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Arduino-Compatible TFT Touchscreen Wall Plate

When a customisable interface is needed, it's hard to go past a graphic LCD and touch screen.

The K9660 is based on the Arduino Due, and integrates a 2.8" 16bit Colour QVGA screen, alongside a resistive touchscreen and Uno shield headers allowing a huge level of versatility for projects of all types.

K 9660

There are a number of driving methods available to drive the ILI9341 controller in the TFT LCD, utilising either parallel or serial interfacing. These are controlled via the IM(0..3) pins on the LCD. Parallel control offers potentially very high speed data transfers, however it requires a large number of IO pins which can't be otherwise used. Additionally, if the pins are spread out across microcontroller ports it can require a significant amount of the processor's time to send the data, requiring multiple port reads and writes per data transmission.

As an alternative, the serial interface requires only 4 data pins (, compatible with the SPI interface standard, or 3 wires if using a single IO line for reads and writes), but since it has to shift data out one bit at a time, is up to 16x slower for the same clock speed. At the ILI9341's maximum serial clock speed of 10MHz, redrawing the entire screen will take >120ms just for the pixel data. With communication overhead added on, the total time can be far higher. While not suitable for high-rate video display, this time is significantly reduced when only redrawing a portion of the screen. In most applications buttons/graphics will be updated one at a time, and for this, the serial interface is fast enough that drawing can appear almost instantaneous.

Another advantage from the use of SPI is the ability to offload the sending of data to the microcontroller's DMA (Direct Memory Access) peripheral. The DMA peripheral is capable of autonomously transfering the contents of an area of memory to be sent out the SPI peripheral without any intervention from the microcontroller, other than the initial transfer setup. While this doesn't speed up the transfer of data (since it's still limited by the SPI clock speed) it frees up the microcontroller to perform other tasks while the transfer is happening (Unless a blocking function is used, which has the alternative benefit of simplifying program flow), such as reading the touch screen or loading images from an SD card.
In the K9660, serial mode is used to communicate with the LCD via the SAM3X's SPI peripheral. Transfers can be handled either directly, or via DMA using commonly available libraries.

The touch screen used on the LCD is a resistive type. In this screen two resistive sheets are separated by a insulating gap, a touch on the screen closes the gap, making contact between the two sheets. To make a reading of the touch position, a voltage gradient is applied across one sheet (up/down or left/right) and the voltage present on the second sheet is measured. The voltage present on the second sheet will represent where on the voltage gradient the point of contact is. The roles are then reversed, and a voltage gradient is applied to the second sheet (left/right if first is top/bottom and vsvs) and the potential of the first sheet is measured. Using the two measurements obtained the relative position of the touch point can be determined. The "pressure" associated with the touch can also be obtained by differentially measuring the additional resistance associated with the contact between the sheets.

PCB Construction:

The SAM3X at the heart of the K9660 is a rather large IC, and between the IC and its required ancillary components, takes up the majority of the available board space. To fit the required circuitry into the available space SMD components have been used. Since many of these are either small (0603 resistors/capacitors) or involve tight pin spacings (such as the LCD connector and the SAM3X processor) the board has been supplied with the majority of components pre-populated.

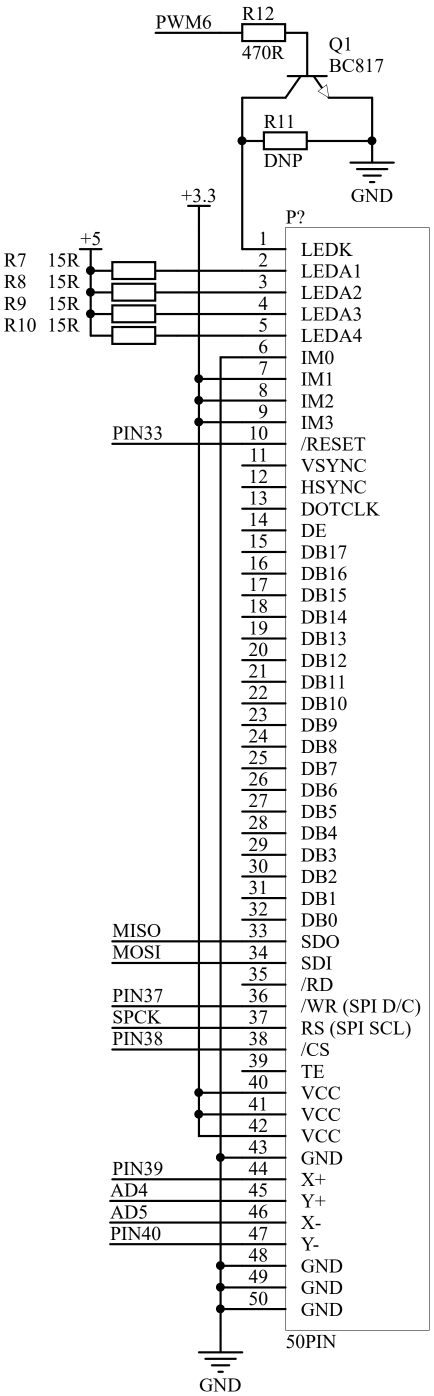


Fig 1. The K9660 is built around a 2.8" LCD. This is connected via a 50pin FPC connector, which contains both the LCD signals, and the touch screen electrodes. In order to reduce the required number of pins the LCD is connected in SPI mode. The backlight is controlled via a BC817 transistor, with an optional resistor to set a minimum brightness.

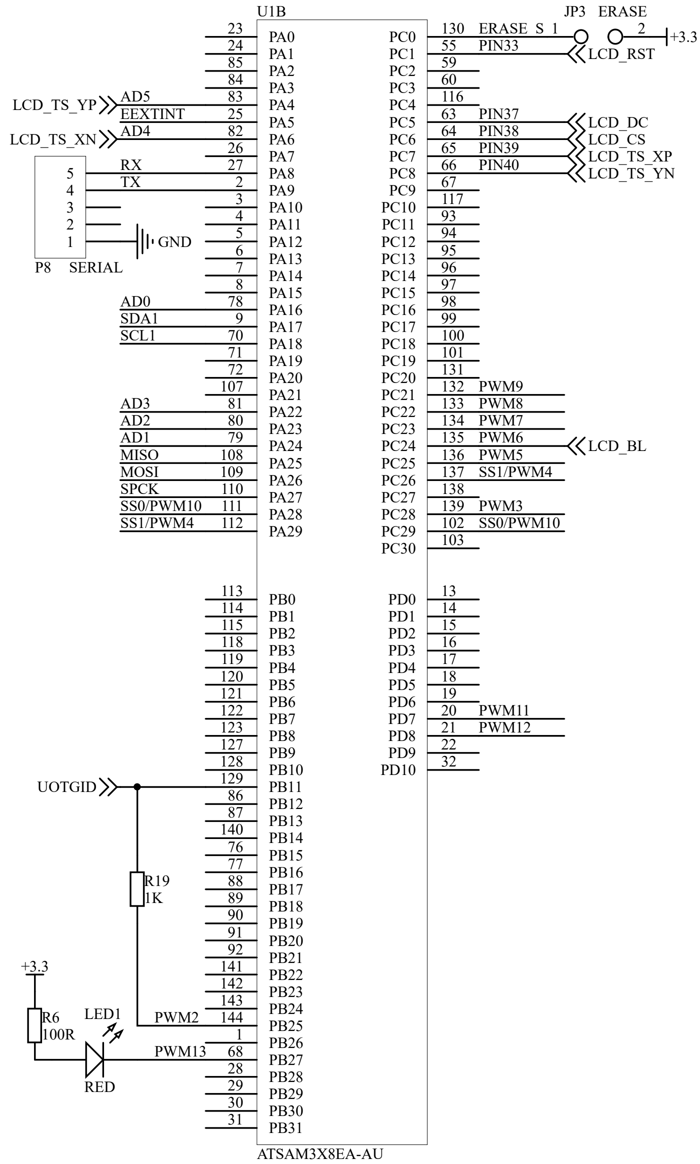


Fig 2. Due to the use of SPI for the LCD, and only having room to break out the Uno headers, there are very few connections into the SAM3X micro controller.

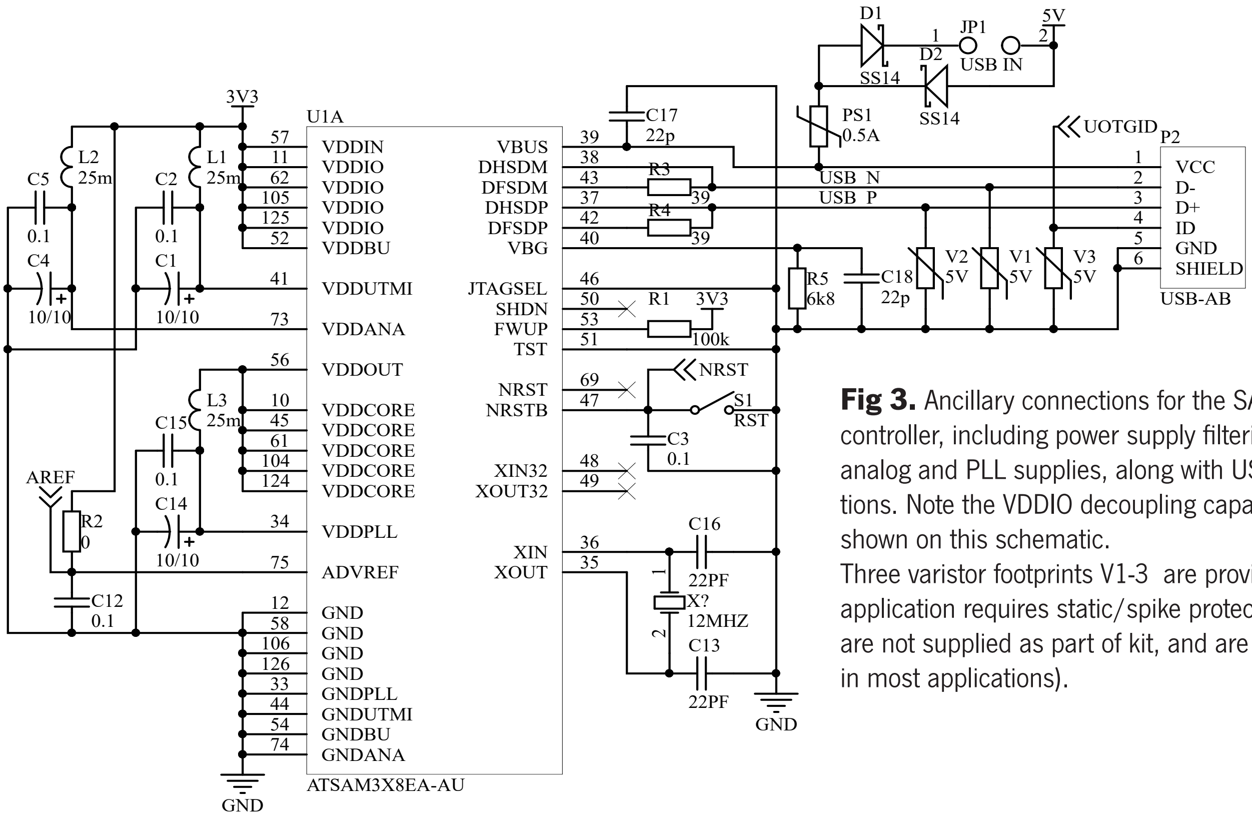


Fig 3. Ancillary connections for the SAM3X micro controller, including power supply filtering for the analog and PLL supplies, along with USB connections. Note the VDDIO decoupling capacitors are not shown on this schematic.
Three varistor footprints V1-3 are provided incase an application requires static/spike protection (varistors are not supplied as part of kit, and are unneccessary in most applications).

To complete assembly a number of through-hole parts need to be soldered. The voltage regulator, REG1, should be fitted so it fits neatly within the silkscreen outline on the PCB. The remaining components are headers/screw terminals and reset button, and can be fitted in any orientation.

Two header rows are provided for the Arduino shield pins, the outer set matches the Arduino shield spec, while the inner set is spaced around ~42.5mm and while not compatible with shields, will neatly fit inside a standard electrical wall-box. A 5-pin header on the bottom of the board breaks out RX(D0), TX(D1) and a GND connection for connecting a serial monitor incase a USB connection isn't available. These can be fully/selectively populated, or left unpopulated as needed. Fit and solder all remaining components.

The PCB assembly is now complete.

Final Assembly:

The LCD mounts to the rear of the PCB, held in place with double sided tape, which doubles as electrical insulation between the PCB components and the metal mounting frame of the LCD. Firstly, ensure all component legs in and around the LCD's silkscreen outline are cut as close to the PCB as possible. Using the supplied double-sided tape apply an insulating layer over the metal frame on the rear of the LCD. Feed the LCD's FPC cable through the PCB cutout, noting the orientation of the LCD. Gently pull the locking bar on the FPC connector into it's extended position (be carefull to not apply too much force and pull it off the connector). Feed the FPC cable into the connector, and when it's fully inserted and centered, gently push the locking bar back into it's locked position. You may need a small pair of needle-nose pliers to help push it back all the way. Once the LCD is attached, peel the protective layer from the double sided tape and fit the LCD as centrally as possible within the silkscreen outline on the PCB.

The PCB is mounted to the wall plate by two M3x10 countersunk bolts. These are fitted to the top right, and bottom left corners (viewed from the rear), and held in with metal M3 hex nuts, which also act as spacers to stand the LCD off from the wall plate's surround, preventing it from interfering with the touch screen. Once the PCB is fitted, it is held in place with a second set of nuts. Loosely fit this second set of nuts and use the additional width in the mounting holes to manuver the PCB so the LCD active area sits as centrally as possible (The electrode bars of the touch screen should not be visible on any of the sides when the LCD is properly centered. With the LCD held in this position, tighten the nuts. The cutout for the USB connection is covered by the wall plate covers, so can be left off untill a project is ready for installation.

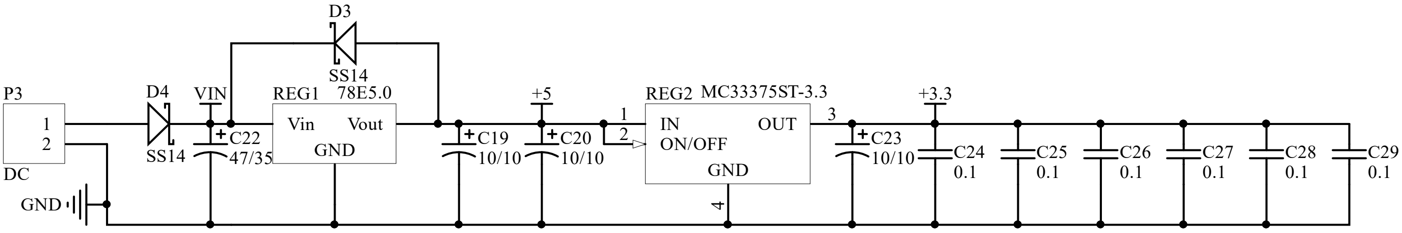
Unit assembly is now complete.

Code example:

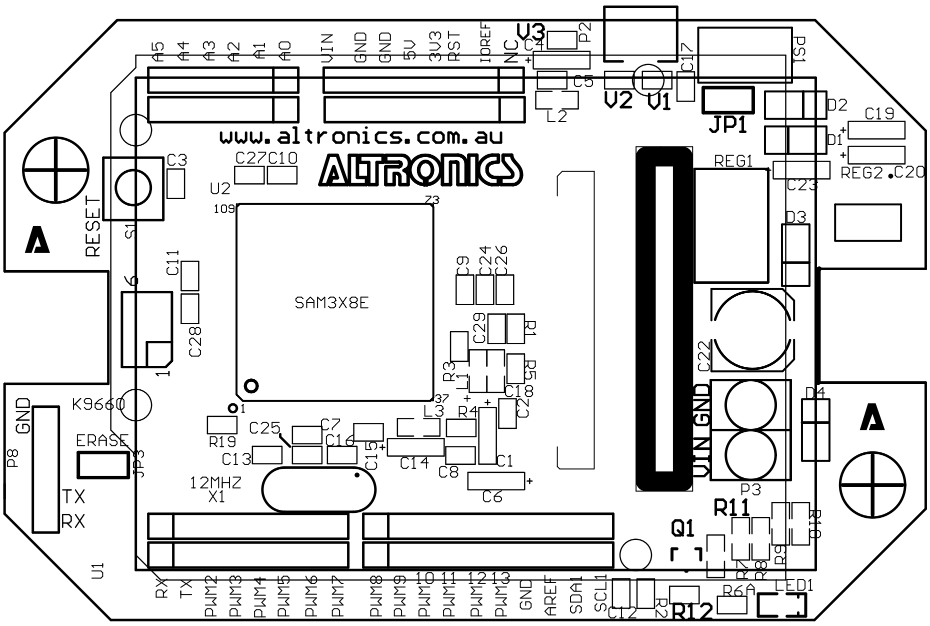
The unit comes pre-programmed with an example demonstrating displaying an image from flash, calibration of the touch screen, and general purpose and text drawing on the LCD. To run the LCD using the Due's DMA capability the "ILI9341_due" library by Marek Buriak is used, alongside the Adafruit TouchScreen library, and BasicLinearAlgebra, used in the touch screen calibration.

The ILI9341 library uses (by default) the hardware SPI, and requires the additional LCD control pins to be specified. These are the chip select (connected to D38), data/com-

Fig 4. Power supply and VDDIO decoupling capacitors. Note that only the screw terminals have reverse polarity protection. The K7805-500R3 switchmode supply providing the 5V rail can handle an input voltage from 6.5-36V, while the 47μF input capacitor is limited to 35V.



Overlay Diagram



mand (connected to D37) and reset (connected to D33). The touch screen requires the pin connections for the 4 electrodes (X+=D39, X-=A5, Y+=A4, Y-=D40), and optionally takes the x-plane resistance measurement to aid in accurate pressure measurements. The values reported by the touchscreen library are the raw values read from the screen, and will need calibration (or at least scaling) to compensate for non-ideal behaviours in the screen and measurement system. In the example code, the calibration routine used is based on the "minimum mean square error" (MMSE) algorithm detailed in Analog Devices application note AN-1021.

Follow the instructions on the screen and the example will run through the calibration procedure. Open a serial terminal targeting the board, from the Arduino IDE for a more detailed look at the sketch's operation, and to obtain the calibration results for future use.

Finally a minimalist Paint-like demo program is left running, showing off the precision capable by the touch screen.

The example's source code is available to download from the K9660's web entry on the Altronics website.

Important Note:
Please note that we can offer a warranty only on the components supplied with this kit. Because we are unable to guarantee your labour, there is no warranty on either partially or fully built kits. We are able to offer a repair service, but once construction has commenced, this service is chargeable.

Dear Kit Constructor,
At Altronics we take great pride in the quality and presentation of our kits. If you find any deficiency in this kit or have any constructive comments whatsoever, please write to us.

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