SLED4C
Serial LED 4-Digit Clock Display Module

General Description

The SLED4C provides a simple 3-wire synchronous serial interface to a high contrast, four-digit seven-segment super red LED display module. Using the SLED4C reduces the number of MCU I/O-pins for display control from 13 to a mere 3 I/O-pins. These 3 I/O-pins control 35 individual LEDs on the display module consisting of four seven-segment display digits, four right-hand decimal points, two LEDs for the colon, and one additional upper right-hand decimal point.

Embedded designs integrating colorful and highly visible 4-digit LED displays will recover up to 10 valuable MCU I/O-pins for other tasks, and multiple SLED4C display modules can share a common serial bus. Sharing the data and clock pins on the serial bus allows additional display modules to be added to the design with only one I/O-pin required for each additional display module enable pin.

Features

- Onboard display controller maintains display contents eliminating the need for continuous display update/refresh loops in firmware
- Wide viewing angles with extended viewing distances compared to LCD type displays
- Supports serial data clock rates up to 4MHz
- 3-wire synchronous serial protocol compatible with Motorola™ SPI, National Micro-Wire™ and Parallax BASIC Stamp™ SHIFTOUT command
- Automatic LED display refresh rates up to 1.9kHz
- Onboard display controller outputs 7-segment format numerals 0 to 9, hexadecimal characters A to F, plus 15 additional letters and symbols with hexadecimal, special, and no decode modes
- Special circuitry minimizes EMI during normal display operation, and eliminates EMI completely during power-down mode
- Single byte configuration register for display mode and power-down control
- Low-power mode extinguishes all display LEDs and restores last display digits on return to normal power mode
- Low-power mode quiescent current draw ~100uA typical
- Flexible operating voltage range from 4.5 to 5.5VDC
- Small foot-print PCB measuring 2.4" x 1.2"
- Power-on reset automatically blanks display independent of power supply ramp up time
- Serially controlled display brightness switching between 50% to 100%
- Optional display brightness control with external potentiometer, fixed resistor, or CDS photocell for manual or automatic intensity adjustments under variable lighting conditions
- Multiplexed operation for reduced power consumption

Operation:

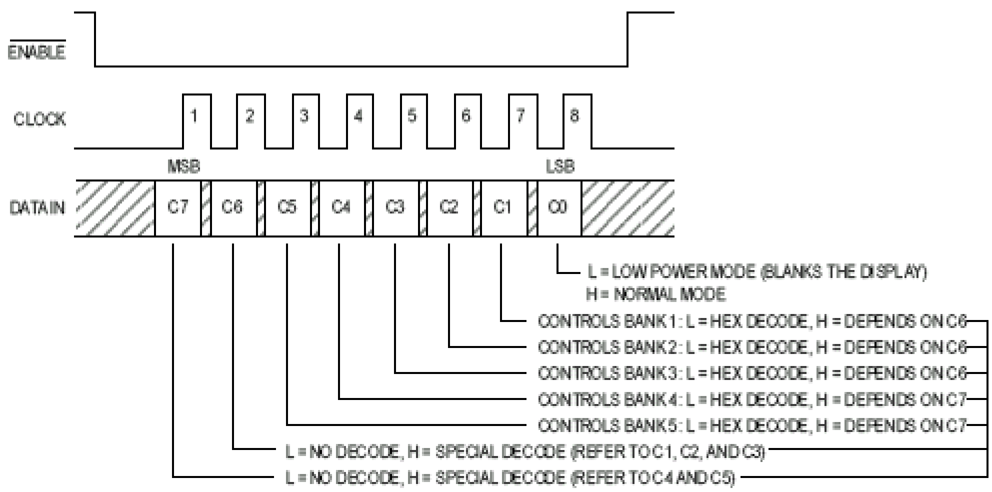
On power up, the SLED4C display controller will automatically blank all LEDs regardless of the power supply ramp-up time, eliminating random display of data on power-up.

A single byte-sized register is used to set the display decode configuration modes, and for control of power-down and normal power mode. Once the display has been configured, 24-bits representing the data to be displayed on the LED digits is clocked into the display.

Display Configuration Register

A single byte written to the display configuration register will set the decode mode for each display bank, and control power-down/normal power modes. The most significant 7-bits of data written to the configuration register determine how data for individual digits in each bank will be decoded & displayed. The least significant bit of the configuration byte controls the display power-down and normal power modes as illustrated below in figure 1.

The enable pin should idle at logic 1. The clock pin should idle at logic 0. Taking the enable pin to logic 0 enables data entry into the display configuration register. Each data bit is placed on the data input pin, and the clock pin transition from 0 to 1 clocks in each bit. At the end of each data packet the enable pin is returned to logic 1 transferring data into the display configuration register. Multiple display modules can share the same clock and data bus with only a single enable pin required for each display module.



(1 Byte) Configuration Register

Figure 1 SLED4C Configuration Register

The two most significant bits of the configuration register C7 and C6 control the decode modes for LED banks 1 through 5. All data must be shifted into to the SLED4C display most significant bit first, while the enable pin is low. After the 8^{th} clock and data bits, the enable pin is returned to logic 1 to complete the write cycle, and transfer data into the display configuration register.

Decode Modes

Three decode modes are available to set how data will be displayed on each LED. An 8-bit value of $FF in the configuration register would set banks 5, 4, 3, 2 and 1 to *special decode* mode. In *special decode* mode all LED banks will display the special characters as shown below in figure 2 under the *special decode* column when the corresponding hexadecimal values shown under the *bank nibble value* column are shifted into the display register.

In *hex decode* mode, numerals 0–9, and characters A-F shown under the *hex decode* column in figure 2 will be displayed. The values shown under the *bank nibble value* column, when sent to the display registers, will cause the module to display the numerals and characters shown under the hex decode, special decode, and no decode columns as shown in figure 2 dependent on the decode mode selected for each display bank in the display configuration register.

The *no decode* mode as shown below in figure 2 will light only LED segments A, B, C and D on each of the seven-segment LED display digits. This mode may be of use for special applications or special effects. Refer to the sample code provided with the SLED4C display module for various examples of hex & special decode modes in use.

Bank Nibble Value		Hex and Special Decode Modes 7–Segment Display Characters		Lamp Conditions No Decode (Invoked via Bits C1 to C7)			
Hexadecimal	Binary MSB LSB	Hex Decode (Invoked via Bits C1 to C5)	Special Decode (Invoked via Bits C1 to C7)	d	c	b	a
$0	L L L L	0					
$1	L L L H	1	c				on
$2	L L H L	2	H			on	
$3	L L H H	3	h			on	on
$4	L H L L	4	J		on		
$5	L H L H	5	L		on		on
$6	L H H L	6	n		on	on	
$7	L H H H	7	o		on	on	on
$8	H L L L	8	P	on			
$9	H L L H	9	r	on			on
$A	H L H L	A	U	on		on	
$B	H L H H	b	u	on		on	on
$C	H H L L	C	y	on	on		
$D	H H L H	d	-	on	on		on
$E	H H H L	E	=	on	on	on	
$F	H H H H	F	o	on	on	on	on

Figure 2 SLED4C Digit Decode Modes

As shown above in figure 2, the 4-bit bank nibble values and bank decode modes determine how received data will be decoded and displayed on the seven-segment LED digits.

Display Register

After configuring the display by writing to the 8-bit display configuration register, data for display on each LED digit can be clocked into the 24-bit display register. As shown in figure 3, the MSB (most significant bit) D23 is used to set the display brightness. A logic 0 in bit position D23 sets the display intensity level to 50% as set by the onboard 10K Rx resistor, external potentiometer, fixed resistor, or CDS photocell. Logic 1 in this bit position will set the display intensity to 100%.

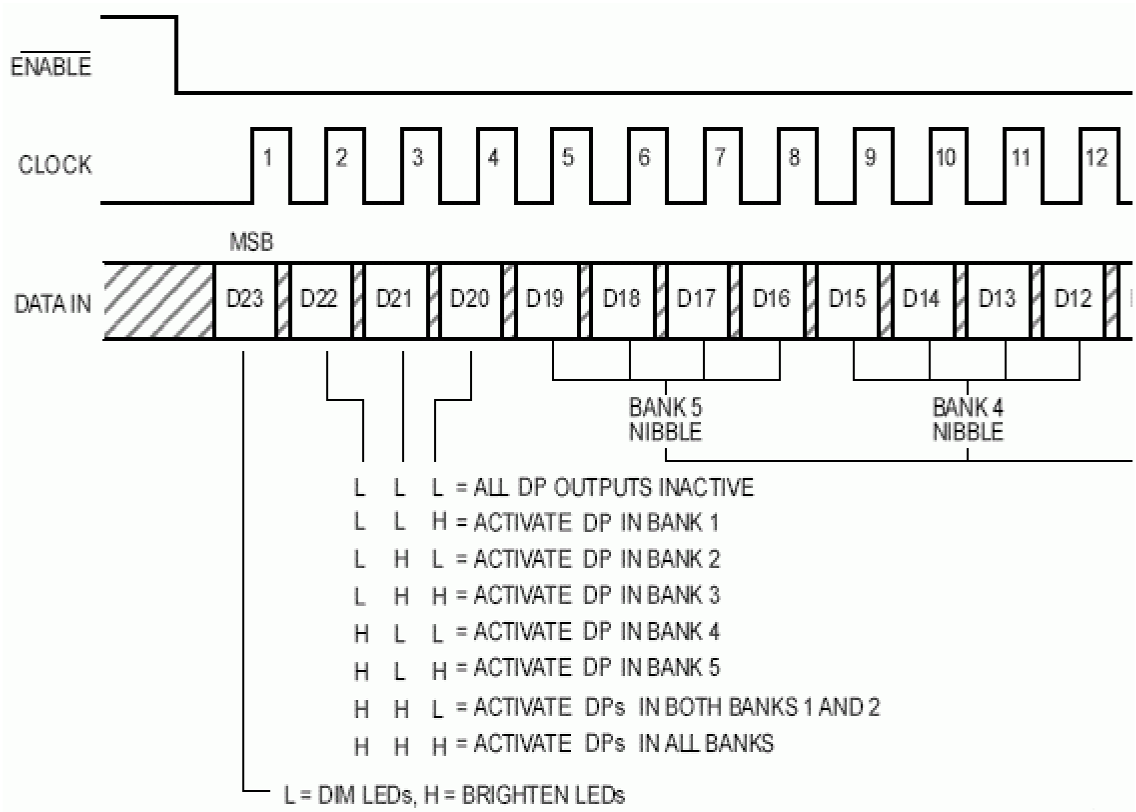


Figure 3 SLED4C Display Register

Figure 3 shows one half of a 24-bit display data packet being shifted into the display register. The display register must receive a total of 24-bits before the enable pin returns to logic 1. This 24-bit display data packet is clocked in MSB (most significant bit) first. As shown in figure 3, bit position D23 controls the display brightness setting. Bits D22, D21 and D20 are used to turn on or off the four right-hand decimal points.

The remaining 20 data bits D19 to D0 are the bank nibble values for display banks 5, 4, 3, 2 and the colon, which is controlled by bank 1. Each bit of the 24-bit packet is clocked into the display register on a low-to-high transition of the clock pin, MSB first.

As shown below in figure 4, display bank 5 is the leftmost seven-segment LED digit. Bank 4 is the 2nd digit from the left. Bank 3 is the 3rd digit from the left. Bank 2 is the right digit, and bank 1 controls the display colon LEDs L1, L2 and the right-hand upper decimal point LED labeled L3.

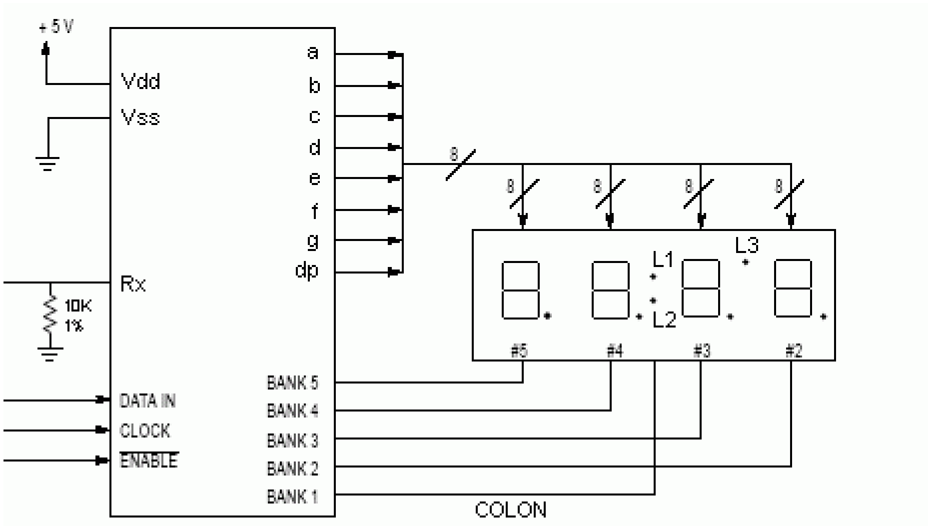


Figure 4 SLED4C Display Module Schematic

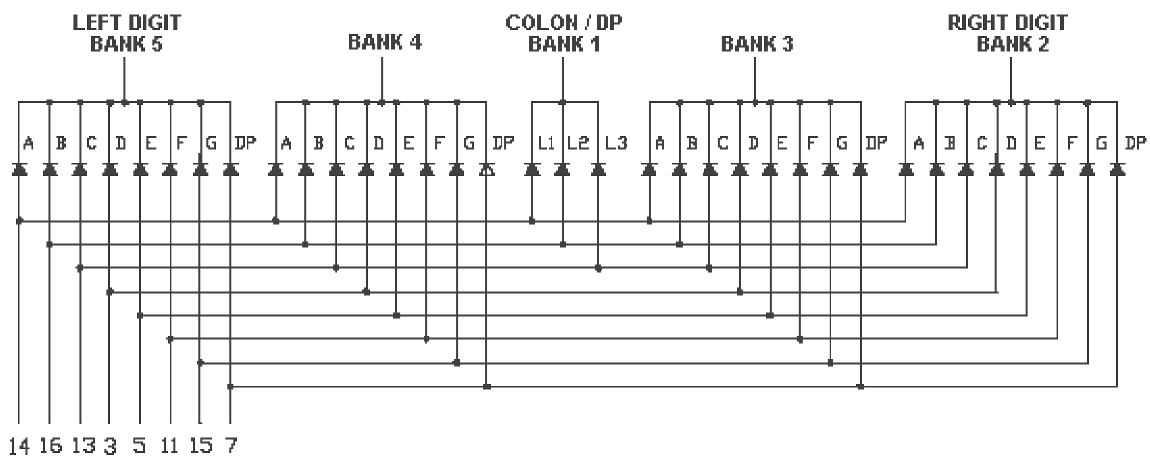


Figure 5 Multiplexed LED Segments & Bank Wiring Diagram

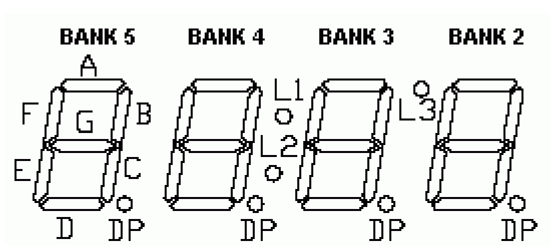


Figure 6 SLED4C Seven-Segment Display LEDs

The display colon LEDs L1 and L2 will be turned on by any value shifted into the display bank 1 register that causes seven-segment LEDs A and B to light. The colon may be turned off by any value written to the display bank 1 register that turns segments A and B off.

Listing 1 shows a simple BASIC Stamp2 program to turn the colon LEDs off, turn off all decimal points including the upper L3 LED, configure banks 5, 4, 3 and 2 for hex decode, then display a count from 0 to 1000 on the SLED4C display module.

Note that the display configuration register does not need to be written each time. This is only necessary to initially configure the display, change decode modes, or toggle between power-down and normal power modes.

```
'{$STAMP BS2}
'{$PBASIC 2.5}

EN      PIN 0     ` Enable pin to SLED4C pin #5
CLK     PIN 2     ` Clock pin to SLED4C  pin #4
DOUT    PIN 3     ` Data out pin to SLED4C pin #3
X       VAR WORD
D5      VAR BYTE
D4      VAR BYTE
D3      VAR BYTE
D2      VAR BYTE

Counter:           ` Count from 0 to 1000

CFG CON %11000011   ` Banks 5,4,3,2 HEX decode, bank 1 special decode
GOTO Config          ` Configure display decode modes, display ON

Display:     ` Now write data to the display register

   D2=0 : D3=0 : D4=0 : D5=0 ` Load counter with 0000 on start

   FOR X = 0 TO 1000  ` Count from 0 to 1000
     EN = 0              ` Enable data input into display register
     IF D2 > 9 THEN D2=0 : D3=D3+1 ` Increment higher digit when > 9
     IF D3 > 9 THEN D3=0 : D4=D4+1 ` on lower digit for BCD count
     IF D4 > 9 THEN D4=0 : D5=D5+1
     IF D5 > 9 THEN D5=0         `          dim      5      4      3      2    :=OFF
     SHIFTOUT DOUT, CLK, MSBFIRST, [%0000\4, D5\4, D4\4, D3\4, D2\4, $0\4]
     EN = 1             ` Transfer data into display registers
     PAUSE 250          ` Pause 250mS between counts
     D2=D2+1            ` Increment counter
   NEXT

Config: ` Write to display configuration register

  EN = 0                      ` Enable register data input
  SHIFTOUT DOUT, CLK, MSBFIRST, [CFG] ` Write contents of CFG variable to display
  EN = 1                      ` Transfer data into configuration register
  GOTO Display
```

Listing 1 BASIC Stamp Program Example

Setting/Controlling Display Intensity

The SLED4C display module includes an onboard 10K 1% current-setting resistor, which sets the peak segment drive current to approximately 1.5mA per LED segment. An external resistor may be connected from ground to the display module pin #1 labeled Rx as required to change or adjust the default display intensity.

An external fixed resistor, potentiometer or CDS LDR (light dependant resistor) may be used as required to change or make adjustments the default display intensity. Connecting the external resistor between pin #1 and ground places the external resistor in parallel with the onboard 10K 1% Rx resistor.

Figure 7 illustrates the relationship between the Rx resistor value, and peak LED segment drive current levels.

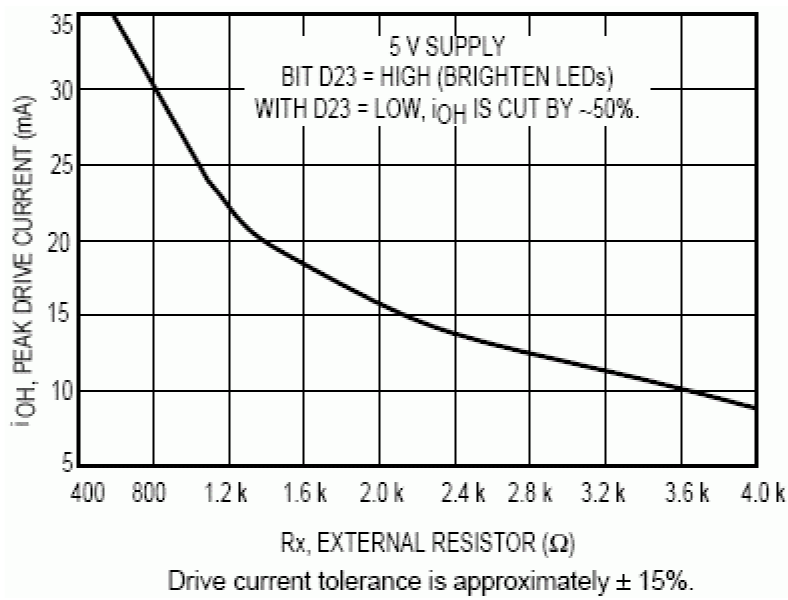


Figure 7 A Through DP Nominal Segment Current Output VS Rx

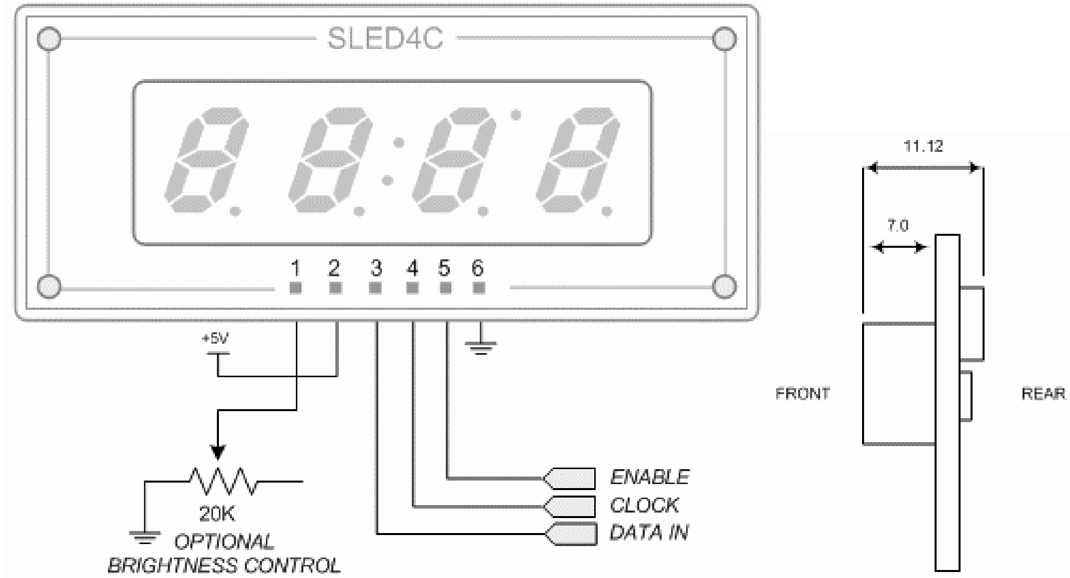
Note: When placing an external display intensity control resistor between the display Rx pin and ground, the external resistor will be in parallel with the onboard SLED4C 10K 1% Rx resistor. The following equation may be used to determine the total parallel resistance.

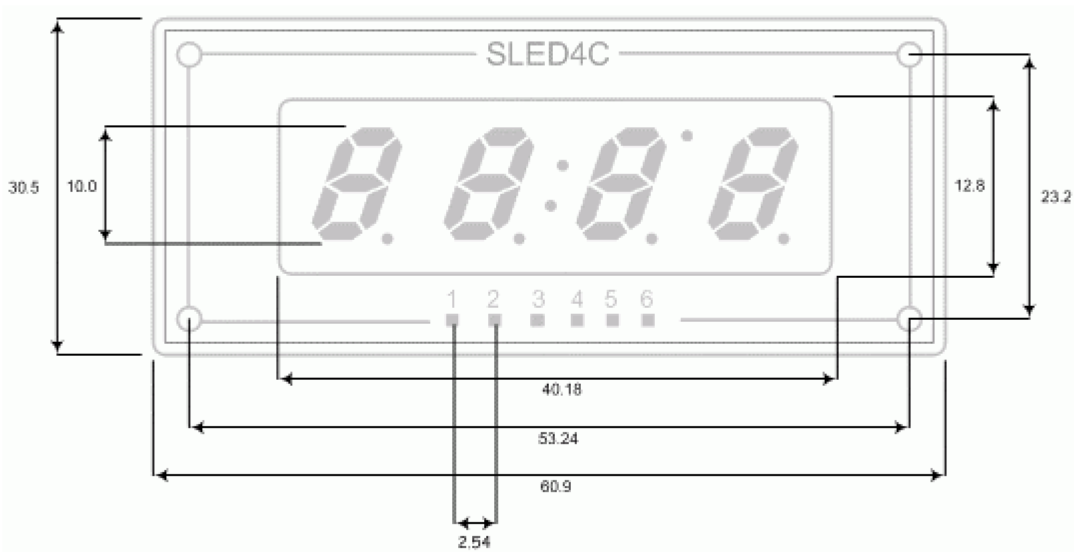
Rt = Parallel resistance total
R1 = SLED4C onboard 10K 1% Rx resistor
R2 = External resistor connected between the SLED4C Rx input pin #1 and ground

Rt = R1 x R2 / R1 + R2. To set an approximate maximum current of 18mA per segment, use an external resistor value of 2K. Rt = 10K x 2K / 10K + 2K = 20,000,000 / 12,000 = 1.6K. As shown in figure 7, 1.6K results in ~18mA peak drive current.

The drawing on page 8 illustrates one optional method of using an external 20K potentiometer for manual display intensity control.

For automatic display intensity control in varying ambient lighting conditions, the potentiometer may be with a CDS LDR (light dependant resistor) for automatic display intensity control.





Note: All dimensions in mm

Code examples supporting the BASIC Stamp™, PicBasic Pro™ compiler, and CCS C™ compiler may be downloaded from http://www.rentron.com/Products/SLED4C.htm .

These examples include a 4-digit time and temperature display with Dallas Semiconductor DS1620 temperature sensor, and DS1307 real time clock ICs, several counter examples, a lamp test routine, how to display text messages OUCH and H.E.L.P., using power-down mode, and other display test routines.