Hardware interface Guide:

Many current motor driver boards require a Centronics compatible 25 pin parallel cable having a DB-25F connector to interface with the controller. Because Macintosh computers do have a parallel port output, many existing motor driver cards require an intermediate adapter card to convert a USB or ethernet connection to the equivalent parallel port output. However, similar PC based applications are adopting similar solutions as PC manufacturers abandon support for the parallel output.

The recent availability of several inexpensive yet powerful micro-controller cards makes this intermediate adapter solution cost effective. RiceMotion has focused on the introductory priced TI LaunchPad evaluation boards. The boards currently supported and soon to be supported by the application are:

Manufacturer	Product ID	Product Name	Price	Processor	Interface
Texas Instruments www.ti.com	EK-TM4C1294XL	Tiva C Series Connected LaunchPad Evaluation Kit	$19.99 shipping included	120 Mhz TM4C1294NCPD TI 1 MB Flash, 256K RAM, FPU, 72 GPIO pins	Micro-B to USB-A and ethernet cables (included)
Texas Instruments www.ti.com	EK-TM4C123GXL	Tiva C Series LaunchPad Evaluation Kit	$12.99 shipping included	80 Mhz TM4C123GH6PM 256K Flash, 32K RAM, FPU, 36 GPIO pins	Micro-B to USB-A cable (included)
Texas Instruments www.ti.com	TMS320F28377S	C2000™ LaunchPad XL	$29.99	dual 200 Mhz 1 MB Flash, 164K RAM, FPU	Micro-B to USB-A isolated

These boards connect and can be powered via a USB interface with optional additional power input. The newer EK-TM4C1294XL board is preferred as it adds an ethernet port, additional memory and an extra 40 pin BoosterPack connector. The smaller EK-TM4C123GXL board can easily handle at least four motors but the USB interface can be susceptible to noise from higher powered motors. The TI ARM Cortex M4 processors have more memory, motor control features and are significantly faster due primarily to the processor's Floating Point Unit.

Separate motion control processor boards relieve the host computer of real-time processing tasks such that the host application uses only a small percentage of the CPU time. Your computer will be able to run other applications while controlling one or more machines.

All selected cards have general purpose input output (GPIO) pins that can generate PC parallel port compatible signals for connection to your existing machine driver board, albeit at a lower voltage of 3.3 volts rather than 5 volts. Most boards will operate with the lower voltage and, only the micro-controller card and DB25F adapter cable will be required. However, for reasons mentioned earlier, this interface type is rapidly becoming obsolete.

The LaunchPad cards will easily drive and coordinate six or more motors with micro-stepping at high frequencies. The FPU interpolation accuracy is 32 bits for both linear path and cubic bezier curve paths, however, some position variables are extended to 64 bit precision.

Signal level compatibility:

Newer high performance processors operate with lower voltage and power. The processors operate using 3.3 volts and cannot output a 5 volt signal directly. The processors all have both a per pin maximum output current, both source and sink, and a cumulative maximum output current rating before the chip will overheat as in the following table:

Processor	Cumulative Maximum Output Source Current	Pin Maximum Output Source Current
TM4C123GH6PM	145 milliamps	8 milliamps
TM4C1294NCPDTI	400 milliamps	8 milliamps

Newer motor driver boards will operate reliably from the 3.3 volt signal level, but older boards may require either a 5 volt signal level or a higher output current. If your motor driver board interface is not working reliably then you have some options to boost either the output voltage or current or both.

To obtain a 5 volt output signal level, where a higher current is not required, you can configure the output to open-collector mode and use a pull-up resistor, e.g., 1K ohm, to a 5 volt source. If 5 volt power is used from the board, then care must be taken that collective pull-up current will not exceed the cumulative maximum output current rating.

For current-loop interfaces including relays, you can boost current and voltage somewhat by configuring the outputs to open-collector, connect the positive current-loop input to a +5 volt source and connect the open-collector signal output to the negative current-loop input. If the load is inductive, i.e., an electromagnet coil, then you will need a diode to across the coil to prevent the generation of high voltages that could damage the open-collector output. Be sure that the diode is reverse biased, i.e., cathode positive, when the coil is active. Optically isolated current-loop interfaces, e.g. solid state relays, are non-inductive so no diode is required.

However, the preferred solution is to use a buffer IC to boost both voltage and output current. A 74ABT244 octal line driver IC will raise 8 outputs to 5 volt level while providing a 32 ma source and a 64 ma sink capability. If the total required output current exceeds the current supplied by the USB port, then additional power can be supped to the board or the buffer can be powered from an alternate 5 volt source. The LaunchPads can accept 5 volt power from a BoosterPack.

Driver Signaling Interface:

The system currently supports four driver interface signaling methods:

1. Step and Direction (2 wire),
2. Discrete (4 wires),
3. Quadrature (2 wire)
4. Three Phase (3 or 4 wires) and
5. Serial Peripheral Interface (SPI)(4 wire)

Step and direction is by far the most commonly used signaling method even though discrete and quadrature have the advantage of being grey code and able to step twice as fast using the same clock rate. This is because the step signal requires one interrupt period to set the pulse and another to reset it. The quadrature signaling method is a grey code such that one pin can change state for each interrupt period. Direction is indicated by which pin changes state. Some older driver boards will use a discrete four pin interface with a pin corresponding to each unipolar motor winding. This interface method is supported in a half-step grey code.

Slave Mode Signaling Interface:

The system now supports two interface methods for slave mode operation. They are:

1. Step and Direction (2 wire) and
2. Quadrature (2 wire)

Slave mode input enables the system to be used to configure and interface with your drivers but then turn motion control functionality over to another motion control system. The system will track the motor velocities and position and, int he case of the BOOST-DRV8711 driver boards, it will be able to dynamically change the torque current for Accelerating, Decelerating, Constant speed and Holding states.

For users having an investment in other CNC software, slave mode provides a transition strategy enabling unique capabilities of the system to used as convenient.

The alternate system micro-step mode must match the configured micro-step mode. The alternate system must provide the pulse timing for coordinated and feedrate limited motions. However for rapid uncoordinated moves, the alternate system can use a burst input and allow the firmware to generate an appropriate acceleration/deceleration speed profile.

SPI interface Drivers:

Both the EK-TM4C1294XL and EK-TM4C123GXL supports up to 4 SPI (4-wire) serial interfaces.

A Serial Peripheral Interface (SPI) bus, sometimes called a Synchronous Serial Interface (SSI), four wire serial bus or micro-wire bus, has the advantage of bi-directional communication. They enable the MCU to set parameters and read back status information in addition to stepping. Two SPI interface drivers are currently supported:

1. TI BOOST-DRV8711

2. TI BOOST-DRV8305EVM and

3. ST Microelectronics L6470 dSpin.

The higher power TI BOOST-DRV8711 driver boards are preferred for both cost and versatility.

Support for the new TI BOOST-DRV8305EVM three phase motor driver board is preliminary.

Other control interfaces may be added upon request or as new devices become available.

I2C interface Drivers:

The EK-TM4C1294XL supports up to 10 I2C (2-wire) serial interfaces. The EK-TM4C123GXL supports up to 4 I2C (2-wire) serial interfaces.

A Inter-Intergrated Circuit (I2C) bus two wire serial bus supports flexible (multi-master, multi-slave) bi-directional communication.:

1. TI DRV10983

2. TI DRV10975

The DRV10983 and DRV10975 are sensorless three-phase BLDC motor drivers identical except for the operating voltage range supported. The higher power DRV10983 operates in the range of 8-28 volts (24 volts nominal) at 2 amps continuous. The DRV10975 operates in the range of 6.5-18 volts (12 volts nominal) at 1.5 amps continuous.

The chips can startup, accelerate and run BLDC motors at a constant speed with little controller intervention. By contrast, the BOOST-DRV8305 requires the commutation to be performed by the EK-TM4C1294XL and this processor time is better dedicated to interpolation.

The DRV10983 and DRV10975 use an EEPROM to save and restore motor parameters to optimize open-loop startup and other options. RiceCNC can be used to program and test the EEPROM parameters. The driver can then be used either with RiceCNC or moved to another system.

BOOST-DRV8711 interface:

The TI BOOST-DRV8711 is a high power driver board using an 8711 controller driving external 60-V N-Channel NexFET™ Power MOSFETs. Each board is rated 8.2-51 volts and up to 4.5 A continuous for each H-Bridge. This will handle stepper motors down to 2.0 volts with 0.5 ohm windings. The 8711 offers 1/256 micro-stepping and an bewildering array of configuration options although most users can use default settings. The evaluation board price of $25.00 plus shipping is very low for a high power driver board. The BOOST-DRV8711 is now the preferred driver board to use with this system.

The EK-TM4C1294XL μP boards will carry up to two BOOST-DRV8711 piggy-back on the BoosterPack connectors but most machine users will need three or four driver boards. It is also desirable to keep the piggy-back positions available for other expansion boards, e.g., the new Grove Base BoosterPack.

A Do-It-Yourself (DIY) backplane interconnect board can be used to add up to five more BOOST-DRV8711 boards to the μP board. DIY instructions are included in an appendix below and on the instructables.com website.