Angelis 6602 Control Panel™ Technical Sheet

Revision: May 5, 2014

Introduction

Congratulations on acquiring an **Angelis 6602 Panel™** board. This is a very versatile board for creating beautiful and efficient user interfaces for microprocessor-based systems. You are now able to save both the time to re-invent a control panel and the cost of all the single-piece parts. It has been designed to be wired in many different configurations, with the flexibility to be used for many kinds of microprocessor and computer interfaces, including Arduino, Raspberries, Beagles, PICs or whatever kind of machine you are using.

Best of all, you can get a precision, anodized aluminum front panel that is designed precisely for the printed circuit board and avoid all that cutting and drilling! It attaches to the board with hidden M3 studs and nuts that are invisible from the outside. Only the four 1/8" diameter panel mounting screws are visible. Another option is a customized enclosure to finish your entire project in a sturdy, extruded aluminum enclosure.

Four different options are offered (with red or green LEDs, with or without **Clickfeel™** relay). Additionally, either zero, four or eight pull up resistors can be installed as needed. Any of the twelve varieties can be built with the special unassembled kit version for do-it-yourself folks. The kit includes all the parts for any of the circuit options. A special add-on kit is also available so you can mix and match your keycap colors to your design. Take a look at the features listed below, and you will see that no effort was spared in making this board reliable and easy to use in many different circuit designs.

Features

- Two continuously turning rotary encoders with integrated push switches.
- Six momentary-contact tactile feel buttons with available colorful selection of keycaps. Including the two push switches in the encoders, there are a total of eight momentary switches.
- The six additional buttons are arranged in three groups of two button pairs.
- Six LEDs, one paired to each button, each with a current limiting resistor. Red and green are offered and both supplied with the kit, but you can make them any colors you want with a suitable current-limiting resistor.
- One totally unique **Clickfeel™** relay, which provides a satisfying click sound and vibration with each key press. It makes the buttons feel like very high-quality devices.
- The **Clickfeel™** circuit has a transistor driver to reduce current drain on the controlling output.
- Connected with a 34-pin dual-row header for connection to an IDC ribbon cable. In the kit this connector can be installed front or back depending on configuration needs.
- Three 1/8" mounting holes for secure attachment to any panel or frame.
- Full, two-sided ground plane to help reduce interference and noise in your system to help prevent mysterious, erratic operation.
- Each 4-switch group of buttons can be tied to the ground plane or isolated for use in a multiplexed system. The LEDs can also be isolated or connected to ground.
- Uses thru-hole components for easy construction, modification or repair.
- High-quality double-sided printed circuit board with solder mask for reliable and short-free soldering.
- Plated thru-holes for high reliability.
- Silk-screen printing to make it easy to identify part locations and connections.

- Extra keycap colors, high-quality encoder knobs, a matching precision-machined front panel, and a full enclosure with matching front panel are available as accessories.

Many Ways to Hook-Up and Use –

The **Angelis 6602 Panel™** board was designed from the start for versatility. It can be mounted horizontally with the LEDs on top of the three function switches, or vertically with the LEDs to the left of the function switches. (You could of course also mount it with the LEDs below or to the right.)

While the **Angelis 6602 Panel™** board can simultaneously hold switches and LEDs, it is also cost-effective enough to be useful for holding an array of switches without any LEDs. Several of these units can be assembled for even more encoders, switches and lights in a single control panel. Instead of creating a vast expanse of buttons and LEDs, you can organize these controls in discrete functional groups, making your machine easier to comprehend and operate.

Beginners and students will be able to simply wire all these components with a 1-to-1 correspondence between the devices and the microprocessor I/O pins, making programming easy. More advanced engineers who want to wring out the most cost-effective designs can use these boards to wire a multiplexed switch matrix, or LED matrix, or both at the same time. Multiplexing both switches and LEDs can even share the same active-low column driver pins.

Multiplexing allows the design to use fewer I/O pins but requires the use of some relatively simple scanning code in the microprocessor. If you are building a larger control interface, with (for example) 16 switches, multiplexing can save a lot of I/O pins on your microprocessor. 16 switches will only need 8 I/O pins, instead of 16 without multiplexing. This example would use two of these **Angelis 6602 Panel™** boards.

Connector -

This board is designed to accept a 34-pin dual-row header. The use of a dual-row header (supplied with both assembled and kit versions) allows you to connect this with a standard 0.05” ribbon cable and an IDC connector. By default the header is installed on the back side away from the user, and the pin numbers are by default reversed as shown on the schematic. The kit builder has the option to mount it on the front face of the circuit board also.

The basic board layout has the 34-pin connector on the back so that the connector can be connected or disconnected from behind without removing the board from a front panel. The rear-mounted connector will not interfere with the panel devices. However, in cases where this panel will be used for education or experimentation in an open-breadboard type system, the connector can be soldered to the front. The only requirement is to remember to convert the odd and even pin numbers you see on the schematic.

The 0.1” centered thru-holes allows you to omit the connector completely, and just solder wires to all the plated contact thru-holes. They are conveniently labeled (on the top side of the printed circuit board).

Switches –

These momentary-on button switches are the popular “tactile-feel” type, meaning that you feel a solid click when they are pressed, so you know the switch contact has been made. These switches are rated for 10 million operations. Like all switches, these switches are prone to contact bounce. Your circuitry, or more likely your software, must accommodate switch bounce. This can be a simple method of

delaying until the processor "sees" that the switch is no longer changing state, or just programming so that a button pressing event calls its associated software process only once and never again (or at least until a reasonably long time delay has passed).

The **Angelis 6602 Panel™** board includes places for adding blocking/steering diodes. These are only needed for a multiplexed or scanned keypad panel if you want to be able to detect multiple simultaneous switch closures. If using these switches as direct 1-to-1 inputs, then all you need is a small jumper wire to replace the diodes. Use the extra wire leads from the resistors on the board to act as jumper wires. It's better than throwing them out. Assembled units have these diodes installed already, and they will work with either direct connections or multiplexed scanning, so there is no need to remove them.

Many microprocessors have digital inputs with built-in pull ups. You should consult with your particular microprocessor's data sheet to be sure, and they may need to be turned on via software. If this is not the case with your particular application, then you can add 10K pull up resistors to this circuit board. 10K ohms is a typical value that will work for almost everything. If using external pull ups, then the +5L signal needs to be connected to a Vcc or Vss (+5 or +3.3) voltage source for these to work. The two switches internal to the rotary encoders are grouped with the other six switches, and share the same pull up power on +5L.

If you are using pull up resistors in a multiple board system with multiplexed switches, only *one* board needs to have pull ups, and only *one* board needs to have the clicker relay. Unlike our previous designs, you can wire the same board for the pull up resistor voltage and for the relay voltage (+5V is recommended) because the relay power is provided on a separate pin (+5R).

Rotary Encoders –

The two rotary encoders have integrated push switches that are activated when the encoder knob is pressed down. These two switches are wired with the other six push switches, so see the above section on switches for details.

The rotary encoders have 2-bit quadrature coded outputs. They have 12 detents and 12 pulses per revolution. The outputs are active low, that is they close to ground. When rotated clockwise, the A output precedes the B output. When rotated counter-clockwise, the A output lags the B output.

They are rated to turn at no more than 100 rpm, however we recommend a maximum speed of 60 rpm – or 1 rev per second max. In normal operation, at about 15 rpm, switch bounce can be up to 5 milliseconds.

To help with the tracking accuracy, the **Angelis 6602 Panel™** has filtering included on the circuit board. This filter has a RC time constant of 2 mSec rising and 1 mSec falling. Some device inputs may require additional filtering depending on the noise sensitivity of the inputs. If this is the case, adding an additional 0.1uF to 0.5uF across C1, C2, C3 and C4 should solve the problem.

The encoders have a rotational life rating of 100,000 cycles, the push switches on the encoders has a life rating of 20,000 cycles.

Clickfeel™ Circuitry –

The **Clickfeel™** circuitry is an innovation that provides a satisfying snap every time you press a button. You don't need to wire it up so this circuit is entirely optional, but I enthusiastically suggest you give it a try. It is simply a small mechanical relay that is attached to the circuit board that is activated by a single

digital output of the microprocessor whenever it detects a button press. It has the almost subconscious effect of giving the user an immediate acknowledgement for each button press, making them feel more confident operating the device. The **Clickfeel™** system can work well with a rotary encoder also.

A roughly five or ten millisecond high pulse is all that is needed on the RLY-EN pin. The +5R pin should be tied to +5 volts (or +3.3 volts if +5 isn't available). In rare cases you may need to lengthen the pulse width for sluggish relays with a 3.3 volt system, but this has never been seen.

Your processor pin should have no trouble driving the current for the relay because it will be less than 1 mA. This is because the **Angelis 6602 Panel™** has a built-in relay driver. For this to work, (if building from a kit) make sure Q1 and R12 are installed.

If you are going to use a multiple-board switch system that is multiplexed (this doesn't apply to the simpler 1-to-1 button-to-input connection scheme), consider the following: Only one board needs to have the relay, and only one board at most needs to have pull up power applied (if not supplied by the microprocessor input pin). You can of course have some serious click going by using both relays. This board design allows you to still use the clicker relay at any desired voltage, and also use pull ups to any desired voltage. +5R is used to power the relay, while the +5L is used to power the pull up resistors. The two switches internal to the rotary encoders are also pulled up with the +5L supply. +5E is used only to pull up the encoder's A and B outputs just in case that is being input to a different logic family.

The diode included on the circuit board with the relay is a high-voltage clamping diode. This is there to absorb any kick-back voltage that normally appears on an inductive load (such as this relay). Without the diode, this opposite-polarity voltage that appears from the collapse of the magnetic field on the coil may induce a strong enough current into the driver to destroy it. The diode, which at first may appear to be backwards, prevents this from occurring.

The sound of the relay is enhanced by its solid connection from the circuit board to the front panel or frame of the device it is installed in, making a unique, but subtle acoustical click. It does sound much, much better than the overly-used, squealing "peep" of a piezoelectric beeper tone, and is certainly better than nothing.

LEDs –

The normal LED colors will be a single red or green light associated with each of the six function buttons. This allows for an indicator for "Off/On", or something similar for each button function. Of course the LEDs can have nothing to do with the switch function; it's all up to the designer of the system. The colors red or green were chosen because they are the most common and affordable, and they are the most efficient colors. Yellow is also an affordable and easy to find choice that uses similar driving voltages. There is no reason you can't substitute these with blue, white, pink, orange, or whatever color you like and can find. These LEDs are the standard round 5mm or T1-3/4 size. T1 or 3mm will also work, but are too small for the opening of the optional machined front panel.

Please be aware that not all LEDs are the same. Not only are different colors sometimes drastically different, but there are often voltage and current variations in a given color. Every LED requires a specific current-limiting resistor value based on the voltage being used and its rated current. Some unusual LEDs may require a change in the resistor value. Many websites should be able to help you select the best value based on the LEDs forward voltage and continuous current ratings. Blue and white LEDs will often require a higher driving voltage, and often a higher current limiting resistance.

The supplied 150-ohm, 1/8 watt resistors are fine for most normal use LEDs. This provides 20 mA of current to an LED with a 2-volt drop if using a 5-volt power source. Naturally, 3.3 volt supplies will make the LEDs a bit dimmer, but should be fine. Most red, green and yellow LEDs will work with this value, but some white or blue LEDs may need a different resistor value for optimal luminosity and reliability. The resistors designated R1…R6 are directly associated with the LEDs designated L1…L6 for easy identification.

Mounting –

There are three mounting holes in the **Angelis 6602 Panel™** board. If you want a nice, solid, long-lasting device I recommend using all three mounting holes in your system. If you use fewer, the board is likely to flex a bit when the buttons are clicked, making them feel less solid. With a less solid mounting, the **Clickfeel™** relay will not be able to resonate with the enclosure, making it quieter and less satisfying. Over time, the additional flexing may stress the solder joints and the printed circuitry, and you may end up with a premature failure of the board. Movement of the board may also stress the connector and wiring leading to the rest of the system. A solid mounting is the most reliable.

Angelis Electronics offers a precision-machined black-anodized aluminum front panel that exactly fits this board. It has hidden mounting studs (3.0mm threads) and nuts in the back so the board can be directly attached to the front panel plate. The plate is then mounted with four 1/8" corner holes to the front of your device. Two front plates are offered, one specifically for the enclosure we offer (4820-box), and the other for any other enclosures. The only difference is the plate for any enclosure does not have countersinks in the mounting holes.

Multiplexing –

Don't let this big word scare you. *Multiplexing*, or *Scanning* as it is often referred to, is simply a method used to save on digital input/output pins on a microprocessor. This is a great idea if you ran out of I/O pins on your processor board, or want to save a few pins for other devices, and don't want to upgrade to a larger, more expensive processor with more I/O.

On the **Angelis 6602 Panel™** board, either the switch inputs or LED outputs or both can be multiplexed to save pins. If you like to keep it simple, a direct one-to-one connection is perfectly fine. But consider multiplexing if you want to 1) more efficiently use your I/O pins or 2) if you just want to experiment and learn how to do it. The drawback is that the circuitry must be combined with some software programming to work.

Wiring switches or LEDs for multiplexing simply involves removing or cutting the associated ground jumpers (two for LEDs, two for switches). This frees the common point to be driven active-low to enable the particular set of switches / LEDs. Remember though that only one board should have pull up resistors, or none of them if the microprocessor pins have them turned on internally. The pull up resistors are R31 thru R38. If multiplexing and you need pull up resistors in a 4-wide matrix, only include R31, R32, R33 and R34. The other four (R35-R38) should be removed. If using an 8-wide matrix and you need pull up resistors, install all 8 resistors.

Unfortunately this document can't become a whole lesson on multiplexing. If this is enough for you to experiment with, great! You may want to study this method in more detail though. I only wanted to point out that the **Angelis 6602 Panel™** board can be wired to use multiplexed circuitry if you want to do that.

Multiplexed Circuit Modifications –CUT THE JUMPERS!

Note that if any of the jumpers described below are cut or removed to isolate a circuit from the ground plane, the ground plane of the board will still be connected to the case ground if any one of the three mounting holes are properly attached to a ground. Use of a solid metal standoff and star washers to a metal case, or attaching a ground wire thru a crimp lug directly to a mounting screw will usually accomplish this if your case is grounded. Use Nylon standoffs if you don't want this board grounded.

Multiplexed LEDs

If you decide to multiplex the LED section of the **Angelis 6602 Panel™** board, you must be sure to cut the jumper wire labeled LED13-GND and LED46-GND. This breaks the connection to the LED ground and the groundplane, and allows you to connect the LEDnn-GND signals to a suitable cathode driver circuit. For normal 1-to-1 use, leave this jumper connected so you have a return current path for the LEDs.

Multiplexed Switches

If you decide to multiplex the switches of the **Angelis 6602 Panel™** board, you must be sure to cut the jumper wire labeled SW14-GND and SW58-GND. This breaks the connection to the switch ground and the groundplane, and allows you to connect the switch's common points (SW14-GND and SW58-GND) to a suitable driver. For normal 1-to-1 use of the buttons, leave this jumper connected so you have a return current path for the switches.

If you are using a 4-wide matrix, SW14-GND acts as the common for the first four switches SW1-SW4. SW58-GND acts as the common for the next four switches SW5-SW8. If you are using a larger 8-wide matrix, tie the SW14-GND and SW58-GND signals together for a single common point.

The **Angelis 6602 Panel™** board has provisions for adding steering/blocking diodes, so the switch matrix will be able to support multiple simultaneous button-presses. If you wish to support multiple button presses, you will need to install the signal diodes in series with each switch output, one diode for each switch in the system. If you are using direct 1-to-1 wiring of the switch inputs to the processor, you don't need the diodes installed, so save them for another project and replace these diodes with a jumper wire (Use the extra wire from resistor leads for jumpers). It won't hurt to have the diodes in already; the switches will operate just as well.

If you are using multiple **Angelis 6602 Panel™** boards on a multiplexed switch input system make sure that you do not populate pull up resistors on *all* the boards. If your processor's inputs do not provide pull ups, designate one and only one board to have the pull ups, and leave the resistors out of all the other boards. Too many pull up resistors on a single circuit will cause too much current draw when buttons are pressed, which could lead to reduced switch life and excessive transient noise in the circuitry. (That's not a good thing.)

The positive power supply for the pull ups is connected to the board using the +5L signal. This includes the two switches internal to the rotary encoders. This can be either 3.3 volts or 5.0 volts depending on your microprocessor inputs. The +5L power input is only used to supply pull up power to the encoders A and B outputs, but not the push switch. The push switches are part of the switch matrix with the other six buttons.

Assembly Varieties Offered

The **Angelis 6602 Panel™** is offered as an unsoldered kit with all possible PCB parts supplied (but not including the anodized aluminum front panel, case, pot knobs or extra keycap colors).

Completed and tested units can be ordered in four different flavors, depending on LED color choice and whether you want the **Clickfeel™** relay. You should also select one of the three pull up resistor options. Choose the type you need based upon how you intend to connect it to your system. If unsure of pull up requirements, choose all 8; your design is very likely to work with all installed, and they can easily be cut out if you believe it will cause a problem. ALL of these types include 6 switches with white keycaps, 6 red or 6 green LEDs, 34-pin header, and steering diodes (needed for multiplexed switches but works with 1-to-1 designs also).

Available Models for the Angelis 6602 Panel™

All models include 6 switches with white keycaps, 6 LEDs, and steering diodes

MODEL NUMBER	ASSEMBLED & TESTED?	LED COLORS Choose between red or green LEDs.	PULL UP RESISTORS? Choose between 0, 4 or 8.	Clickfeel™ Relay?
6602-RC0	ASSEMBLED & TESTED	6 Red	Not installed. For systems with pull up resistance already.	Installed
6602-GC0		6 Green		
6602-RC4		6 Red	R31, R32, R33, R34 installed. For 4-wide multiplexed applications.	
6602-GC4		6 Green		
6602-RC8		6 Red	All 8 installed. For simple 1:1 wiring in systems with no pull up resistance, or for 8-wide multiplexed applications.	
6602-GC8		6 Green		
6602-R0		6 Red	Not installed. For systems with pull up resistance already.	Not Installed
6602-G0		6 Green		
6602-R4		6 Red	R31, R32, R33, R34 installed. For 4-wide multiplexed applications.	
6602-G4		6 Green		
6602-R8		6 Red	All 8 installed. For simple 1:1 wiring in systems with no pull up resistance, or for 8-wide multiplexed applications.	
6602-G8		6 Red		
6602-Kit UNASSEMBLED	This is a special kit that is for do-it-yourself assembly. Requires knowledge of component identification, soldering, assembly and schematic reading. This kit includes ALL PCB parts, including the diodes, 8 pull up resistors and Clickfeel™ relay parts. Includes 6 red and 6 green LEDs for any color combination. (Does NOT include the extra keycap colors, case, or aluminum front panel.) YOU get to decide what parts you will want to install or omit for your project!			
Caps-6	This is a special option kit you can add to any above board type. You get extra keycaps in different colors so you can match your case design or mix-and-match different colors for different functions. Includes 6 Black, 6 Off-white, 6 Blue, 6 Red, 6 Orange and 6 Green keycaps that snap on with just a push and a click.			
6602-Plate	This is a special add-on kit that includes a precision CNC-machined black-anodized aluminum panel that matches the 6602 Panel board. It is 2.5" tall X 5.4" wide, and 1.5 mm thick. It includes three hidden 3mm studs on the back to hold the circuit board and 6 nuts. It is identical to the 6602-Front but does not have countersinks in the four corner holes.			
6602-Front	This is a special add-on kit that includes a precision CNC-machined black-anodized aluminum panel that matches the 6602 Panel board specifically sized for the custom box. It is 2.5" tall X 5.4" wide, and 1.5 mm thick. It includes three hidden 3mm studs on the back to hold the circuit board and 6 nuts. It is identical to the 6602-Plate but adds countersunk holes in the four corners.			
4820-Box	This is a custom enclosure for both the 6602 and 4820 Control Panel PCB. Outside dimensions are 7" front-to-back, 6.25" width, and 3-3/8" height.			
NOTE: If you decide on one of the assembled and tested boards above and later decide you need to add the pull up resistors, don't worry! You can always obtain and solder those components in yourself.				

Reliability and Legal Disclaimer –

Due to the virtually unlimited possible methods of connection to an electrical system, it is the responsibility for the designer and/or user to use and verify proper electrical safety grounding and shielding in any powered system in which Angelis Electronics™ components are installed. Angelis Electronics™ assumes no liability for electrical safety in any system it which it may be installed.

All designs, parts, embedded software and products offered by Angelis Electronics™ are consumer-grade electronics and are not intended or warrantied for use in safety critical applications, including but not limited to medical, life-support, emergency, aviation, public transportation, high-power, explosive, military, industrial, food processing, safety or security applications.

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