

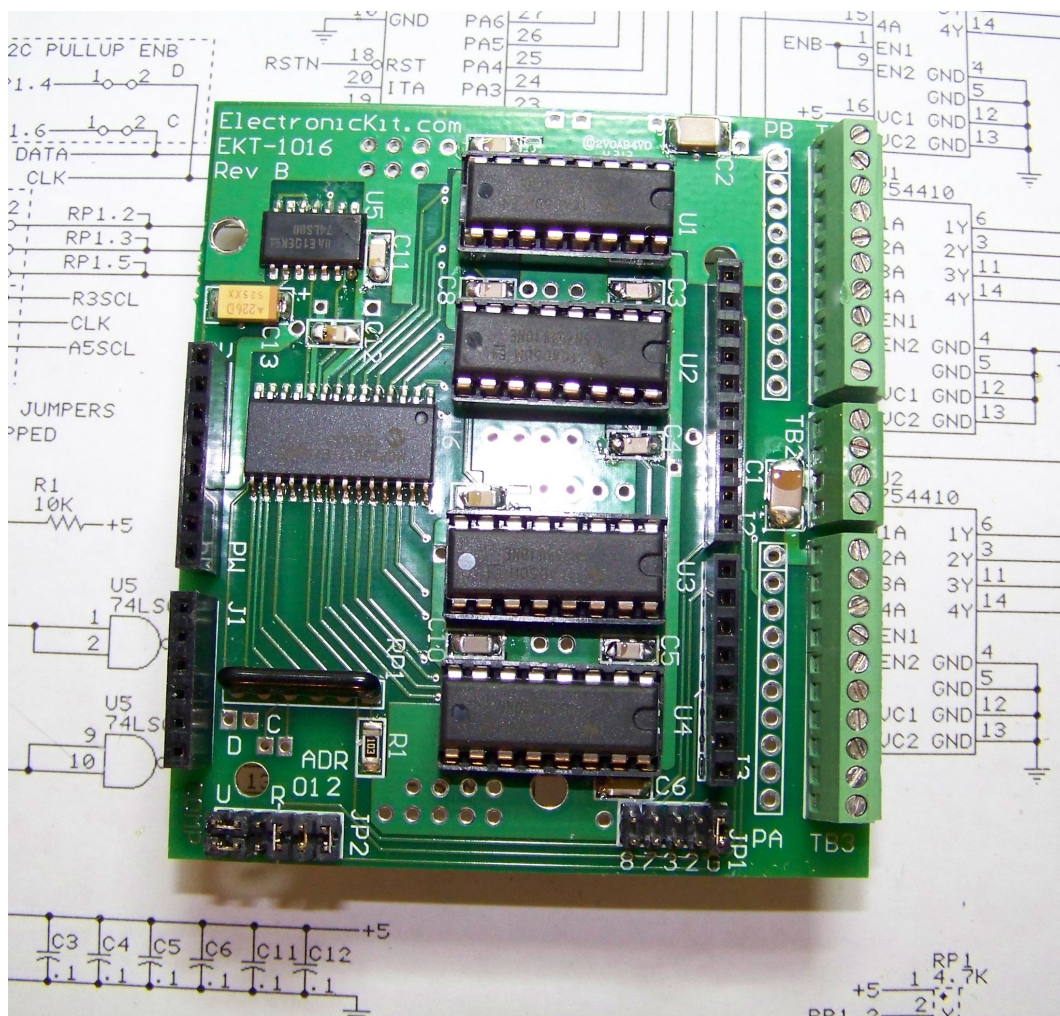
EKT-1016

Arduino 16-Channel Power Driver

User's Manual

ELECTRONICKIT

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Features

- ◆ 16 Channels of Digital Power Output (1 Amp continuous)*
- ◆ External power driver source from 5 to 36 volts
- ◆ RoHS Compliant – Lead Free parts and construction
- ◆ Designed and Made in the USA – both PCB and Assembly
- ◆ Easy terminal block interfacing with discrete wires
- ◆ Uses I2C for card control – Only 2 Arduino data signals required
- ◆ Programs using the 'WIRE' library in the Arduino IDE - sample code on website
- ◆ Multi-card operation – card select jumpers and stackable Arduino connectors
- ◆ Compatible with Arduino UNO Duemilanove, UNO R3 Leonardo and 100% Arduino clone cards
- ◆ Surface mount technology (SMT) and socketed power drivers
- ◆ Software output driver disable option for lower stand by power
- ◆ Solder pads for external Schottky blocking diodes (added power dissipation) or for user supplied status LEDs (see Appendix B)

****NOTE: There is a continuous current limit of 6 Amps for the PCB - that is due to the trace width and individual driver IC wattage limitations. User should determine current use and design accordingly. Additional heat sinking and/or a fan would be recommended for continuous high current operation.***

Overview

The EKT-1016 shield gives the Arduino system designer 16-pins of digital power driving capability. There are enough output pins to drive 4 stepper motors (unipolar or H-bridge), 16 power LED strings or 16 relays to sequence electric sprinkler valves for an Arduino based gardening system. **Each driver can handle 1 Ampere of current, but each power driver chip supplying 4 channels, has a 2 watt maximum power dissipation.**

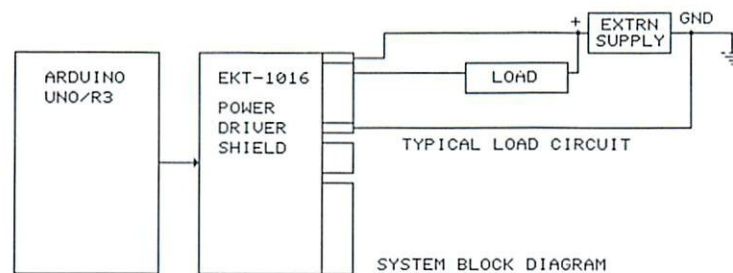


Fig 1 – Basic EKT-1016 System

An application example would be where one EKT-1016 plugged into an Arduino UNO inside of an office remotely turns 2 stepper motors via port A connected to worm gears that tilt and/or pan a small roof mounted solar array to follow the Sun for maximum energy generation. Aiming would be performed either by time-of-day (and day-of-year), or by measuring power output and adjusting for maximum signal input to analog input pin(s). Port B, externally powered

from the batteries charged by the solar array during the day, could be used to drive LED lighting in the evening. By monitoring battery voltage (again, through an analog input line on the Arduino) the user's sketch could turn off LEDs as needed by control of ports B's 8 channels.

As for terminology, several references are made to 'card / add-on card' and 'program' which are commonly referred to as 'shield' and 'sketch' respectively in Arduino parlance. There is some information repeated under the various sub headings of the manual. This is handy for the user who just wants to quickly get into using the card without reading the whole manual. The author has found that repeating information reinforces the important points and insures the designer will have a better chance of reading a warning, tip or application at least once while going through the manual. The manual represents the authors attempt to cover the shield's detailed operation in the hope that it will *save time and reduce the learning curve* to apply the EKT-1016. **Important information like warnings and limitations are highlighted by being in bold, italic and underlined (like this).**

Mechanical Specifications

Shield size: 2.9" X 2.6" (74mm x 66mm)

Connectors: 2 – 10-pin Terminal Blocks for port A/B output
2 – Sets of 10 solder pads for 0.1" (.254mm) pins for A/B output
4-pin Aux. Terminal Block for external driver voltage input
Standard stacking connectors for Arduino interfacing

Electrical Specifications

Power requirements = +5v @ 30 ma
(Arduino is power source)

External Voltage(s) = +5v to +36v DC at 6 Amps MAX (depends upon user application)

Card Installation

Turn off power to the Arduino and any other attached equipment before performing the shield installation. ***Never install or remove the EKT-1016 with the power applied to the Arduino or any of the attached equipment. This could result in permanent damage to the card due to static discharge.***

Normally the shield is plugged directly into the circuit side Arduino bus connectors. The user should use standoffs from the Arduino to the EKT-1016 for permanent installations to assure good long-term connection and added heat sinking.

Shield Powering

The power for the ElectronicKit.com shield is from +5V and GND on the Arduino PW/J4 connector (see page 2 of the schematic). Average current used by the shield is xxx ma. ***Remember, to power the attached equipment to the EKT-1016, the user must attach an external source of DC voltage. The Arduino regulator can not supply enough current for power driving applications.*** That is why there are no jumpers for the user to connect the Arduino power +5v to power drivers even though that might be handy for testing – the user could easily forget to remove such a jumper, connect an external power supply to the output port terminal block and burn up the Arduino card.

External Powering

The Arduino can **NOT** provide enough current through its on-board voltage regulator to drive much power for 16-channels of output. That is why there are terminal block pins, IDC pins and even a separate 4-pin terminal block to ensure the user can apply an external DC voltage with enough current to drive the outputs. ***Do not wire up the +5v from the Arduino to power the output drivers unless you are sure of what you are doing.*** An external +5 to +36 voltage source may be feed into pin 1 of the port A (TB3) or B (TB1) 10-pin terminal block. The ground return from the external power supply should be connected to pin 10 of the respective port terminal block.

Additionally, there are 2 groups of 10 solder pads that line up behind TB1 and TB3 for the user to use when SIP connectors or soldered connections are desired to the power driver outputs. Each pad follows the pin function of the terminal block in front of it. These pad rows also can be used for adding external Shockley blocking diodes to increase card power dissipation or even adding LEDs for status of each driver.

The designer can also use pins 2 and 4 of the 4-pin terminal block (TB2) for powering port A and B respectively. Why? Because the user may want to use a peripheral board which needs powering, and using TB2 to supply power allows taking power from pin 1 on each port terminal block.

You can have 2 different voltages on the EKT-1016 card. Meaning you could run port A with +12v DC, and port B with a +9v DC source. See figure 1 below for the terminal block pinouts.

Provide external power to ONLY one of the 3 possible single port powering pins. This means to power port A, use either pin 1 of the TB3, or pin 1 of the PA IDC pad or pin 4 of TB2 and for power to port B, use either pin 1 of TB1, or pin 1 or PB or pin 2 of TB2. For advanced users, you could diode isolate 2 sources of DC voltage to provide a backup supply for operation.

Shield Control

The 'reset' signal on the EKT-1016 is drawn from the Arduino PW/J4 connector (see page 2 of the schematic). Along with 'reset', 'SDA' and 'SCL' are used for I2C control (see page 2 on the schematic for physical pin location). Optionally, the user can use one additional digital line for enabling the power output drivers, or choosing to enable the drivers always (as shipped). The designer can jumper select any one of D2, D3, D7, or D8 for driver enabling by program control. Sample 'C++' code is listed under the "Programming the EKT-1016" heading below to show how sketches can enable and disable the drivers as required.

Shield Jumper Options

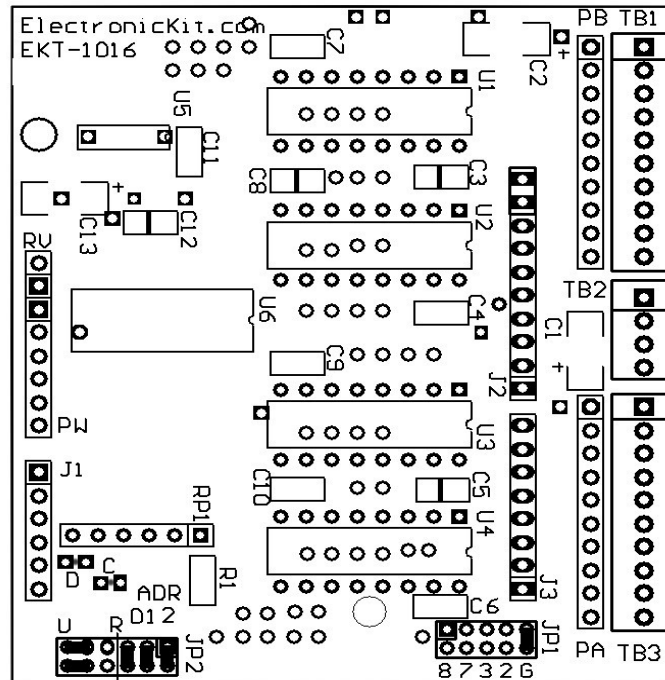


Fig 2 - EKT-1016 jumper locations set as shipped

When shipped, the EKT-1016 is set for:

- ✓ Power drivers enabled always
- ✓ I2C device address set to 0 (00H-1F hex range)
- ✓ I2C control lines on pins 5 and 6 of J1(works for UNO and R3)
- ✓ SDA/SCL pull up resistors enabled

All references to 'horizontal' and 'vertical' below are in respect to figure 2 above. The Appendix D schematic, gives another view of the jumpers showing the settings by their physical electronic function.

Easiest to work on the card while it is mounted on top of the Arduino stack and unpowered. This makes testing the shield easy while jumper changes are being made. **Avoid the temptation of changing jumpers while the card is powered!**

Driver Enable - JP1

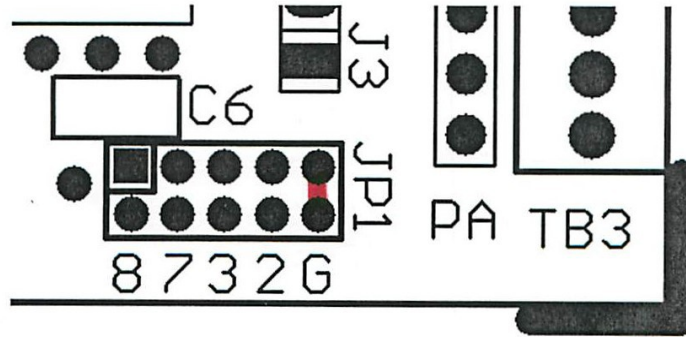


Fig 3 – Driver Enable Jumper

The EKT-1016 can be output controlled by selecting one of four data lines, or the driver's can be enabled always (as shipped, by setting JP1 to Ground – the G position jumper). On power up or reset, the data lines on the Arduino CPU are set to input, R1 pulls up the gate inputs to U5 and that disables the output drivers of the shield. Now the user's sketch can initialize the card's control and preset the data bytes BEFORE enabling the drivers. That insures a consistent start up and helps prevent all 16 drivers from coming on at once – which could be bad depending upon the application. In addition, the program can also disable the driver output pins to lower power used and reduce system heat. A single jumper is used for this option, but multiple EKT-1016 could have different settings. Why disable the drivers under software control? If you needed to do an initial position setting of a worm gear attached to a stepper motor, disabling the stepper motor power would allow turning the motor by hand. **Remember, controlling the driver output can significantly lower the current used and heat generated by the card. Only one data bit can be selected, but separate shields can use different enable data lines if desired.** The table below details the setting options by data bit:

Card Driver Enable – JP1

Signal	Function	Jumper Pin	Comment
D8	Data bit 8	8	uses PB0 for control
D7	Data bit 7	7	uses PD7
D3	Data bit 3	3	uses PD3
D2	Data bit 2	2	uses PD2
GND	Ground	G	Always on (as shipped)

Note also that the user could use the G jumper pair for wiring an external collection of (series-connected) normally-closed limit switches. In this way when a limit switch is opened, all power to the drivers would be disconnected.

I2C Address and Source Select - JP2

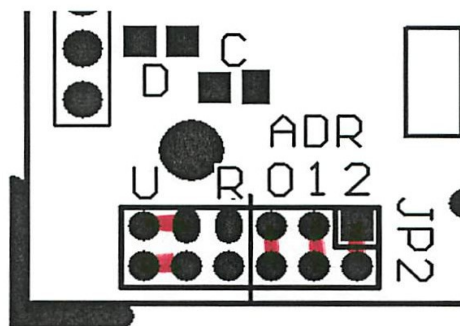


Fig 4 – I2C Addr and Source

I2C Address Jumpers

Jumper 2, located on the lower left hand side of the PCB, is really two sets of 6-pins combined into one 12-pin jumper. The right hand set of 6-pins sets the shield software address and the left hand 6-pins set the I2C signal source.

The 3 right hand shunts set the A0, A1 and A2 address (labeled 0 1 2 in figure 4 above) that the card will answer to on the I2C bus. When shipped, all 3 shunts are shorted across the pair of pins to produce a '0' (LOW) address bit, producing address x00H (00 hex). Opening a shunt by removing it will produce a '1' (HIGH) to the corresponding address bit. The table below details the address combinations:

Card Address – JP2/ADR

Card Adr	Adr Range (hex)	0	1	2	Comment
0	00-1F	LOW	LOW	LOW	As shipped
1	20-3F	HIGH	LOW	LOW	
2	40-5F	LOW	HIGH	LOW	
3	60-7F	HIGH	HIGH	LOW	
4	80-9F	LOW	LOW	HIGH	
5	A0-BF	HIGH	LOW	HIGH	
6	C0-DF	LOW	HIGH	HIGH	
7	E0-FF	HIGH	HIGH	HIGH	

Each setting covers 32 (1F hex) addresses. For the EKT-1016 card only 4 addresses per setting is used. The other addresses can not be safely used by other I2C cards, but there should be no problem with an address conflict even if four EKT-1016 shields were stacked on a single UNO/R3 card. There are 2 address settings that the user should be aware of: 0 (00-1F hex) and 7 (E0-FF hex). For most EKT-1016 applications, it will not be a problem but there are 'reserved' addresses within those two address ranges.

addr	R/W	Description
0000 000	0	General call address
0000 000	1	START byte
0000 001	X	CBUS address
0000 010	X	Reserved for different bus format

0000 011	X	Reserved for future purposes
0000 1XX	X	Hs-mode master code
1111 1XX	X	Reserved for future purposes
1111 0XX	X	10-bit slave addressing

The author has run the EKT-1016 using the Arduino IDE's 'WIRE' library with both 0 and 7 without a problem. **Running other libraries that generate I2C communication may have a different result.**

I2C Source Jumpers

The left most 6-pins of JP2 are used to select the source of the I2C data (fig 4 above). The jumper pairs on JP2, located at the lower right hand side of the PCB, allow the designer to swap the I2C SDA and SCL source. A change was made to the Arduino R3 hardware that dedicates two I2C pins located on J2 of the Arduino expansion connector. This jumper option handles any future issues of I2C compatibility by allowing the user to select the dedicated I2C pins and free up A4 and A5 on J1 for other uses. ***When shipped, the I2C source is the original A4/SDA and A5/SCL pins of the Arduino UNO. That is, both horizontal pins are plugged into the center and left pin of the jumper set (U on silkscreen fig 4).*** The designer should change both jumpers from center pin to right pin if it is desired to use the newer pins located on J2 (R on silkscreen fig 4). **This feature is probably not to useful on the EKT-1016 with the Arduino R3 or UNO as both sources of SDA and SCL are the same on those Arduino CPU cards. This choice of I2C sources may be useful on future Arduino CPU card versions.**

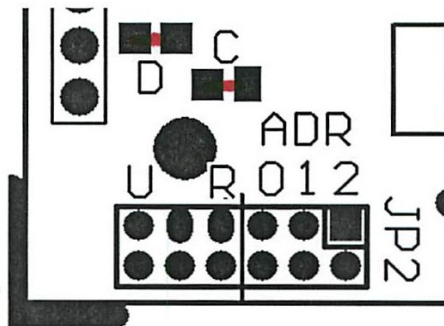


Fig 5 – Pull up Resistor D and C Jumpers

I2C Pull up Enable – JP 'D' and 'C'

If the user is stacking multiple shields onto the Arduino expansion connectors that make use of the I2C interface, these two jumpers, designated D (data) and C (clock) and located above the JP2 jumper, should be disconnected on all but the topmost shield on the stack. Multiple pull up resistors may work (especially if it is only 2 cards), but for the best signal, only one pair of resistors should be enabled. The user should carefully cut the small trace running between the 2 pads located near the 'D' and 'C' silkscreen letters located on the solder side (back) of the PCB.

Connecting Devices to the Drivers

Attaching devices to the EKT-1016 is straightforward if the user understands **the drivers operate by pulling their output to ground**. This means one end of the attached device (see the figure below for examples) is connected to an appropriate +voltage for operation while the other device lead is attached to a shield terminal block driver pin. There are a few exceptions, but for a majority of applications, **that is the only correct (or workable) technique for operation**. The user also needs to connect the external power source to the port on pin 1 for proper operation. Wire the external power supply ground to pin 10 (see fig 6 and 7 below).

The EKT-1016 is for applications with medium power digital devices. That means the usual output control limitation of 40ma from the Arduino digital pins can now be up to 1 Amp. Medium power stepper motors, high power LEDs, relays, etc. can be easily handled by this shield. **There are limits of what the user can do as the circuit board traces and terminal blocks (plus common sense) limit the card to 6 Amperes running concurrently**. That is a lot of current, but the user should still be aware of what is being controlled and the current the 16 channels are drawing with all outputs on. The EKT-1016 can run 4 stepper motors at the same time because not all of the outputs are running at the same time. 4 motors might mean as many as 8 channels on at the same time so the user would have to 1 - make sure the motor is not drawing more than about 750 ma per lead and 2 – that air is being moved over the PCB to cool the driver chips. The user could run 16 high power LED strings at the same time with 375 ma per channel.

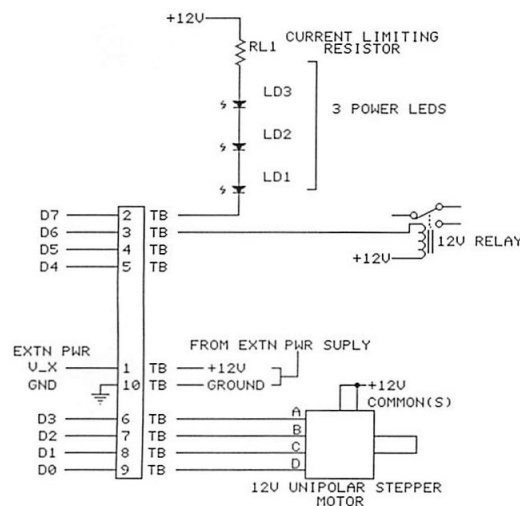


Fig 6 – Attaching a device for card control

The schematic in figure 6 above shows 3 different types of devices being controlled by the EKT-1016. Note that all 3 example device types are being powered by the same +12V external power supply (and ground return). Attach an additional wire from the external +V to pin 1 (VAX or VBX) of the terminal block being used. In addition, connect a wire from the external power supply to the ground to pin 10 of the port being used. Only one external voltage per port can be accommodated, but you can 'match' a device (like the power LEDs above) with a load resistor, zener diode, LDO, etc. if need be. Most of the time you will be connecting devices of the same voltage up to the individual port(s).

Terminal Block Device Connection

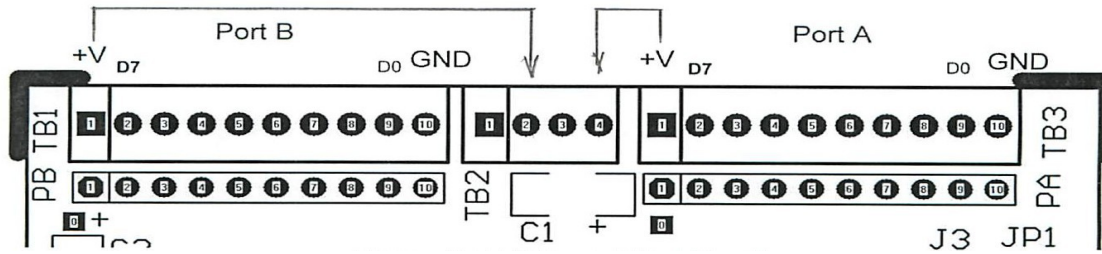


Fig 7 - Driver terminal blocks and TB2 Aux power block

Port A - TB3 and PA connections

Signal	Function	Pin #	Comment	Data Direction
VAX	External +V to Port A	1	Extn +V DC	Input to card
D7	Data bit 8	2	Most significant bit	Output from card
D6	Data bit 7	3		Output from card
D5	Data bit 6	4		Output from card
D4	Data bit 5	5		Output from card
D3	Data bit 4	6		Output from card
D2	Data bit 3	7		Output from card
D1	Data bit 2	8		Output from card
D0	Data bit 1	9	Least significant bit	Output from card
GND	Ground Port A	10	Ground Return	Input to card

Port B – TB1 and PB connections

Signal	Function	Pin #	Comment	Data Direction
VAX	External +V to Port B	1	Extn +V DC	Input to card
D7	Data bit 8	2	Most significant bit	Output from card
D6	Data bit 7	3		Output from card
D5	Data bit 6	4		Output from card
D4	Data bit 5	5		Output from card
D3	Data bit 4	6		Output from card
D2	Data bit 3	7		Output from card
D1	Data bit 2	8		Output from card
D0	Data bit 1	9	Least significant bit	Output from card
GND	Ground Port B	10	Ground Return	Input to card

Auxiliary +V DC Inputs for Port A and B

Signal	Function	Pin #	Comment	Data Direction
GND	Ground	1	Ground	Input to card
+VBX	Extn +V to port B	2	Extn +V DC port B	Input to card
GND	Ground	3	Ground	Input to card
+VAX	Extn +V to port A	4	Extn +V DC port B	Input to card

The two 10-pin terminal blocks located along the right hand side of the PCB provide the user connections for discrete driver wiring of port A/B, and for the external power supply +voltage and ground associated with each port.

The table “Connections to the EKT-1016” above shows the pinouts for an external source of DC to power port A and port B in addition to the individual driver outputs.

There are also two sets of 10 pads, pictured above, on the EKT-1016 circuit board that run parallel to the terminal blocks. The user can solder 0.025" square IDC type pins into for ribbon cable interfacing application. These may be useful in applications where fast card replacement is required or to directly interface pin compatible 8-relay cards.

Figure 7 above shows the pads as black dots and are designated PA and PB on the cards silk screening. The pinout assignments match the respective TB1 and TB3 (port B and A). From a program (sketch) standpoint, the user turns a driver ON by setting the corresponding port bit weight to a '0'.

For example, **writing B11111100 to port A would turn ON D0 and D1**, the lower 2 drivers. It is more logical to set the drivers 'ON' from a coding point of view with a '1'. That can be done by generating a compliment of the 8 bit data just before outputting it to the port. In other words using the C++ coding:

```
Wire.write(255-(data)); // invert data to Port
```

There is probably a better way to do this, but the author is a novice when it comes to C++ coding. The object is to generate a 'one's compliment' of the data byte. In machine language the author would execute a CPL A (compliment accumulator) before outputting the data byte.

Programming the EKT-1016

Below are several C++ code fragments that detail how to enable the power driver outputs, set/control a specific card address and outputting data to port A/B. The author notes that there are several C++ variable naming conventions which have not been adhered to with the labels to make them easier to understand in the example code (the code compiles fine in the Arduino IDE). There are example sketches on the ElectronicKit.com website at:

<http://www.electronickit.com/kitproduct/ekt-1016/sketch1016.zip>

Beginning of sketch:

```
#include "Arduino.h"
#include "Wire.h"

// Enable Driver Output
// Card shipped with enb = on always (G jumpered)
//
// Enable only one line below
//
const int EnbAB = 0; // Always Enabled - as shipped
// const int EnbAB = 2; // use PD2
// const int EnbAB = 3; // use PD3
// const int EnbAB = 7; // use PD7
// const int EnbAB = 8; // use PB0

// Chose I2C Shield Address
// 0 = jumpered, 1 = no jumper
// Card shipped with adr = 000 (all 3 jumpered)
//
// Enable only 1 line below
//
//           A2 A1 A0
const byte Adr = 0x00; //0 0 0 - as shipped
// const byte Adr = 0x01; //0 0 1
// const byte Adr = 0x02; //0 1 0
// const byte Adr = 0x03; //0 1 1
// const byte Adr = 0x04; //1 0 0
// const byte Adr = 0x05; //1 0 1
// const byte Adr = 0x06; //1 1 0
// const byte Adr = 0x07; //1 1 1

const byte Base = 0x20 + Adr; // shield base address
const byte GpioA = 0x12;      // port A data reg
const byte GpioB = 0x13;      // port B data reg
```

'Setup' segment:

```
void setup()
{
  if (EnbAB > 0)
  {
    pinMode(EnbAB, OUTPUT);
  }
}
```

```

    digitalWrite(EnbAB, HIGH); // disable all drivers
}
Wire.begin(); // start

// Set Port A and B to Output

Wire.beginTransmission(Base); // Base address
Wire.write(0x00); // IODIRA set port A I/O
Wire.write(0x00); // Port A = output
Wire.endTransmission();

Wire.beginTransmission(Base); // Base address
Wire.write(0x01); // IODIRB set port B I/O
Wire.write(0x00); // Port B = output
Wire.endTransmission();
}

```

Enable/disable drivers:

```

// Enable EKT-1016 Port A and B
if (EnbAB > 0)
{
    digitalWrite(EnbAB, LOW); // enable drivers
}
// Disable EKT-1016 Port A and B
if (EnbAB > 0)
{
    digitalWrite(EnbAB, HIGH); // disable drivers
}

```

Write data to port A and B:

```

Wire.beginTransmission(Base);
Wire.write(GpioA); // port A
Wire.write(255-(dataA)); // invert data to Port A
Wire.endTransmission();

Wire.beginTransmission(Base);
Wire.write(GpioB); // port B
Wire.write(255-(dataB)); // invert data to Port B
Wire.endTransmission();

```

Note: user sets the variables 'dataA' and 'dataB' to a hex or binary integer within their program to the driver(s) desired to be turned ON. The (255 - data) inverts the user's 8 bits of data into correct 'negative true' bit pattern.

Complete EKT-1016 Sketch – ripple1016.ino

The sample below is a complete sketch to 'ripple' through all 16 drivers on both ports starting from D0 through D7 and then repeating.


```

Wire.write(0x00);           // Port B = output
Wire.endTransmission();
}
void loop()
{
  for (i=0; i<8; i++)
  {
    Wire.beginTransaction(Base);
    Wire.write(GpioA); // port A
    Wire.write(255-(Shift)); // invert data to Port A
    Wire.endTransmission();

    Wire.beginTransaction(Base);
    Wire.write(GpioB); // port B
    Wire.write(255-(Shift)); // invert data to Port B
    Wire.endTransmission();

    Shift = Shift + Shift;
    if (Shift > 0x100)
    {
      Shift = 1;
    }
    if (EnbAB > 0)
    {
      digitalWrite(EnbAB, LOW); // enable all drivers
    }
    delay(100); // 1/10 second delay
  }
}

```

Appendix A – EKT-1016 Troubleshooting Guide

Overview

Although this shield is a new 2013 card, the author has had a lot of experience with similar industrial control products. Here are the most common sources of problems and tests you can make to diagnose a problem.

Driver Channel Problems:

LED Test

You can verify that the ElectronicKit.com shield is working by doing a simple LED shift test. Set all jumpers to the factory default (the 'as shipped' positions) per this manual. The user may need to disconnect attached equipment from the driver outputs depending their application, and attach LEDs to monitor driver output. Download the 'ripple1016.ino' sketch from the ElectronicKit.com website (<http://www.electronickit.com/kitproduct/ekt-1016/sketch1016.zip>), unzip the file and upload the ripple1016.ino program to your Arduino using the IDE as usual. The drivers should ripple upward (D0 to D7) if everything is working correctly. Each individual port should light for about 100ms before the LED right of it comes on. This should continue for all 8 LEDs on each port then repeat. The user can speed up or slow down the ripple by changing the last line of the sketch. (see PROGRAM OPERATION above and Appendix B below for schematic of LED test fixture).

Wiring or Cabling (a common problem)

If one of the driver wires is not connected (open) or shorted that driver will not operate and may even damage the driver(s). **An open +V connection to either port A or B, may cause the port(s) not to work or damage all the drivers.** Check the wiring by testing continuity. Be sure to power down the system before checking continuity, or any other physical connection testing.

Remember if you have an inductive component attached to the shield (motor, relay, choke coil) to disconnect it before running a continuity test.

If possible, try the LED test described above *at the far end of the wiring* to verify operation. If you can not get the LED test to work through your wiring, it will not work in your application. Even cables purchased with molded ends can be defective.

Over Current

Be sure you are not drawing more current than the EKT-1016 can supply. Each driver can handle 1 Ampere DC continuously, but there is a chip limit and trace limit to the amount of total current that can be supplied by the shield. A good average current number to shoot for is 375ma/driver. Adding a heat sink to the driver chips and/or a fan blowing over the card will help. Disabling the driver output or turning off individual outputs will lower the overall current used also. The driver chip is over temperature protected, so if more current by single chip is detected by heating, the chip will automatically shut down (and reset after power is removed and the chip cools down).

Overall Shield Operation:

Signal Control Jumpers

There are four main jumpers that control the operation of the EKT-1016. Double check that you have set the jumpers correctly for your application. All four jumpers must be installed for the shield to work properly and it is possible to have one mis-setting cause the shield to appear non-operational. Check the shield jumper settings against the Appendix D schematic (left hand

side). As a baseline, restore all jumper settings to the factory defaults shown on the schematic and test using the 'ripple1016.ino' sketch down loadable from the ElectronicKit.com website: <http://www.electronickit.com/kitproduct/ekt-1016/sketch1016.zip> .

I2C Signal Termination

Reflected signal produced by the I2C pins that are not terminated properly will cause data transmission errors. A terminated connection matched to the impedance produces the best signal transfer and dampens the ringing of a reflected signal. If you are using the EKT-1016 to interface with 2 or more devices having 10K ohm termination resistors, that only one of them is enabled on the card furthest away from the Arduino CPU card.

Powering

Be sure that the external +V DC being applied to the driver ports are on. Unlike most other shields, the EKT-1016 requires one or two external DC power sources provide drive current to the attached motors, LEDs, relays, etc. Here again, if the external powering source(s) is off, the card will appear to not be working at all.

Program Operation

If the program or card jumpers are not set up right, the shield will appear not to be working at all. The application program you are using needs setup steps performed in order to operate. Selecting the port address, sending initial configuration commands and port data plus setting the level of the enable signal (if data line enabled) at a minimum.

Check that the card address matches the code address, and that the enable jumper matches the enable driver code.

Each time the program writes out a new change of state to the port(s), the previous state is gone – the user must keep track of what bits are on and off in order to 'build' a data byte to output to the desired port. Generally, you keep a copy of the byte to be output in RAM then 'AND' in a 1's compliment mask to turn a bit off or 'OR' in a bit to turn a driver on before saving the byte and outputting it to the driver port.

Now What?

If none of the above seems to fix the problem, but the LED test works, the shield is working and you may need to connect an oscilloscope up to examine and monitor the power driver signals and the I2C signals being generated by the Arduino and running with your program. Refer to the schematic at the back of this manual. It is easy to put a scope probe onto the tops of the solder pads for the power driver ports (PA/PB) and verify that the signals are present. Test the +V to the shield by attaching a probe to PA pin 1 or PB pin 1. Look for excess noise on any of the control lines that might be fouling the operation.

We do have a limited warranty on factory built products from 1 year of invoice date, so if it still does not work, email ElectronicKit.com (addr on website under 'contact').

Appendix B – User Installed Status LEDs

A user built LED status display provides an easy functional visualization of operation for initial test, debug and troubleshooting finished equipment. Download and program your Arduino with the 'ripple1016.ino' sketch from the 'electronickit.com/kitproduct/ekt-1016/sketch1016.zip' URL.

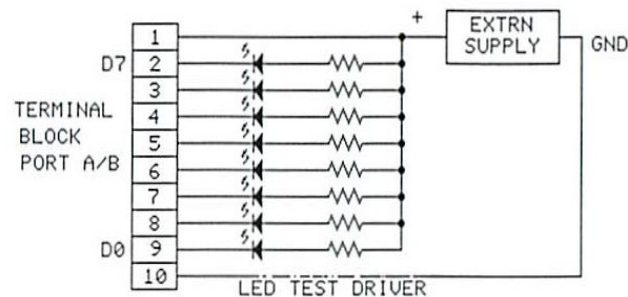


Fig 8 LED Test Fixture

Each port status display is made up of eight LED anodes and suitable current limiting resistors and a wire jumper to port pin 1 with a +DC voltage (like +5v). The LED cathodes are put into the port's 8 terminal block driver outputs. This table will help in interpreting the LEDs:

Indication on Each Driver Port	Meaning
Sequential LED on/off moving from D0 to D7	Normal operation. <i>This is the most useful indication of shield operation.</i>
LED(s) always off	Check external +V for LED operation and check the +V is connected to pin 1 of port under test. Check shield jumper settings and be sure program settings match. Check driver enable jumper installation. External +V must be attached to pin 1 of port (External supply ground on pin 10) and must be attached to the LEDs common. Possible blown driver chip(s).
LED(s) always on	Check external +V for LED operation and check the external +V is connected to pin 1 of port under test. Be sure Arduino is powered and running the sequential LED sketch. Check PCB for a shorted trace to ground associated with the LED(s) always on. Possible blown driver chip(s).
Multiple LEDs of same port on (should only be one on at a time)	Power down - Check wiring - most common source of problem. Check the terminal block for a short. Check for something causing a short on the EKT-1016 pcb by following traces backward from the faulting LED(s). Possible blown driver chip, although rare.

Appendix C - Kit Assembly

The kit is designed for an advanced electronics builder – be sure you have the right tools and equipment before starting assembly. Don't be in a big hurry to get the kit built and try not to drink a whole pot of coffee before starting! There are at least 4 ways to build a PCB that have SMD parts. The author has written this appendix for this specific electronic kit, but much of the information here applies to any of the kits electronickit.com offers.

If you have your own favorite SMD soldering technique, you can probably skip down to the assembly drawings in Appendix E and get started. The technique the author will cover here in detail is using a soldering iron for SMD assembly.

Toaster Oven – The author's favorite way to build prototypes. **DO NOT USE YOUR KITCHEN OVEN OR KITCHEN TOASTER OVEN.** This technique is a one way trip for a toaster oven as it leaves a lot of chemicals on the heated surface after it is used even ONE TIME for SMD soldering. You use a syringe of lead free solder paste (available from Amazon, Digikey or Mouser) **sparingly** applied to each land (SMD pad). Placing the components onto the lands with a tweezers, placing the PCB onto the oven tray and then running up the toaster oven with the door held slightly open until the gray solder paste turns bright silver (then add 10-15 seconds more). You then open the toaster door (which turns off the oven) and, using pliers, CAREFULLY pull the toaster oven tray 2/3rds of the way out. I place a small fan set to a low speed, near the open door to increase the cool down speed. You can build multiple cards this way and it yields pretty consistent results. The author also notes there are conversion kits available for re-purposing toaster ovens for use as an SMD oven. *A near perfect application for an Arduino + type K thermistor + solid state relay (SSR) by the way.*

Hot Plate – There is a PID controlled lab hot plate around here, but the author has not used it for SMD soldering. You can find videos and internet articles covering this technique. Be aware that an inexpensive kitchen hot plate is not the type to use, but rather a laboratory type with better temperature control and a single flat heated surface to spread the heat evenly. This technique also requires solder paste in a syringe, preheating the hot plate and placing the PCB on it. You watch for the solder paste go from a dull gray to a bright silver and then carefully remove the PCB from the hot plate. You have to remove the PCB as the hot plate will not cool down fast enough to prevent overheating the PCB. The author notes that a **really steady hand** would be required to remove the PCB from the hot plate with pliers. Placing the PCB on a sheet of 1/8" (3mm) aluminum, and removing it from the hot plate might be way easier to do.

Hot Air Gun / SMD Air Soldering Station – Once again, you use a syringe of solder paste and tweezers to place the SMD parts. The added task is to heat the individual SMD parts by bringing the heated air source **just close enough** to melt the solder paste, but not burn up the card and components or blow the parts off of the card. You can glue the SMD parts onto the PCB to help prevent the hot air from moving or blowing them off, but the author does not know how that could be done practically in a non-pro setting. More practical might be to solder the corner component pins of the semiconductors, and hand solder the small capacitors and resistors.

A good trick is to place a small 'blob' of solder paste on the back of the SMD ICs, and carefully watch for it to melt – an indication that you have reached the right distance, temperature and time. You now need to apply a few more seconds of heating to get the component lead solder paste to melt (turn bright silver). I have used this technique to remove and replace SMD parts, but not to solder an entire card.

Solder Iron – This is by far the easiest and lowest cost technique for the electronic kit builder. You use lead free .032”(0.8mm) DIA solder and carefully apply a tiny amount of solder between the SMD lead and the SMD land using a small-tipped solder-wetted iron. Every electronic kit the author designs is built at least one time this way to insure that the technique is usable for building the project.

The technique the author will cover here is the soldering iron approach. At a minimum you will need:

- ✓ A small soldering tip as the SMD ICs have .050” (1.3mm) pitched lead spacing
- ✓ Tweezers – to hold the SMD components in place while soldering
- ✓ A free standing magnifying lens (probably age dependent rather than absolutely required)
- ✓ Lead free solder (included with kit) or lead free solder paste
- ✓ Solder flux – liquid or paste, makes soldering the SMD ICs a lot easier (from Amazon, Digikey, Mouser).

The Kit Sheet

The components are **not** put onto the sheet in assembly order, but closer to their function. The bags are stapled onto a printed rectangle that gives the part designation, quantity, description and any warnings to be aware of. Some of the parts the builder determines by the size and quantity in the individual bag. C1 and C2 are the only 2 same sized capacitors in the passive component SMD bag for example. You may end up with a few extra passive SMD parts as they were cut from a reel by spacing rather than count.

For assembly, use the assembly drawings of Appendix E below which show where each component is located by designation and the polarity of the part placement. ***Note that the 2nd assembly sheet of Appendix E shows the SMD parts only, which will help doing the surface mount soldering.*** The kit-sheet shows any issues the builder should be aware of with component polarity.

SMD Integrated Circuits

The SMD ICs should be soldered onto the card first, but you may prefer to solder the passive components first – especially if you think you need some practice with SMD soldering

WARNING – be careful handling the semiconductors – they are sensitive to static electricity. The builder is cautioned to observe all rules when working with these parts. The ICs have been packed in antistatic plastic for shipping, but the user should touch some grounded object (like a metal power strip enclosure, appliance or home lighting fixture) to bleed off any static charge before handling integrated circuits. Carpeting, plastic and some types of clothing generate static, so be aware of your particular work situation when building any electronic kit.

The SMD IC leads are fragile so be careful in handling them and avoid handling at all if possible. Use the tweezers on the non-leaded sides to move the part onto the PCB.

Avoid the temptation to use your soldering iron to put solder onto all the SMD IC pads as it does not work in the author's opinion. Instead use your soldering iron to put a small amount of solder onto 2 diagonal corner lands of each SMD IC. Wet all of the component lands with flux including the component leads. **Watch the component polarity and double check it.** Now using the tweezers (a pair that opens enough to grasp the black epoxy IC body) place it over the component lands centered both vertically and horizontally. Apply the soldering iron to one of the

two corner lands you have put a small amount of solder on. **This 1st soldered SMD lead is the most important one.** If you have soldered the corner component lead with good alignment, do the 2nd diagonal corner lead being sure that all of the other leads are right over there respective lands. **If the first soldered lead is not near perfectly aligned, it makes it way harder to get the 2nd corner lead to align right.** Center the chip to that there is equal land showing on each side of the chip's leads. After you have the two corner pads soldered, reapply some of the liquid flux to the rest of the unsoldered leads. Then by heating one lead at a time where the ends of the lead meets the land, use a solder wetted tip to apply a small amount of solder. The solder will be pulled into the lead-land junction by capillary action. If this all goes well the 1st time you try it - you sir are a steely-eyed SMD kit builder. **The author can not stress enough the importance of flux and a clean, wetted soldering tip.**

You may prefer to use solder paste, which does work in this application. Put a **small amount** of paste on all of the SMD pads with a toothpick. Then place the component in place over the lands with tweezers. Holding the part in place, use the soldering tip as above to heat the junction between the lead and the land on two opposing component corners as above. When you have the lead-to-land alignment correct, work on doing the remaining component leads by heating the lead-land junction edge.

Take your time and work from the smallest IC to the largest. When done with each part, use a magnifying glass to examine the soldered connections. **The most common issue is getting solder onto the lead, but not on the SMD pad.** My solution is to bias the soldering wetted tip onto the land first, then the component lead. Doing the soldering this way helps prevent solder bridges, but if that occurs I use solder braid to soak up the extra solder. There are also desoldering tools which can be useful to fix bridging. **It is always better to use less solder than you think is necessary with SMD parts.**

Passive SMD components

The capacitor and resistor SMD parts are easy compared to the ICs. **Be sure to note the polarity of the tantalum capacitor(s) and match the strip on the component with the silkscreened '+' near the positive SMD land.** For these parts general, apply a small amount of solder to one PCB land of each component. Then using the tweezers, hold the component in place, heat the component end to land junction until the solder reflows onto the part. After all of the passive parts are soldered on one end, go back and solder the other end making a normal solder junction between the component end and the SMD land.

Through hole components

For the remaining parts, start with the shortest height components and work to the tallest (sockets, resistor pack, 2mm jumpers, terminal blocks, stacking connectors). That way, as you add parts on the component side of the card, you can flip the card over for soldering with the part held in position against the work table. **Be sure to double check any parts on the kit-sheet that indicate a warning about polarity.** Watch that resistor pack and which way the terminal blocks are facing before soldering.

Stacking connectors (solder last)

The 2013 dated kit includes a combination of stacking connectors to tailor the assembly toward use with the original Arduino UNO or the newer R3 Leonardo. Future kits will have connectors for the R3 only as they will work with both versions. The kit-sheet shows the connector length to use with both Arduino CPU versions. There are two differences between the card versions involving the length of PW/J4 and J2 (see page 2 of the schematic). The total added 4 pins make little difference as far as the author can tell, and no difference in operation. There may be

some concern if more shields are added onto the kit shield. **If you are unsure how to proceed, the author suggests building up the card with the higher pin count connectors.** That way at some future time if you are switching from using an UNO to a newer Arduino version, your card will be fully compatible. **Be sure the 2 extra pins of PW/J4 and J2 do not touch other components on the Arduino UNO** and if necessary, bend them slightly outward.

As for alignment, put the 4 female stacking connector ends onto another shield's male connectors. Then solder one or two pins of each stacking connector on the solder side. You then remove the 2nd 'alignment shield', check that the connector is seated on the PCB properly and finish soldering the remaining pins.

Final assembly

There are jumper shunts and socketed components to install for final kit assembly. Use this manual's figure 2 above for setting the default shunt positions and the 1st page of Appendix E below for orientation of the socketed ICs. Be careful with the socketed components to observe polarity and be aware that each component lead is going into the socket pin correctly. It helps a lot if you can bend each row of leads slightly inward before installation. The sockets are double-contact and very hard to remove by hand – so if you need to remove a socketed chip, use a removal tool (recommended) or a thin bladed screwdriver to carefully pry up the part. Pulling the part out by hand will: 1) bend the leads and 2) cause the bent leads to jump into your fingers.

Testing and troubleshooting

Ohm Meter Test

Before plugging in the shield, get a multimeter out and set it to a range to cover 2K (2,000) ohms. Put the negative meter lead onto any of the mounting holes and the plus lead onto the '+' end of the yellow filter capacitor C3. You should read about 1.3K to 1.4K (1,300 – 1,400) ohms. Your reading range could be somewhat different due to semiconductor and contact differences, but should be somewhere other than close to 0 (short circuit) and not double the reading above. The author has measured 4 cards, and they all fell between the 2 readings above. If your reading is way different, especially LOW, check the card over for a shorted solder connection. If the reading is HIGH, check for missing solder connection(s). Doing this will minimize the risk of plugging in your new shield and damaging it, or your Arduino card.

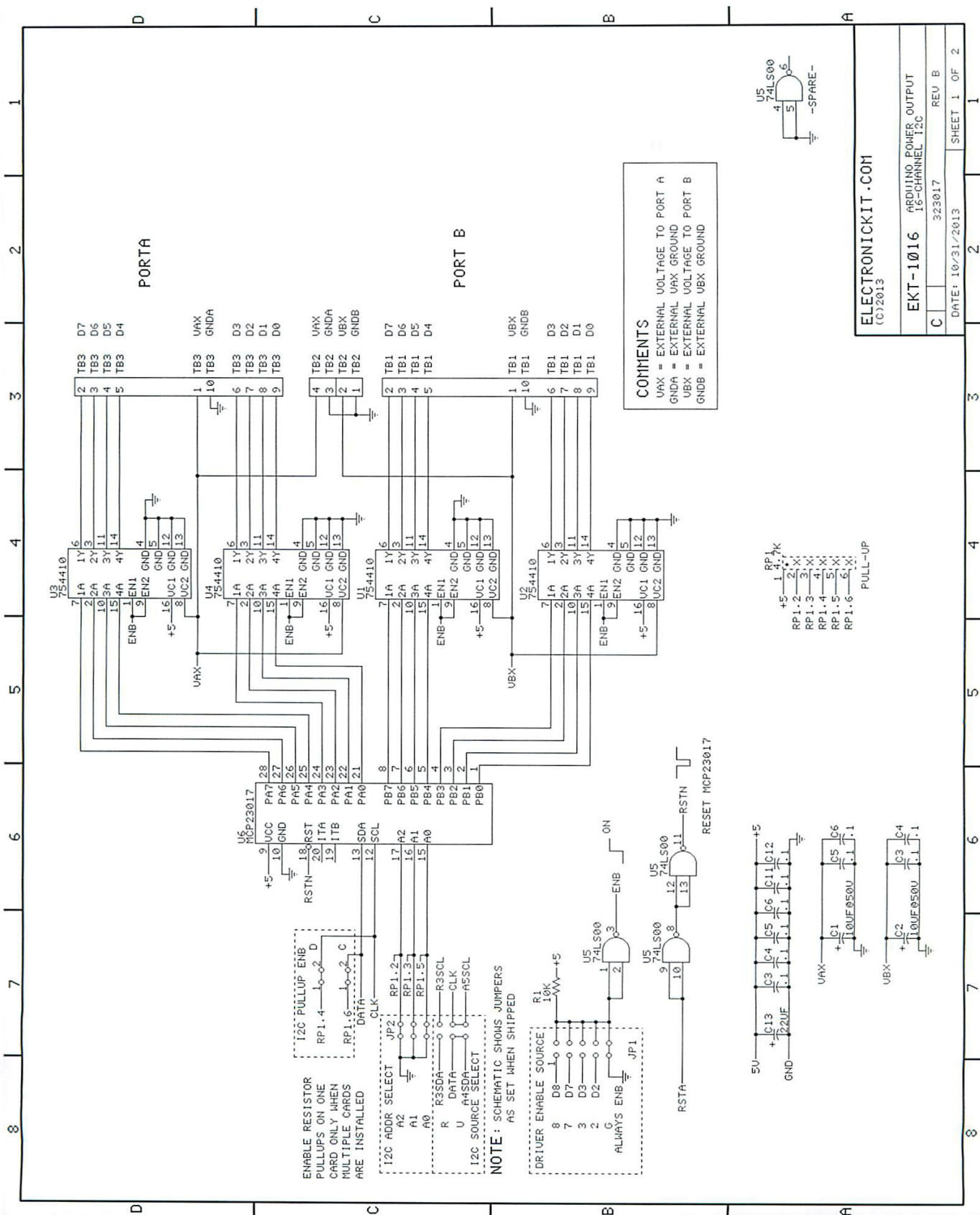
Download the test 'ripple1016.ino' program from the electronickit website:

<http://www.electronickit.com/kitproduct/ekt-1016/sketch1016.zip>. Load the 'ripple1016.ino' sketch onto your Arduino CPU using the usual process via the Arduino IDE. Power down and plug the add on shield onto your Arduino being careful to watch the stacking pin alignment. A LED attached to one driver per figure 6 in this manual is the easiest way to do an initial test. Remember that the external voltage must be applied to the port being tested in addition to the anode of the LED. Though not generally done, in this case the user can use the +5V of the stacking PW/J4 connector to draw power for the LED test. After powering up, the LED should flash about once per second if everything is working correctly. **If no flashing of the LED occurs – POWER DOWN and check your setup.** Moving the LED from driver output to driver output will verify that all drivers are working properly. If there is some problem with a particular LED connected driver – use the schematic in the next appendix to trace back to the MCP23017 SMD chip as that is where the soldering problem is usually located before tracing forward to the terminal block.

If none of the LEDs light or there is intermittent driver operation, examine the solder connections on the MCP23017 (*which represents 95% of the shield's circuitry*) for the control input signal operation. SDA, SCL, RESET, A0, A1, A2, +5v and GROUND all have to be connected and

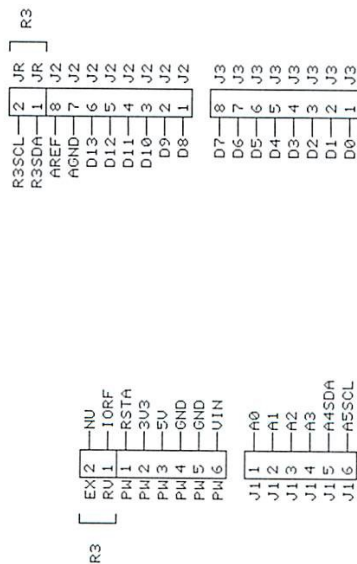
working for the chip to operate. Refer to the schematic in Appendix D for locating the chip's pinouts. Next check that the external voltage is present on the port terminal block pin 1 and LED anode. **The RESET line on the MCP23017 should normally be HIGH** as it uses negative true logic. More troubleshooting means getting out an oscilloscope to examine the RESET, SDA and SCL signals in more detail to physically examine their waveform. Appendix A and B above may also be of help in locating a 'system' type problem, but you must suspect a solder, or component problem, on any kit project.

Appendix D EKT-1016 Schematics



1 2 3 4 5 6 7 8

D C B A



ARDUINO UNO
AND R3/LEONARDO

ELECTRONICKIT.COM
(C)2013

EKT-1016 ARDUINO PINOUTS
UNO R3

C 323017 REV B

DATE: 10/02/13 SHEET 2 OF 2

1 2 3 4 5 6 7 8

Appendix E Assembly Drawings (full and SMD only)

ITEM	QUAN	DES	DESCRIPTION
1	2	C1, C2	10F/50V CERM
2	10	C3-C12	0.1UF/50V CERM 1206
3	1	C13	22UF TANT 1210
4	1	JP1	5-PIN DUAL 2MM
5	1	JP2	6-PIN DUAL 2MM
6	1	R1	RES 10K 1206
7	1	RP1	RES PK 6PIN 4.7K
8	4	S1-S4	SOCKET 16-PIN
9	2	TB1, TB3	TERM BLK 10-PIN
10	1	TB2	TERM BLK 4-PIN
11	4	U1-U4	IC 754410 16-DIP
12	1	U5	IC 74LS00 SOIC
13	1	U6	IC MCP23017 SOP
14	5	SH1-SH5	SHUNT 2MM
15	1	J1	CONN STAK 6-PIN
16	1	J3	CONN STAK 8-PIN
17			
18			
19			
20			
21	BELOW ARE UNO/R3 DEPENDENT		
22	1	J2 UNO	CONN STAK 8-PIN
23		R-3	CONN STAT 10-PIN
24	1	J4/PW UNO	CONN STAK 6-PIN
25		R-3	CONN STAK 8-PIN

ElectronicsKit.com

EKT-1016

Rev XX

TB1

TB2

TB3

C1

C2

C3

C4

C5

C6

C7

C8

C9

C10

C11

C12

C13

U1

U2

U3

U4

U5

U6

J1

J2

J3

J4

JP1

JP2

R1

RP1

S1

S2

S3

S4

SH1

SH2

SH3

SH4

SH5

TB1

TB2

TB3

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EKT-1016

Rev XX

ElectronicsKit.com

EKT-1016

ASSEMBLY DRAWING

SIZE A DRAWING 11016

REV B

DATE: 10/31/13

SHT 1 OF 1

Assembly Drawing SMD Parts Only

SMD ASSEMBLY DRAWING

ElectronicKit.com

EKT-1016

Rev XX

C1

C2

C3

C4

C5

C6

C7

C8

C9

C10

C11

C12

C13

U5

U6

R1

ITEM	QUAN	DES	DESCRIPTION
1	2	C1, C2	10F/50V CERM
2	10	C3-C12	0.1UF/50V CERM 1206
3	1	C13	22UF TANT 1210
4			
5			
6	1	R1	RES 10K 1206
7			
8			
9			
10			
11			
12	1	U5	IC 74LS00 SOIC
13	1	U6	IC MCP23017 SOP
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EKT-1016

SMD ASSEMBLY DRAWING

SIZE A

DRAWING

11018

REV B

DATE: 10/31/13

SHT 1

OF 1