Smart Encoder Interface (SEI) Application Guide
Firmware V1.05 ~ 22 August 2008

Introduction

The SEI coprocessor represents Decade Engineering's replacement strategy for the discontinued BOB-3-S (simple distance display, or SDD version) and similar products. BOB-3-S was embedded on customer-designed host boards along with a 'dumb' encoder interface chip, i.e. US Digital's LS7084. In essence, SEI stands in for the LS7084 chip and works with ***standard BOB-4 modules***. Standard BOB-4 modules are normally available from Decade Engineering stock, without lead-time, and are priced considerably below BOB-3-S. Operator control switch functions are unchanged from BOB-3-S, but the switches now connect to SEI instead of the BOB module. SEI sends display formatting commands and printable data to BOB-4 through its SPI communication interface, using BOB-4 as an SPI slave device.

SEI is implemented in Atmel's ATmega88 (AVR family) microcontroller IC, which is available in TQFP-32 or conventional DIP-28 packages from Atmel distributors. SEI offers several improvements in functionality relative to BOB-3-S, including precise calibration for any reasonable encoder installation. Most of these improvements must be configured through a temporary debug serial port connection to a PC. A simple PC terminal program such as HyperTerminal provides the installer's interface.

SEI object code for chip programming is available without charge from Decade Engineering, giving customers the freedom to manufacture BOB-4 encoder interfaces as desired. Decade Engineering will not supply pre-programmed SEI chips. Please use good engineering practices when implementing the following suggestions. Decade Engineering accepts no responsibility for the use of this information.

Hookup Notes

See schematic attachment for hookup information based on the Atmega88 chip in TQFP-32 packaging and used with unmodified SEI firmware. This schematic was lifted from another project, and it might not include sufficient power supply bypassing to guarantee unconditional stability. Note that vehicle power sources can sometimes develop severe transients. The suggested 5V regulator circuit (U5 and associated components) might not be sufficiently robust for use in a vehicle. National's LM2940 is a possible solution, but watch out for capacitive load issues.

The 3.3V regulator (U6) probably could be deleted, because BOB-4 has a 3.3V auxiliary output with enough juice to power SEI under most conditions. If reliability under high ambient temperature conditions is a priority, then this independent regulator (or something like it) should be retained. Be wary of capacitive load specs for low-dropout regulator ICs; some of them oscillate violently when used with certain types and values of load capacitors.

The AVR-ISP port (J4) allows SEI firmware to be installed and upgraded after PCB assembly. Use Atmel's ATAVRISP2 in-system programming adapter for this purpose. It comes with PC software (AVR Studio) to program firmware into the chip. See: http://www.atmel.com/dyn/products/tools_card.asp?tool_id=3808

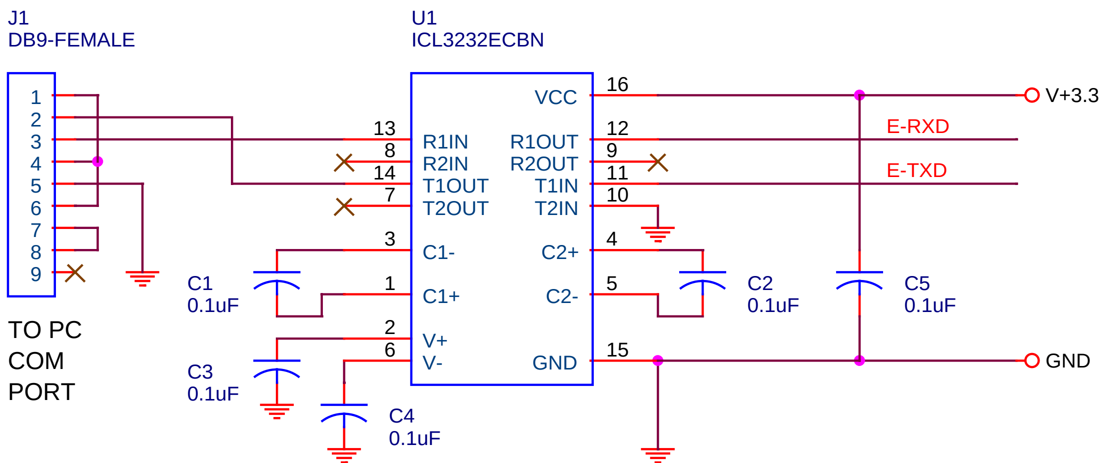
ACR0/SPCK, MISO, MOSI, and SS0\ are the SPI data communication signals for hookup to BOB-4. BOB-4 must be configured as an SPI slave in SPI clock mode 3 to work with the SEI chip. Here's the current BOB-4 App Guide: http://www.decadenet.com/bob4/B4AppGuide.pdf

E-FIG0 and E-FIG1 are SEI configuration lines. Your host board should allow either or both to be grounded. These are currently unassigned, but might be used for debug port baud rate configuration or other purposes.

C7 & C8 (along with U4) are needed to implement the power fail warning system, which lets SEI preserve the most recent count data through a power failure. Power supply holdup time must be >15mS at full system current drain, including encoder. Measure holdup time after open-circuiting the main power supply, from the E-PFW\ signal event to V+3.3 start of decay. A total of 4,700~10,000uF is typically more than sufficient when the raw power supply is near 12VDC.

The LEDs labeled “CH-A” & “CH-B” are optional encoder signal activity indicators. If they track the encoder inputs, it proves that the encoder is functional and SEI is executing its firmware.

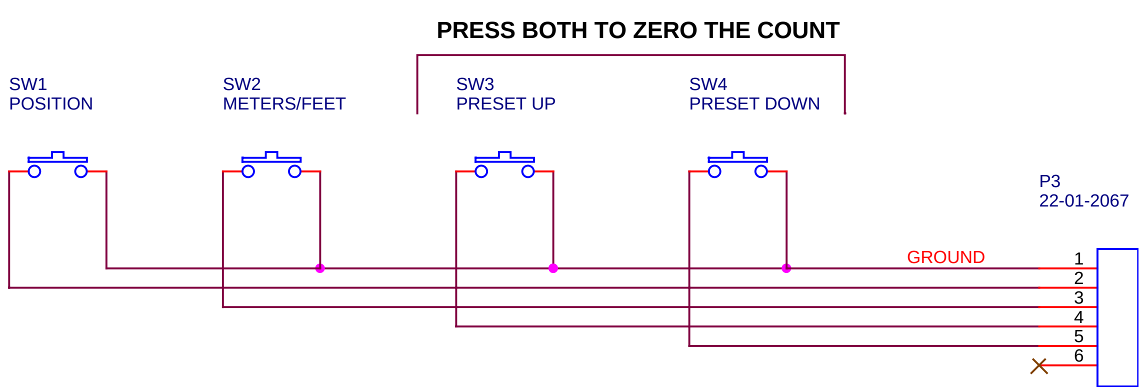
The debug port (J1) provides PC access for SEI configuration and distance display calibration. The required RS-232 interface hardware could be integrated on the customer’s host board, or built into an adapter cable for hookup to the serial COM port of a PC. Here’s an RS-232 interface circuit example:



In this RS-232 interface example, the PC’s hardware handshake signals are looped back so you don’t have to deal with PC handshake setup issues. J1 pin connections are for a standard male/female 9-pin modem cable with all pins wired straight through. This hookup will not work with null-modem cables. Analog Devices’ ADM3202 and TI’s MAX3232 are good subs for the Intersil chip.

SEI firmware supplied by Decade Engineering has the debug port configured to 9600bps, eight data bits, no parity, and one stop bit (8N1).

Four operator control switches must be connected to J3. Note the alternate method of clearing the distance reading described on the schematic. These switches must be Normally Open (NO) momentary type, providing contact closure to ground (J3 pin 1) when activated. Short stroke “tactile” (snap-action) switches are preferred for this application. Use a Molex 22-01-2067 or equivalent crimp terminal housing to mate with a Molex 22-11-2062 header on the PCB.



J3 Pin	Operator Control Connection
1	Ground (switch common)
2	Display Position switch
3	Metric/English switch
4	Count-Up distance preset switch
5	Count-Down distance preset switch
6	N/C

Caution

J3 in the example hookup schematic connects to a set of operator control switches with functions identical to BOB-3-S. No external pullup resistors are needed. As with BOB-3-S, be aware of ESD (electrostatic discharge) hazards here! Sparks happen! Add protective networks if your switches don't guarantee that ESD strikes are shunted to ground.

ATmega88 Chip Programming Notes

Set the following fuses:

Brownout detection: 2.7v
External crystal osc frequency: 8.0- MHz
Startup time PWRDOWN/RESET: 16K CK/ 14 CK + 65 ms [CKSEL=1111 SUT=11]

AVR Studio can read out EE data memory through the AVR-ISP cable after the SEI chip has been configured through the debug interface. If this data is saved to a file and then used to program EE space in subsequent SEI chips, they will inherit configuration settings from the first chip.

Debug Commands

The command prefix **<CSI>** is a two-character escape sequence consisting of two special code bytes: <ESC> (0x1B, Ctrl-[ ), and "[" (0x5B); otherwise known as the <CSI> (Control Sequence Introducer). PC terminal programs normally generate <CSI> with just two keystrokes: "Esc" followed by "[".

c <CSI>n;mc Distance calibration

If **n**=0, the raw count is multiplied by **m** to get feet display. **m** is a positive floating point number with a maximum of 15 digits to the right of the decimal point. If **n**=1, then **m** is the desired display value at the current count (the actual calibration multiplier is calculated internally). For metric display, the result is further multiplied by 0.3048. The default calibration multiplier is 0.1000, which is appropriate for a 10 cycle per foot distance encoder installation.

d <CSI>nd Set number of digits to the right of the decimal point

n = 0~4. Display width is not changed. Default = 1.

f <CSI>nf Set font

For **n**=0 (default), use 12x13 pixel font. For **n**=1, use larger 13x32 font.

p <CSI>n;x;yp Set starting print position (row & column) for each of five display locations on screen

n = data display location, **x** = column position, **y** = row position. See table for default values:

Display Location	Column (x)	Row (y)	Comment
0	0	0	Upper left
1	26	0	Upper right
2	14	7	Center
3	0	15	Lower left
4	26	15	Lower right

Note that a total of six display 'locations' may be selected. The location that's missing from this table is reserved for turning **off** the data display. Locations listed in the Comment column are based on the 12x13 default font and default data field width.

r <CSI>r Restore default configuration values

s <CSI>s Transmit status report

u <CSI>n;mu Set units label

If **n**=0, label is for English units (feet). If **n**=1, label is for metric display. **m** is decimal ASCII code value of character desired for label. If **m**=32, (ASCII <SP>; the space code), no label is displayed. Defaults are "F" and "M". ASCII tables are widely published on the web. Here's one: http://www.asciitable.com/

v <CSI>nv Set video standard

For **n**=0 (default), use NTSC. For **n**=1, use PAL.

w <CSI>nw Number of characters in the data display

n = width of the numeric display *including the sign character but not the units label*. Default is seven characters. With a single place to the right of the decimal (default), the distance data display consists of a sign character, four digits left of the decimal point, a decimal point, and one digit to the right of the decimal point. Also see **d** command.

Obligatory Boilerplate

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FAQ

Useful comments from recent customer communications, collected here for quick publication.

Latest BOB-4 Application Guide: **http://www.decadenet.com/bob4/B4AppGuide.pdf**
Latest version of this document: **http://www.decadenet.com/bob4/SEIAppGuide.pdf**
Latest SEI source code: **http://www.decadenet.com/bob4/SEIsrc.zip**
Latest SEI object code: **http://www.decadenet.com/bob4/SEIhex.zip**

Recent (as of 22 August 2008) versions of the AVR-GCC compiler apparently generate SEI object code that exceeds the 8kB flash memory capacity of the recommended ATmega88 microcontroller chip. The simplest cure is to use an older compiler, i.e. WinAVR Version 20070525 (GCC 4.1.2). Other possibilities include switching to an ATmega168, and porting SEI to a compiler with better AVR code optimization features. IAR is probably a good choice, but that's unconfirmed.

Add more power supply decoupling capacitors if the SEI schematic still shows only one 100nF cap at the processor chip. Four-layer PCBs with continuous ground planes are best, but stable two-layer designs are apparently achievable. Revisit this issue if you select another processor chip or change operating voltage (or clock rate). Note that 3V/5V logic level translators (for SPI) will be needed with 5V MCUs. MC74VHC1GT125DT1G single-gate buffers should handle this job neatly. Avoid logic level translators with internal series resistance, e.g. MAX3001.

Both versions of BOB-4 offer three serial communication interfaces:

[1] The main 'TTL-232' control port
[2] The debug port; also 'TTL-232' style
[3] The SPI port, which is an alternate control port (in slave mode)

SEI is an SPI master. It controls BOB-4 through the SPI (slave) port, so this hookup is mandatory in order to use unmodified SEI firmware. Of course you can modify SEI as desired, but the ATmega88 has only one UART, which we deployed for SEI debugging and configuration.

The BOB-4 SPI port consists of those pins labeled MISO, MOSI, ACR0/SPCK, and SS0\. See the BOB-4 Application Guide for details. ACRx pins must be pulled up (not tied high) or grounded, to configure the control ports, except that ACR0/SPCK is SPI clock input in SPI slave mode.

We recommend including at least a minimal connector footprint for the debug port (DTX and DRX) in all BOB-4 application board designs. For convenience, add a ground pin and a +3.3V power pin (to power an RS-232 interface chip).

That 1/4 ohm resistance in series with pin 2 of the NCV1117 regulator chip guarantees that it won't oscillate. If you read the NCV1117 data sheet closely, you will see that instability is possible with ceramic capacitors directly on this chip's output line. Many low-dropout regulators exhibit similar quirks. NCP5501DT33G is a possible alternative, but note the pinout difference.

Decade Engineering does not publish BOB-4 schematics at this time. The BOB-4 App Guide provides detailed pinout information, hookup guidance, and a mechanical drawing to assist with BOB-4H host PCB design. We can supply a SIMM socket drawing for BOB-4S, but we recommend against using this version of BOB-4 in new applications with ongoing production requirements.

SEI can process more than 200,000 encoder phase transitions or 50,000 complete quadrature cycles per second when running V1.04 firmware at 9.8304MHz.

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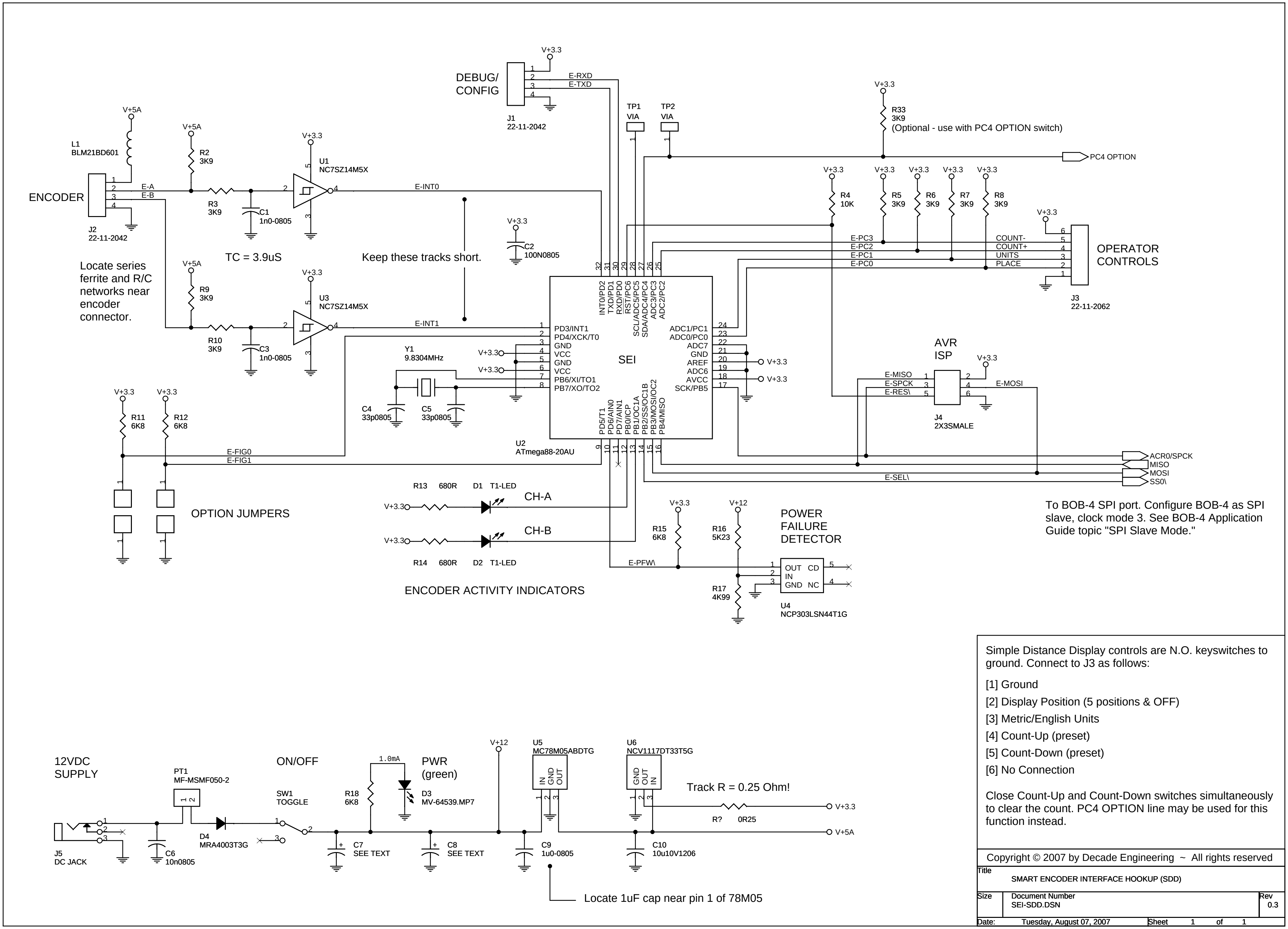

Simple Distance Display controls are N.O. keyswitches to ground. Connect to J3 as follows:

[1] Ground

[2] Display Position (5 positions & OFF)

[3] Metric/English Units

[4] Count-Up (preset)

[5] Count-Down (preset)

[6] No Connection

Close Count-Up and Count-Down switches simultaneously to clear the count. PC4 OPTION line may be used for this function instead.

Title	SMART ENCODER INTERFACE HOOKUP (SDD)
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Rev	0.3
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Sheet	1 of 1