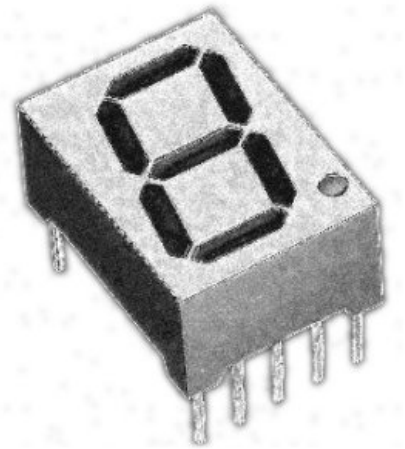
binary/bcd to 7-segment decoder

for PIC16F627A / 16F628A



- Page last updated: July 24, 2018

Overview

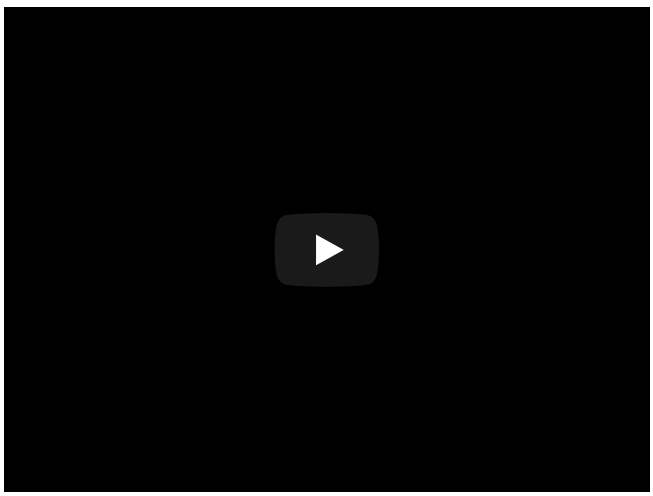
This is a building block project I developed to try out a few ideas. It decodes a 4-bit binary word to outputs that will drive a 7-segment LED display. Functionality it is similar to the 7447 BCD-to-seven-segment decoder/driver IC. However, because it's implemented using a microcontroller, the segment control data can be customised to display any set of 16 characters you wish to create. It also has an 'invert' control input that allows it to drive either common anode (active low) or common cathode (active high) LED modules.

Binary/BCD or Gray to 7-segment decoder

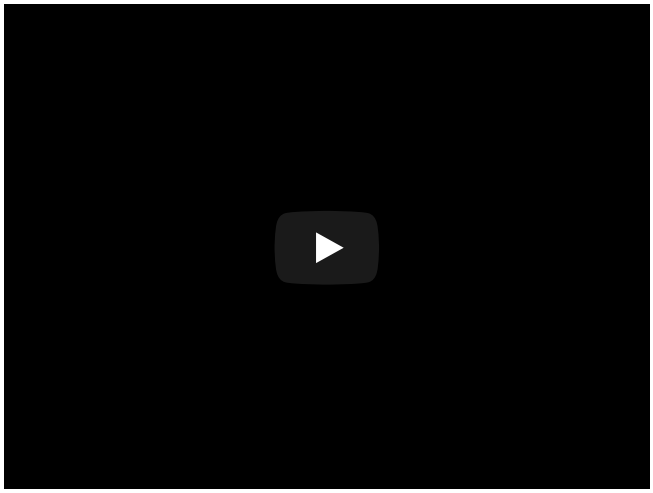
- Depending on firmware:
  - 4-bit binary input to 7-segment decode, 0-9, A-F
  - 4-bit Gray input to 7-segment decode, 0-9, A-F
- Lamp test input
- Zero blanking
- output invert, allows use of common anode or common cathode displays
- input latch
- Outputs rated at 20mA per segment (Max)

Since the decoding is done with a lookup table it is possible to map the binary input to any character on the 7-segment display. There are now two variants of the software available to download, the original 4-bit binary to 7-segment hex decoder and a 4-bit Gray code to 7-segment hex decoder.

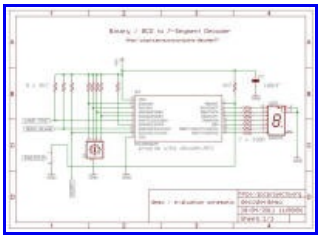
Video clip below shows the board I used to test and develop the code. Actually I developed the code entirely using the Oshonsoft PIC simulator and only did final testing on real hardware. The 8 pin chip on the left side is a PIC12F629 programmed to generate a 4-bit binary count. The green LEDs show the binary input to the decoder which is running the decoderBin.HEX firmware.



Decoder taking Gray code input (decoderGray.HEX firmware). In this clip the 12F629 has been programmed to generate a 4-bit Gray code output.



Schematic



Demo / evaluation schematic

The idea behind this project is that the PIC can be used as a decoder for 7-segment LED displays and therefore it will be built into some other application. The schematic is provided for evaluation only. Since it uses a binary hex rotary switch at the input make sure you use the decoderBin.HEX file and not decoderGray.HEX

Note on the hex rotary switch type.

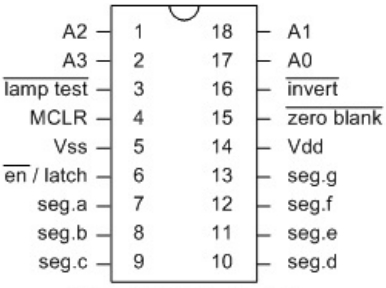
> *The hex rotary switch shown in the schematic is an inverted or complimented output type. That is the internal switches close for a binary 0 and open for a binary 1.*
>
> *If you use a normal/real output type where the switches open for a binary 0 and close for a binary 1 you would need to connect the switch common pin to +5v and the four resistors to Gnd.*

Description

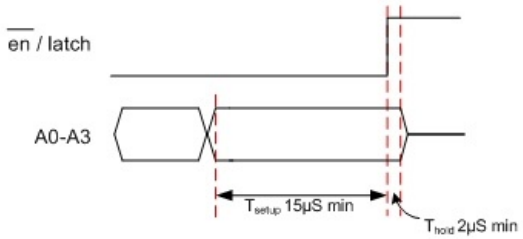
Binary Decode Datasheet

Gray Decode Datasheet

Binary/BCD to 7 segment decoder
Using PIC16F627A / 16F628A



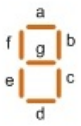
Pull-up resistors required on inputs unless driven. MCLR must be pulled up always



Proprogation delay, A0-A3 to segment outputs: 15µS maximum

en / latch input is high, A0-A3 input data is latched
en / latch input low, outputs follow A0-A3 input data

Input number and corresponding 7 segment output

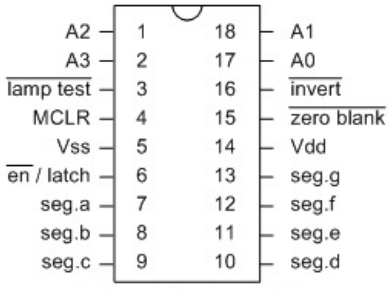


Decimal or Function	Inputs						Outputs						
	$\overline{LT}$	$\overline{ZB}$	A3	A2	A1	A0	a	b	c	d	e	f	g
0	H	H	L	L	L	L	On	On	On	On	On	On	Off
1	H	X	L	L	L	H	Off	On	On	Off	Off	Off	Off
2	H	X	L	L	H	L	On	On	Off	On	On	Off	On
3	H	X	L	L	H	H	On	On	On	On	Off	Off	On
4	H	X	L	H	L	L	Off	On	On	Off	Off	On	On
5	H	X	L	H	L	H	On	Off	On	On	Off	On	On
6	H	X	L	H	H	L	On	Off	On	On	On	On	On
7	H	X	L	H	H	H	On	On	On	Off	Off	Off	Off
8	H	X	H	L	L	L	On	On	On	On	On	On	On
9	H	X	H	L	L	H	On	On	On	On	Off	On	On
10	H	X	H	L	H	L	On	On	On	Off	On	On	On
11	H	X	H	L	H	H	Off	Off	On	On	On	On	On
12	H	X	H	H	L	L	Off	Off	Off	On	On	Off	On
13	H	X	H	H	L	H	Off	On	On	On	On	Off	On
14	H	X	H	H	H	L	On	Off	Off	On	On	On	On
15	H	X	H	H	H	H	On	Off	Off	Off	On	On	On
ZB	H	L	L	L	L	L	Off	Off	Off	Off	Off	Off	Off
LT	L	X	X	X	X	X	On	On	On	On	On	On	On

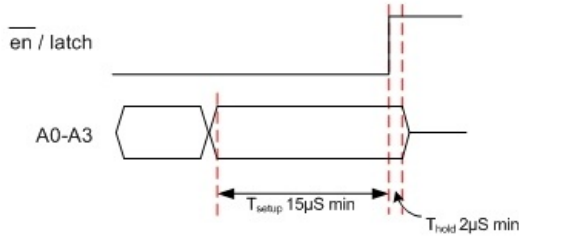
H = high, L = low, X = don't care

Invert input = high , on = high, off = low
Invert input = low , on = low, off = high

4-bit Gray Code to 7 segment decoder
Using PIC16F627A / 16F628A



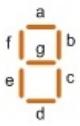
Pull-up resistors required on inputs unless driven. MCLR must be pulled up always



Proprogation delay, A0-A3 to segment outputs: 15µS maximum

en / latch input is high, A0-A3 input data is latched
en / latch input low, outputs follow A0-A3 input data

Input number and corresponding 7 segment output



Decimal or Function	Inputs						Outputs						
	$\overline{LT}$	$\overline{ZB}$	A3	A2	A1	A0	a	b	c	d	e	f	g
0	H	H	L	L	L	L	On	On	On	On	On	On	Off
1	H	X	L	L	L	H	Off	On	On	Off	Off	Off	Off
2	H	X	L	L	H	H	On	On	Off	On	On	Off	On
3	H	X	L	L	H	L	On	On	On	On	Off	Off	On
4	H	X	L	H	H	L	Off	On	On	Off	Off	On	On
5	H	X	L	H	H	H	On	Off	On	On	Off	On	On
6	H	X	L	H	L	H	On	Off	On	On	On	On	On
7	H	X	L	H	L	L	On	On	On	Off	Off	Off	Off
8	H	X	H	H	L	L	On	On	On	On	On	On	On
9	H	X	H	H	L	H	On	On	On	On	Off	On	On
10	H	X	H	H	H	H	On	On	On	Off	On	On	On
11	H	X	H	H	H	L	Off	Off	On	On	On	On	On
12	H	X	H	L	H	L	Off	Off	Off	On	On	Off	On
13	H	X	H	L	H	H	Off	On	On	On	On	Off	On
14	H	X	H	L	L	H	On	Off	Off	On	On	On	On
15	H	X	H	L	L	L	On	Off	Off	Off	On	On	On
ZB	H	L	L	L	L	L	Off	Off	Off	Off	Off	Off	Off
LT	L	X	X	X	X	X	On	On	On	On	On	On	On

H = high, L = low, X = don't care

Invert input = high , on = high, off = low
Invert input = low , on = low, off = high

Operation

The PIC use an internal clock source so no external timing components are required, you will need to fit a decoupling capacitor across the Vdd/Vss supply close to the PIC; 100nF ceramic will do the job. The PIC microcontroller requires a power supply voltage between 3 and 5 volts.

Inputs require an external pull-up resistor unless actively driven by an external source. All unused inputs should be tied to Vdd via a 4K7 resistors. The MCLR input (pin 5) is the microcontrollers reset line and needs to be tied to Vdd via a resistor (anything from 1K to 10K)

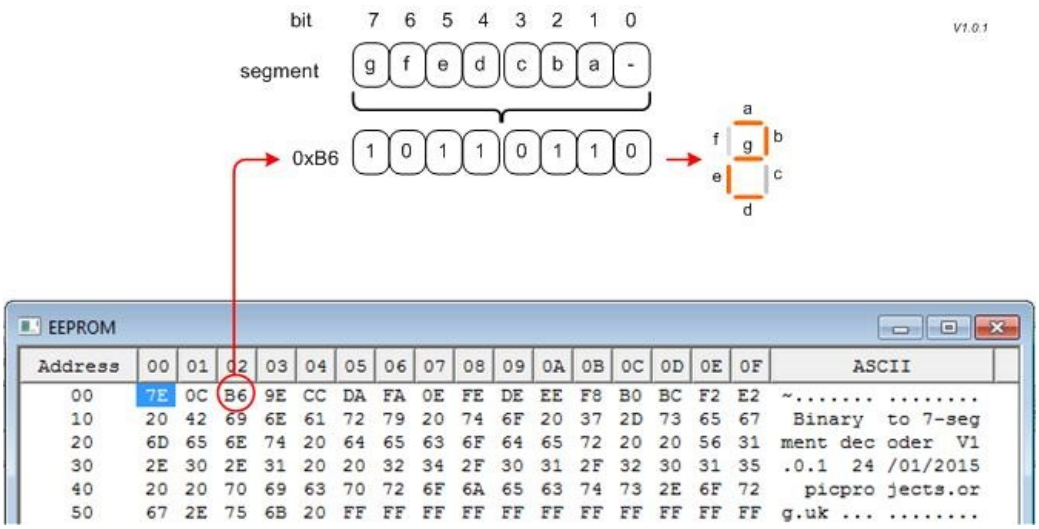
Because the decoder is implemented in software running on the PIC, input to output propagation delay can be up to 15uS from valid data appearing on the A0-A3 inputs to the decoded data appearing on the 7-segment display outputs. Input data on A0-A3 should be held and valid for 15uS before the en/latch input goes high to ensure the correct input data is latched.

Outputs on the PIC16F627A / 628A are rated at 25mA with a maximum of 200mA for all I/O pins. This means it can drive a 7-segment LED display directly (via current limit resistors).

Customizing Segment Data

The segment data used to drive the outputs is held in the EEPROM of the PIC making it easy to edit without having to reassemble the source code.

The data is held at addresses 00 to 0F in the format shown below



Download

Description	Filename	Download link
Source code for 16F627A / 16F628A	decoder.asm *04/03/2013*	download
HEX file ready to program into the PIC. *Use with 16F627A or 16F628A*	decoderBin.HEX *04/03/2013*	download checksum 0x0A86
HEX file ready to program into the PIC. *Use with 16F627A or 16F628A*	decoderGray.HEX *04/03/2013*	download checksum 0x0A86

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