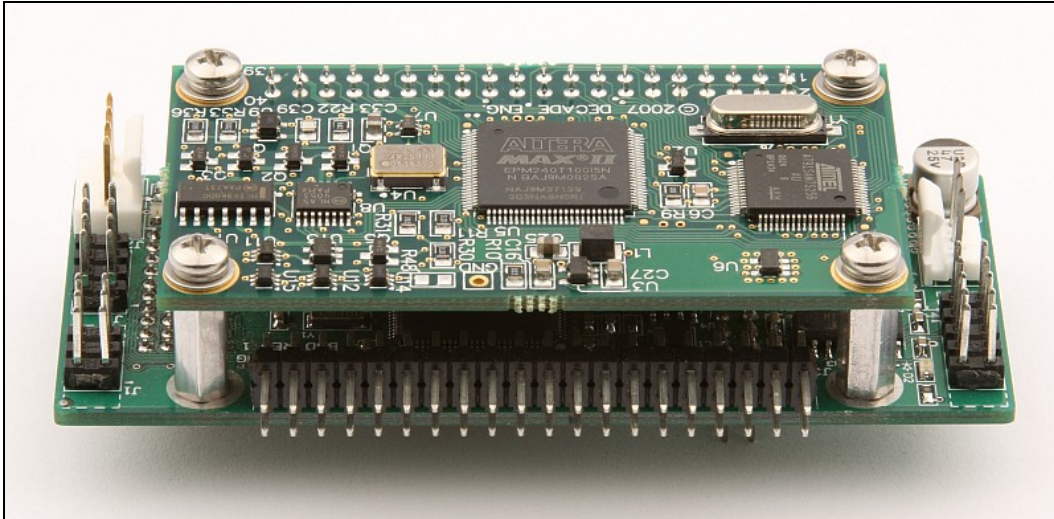




BUD-1H Application Guide Preliminary ~ 30 March 2012

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BUD-1H shown with optional BOB-4H module mounted on top

Introduction

BUD-1H is a compact demo/developer ‘buddy’ board for Decade Engineering’s BOB-4H video information overlay modules. It delivers sufficient local processing power and peripheral interfaces to completely implement many BOB-4H customer applications. Demonstration software supplied by Decade Engineering allows first-time users to immediately exercise the combined functionality of BUD-1H and BOB-4H. GPS data display, TV Typewriter, and Real-Time Clock example programs are currently available.

BUD-1H can also serve as a general-purpose Atmel ATmega640 microcontroller developer board, with or without the piggyback BOB-4H module. With BOB-4H installed, BUD-1H can easily generate complex text and graphics displays on conventional TV monitors.

Please use this document together with the [BUD-1H schematic drawing](#), which is published separately on the Decade Engineering website.

Hardware Description & Specifications

MCU: The BUD-1H system processor is an [Atmel AVR-series ATmega640](#) running on 5V power at 14.7456 MHz. This microcontroller chip has much to offer embedded system developers, including 64KB of in-system programmable (ISP) flash memory, numerous on-board peripherals, and impressive execution speed resulting from its full-instruction-cycle per clock cycle core design. BUD-1H ships with an RS-232 serial bootloader installed, so it’s unnecessary to purchase additional device programming equipment. For those who must have full control over MCU flash memory space, the six-pin ISP header (J1) on BUD-1H is compatible with Atmel’s low-cost [AVRISP mkII](#) USB programming adapter. An optional (customer-installable) JTAG TAP connector (J2) is available on the PCB backside. This 10-pin port is compatible with Atmel’s [JTAG ICE mkII](#) in-circuit emulator, for customers who

require debug visibility inside the processor. Atmel's free [AVR Studio](#), the free (GNU) AVR-GCC C compiler, and a number of low-cost BASIC compilers support AVR software development.

I/O: Many of the processor's most useful I/O pins are brought to a conventional 0.100" pitch 2x20 right-angle general-purpose input/output (GPIO) pin header (J3) for convenient application hookup. Except for PG5, which drives a red LED (D2), the remaining processor I/O pins that are not dedicated to internal functions are brought to a pair of optional (customer-installable) 2mm backside headers at J9 and J10.

Serial com: Four USARTs are available on the ATmega640. One is committed to internal BOB-4H communication. A second USART is interfaced for direct connection to a PC COM port at J4, which is pinned out for convenient PC hookup with ribbon cable and IDC connectors. The two remaining USARTs are brought out to the GPIO header, along with an industry-standard RS-232 hardware interface (hookup option) for one of these. Note that USARTs support synchronous communication (e.g. SPI) as well as RS-232-style async communication.

ADC: Four of the processor's port F analog voltage input pins, and all (eight) of port K are brought to the GPIO connector. PF0~PF3 are 'preferred' ADC inputs, due to better grounding provisions. The 10-bit ADC is furnished with a precision ($\pm 0.1\%$ @ 25°C) on-board voltage reference of 4.096V, which defines the upper limit for direct voltage measurement. To support ratiometric measurement, this voltage reference is also available as a dedicated output on the GPIO port.

Data memory: The processor has 4KB of on-board EEPROM. An optional (customer-installable) Atmel AT45-series DataFlash[™] memory chip is attached to the processor's SPI port. As an example, 4MB of user data memory would be available with an AT45DB321D installed in this position. A second optional DataFlash[™] chip may be installed for BOB-4H font memory expansion.

RTC: An NJU6355 real-time clock chip connects to BUD's processor via ordinary I/O pins. The RTC chip's oddball serial interface is supported by bit-banging software (example provided). Timekeeping power may come from an optional (customer-installable) on-board lithium coin cell or from an off-board source, through the power supply connector. To implement the on-board power option, install an Eagle Plastic Devices 122-2820-GR coin cell mount and 20mm coin cell type BR2032 (Panasonic) or equivalent.

Power: BUD-1H accommodates 6~12VDC unregulated power supplies. It consumes about 150mA with a BOB-4H module attached and operating normally, or about 43mA without. The internally regulated +5V supply is available at two locations on the GPIO connector. Customers are advised to check operating temperature of the on-board linear regulator IC (U9) if significant loads are added or if ambient temperature is above 70°C, especially if raw supply voltage is near the upper limit. Reliable operation from -30°C to 80°C ambient was a design goal (limited by RTC chip), but as of this writing, BUD-1H has not been tested at operating temperature extremes. U9 was placed near a standoff post on the PCB to aid in heat dissipation, which presents an opportunity for customer enhancement if necessary.

BOB-4H hookup options (also see [BOB-4 Application Guide](#)):

J5 provides access to BOB-4H hardware configuration pins ACR0~ACR3. BUD-1H ships with no shunts installed on J5. This configures the BOB-4H main serial port to 115.2kbps, for compatibility with BUD-1H demo firmware installed at the factory.

An optional (customer-installable) debug port connector for the BOB-4H module is provided at J11. Customers must provide an inline 3.3V RS-232 hardware interface when connecting this port to a PC. Analog Devices' ADM3202 interface chip is one of many possible solutions.

An optional (customer-installable) SPI control port for the BOB-4H module is provided at J12. This port may not be used simultaneously with the BOB-4H font memory expansion option (U6), because BOB-4H cannot be both master and slave on its SPI port.

An optional (customer-installable) BOB-4H analog input connector is provided at J13. This port directly accesses both ADC input channels of standard BOB-4H modules as well as a reference voltage input that follows BOB-4H rules. R15 (zero ohms) normally links that reference input to +3.3V, as required by BOB-4H, so it must be removed if the customer wishes to apply some other reference voltage.

Connector Information

General:

BUD-1H does not use polarized dual-row header connectors due to its very compact size. Take special care to avoid mis-mating these connectors!

For all connectors, pin number one is identified in the silkscreen with a small white arrowhead symbol. Pin number one is also identified with a square solder pad, which is visible only on the opposite side of the board.

Dual-row connector pins are numbered by skipping from row to row, so that odd-numbered pins appear in one row and even-numbered pins in the other. See schematic if this explanation isn't clear.

Excepting J9 and J10, all connectors in BUD-1H are industry-standard .025" square post headers with .100" pin spacing. Mating connector data appears in the detailed descriptions below.

The optional 3V Lithium coin cell holder at BT1, for the timekeeping IC, is an Eagle Plastic Devices 122-2280-GR. This holder accommodates a single BR2032 or equivalent 3V coin cell, which is twice the thickness of coin cells such as the CR2016. Do **not** use two cells, because the resulting voltage could easily damage the RTC chip.

J1 – AVR ISP header:

Pin	Name	Dir	Description
1	MISO	I/O	Master input – slave output
2	V+5D	OUT	+5V supply for the programming adapter
3	SCK	I/O	SPI clock
4	MOSI	I/O	Master output- slave input
5	RST\	IN	CPU reset – low true
6	GND	X	Ground

This connector is compatible with Atmel's *AVRISP mkII* in-system programming adapter.

J2 – JTAG TAP (optional):

Pin	Name	Dir	Description
1	TCK	IN	Test clock
2	GND	X	Ground
3	TDO	OUT	Test data output
4	V+5D	OUT	Logic reference voltage and power for level translators in JTAG ICE
5	TMS	IN	Test mode select
6	RST\	I/O	Bidirectional open-collector CPU reset – low true
7	V+5D	OUT	Not used by Atmel's JTAG ICE
8	N/C	X	Not connected
9	TDI	IN	Test data input
10	GND	X	Ground

This connector is compatible with Atmel's *JTAGICE mkII* in-circuit emulator.

J3 - GPIO right-angle header:

Pin	Name	Dir	Description
1	RX232-0	IN	Channel 0 receive data input to RS-232 interface chip; link RX5V-0 to PE0/RXD0 if this input is used.
2	TX232-0	OUT	Channel 0 transmit data output of RS-232 interface chip
3	PE0/RXD0	I/O	GPIO, USART0 data input, pin change interrupt 8
4	PE1/TXD0	I/O	GPIO, USART0 data output; also tied internally to transmit channel 0 input of RS-232 interface chip (final output is on TX232-0).
5	PE2/XCK0	I/O	GPIO, USART0 clock I/O, analog comparator positive input
6	PE3/OC3A	I/O	GPIO, timer 3 output A, analog comparator negative input
7	PE4/OC3B	I/O	GPIO, timer 3 output B, interrupt input 4
8	PE5/OC3C	I/O	GPIO, timer 3 output C, interrupt input 5
9	PE6/T3	I/O	GPIO, timer 3 clock input, interrupt input 6
10	PE7/ICP3	I/O	GPIO, timer 3 input capture, divided system clock output, interrupt input 7
11	RX5V-0	OUT	Channel 0 receive output of RS-232 interface chip. Link to PE0/RXD0 if the RS-232 hardware interface for USART0 is needed.
12	VREF	OUT	+4.096V ADC reference output; $\pm 0.1\%$ and 100ppm/ $^{\circ}\text{C}$ tolerance; 2mA max load
13	PF0/ADC0	I/O	GPIO, ADC0 analog input
14	GND	N/A	Ground
15	PF1/ADC1	I/O	GPIO, ADC1 analog input
16	GND	N/A	Ground
17	PF2/ADC2	I/O	GPIO, ADC2 analog input
18	GND	N/A	Ground
19	PF3/ADC3	I/O	GPIO, ADC3 analog input
20	GND	N/A	Ground
21	PK0	I/O	GPIO, ADC8 analog input, pin change interrupt 16
22	PK1	I/O	GPIO, ADC9 analog input, pin change interrupt 17
23	PK2	I/O	GPIO, ADC10 analog input, pin change interrupt 18
24	PK3	I/O	GPIO, ADC11 analog input, pin change interrupt 19
25	PK4	I/O	GPIO, ADC12 analog input, pin change interrupt 20
26	PK5	I/O	GPIO, ADC13 analog input, pin change interrupt 21
27	PK6	I/O	GPIO, ADC14 analog input, pin change interrupt 22
28	PK7	I/O	GPIO, ADC15 analog input, pin change interrupt 23
29	GND	N/A	Ground
30	GND	N/A	Ground
31	+5V	OUT	Regulated +5VDC output; see text for load capability
32	+5V	OUT	Regulated +5VDC output; see text for load capability
33	PJ0/RXD3	I/O	GPIO, USART3 data input, pin change interrupt 9
34	PJ1/TXD3	I/O	GPIO, USART3 data output, pin change interrupt 10
35	PJ2/XCK3	I/O	GPIO, USART3 clock I/O, pin change interrupt 11
36	PD0/SCL	I/O	GPIO, SCL (I2C clock), interrupt input 0
37	PD1/SDA	I/O	GPIO, SDA (I2C data), interrupt input 2
38	PL0/ICP4	I/O	GPIO, ICP4 (timer 4 input capture)
39	PL1/ICP5	I/O	GPIO, ICP5 (timer 5 input capture)
40	PB7/OCM	I/O	GPIO, OC0A, OC1C, PCINT7 (timer 0 output A, timer 1 output C, pin change interrupt 7). This pin also delivers output from the Output Compare Modulator (OCM), which can generate waveforms modulated with a carrier frequency.

Logic inputs operate at 5V CMOS logic levels as defined by Atmel's ATmega640 electrical specification: nominally 3V input high minimum; 1.5V input low maximum. This input spec isn't strictly TTL-compatible, but that's a problem only if the driving source is true TTL (bipolar transistor) without a pullup resistor, or heavily loaded 3.3V CMOS. In either circumstance, take care to insure that logic inputs exceed 3V when high.

Logic outputs are specified to source or sink 20mA individually, but combined current is limited. See the [ATmega640 datasheet](#) (large PDF document) for additional details, and observe BUD power supply limitations.

Source impedance to ADC inputs should be 10K ohms or less. For the sake of accuracy, if any ADC port pins are used as digital outputs, they must not change state during ADC measurement cycles.

AMP/TE number 1658620-9 is one of many possible mating connectors. Distributors often stock cable assemblies with this type of connector at one or both ends. Customers can easily assemble custom cables with the aid of a standard machine vise or press to mount the 'crunch-on' connectors. Simple spacer blocks may be needed, but special IDC connector assembly tooling generally isn't necessary unless large quantities must be manufactured.

J4 – PC COM port:

Pin	Name	Dir	Description
1	LINK1	X	Hardware handshake link 1
2	LINK1	X	Hardware handshake link 1
3	TXD	OUT	RS-232 transmit data output
4	LINK2	X	Hardware handshake link 2
5	RXD	IN	RS-232 receive data input
6	LINK2	X	Hardware handshake link 2
7	LINK1	X	Hardware handshake link 1
8	N/C	X	Not connected
9	GND	X	Ground
10	N/C	X	Not connected; trim this wire away at the DB9 connector

J4 pinout is designed for convenient hookup to a PC COM port via ribbon cable and IDC (insulation displacement) connectors. Linked pins make it unnecessary to defeat the PC's hardware handshaking function, which often simplifies application programming. AMP/TE 1658620-1 is a suitable mating connector, but many others work as well. AMP/TE 1658614-4 could be used at the PC end, but again, many other types are acceptable.

J5 – BOB-4H configuration header:

Pin	Name	Dir	Description
1~2	ACR0/BSCK	I/O	Installed shunt pulls signal low. Internal pullup provided.
3~4	ACR1	IN	Installed shunt pulls signal low. Internal pullup provided.
5~6	ACR2	IN	Installed shunt pulls signal low. Internal pullup provided.
7~8	ACR3	IN	Installed shunt pulls signal low. Internal pullup provided.

Refer to the BOB-4 application literature for configuration details. 3M part number 929950-00 or equivalent is a suitable shunt plug. Note that a shunt on pins 1~2 prevents operation of the BOB-4H SPI port, which is needed for font memory expansion or SPI control. BUD-1H ships with no shunts installed on J5, which configures the main serial port of BOB-4H for operation at 115.2kbps. This configuration makes it compatible with BUD software examples from Decade Engineering.

J6 – BOB-4H mounting header:

Pin 36 is linked to a red LED (D3) for missing input video indication. Secure the BOB-4H module on J6 with four 4-40 x 7/16" female threaded standoffs and eight 4-40 x 1/2" truss head machine screws. Alternate hardware combinations may be used if desired, to facilitate BUD installation in customer equipment.

J7 – Video I/O connector:

Pin	Name	Dir	Color	Description
1	VIDEO-OUT	OUT	Yellow	Yellow wire; from BOB-4H module; 1Vpp output if terminated in 75 ohms
2	GND	X	Black	Black wire; ground (shield)
3	GND	X	Black	Black wire; ground (shield)
4	VIDEO-IN	IN	Green	Green wire; to BOB-4H module; 75R internal termination provided

Color data refer to wire colors in the optional cable set available from Decade Engineering.

The mating plug can be AMP/TE 3-640441-4, which is a female insulation-displacement connector (IDC) suitable for 24ga wire. IDC connectors often require the use of brand-specific punch-down tools. Use Molex connector housing 22-01-3047 or equivalent if you prefer crimp-and-poke technology, and note that contacts are usually sold separately.

Video signal hookup is non-critical when connection length doesn't exceed several inches. For longer runs, or in noisy system environments, it's best to use shielded coaxial cable. Choose cable with 75-ohm characteristic impedance, and upgrade to high-performance video cable for long runs (more than about 50~100 feet). Miniature coax can exhibit significant loss in a 20-foot run. Video signal attenuation often becomes a dominant system design issue when cable length exceeds a few hundred feet.

J8 – Power supply connector:

Pin	Name	Dir	Color	Description
1	+6~12V	IN	Red	Red wire; main power supply input; about 150mA plus user loads
2	Li+3V	IN	Blue	Blue wire; optional +3VDC battery power for RTC chip; 3uA typical
3	GND	X	Black	Black wire; ground

Color data refer to wire colors in the optional cable set available from Decade Engineering.

The mating connector can be AMP/TE 3-640441-3, which is an IDC plug suitable for 24ga wire. A compatible punch-down tool is required. Use Molex connector housing 22-01-3037 or equivalent if you prefer crimp-and-poke technology, and note that contacts are usually sold separately.

J9 & J10 – Auxiliary 2mm metric I/O headers (optional):

Consult the schematic for pinout and part number details on these customer-installable 'bonus' I/O connectors. A total of 38 additional I/O pins are available if both connectors are placed in service. Decade Engineering anticipates that very few customers will need so much I/O, but a talented PCB designer magically found room on the PCB! Consult the processor's data sheet for multiple uses of each pin.

J11 – BOB-4H debug port (optional):

Pin	Name	Dir	Description
1	V+3.3	OUT	Power supply for outboard RS-232 interface chip
2	BDRX	IN	BOB-4H debug port receive data input; 3.3V CMOS logic levels
3	BCTX	OUT	BOB-4H debug port transmit data output; 3.3V CMOS logic levels
4	GND	X	Ground

Refer to the BOB-4H application literature for debug port usage.

J12 – BOB-4H SPI control port (optional):

Pin	Name	Dir	Description
1	V+3.3	OUT	Power supply for logic level translators, if needed
2	BMISO	I/O	BOB master input – slave output
3	BMOSI	I/O	BOB master output – slave input
4	BSCK	I/O	BOB SPI clock
5	BSS0\	I/O	BOB slave select; low true
6	GND	X	Ground

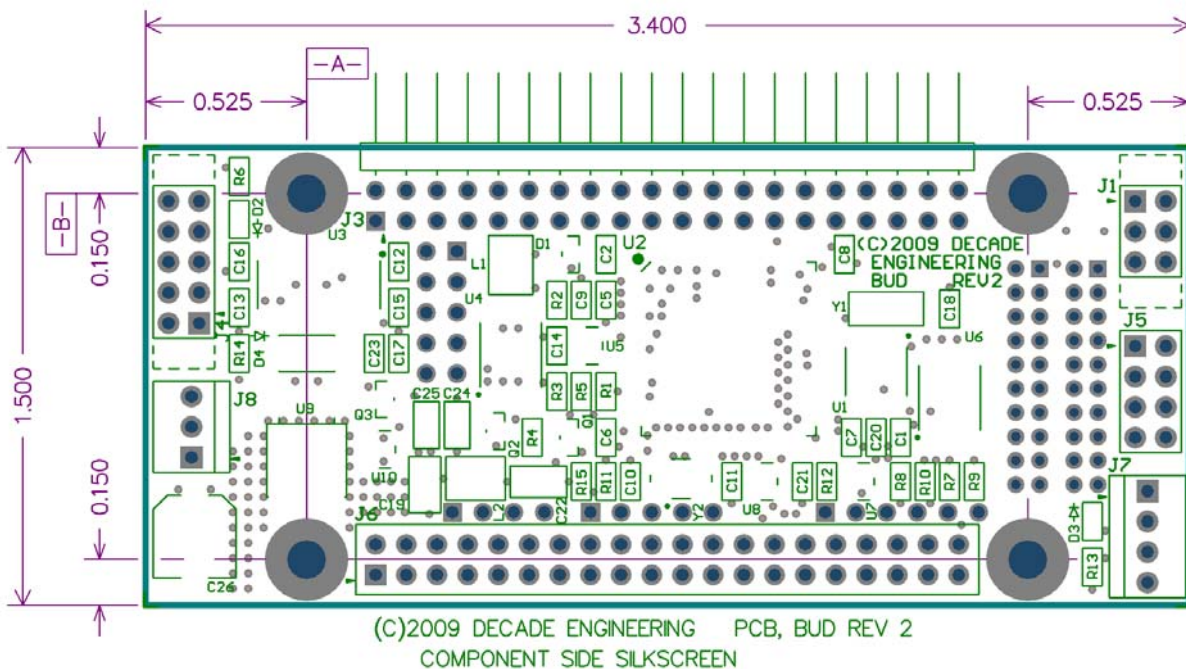
Refer to the BOB-4H application literature for SPI control port usage (slave mode). Be aware that BOB-4H front memory expansion (U6) is incompatible with operation of the SPI control port.

J13 – BOB-4H analog input port (optional):

Pin	Name	Dir	Description
1	V+5A	OUT	Auxiliary +5VDC output
2	AREF	I/O	ADC reference voltage input or output (output by default)
3	ADC6	IN	Analog voltage input 6; upper limit defined by ADC reference
4	ADC7	IN	Analog voltage input 7; upper limit defined by ADC reference
5	GND	X	Ground

The BOB-4 Application Guide offers more information on this port. Be aware that pin 2 is a +3.3VDC output unless R15 is removed. The +3.3V supply isn't a high-quality analog voltage reference, but it's free. It's probably adequate for many non-critical applications, especially when used in a 'ratiometric' measurement scheme. If you connect a precision voltage reference device here, select its voltage within the range of +2.6V to +3.3V.

PCB Dimensions



Firmware Programming

BUD-1H is shipped with 'passthrough' firmware installed, which provides nearly direct access to the BOB-4H module via BUD's PC COM port (J4). A number of additional BUD example programs, including source and executable code files, are available for download from [Decade Engineering](#). For BUD programming with a hardware programmer (e.g. AVRISP), use the following settings:

Target processor:

Atmel ATmega640 at 14.7456MHz

Fuse settings:

1. BODLEVEL Brown-out detection at VCC=4.3V
2. BOTRST enabled (may be disabled if bootloader will not be used)
3. BOOTSZ Boot Flash Size=1024 Boot address=\$7C00
4. JTAGEN enabled (may be disabled if JTAG will not be used)
5. SPIEN enabled
6. SUT_CKSEL Ext. Crystal Osc. 8.0- MHz; Start-up time: 16K CK + 65mS

BUD ships with a bootloader to allow flash memory programming through its RS-232 serial port without any special hardware other than a PC and serial cable. Newer PCs without serial COM ports require a USB/serial adapter as well. IOGEAR model GUC232A is a good choice. Documentation and source code for the bootloader is available in Atmel Application Note [AVR109](#). This bootloader is compatible with the 'AVR Prog' tool available in AVRStudio. It is also compatible with AVROSP (Open Source Programmer). See [AVR911](#) for a complete AVROSP description.

The hardware programming procedure described above must be used if it becomes necessary to reinstall bootloader firmware due to unintended erasure or corruption. A bootloader firmware file is included in the BUD example software distribution from Decade Engineering.

Applying power to BUD with pin 4 of J1 grounded activates the bootloader. This can be accomplished by placing a shunt across pins 4 and 6 of J1.

To program using AVR Prog:

1. Connect the serial cable between the host PC and J4 of BUD.
2. Shunt pins 4 and 6 of J1.
3. Apply power to BUD.
4. On the host computer, start AVRStudio.
5. From the Tools menu, select AVR Prog.
6. When the AVR Prog window appears, click the Browse button in the Hex File section.
7. Navigate to the .hex file that you wish to load and select it.
8. Click the Program button in the Flash section.
9. The program should load and verify.
10. Remove power from BUD.
11. Remove the shunt from pins 4 and 6 of J1.
12. Apply power to BUD; your new program should be running.

Real Time Clock Demo Firmware

The following commands are for use with one of the example applications published for BUD: the Real Time Clock demonstration program. The command parser in this example is similar to that of BOB-4. Commands begin with an 'escape sequence' of two bytes, 0x1b and 0x5b, which is the <CSI> (Control Sequence Introducer). <CSI> may be issued from a terminal keyboard with just two keystrokes: **Esc** followed by [(left square brace). Transmit the RTC commands to BUD through its RS-232 serial port (J4) with terminal communication parameters set as follows: 115.2 kbps, 8 data bits, no parity, 1 stop bit, without handshake. Common PC terminal emulation programs such as HyperTerminal are suitable.

Real Time Clock firmware commands:

r - Read time from NJU6355 chip

<CSI>r

No parameters. Returns comma-separated time/date data.
yy,mm,dd,wkd,hh,ss<CR><LF> (24-hour format)

W - Set current time/date

<CSI>n;m;o;p;q;rw

n=year (0-99)

m=month (1-12)

o=date (1-31)

p=weekday (1-7)

q=hour (0-23)

r=minute (0-59)

d - Set date display parameters

<CSI>n;m;o;p;qd

n=0 disable date display

n=1 enable date display

m=0 format: mm/dd/yyyy

m=1 format: wkd mm/dd/yy

m=2 format: mon dd yyyy

m=3 format: wkd mon dd yyyy

o=column (0-70) horizontal position of date display

p=row (0-24) vertical position of date display

q=font (0-8)

t - Set time display parameters

<CSI>n;m;o;p;qt

n=0 disable time display

n=1 enable time display

m=0 format: hh:mm:ss 24hr format

m=1 format: hh:mm:ss ampm

m=2 format: hh:mm 24 hr format

m=3 format: hh:mm ampm

o=column (0-70) horizontal position of time display

p=row (0-24) vertical position of date display

q=font (0-8)

Decade Engineering Contact Information

Please check our website for the most recent version of this document before concluding that a defect exists. Decade Engineering's hardware warranty, terms of sale, and service information are posted within the online ordering system. See below for software warranty statement.

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Obligatory Boilerplate

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Cautions!

ESD (electro-static discharge) safety precautions MUST be followed at all times when handling BUD-1H boards. Use a grounded wrist strap and grounded work surface. BUD-1H must be stored and shipped in static-shield (metallic, not pink poly) packaging.

External circuitry connected to BUD-1H must prevent ESD strikes from reaching any pin. Treat all pins with the same ESD preventive measures as typical CMOS logic chips.

Use the correct mating connector! Soldering directly to BUD-1H voids the warranty.

