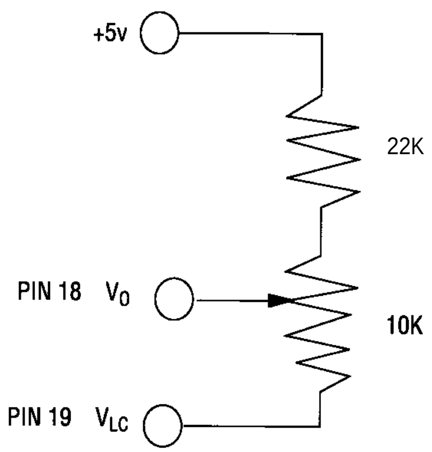
When the VR is supplied external to the G2436: remove the VR, and supply 100KΩ of variable resistance between V_O and V_{LC}.



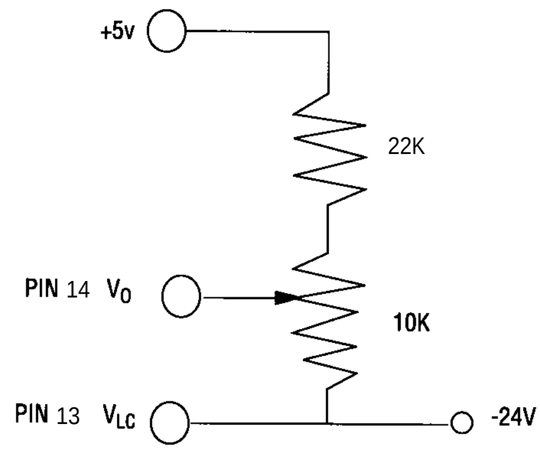
When the DC/DC converter is not used: remove the DC/DC converter and the VR, and apply V_{opr} to the V_{LC} terminal. Set V_O to NC.



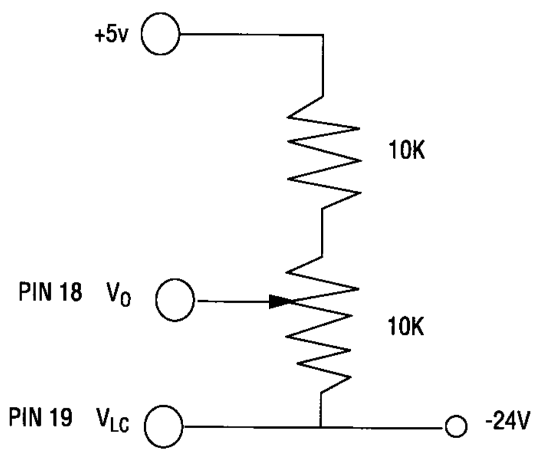
G242C



G649D



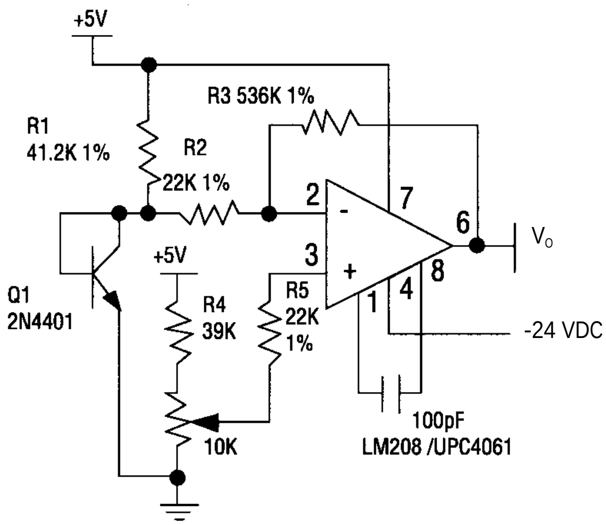
G321D, G324E, G321EV



LCDC-1330 CONTROLLER BOARD

- Apply (V_{LCD}) (V_0) to pin 16 of CN1 (e.g., -1 5V for G191C)
- Use a 10KΩ potentiometer on CN3 to adjust V_O

TEMPERATURE COMPENSATION



Temperature Compensation Circuit

The temperature sensitivity of the base to emitter voltage of a 2N4401 is used to provide automatic temperature compensation to the drive voltage of the STN LCD.

Define V_{be} as the base to emitter voltage of the 2N4401 transistor and V2 as pin 3 of the OP AMP.

Assuming a temperature coefficient of the STN LCD of -55mV/°C, and temperature coefficient of the transistor of 2.3 mV/°C.

The gain is defined as:

$$\text{Gain} = \frac{\text{Temp. coef. of STN LCD}}{\text{Temp. coef. of transistor}} = \frac{-55\text{mV}}{-2.3\text{mV}} = 23.9$$

From the OP AMP circuit, output of the OP AMP is:

$$V_{out} = -\frac{\text{feedback resistor}}{\text{input resistor}}(\text{Inverting I/P - non-inv. I/P})$$

$$= -\frac{R3}{R2}(V_{be} - V2)$$

If we choose R2 = 22K ohm, R3 = Gain x R2
= 23.9 x 22K ohms
= 536K ohms

$$\text{Therefore, } V_{out} = -\frac{536K}{22K}(0.6 - V2)$$

The trimmer of the OP AMP is adjusted at room temperature (25°C) resulting in pin 3 of the OP AMP to be at V2 = 0.272 V.

$$\text{Then, } V_{out} = -\frac{536K}{22K}(0.6 - 0.272)$$

$$= -7.9912V$$

If the temperature is decreased 1°C, the temp. coef. of the 2N4401 transistor is increased by 2.3mV.

So, V_{be} = 0.6V + 2.3mV = 0.6023V

The output of the OP AMP at 24°C

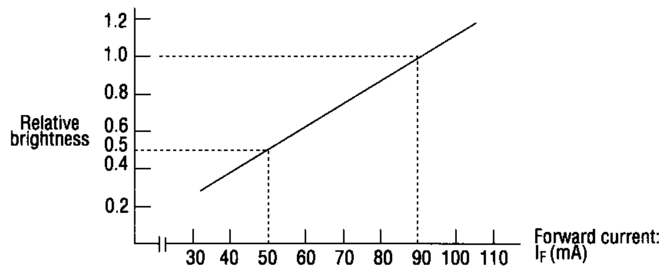
$$V_{out} = -\frac{536K}{22K}(0.6023 - 0.272) = -8.47V$$

Then the output of the OP AMP is increased by 55mV when the temperature drops by 1°C.

Adjust the gain of the OP AMP to match the temperature performance of the display you are using.

LED BRIGHTNESS

The surface brightness of the LED backlight varies with the forward current.



G1216 Forward Current-Brightness Characteristics (Ta = 25°C)

The forward current must be reduced at high temperatures to maintain the LED within safe operating limits.

MODEL	I_F@ 25°C	I_F@ 70°C
G1213	50 mA	25 mA
G1216	100 mA	50 mA
G121C	120 mA	48 mA

In addition, the forward voltage will change with temperature. Here are examples for the G1213, G1216, G1226:

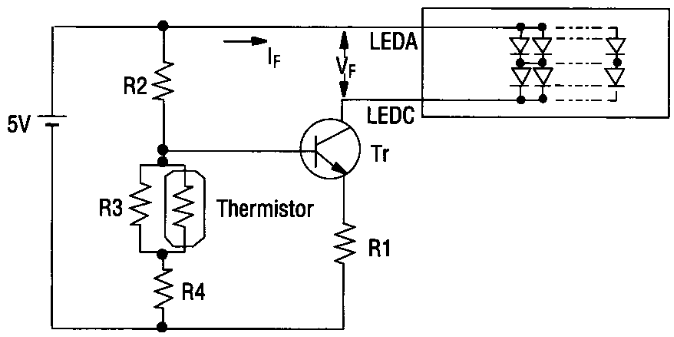
G1213 FORWARD VOLTAGE AT TEMPERATURES

Temperature (Ta)	Conditions	$V_F$min.	$V_F$typ.	$V_F$max.
-20°C	IF = 40 mA	3.7V	3.9V	4.2V
+25°C	IF = 40 mA	3.6V	3.8V	4.1V
+70°C	IF = 25 mA	3.4V	3.6V	3.9V

G1216 FORWARD VOLTAGE AT TEMPERATURES

Temperature (Ta)	Conditions	$V_F$min.	$V_F$typ.	$V_F$max.
-20°C	IF = 90 mA	3.9V	4.3V	4.6V
+25°C	IF = 90 mA	3.8V	4.1V	4.4V
+70°C	IF = 50 mA	3.5V	3.7V	3.9V

To keep the brightness at 25°C, use a thermosensitive element, like a thermistor, and a transistor as shown. Set the thermosensitive element to about IF at 25°C and configure it so that I_F and V_F will be reduced as the temperature rises.



REDUCING SCREEN FLICKER

The 1330 controller chip is constantly reading the VRAM on board to refresh the screen, and when the user is also writing to the VRAM, interference may occur which will show up as scattered noise on the screen.

The only tool given to avoid this is the status register read. Bit 6 of this register goes LOW during the time interval within which it is safe to write to the VRAM without corrupting the screen image.

To utilize this, constantly read this register, and when bit 6 goes LOW, begin writing to VRAM. The register must still be intermittently read at this point, and when bit 6 goes HIGH, writing must stop.

The amount of time available is directly proportional to TC/R - CR, where these are the System Set instruction code parameters. C/R is defined by the number of lines in your display. TC/R must be > C/R + 4. To gain extra time in which to write to VRAM, make TC/R larger.

As TC/R increases, however, the overall frame time will decrease. It is normally around 70 Hz. If TC/R is made twice C/R, the frame time should roughly halve. The formula relating TC/R and frame rate is Fosc >= TC/R x 9 x ~~F x fFR.

As an example, the G321D has a 6MHz clock cycle, and each memory byte takes approximately 9 oscillator cycles. You can calculate approximately how much time you have per line to write to VRAM, and how much the frame rate will be slowed down by increasing TC/R.

If you make TC/R = 50 decimal, with C/R = 40 decimal, then you should have approximately 15μsec.s per line in which to write your graphics data. If you send your data at a cycle time of 0.5 MHz (one byte every 2 microseconds), you could send about 7 bytes per line. Thus it would take about 6 timing rows to input one new line, or about 6 frame times to input one entire new frame. At TC/R = 50, frame time is about 15 msec.s (above formula). Thus it should take about 90 msec.s to input a new frame of data.