For sales contact: Bill Manganaro thex@optonline.net

Present to you:

The IKC “INTEGRATED KEYBOARD CONTROLLER”

Build Documentation
& Engineering Drawings

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What is the Integrated keyboard Controller?

The Integrated Keyboard Controller (IKC) is a low cost, high quality, circuit board that can be used as the main functional building block that allows you to build a custom music synthesizer keyboard. The project was inspired by the Thomas Henry digital keyboard project that appeared in one of his early books entitled “Build a Better Music Synthesizer”. Bill Manganaro and Dan Lavin jointly developed the IKC. Bill handled the electronic design and programming duties while Dan did the PC board layout and some of the analog design. Dan was also very helpful in ideas for the design and for that I thank him very much. The assembly drawing of the IKC circuit card is shown below in figure 1. It can support up to five octaves and will control both your analog and digital music synthesis equipment either simultaneously or separately. It incorporates all the circuits necessary to scan up to five octave, 61 key matrixes, and outputs a tunable 1V/Oct standard control voltage, trigger, gate, and has basic MIDI functionality. The IKC can be paired with an optional digital MIDI Channel Changer (MCC) that interfaces directly with the IKC. The MCC is a small form factor circuit board containing four bits of MIDI channel selection logic and two 0.5” high, blue, seven segment LED displays for MIDI channel indication.

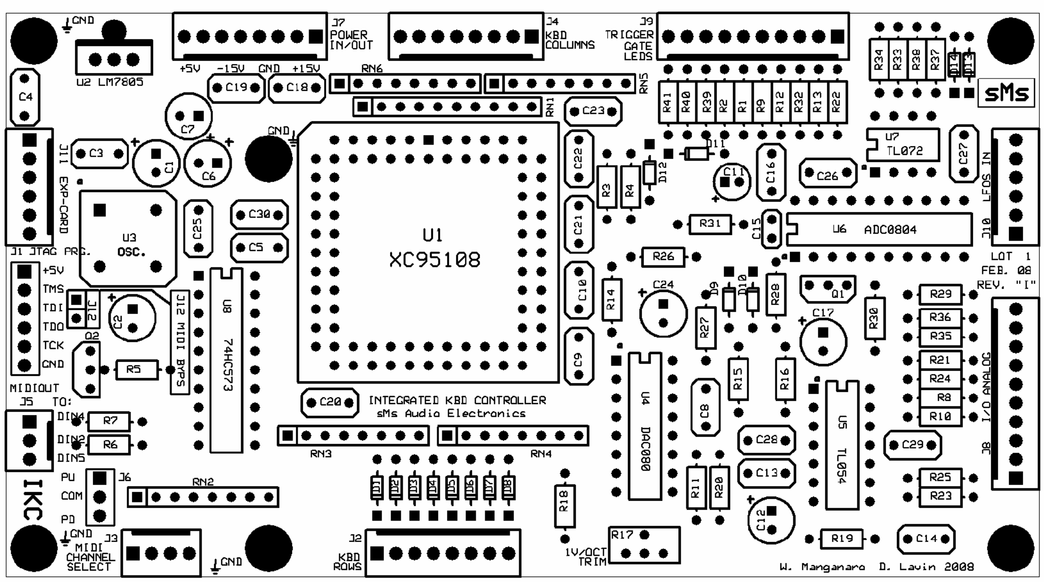


Figure 1 IKC PCB ASSEMBLY

The IKC will also allow the user to build custom keyboards that could deviate from traditional keyboard layouts and allows the complete freedom to create alternate key arrangements.

The IKC also features a reliable eight-chip design and uses a single, medium density, CPLD (Complex Programmable Logic Device) for most of the controllers’ digital logic for reliability and small form factor. The printed circuit board is professionally manufactured for “***sMs Audio Electronics***” and is two layers with white silk-screen on green solder mask. All critical inputs and outputs are electrically protected and brought out to the cards edge and terminate into 0.1" spaced, multi-pin, high pressure "Molex" "KK Style" locking headers. The headers will provide a solid interconnection to other system components and will prove "road worthy". An additional advantage of having the connectors lay along the board's perimeter results in less clutter to ease servicing

The following diagram in figure 2 shows how the IKC integrates into a keyboard system. All the major components are shown. The daughter/expansion card and LCD display are the next products to get released to enhance the IKC functionality. The front panel layout for the controls and jacks is up to you but panel design and manufacturing can be provided on special order from sMs if required. All Fatar 2,3,4, and 5 octave "Fast Touch Synthesizer' bare keyboard assemblies are compatible with the IKC.

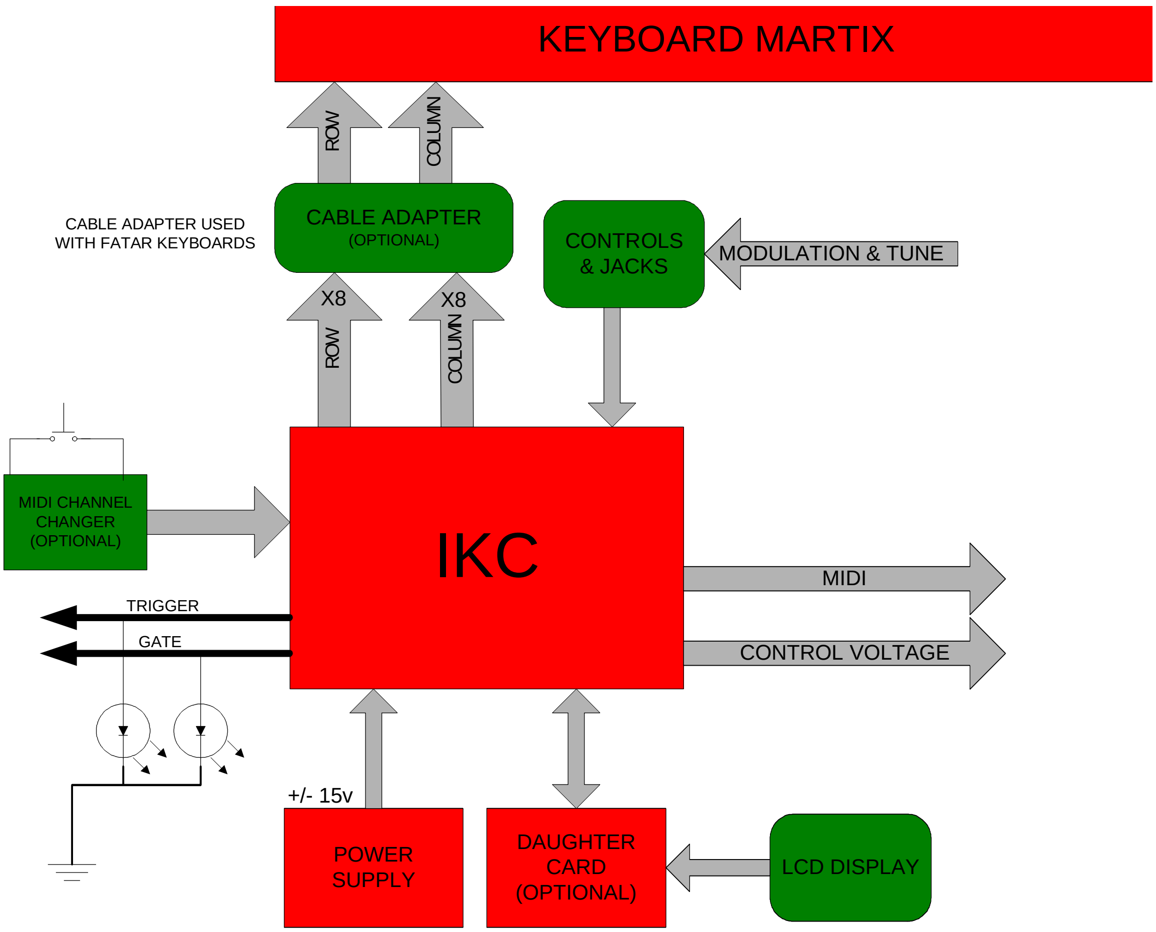


Figure 2 Keyboard System Block Diagram using IKC and MCC

Who would buy the IKC?

Do it yourself Individuals or institutions such as colleges and universities with electronic music departments who are skilled at building their own electronic assemblies for the purpose of learning about and creating electronic music. It would appeal to those want to build their own analog and digital, all in one, synthesizer keyboard using traditional style keyboards or alternate key layouts without having to design from the ground up. It allows the keyboard designer to use the IKC as a core building block for integration into his or her own keyboard system. The recommended skill level should be from an intermediate to advanced level. Pre-built, tested, and calibrated, IKC assemblies are available upon special request.

IKC Digital Features

- Very responsive key scan engine that will scan up to 64 keys in a matrix, or 5 octaves, using standard [8 ROW X 8 COLUMN] interconnection with "lowest key priority" scanning policy to control monophonic synthesizer equipment. Compatible with all Fatar "Fast Touch" synthesizer keyboards of up to 5 octaves. These long awaited keyboards are finally now being supplied here in the US at "Analog Haven" and are available in 2, 3, 4, and 5 octaves.

- Digital control of software and hardware synthesis equipment utilizing standard MIDI OUTPUT port supporting NOTE ON, NOTE OFF channel/voice messages across any one of 16 MIDI channels. An optional MIDI channel changer board (MCC) can be added to facilitate MIDI channel selection and display.

- Expandable design will use planned companion circuit card and backlit LCD display. The card will add many new MIDI system commands and continuous controllers. It will be able to interface with the Doepfer modulation wheel and pitch bend dual wheel interface and joystick assembly, both shown below in figure 3. The board will mount neatly onto your keyboards control panel and use a single 6-Conductor interconnection between it and the IKC.

Figure 3 Doepfer Joystick and Modulation Wheel Assemblies

- Up 8 octaves of control when using the analog and digital octave transpose functions.

- Five volt, GATE and TRIGGER outputs, with LED indicators, to drive external envelope generators, VCA’s, drum modules, or anything that requires a trigger or gate.

- 8 Bit A/D converter for digitization of any 0-5 V input source for use in the MIDI velocity value NOTE ON command. The input is protected from voltages beyond this range.

- Reprogrammable architecture for upgrades allow a simple a low cost JTAG downloader cable to be used that will connect between your PC and the keyboard controller boards JTAG programming header. All programming is done using the free Xilinx “Impact” software available from their website. Parallel downloader cables can be purchased for about $25.00 or less and are referenced in the CPLD programming section of this manual.

IKC Analog Features

- Two wide range analog [LFO 1 & 2] inputs that can span from +10 to -10 V are digitally quantized on the IKC to create a [+0] [+1] [+2] [+3] octave shift in frequency if connected to a 1V/OCT VCO. The transmitted MIDI note data is automatically offset by 12 semitones for each octave shift. Both the LFO input amplitude and quantization threshold can be continuously adjustable for a wide range of effects. LFO input frequencies can range from super low sub-hertz to audio rate frequencies in the kilohertz range for unusual effect.

- Analog “Portamento” on CV output ranging from none to approximately [1.5] second note slew. This slew rate can be modified by changing the value of C14. Larger values decrease the slew rate thus increasing the time it takes to slide from note to note.

- External CV modulation input smoothly transposes up to 1 octave using a 0-10 volt input source. Voltages greater than 10V will create changes of greater than 1 octave.

- Expression “Volume” Pedal 5-volt bias output allows the connection of any resistive expression pedal. The external foot pedal can either modulate the MIDI velocity, analog CV output, or both simultaneously depending on how the user wires their panel.

- Output (CV) is continuously tunable over an octave range with front panel “TUNE” control potentiometer.

- Simple single potentiometer calibration procedure for use in 1V/Octave applications.

IKC CONNECTOR AND SIGNAL DESCRIPTIONS

This section will describe all the connectors and their function pin by pin on the IKC. All the connectors discussed are outlined in RED below in figure 4. These descriptions together with the schematic diagram showing a typical keyboard system interconnect should help you to use the IKC to its fullest capacity.

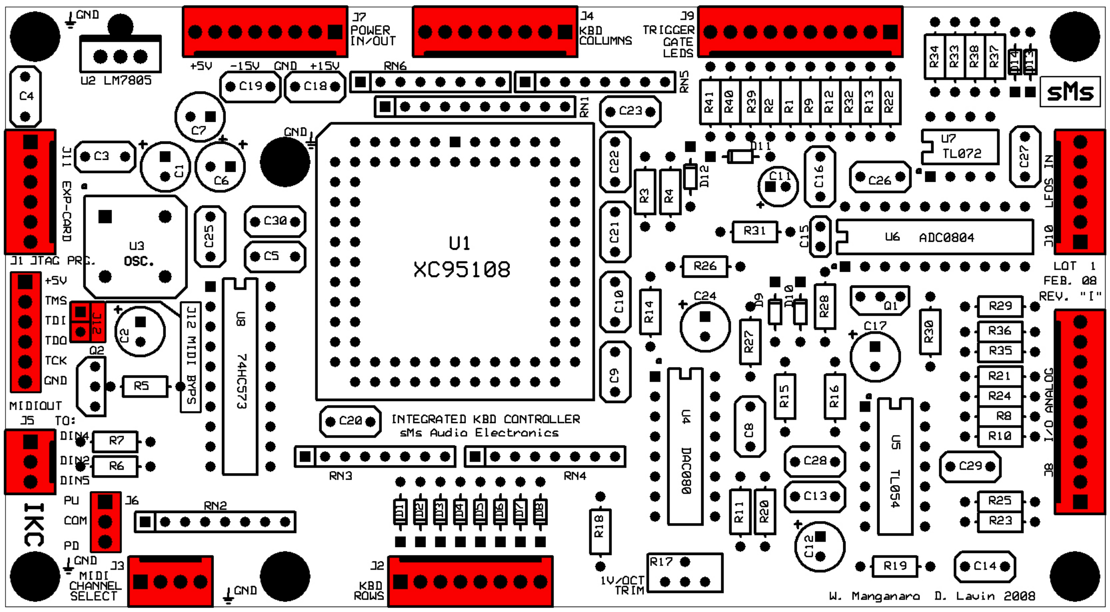


Figure 4 IKC Assembly Diagram Outlining All Connectors

NOTE: [N] = PIN UNMBER ON THE CONNECTOR

J1 JTAG PROGRAMMING PORT

The IKC only utilizes the JTAG port to program the JEDEC configuration file into U1 CPLD chip. As you will read, it really does lots more. This configuration file defines the operation or behavior of the IKC and is non-volatile which means the configuration data will remain in the device and will not be lost when the power is removed. The memory used in the CPLD is called "FLASH" memory and is reprogrammable. The signals on this JTAG connector attach to programming cables with flying leads as outlined in the "IKC CPLD chip Programming" section of this manual. These cables are usually low cost and available from many venders.

For informational purposes only, a more formal description of the JTAG bus follows and will reveal that the JTAG port is not just used for programming devices, but is useful in test and debug of modern electronic hardware. The JTAG (Joint Test Action Group) is formally known as the Test Access Port and Boundary-Scan Architecture. This is a serial bus with four signals: **Test Clock** (TCK), **Test Mode Select** (TMS), **Test Data Input** (TDI), and **Test Data Output** (TDO). The bus is used as a test bus for the 'Boundary-Scan' of IC's, as in Design-For-Testability (DFT). To use JTAG, during the design, you must select JTAG compatible devices. ICs supporting JTAG will have the four additional pins listed above. Devices reside on the bus in a daisy chain, with TDO of one device feeding TDI of the next device. In addition to having the pins listed above each device must have a Boundary-Scan Register. The Boundary-Scan Register may be used to test the interconnection between ICs [Chip-to-Chip] or test within the IC. Boundary-scan tests can be used to check continuity between devices. Continuity checks on PWB nets may be performed by sending out a known pattern and receiving that same pattern at the input to another IC(s). Not receiving the test signal or pattern would indicate a broken PWB trace, a failed IC, or cold solder joint.

IKC JTAG Connector Signal Descriptions:

[1] 5 VDC: 5 volt output to the downloader cable

[2] TMS: [Test Mode Select Input] controls the operation of the test logic, by receiving the incoming data. The value at the input on the rising edge of the clock controls the movement through the states of the TAP controller. The TMS line has an internal pull-up, so the input is high with no input.

[3] TDI: [Test Data Input] receives serial input data which is either feed to the configuration data registers or instruction register, but depends on the state of the TAP controller. The TDI line has an internal pull-up, so the input is high with no input.

[4] TDO: [Test Data Output] outputs serial data which comes from either the test data registers or instruction register, but depends on the state of the TAP controller. Data applies to the TDI pin will appear at the TDO pin but may be shifted out a number of clock cycles, depending on the length of the internal register. The TDO pin is high-Impedance.

[5] TCK: [Test Clock] has noting to do with the board or system clock. The Test Clock is used to load the test mode data from the TMS pin, and the configuration data on the TDI pin [on the rising edge]. On the falling edge test clock outputs the test data on the TDO pin. As with any clock pin this line needs to be terminated in order to reduce reflections.

[6] GROUND : Cable Ground

J2 KEYBOARD ROW SELECTS

The keyboard row select outputs are connected directly to the keyboard ROW inputs for the purpose of scanning the keys. Details on how to connect these lines to keyboard matrixes are outlined in the "Connecting the IKC to a Fatar Keyboard" and "Guidelines When Connecting to Other keyboards" sections of this manual. These signals conform to the TTL logic standard and are configured as outputs. Each ROW output sequentially goes logic high for a period of 64 uS, and then goes back to logic low, until all rows sequentially perform this sequence, then the process repeats. When a key press is detected by the logic, the scan logic will reset this ROW sequence back to ROW 0 and start again. Each output has a series low loss diode and 100 ohm resistor for protection from multiple keys being pressed and accidental short circuits. Although most key matrixes on the market include their own protection diodes, the IKC employs them as an extra measure of protection. All FATAR synthesizer keyboards have these diodes in place so it is very important to connect the ROW and COL signals to the correct locations on these keyboards.

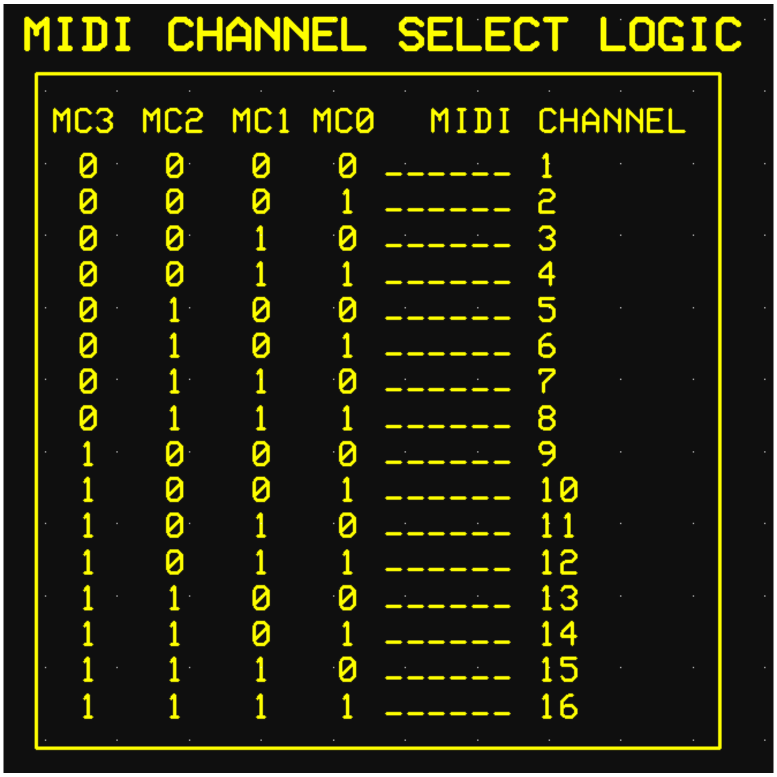
[1] ROW0: Output driving ROW0 of connected keyboard assembly.
[2] ROW1: Output driving ROW1 of connected keyboard assembly.
[3] ROW2: Output driving ROW2 of connected keyboard assembly.
[4] ROW3: Output driving ROW3 of connected keyboard assembly.
[5] ROW4: Output driving ROW4 of connected keyboard assembly.
[6] ROW5: Output driving ROW5 of connected keyboard assembly.
[7] ROW6: Output driving ROW6 of connected keyboard assembly.
[8] ROW7: Output driving ROW7 of connected keyboard assembly.

J3 MIDI CHANNEL SELECT LOGIC

Four-bit logic input for MIDI channel selection. The inputs are positive logic and accept TTL level logic inputs.

[1] MC0: MIDI Channel select Bit “0”
[2] MC1: MIDI Channel select Bit “1”
[3] MC2: MIDI Channel select Bit “2”
[4] MC3: MIDI Channel select Bit “3”

MIDI channels are selected in accordance with the truth table shown below in figure 5. The J3 connector works along with J6 PULL UP/DOWN jumper header and is explained later on in this section. Below that is an interconnect in figure 6 showing how the sMs MIDI Channel Changer (MCC) assembly is connected to the IKC. The MCC is available from sMs Audio Electronics fully assembled and tested.



MIDI CHANNEL SELECT LOGIC

MC3	MC2	MC1	MC0	MIDI CHANNEL
0	0	0	0	------ 1
0	0	0	1	------ 2
0	0	1	0	------ 3
0	0	1	1	------ 4
0	1	0	0	------ 5
0	1	0	1	------ 6
0	1	1	0	------ 7
0	1	1	1	------ 8
1	0	0	0	------ 9
1	0	0	1	------ 10
1	0	1	0	------ 11
1	0	1	1	------ 12
1	1	0	0	------ 13
1	1	0	1	------ 14
1	1	1	0	------ 15
1	1	1	1	------ 16

Figure 5 MIDI Channel vs. MC0-3 Select Bit State

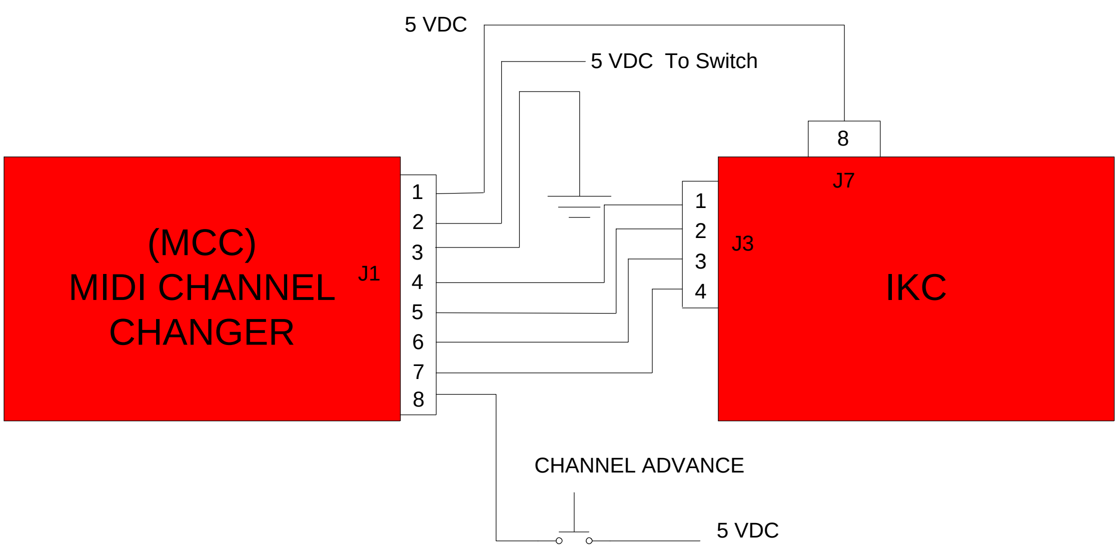


Figure 6 MIDI CHANNEL CHANGER (MCC) CONNECTION TO IKC

J4 KEYBOARD COLUMN SELECTS

The keyboard column select inputs are connected directly to the keyboard COLUMN outputs for the purpose of scanning the keys. Details on how to connect these lines to keyboard matrixes are outlined in the “Connecting the IKC to a Fatar Keyboard” and “Guidelines When Connecting to Other keyboards” sections of this manual. The following is just for informational purposes only. These signals conform to the TTL logic standard and are configured as inputs. Each COLUMN input dwells for a block of 8 keys (512 uS or 8 ROW pulses durations of 64 uS each) and detects if one of the keys in the block get pressed. Each of the 8 columns relate to a unique 8 key block on the connected keyboard, thus, the input logic of the key scanner starts at COL0, “looks” if any of it’s 8 unique keys are pressed, continues onto COL1, looks at another block of 8 keys, and ends at COL7. The process repeats the process starting at COL0 again. The input impedance of each COL input is 5.7K. Each column input is protected by a series 100 ohm resistor.

[1] COL0: Input from COL0 of connected keyboard assembly.
[2] COL1: Input from COL1 of connected keyboard assembly.
[3] COL2: Input from COL2 of connected keyboard assembly.
[4] COL3 Input from COL3 of connected keyboard assembly.
[5] COL4: Input from COL4 of connected keyboard assembly.
[6] COL5: Input from COL5 of connected keyboard assembly.
[7] COL6: Input from COL6 of connected keyboard assembly.
[8] COL7: Input from COL7 of connected keyboard assembly.

The MIDI OUT connector carries the digital MIDI data generated by the IKC. The data from this connector will get connected to a standard 5 pin DIN style MIDI socket shown in figure 7. This socket will be mounted to your front or rear panel and should be wired to agree with table 1 below:

IKC J5 MIDI OUT (from)	***FRONT PANEL MIDI DIN SOCKET (to)***
1	4
2	2
3	5

Table 1 WIRING ASSIGNMENT FOR IKC MIDI OUTPUT

Figure 7 (5) PIN DIN SOCKET PIN REFERENCE

J5 MIDI OUT

[1] MIDI_4: MIDI BIAS
[2] GROUND: MIDI GROUND
[3] MID_5: MIDI SERIAL DATA

Here are some words about ground loops.

Ground loops will cause horrendous hum, buzzes, and other noises, especially when connected to computerized gear or lighting equipment. The noises are caused by differences in voltage potential from one end of the cable to the other. The remedy, of course, is to run balanced audio lines and to NEVER physically connect the chassis grounds of different pieces of equipment together. MIDI instrument designers understand ground loops. In fact, a major design goal of MIDI, as seen in the electrical specification explanation in the MIDI Specification Document, is to prevent any ground loops that might occur with the MIDI cables. This is done by using a balanced current loop through an opto-isolator and only grounding the MIDI outputs. The MIDI IN connector is not grounded to the receiver's chassis. When done correctly, there are no ground loops and no hum or other noises caused by the MIDI setup. Table 2 below shows the MIDI messages the IKC currently supports. New ones will be added in the future. Note that the velocity data is provided over the MIDI output by digitizing a 0-5 volt input to the IKC and impressing it onto the velocity data byte in the MIDI message.

1001nnnn	**0kkkkkkk 0vvvvvvv**	**Note On event. This message is sent when a note is depressed (start). (kkkkkkk) is the key (note) number. (vvvvvvv) is the velocity.**

1000nnnn	**0kkkkkkk** **0vvvvvvv**	**Note Off event.** **This message is sent when a note is released (ended). (kkkkkkk) is the key (note) number. (vvvvvvv) is the velocity.**

Table 2 IKC MIDI Messages

Where “nnnn” = 0-15 (MIDI Channel Numbers 1 thru 16) as determined by the inputs at J3 MIDI SELECT LOGIC connector. Value “0kkkkkkk” represents the key note number generated by the IKC and shall be a maximum of 95 when using a 5 octave keyboard and adding a 3 octave offset.

J6 PULL UP/DOWN JUMPER BLOCK

As stated earlier, this jumper block works directly with the “J3 MIDI CHANNEL SELECT LOGIC” input connector. Depending on the jumper location on this block, the MIDI channel inputs can be either pulled down to ground with 10K resistors or can be pulled up to 5 volts via 10K resistors. This adds a bit more versatility to the “J3 MIDI CHANNEL SELECT LOGIC” by allowing direct digital inputs or use of switches.

When should I use pull up or pull down?

If a standard logic output is used to drive these inputs on the J3 connector (TTL or 5V CMOS), then J6 should be configured as PULL DOWN, pins 2 and 3 shorted. If your logic inputs use switches that require pull up resistors to provide the logic high required by the J3 inputs, then J6 should be configured as PULL UP, pins 1 and 2 shorted.

NOTE: If you have purchased the MCC (MIDI CHANNEL CHANGER) board from sMs Audio Electronics then you must configure J6 as PULL DOWN.

[1]: 5V or (PU)
[2]: RN2 COMMON
[3]: GROUND (PD)

To configure the J6 PULL UP/DOWN

PULL UP (PU) – Short pins 1 & 2, leave 3 open
PULL DOWN (PD) – Short pins 2 & 3, leave 1 open (J3 impedance is 10K)

J7 POWER INPUT / OUTPUT

The connector will accept +15V, -15V and output +5 volts for use by potentiometers and other low current demand devices such as the MCC display board.

[1]: +15 VDC INPUT
[2]: +15 VDC OUTPUT

[3]: GROUND
[4]: GROUND
[5]: -15 VDC INPUT
[6]: -15 VDC OUTPUT
[7]: 5 VDC OUTPUT
[8]: 5 VDC OUTPUT

Pins 2, 4, and 6 are provided for convenience so that the voltages and ground may be used by front panel components such as potentiometers and switches. This connection scheme eliminates having to break out or split these voltages external to the IKC board.

The 15-volt supplies must be able to supply at least 250 milliamps to operate the IKC on each leg for a total of 500 milliamps. A 7.5-watt or better power supply should suffice and can be a switching supply or linear power supply. The 5-volt outputs on J7 can provide up to 100 milliamps collectively for external device connections such as MCC, LED's, or any other device that requires a +5V power supply. The tolerance on this supply is 5%.

The IKC has not been tested using +12 / –12 volt power supplies but calibration and operation is most likely achievable, but not guaranteed, given the wide tolerances of the chips and circuits on board thus should not be a problem.

J8 ANALOG INPUT / OUTPUT

This connector carries some of the IKC analog signaling. The IKC typical interconnect schematic shows an example of how to connect these signals in a keyboard design. The following are the pin assignments and a brief explanation of each function.

[1] PORTA 1: PORTAMENTO POT TOP
[2] PORTA 2: PORTAMENTO POT WIPER
[3] TUNE IN: 0-10 V TUNING VOLTAGE INPUT
[4] MOD CV INPUT: 0-10 V MODULATION CONTROL VOLTAGE INPUT
[5] CV OUT: MAIN CONTROL VOLTAGE OUTPUT FOR 1V/OCT CONTROL
[6] VEL IN: 0-5 V VELOCITY INPUT FOR MIDI VELOCITY
[7] PEDAL BIAS: FOOT PEDAL BIAS VOLTAGE FOR EXP. PEDAL
[8] GROUND
[9] POT_TOP_1: POTENTIOMETER TOP CONNECTION FOR LFO1 THRESHOLD
[10] POT_BOT_1: POTENTIOMETER BOTTOM CONNECTION FOR LFO1 THRESHOLD

PORTA / PORTB

On pins 1 & 2, portamento potentiometer connections, a potentiometer connected in a variable resistor configuration provides a way of generating portamento on the IKC control voltage (CV) output on pin 5.

TUNE IN

The TUNE INPUT allows the keyboard user to adjust the CV tuning in a range of just over 1 octave with a -15 TO -15 volt input from a front panel potentiometer.

MOD CV INPUT

The MOD CV INPUT allows CV amplitude modulation of up to 1 octave with a 10 volt span for vibrato effect. This input can be an external LFO.

CV OUTPUT

The CV output is the IKC main control voltage output for controlling 1V/Oct VCO’s. This output is calibrated using a single potentiometer on the IKC board for precise 1V/Octave functionality. The section on calibration will explain how to calibrate this CV for 1V/Oct operation. The CV output can be connected to multiple destinations. See electrical specifications.

VEL IN

The velocity input is a protected 0-5 volt input voltage that is quantized, at a rate of 5.5 K samples per second, to an 8 bit value using an onboard A/D converter, The most significant 7 bits are used by the MIDI output function of the IKC to represent MIDI VELOCITY.

PEDAL BIAS

The PEDAL bias output provides the necessary bias voltage for a resistive expression pedal to be connected to the IKC. The output of this pedal can be input to any of the velocity or modulation inputs of the IKC. An example is shown in the interconnect diagram.

POT_TOP_1 / POT_BOT_1

The POT_TOP_1 and POT_BOT_1 outputs are used to bias an external potentiometer whose output will provide the LFO1 input threshold for analog octave shift function.

J9 TRIGGER / GATE / INDICATORS

This connector carries the IKC trigger, gate, digital octave transposition, LFO potentiometer biases, and LED indicator outputs. The IKC typical interconnect schematic shows an example of how to connect these signals in a keyboard design. The following are the pin assignments and a brief explanation of each function.

[1] TRIGGER: TTL TRIGGER OUTPUT
[2] TRIGGER LED: SIGNAL TO DRIVE LED FOR TRIGGER INDICATION.

[3] GATE: TTL GATE OUTPUT
[4] GATE LED: SIGNAL TO DRIVE LED FOR GATE INDICATION.
[5] TWELVE: TTL +1 OCTAVE SHIFT DIGITAL INPUT.
[6] TWENTY FOUR: TTL +2 OCTAVE SHIFT DIGITAL INPUT.
[7] POWER LED: SIGNAL TO DRIVE LED FOR POWER ON INDICATION.
[8] POT_TOP_2: POTENTIOMETER TOP CONNECTION FOR LFO2 THRESHOLD.
[9] POT_BOT_2: POTENTIOMETER BOTTOM CONNECTION FOR LFO2 THRESHOLD.
[10] PEDAL MOD: EXPRESSION PEDAL MODULATION INPUT.

TRIGGER

This is a TTL compatible, positive going pulse whose duration is 1 millisecond and is generated each time a key is pressed on the keyboard. It is typically used to trigger an ADSR or AD envelope generator that will, in turn, drive the input control voltage (CV) of a voltage controlled amplifier (VCA). This arrangement would allow an output from an oscillator to sound a note whose attack and decay from the ADSR or AD generator characterize its intensity over time and whose pitch is dependant on the CV generated by the IKC to the oscillator being controlled.

A few more words about when triggers are generated by the IKC. As mentioned above, a single trigger will be generated only at the onset of pressing a key on the keyboard and none when releasing it. Although the IKC is designed to control monophonic synthesizer gear, one note at a time, generally keyboardists sometimes will overlap two keys at once then rapidly toggle one key while keeping the other pressed for legato effect. This behavior is due to the low-key priority scanning policy that is employed in the IKC. Legato style play is achieved by pressing two keys and then, while still holding the higher order key depressed, toggling the lower order key rapidly to seamlessly change between two notes. If two keys are simultaneously pressed and the higher key is toggled, no new triggers or MIDI data will be generated. If two keys are simultaneously pressed and the lower key is toggled, new triggers and MIDI data will be generated. The TRIGGER output can be routed to multiple destinations. See electrical specifications.

TRIGGER LED

This output will connect directly to an LED anode. Due to the short duration pulses (1 millisecond) that drives this LED, a 47-ohm limiting resistor is used in the IKC that will provide a peak pulsed current of approximately 50 milliamps when using LED's with a forward voltage of 2.75V is used. This higher pulsed current will increase the intensity of the LED without any damage. Also, the use of a high intensity LED, such as the white and blue LED's on the market today, will further help in seeing the brief turn on of this LED. This arrangement eliminates the need for any type of pulse stretching circuit to make the LED visible when a trigger occurs, thus, reducing circuit complexity.

GATE

The GATE signal is a TTL compatible signal that is normally low and goes to logic high for the duration of any key, or combination of keys, that are depressed. The GATE signal is used to drive the gate input of an ADSR generator but is not limited to this function. The gate can directly drive the input of a VCA to allow an audio signal to pass also.

The GATE output can be routed to multiple destinations. See electrical specifications.

GATE LED

This signal connects to an LED for indication when the gate signal is active.

TWELVE

This is a TTL compatible input with a 10K input resistance. When a logic high is applied exclusively to this input, the CV output will increase by 1 volt, or 1 octave, furthermore, the MIDI note value will increase by 12 counts, or 1 octave over the MIDI OUTPUT port on the assigned channel.

TWENTY-FOUR

This is a TTL compatible input with a 10K input resistance. When a logic high is applied exclusively to this input, the CV output will increase by 2 volts, or 2 octaves, furthermore, the MIDI note value will increase by 24 counts, or 2 octaves over the MIDI OUTPUT port on the assigned channel.

SOME ADDITIONAL NOTES ON THESE SIGNALS:

When TWELVE and TWENTY-FOUR signals are logic high simultaneously, the CV will increase by 3 volts, or 3 octaves. The MIDI note value will be offset by a value of 36 counts, or 3 octaves.

These two digital inputs are logically “OR’ed” with two other signal pairs. This means that TWELVE has three sources and TWENTY-FOUR has three sources. The second pair can be driven by the proposed expansion board to produce unique arpeggios via microcomputer control. A third pair of inputs is generated from analog comparator circuits. The inputs to these comparators are analog signals from LFO’s for example. The outputs of these comparators are translated to digital control signals. These LFO input octave controls are enplaned wholly in the section describing J10, LFO control.

POWER LED

Power ON indicator

POT_TOP_2 /POT_BOT_2

The POT_TOP_2 and POT_BOT_2 outputs are used to bias an external potentiometer whose output will provide the LFO2 input threshold for analog octave shift function.

PEDAL MOD

A modulation voltage input from an external expression pedal used to amplitude modulates the IKC CV output voltage.

J10 LFO CONTROL

Two wide range analog [LFO 1 & 2] inputs that can span from +10.7 to –10.7 V are digitally quantized on the IKC to create a [+0] [+1] [+2] or [+3] octave shift in frequency if connected to a 1V/OCT VCO. The transmitted MIDI velocity data is automatically offset by 12 semitones or counts for each octave shift. Both the LFO input amplitude and quantization threshold can be continuously adjustable for a wide range of effects. LFO input frequencies can range from super low sub-hertz to audio rate frequencies in the kilohertz range for experimental or avant-garde effect.

This connector provides the inputs for the two LFO signals and LFO threshold 1 and 2.

[1] LFO 1: LOW FREQUENCY OSCILLATOR INPUT 1
[2] GROUND
[3] LFO 2: LOW FREQUENCY OSCILLATOR INPUT 2
[4] GROUND
[5] LFO 1 THRESHOLD: A DC INPUT VOLTAGE FROM –11 TO +11 VDC SETTING THE THRESHOLD AT WHICH THE INPUT LFO WILL TRANSPOSE THE OUTPUT CV AND MIDI NOTE NUMBER BY ONE OCTAVE
[6] LFO 2 THRESHOLD: A DC INPUT VOLTAGE FROM –11 TO +11 VDC SETTING THE THRESHOLD AT WHICH THE INPUT LFO WILL TRANSPOSE THE OUTPUT CV AND MIDI NOTE NUMBER BY ONE OCTAVE

J11 EXPANSION CARD

The expansion card connector will be used to extend the capabilities of the IKC by connecting a board that will be released by sMs Audio Electronics in 2009. The capabilities will add an LCD display, and add MIDI functionality such as continuous controllers and system level commands like sequencer START, STOP, ALL NOTES OFF, etc., the details to be released.

Each signal applied to pins 1 and 2 MUST have a series diode connection to prevent signal contention with other signals feeding this connector. Thus, the internal source within the expansion card is connected to the anode of a diode and the cathode then connecting to the IKC expansion connector inputs at pins 1 and 2. Referencing the schematic shows how these signals must be driven. As stated earlier in this document, the twelve and twenty-four digital inputs are sourced from several inputs.

[1] TWELVE: TTL +1 OCTAVE SHIFT DIGITAL INPUT FOR CONTROL BY EXPANSION CARDS MICROPROCESSOR.
[2] TWENTY-FOUR: TTL +2 OCTAVE SHIFT DIGITAL INPUT FOR CONTROL BY EXPANSION CARDS MICROPROCESSOR.
[3] MIDI_MIX: MIXED MIDI OUTPUT FROM EXPANSION BOARD
[4] MIDI: MIDI INPUT FROM IKC
[5] 5VDC: 5 VOLTS SUPPLY TO EXPANSION BOARD
[6] GROUND: GROUND FOR EXPANSION BOARD

J12 MIDI BYPASS HEADER – (Figure 8)

The MIDI by-pass is utilized when no expansion card is connected to the IKC. When no expansion card is used, shorting pins 1& 2 on this header will allow the MIDI from the IKC to get passed onto the J5 MIDI OUTPUT connector.

If an expansion card is used, it is very important to remove any short across these two pins. If not, MIDI failure will result.

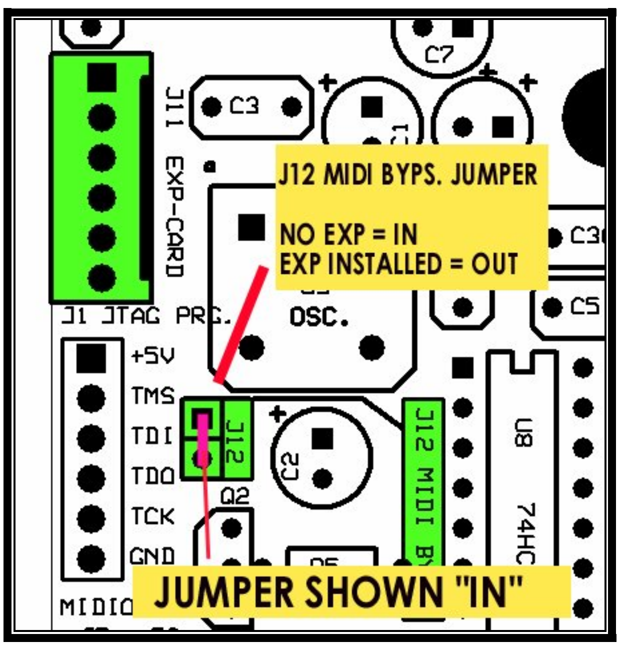


Figure 8 MIDI BY-PASS HEADER

When the expansion card is used and no jumper is installed on J12, the signal "MIDI" that is produced by the IKC is passed to the expansion card, and is input to the expansion card's microcomputer, mixed with MIDI information generated by the expansion card's microcomputer then output on the MIDI MIX signal and passed back to the IKC for output.

The next section provides a very comprehensive parts list for the IKC should you want to gather them yourself. Digikey is listed as the vender for these parts but they can be purchased at many other major parts distributors such as Mouser or Allied Electronics for example.

IKC PARTS LIST

Fixed Resistors

REF. DESIG.	QTY.	VALUE	COMMENTS	DIGIKEY PART NO.
R1,R22,R22 R32	4	100	5% TOL. 1/4W	100QBK-ND
R3,R4,R26				
R27	4	10K	5 % TOL. 1/4W	10KQBK-ND
R5	1	4.7K	5% TOL. 1/4W	4.7KQBK-ND
R6,R7,R12 R21	4	220	5 % TOL. 1/4W	220QBK-ND
R8,R10,R41	3	1.00M	1% TOL. 1/4W	1.00MXBK-ND
R9	1	270	5% TOL. 1/4W	270QBK-ND
R11	1	68K	5% TOL. 1/4W	68KQBK-ND
R13	1	47	5% TOL. 1/4W	47QBK-ND
R14,R15	2	1.8K	5% TOL. 1/4W	1.8KQBK-ND
R16	1	330	5% TOL. 1/4W	330QBK-ND
R18	1	22K	5% TOL. 1/4W	22KQBK-ND
R19,R25	2	4.75K	1% TOL. 1/4W	4.75KXBK-ND
R20	1	100K	1% TOL. 1/4W	100KXBK-ND
R23	1	2.2K	5% TOL. 1/4W	2.2KQBK-ND
R24	1	1.5K	5% TOL. 1/4W	1.5KQBK-ND
R28	1	22K	5% TOL. 1/4W	22KQBK-ND
R24	1	1.5K	5% TOL. 1/4W	1.5KQBK-ND

R29,R30	**2**	**6.8K**	**1% TOL. 1/4W**	**P6.80KCACT-ND**
R31	**1**	**15K**	**5% TOL. 1/4W**	**15KQBK-ND**
R33,R37	**2**	**100K**	**5% TOL. 1/4W**	**100KQBK-ND**
R34,R38	**2**	**20K**	**5% TOL. 1/4W**	**20KQBK-ND**
R35,R36,R39,R40	**4**	**2K**	**5% TOL. 1/4W**	**2.0KQBK-ND**

Resistor Networks

REF. DESIG.	**QTY.**	**VALUE**	**COMMENTS**	**DIGIKEY PART NO.**
RN1	**1**	**5.6K**	**9RES 5.6K 10PIN**	**770-101-R5.6KP-ND**
RN2	**1**	**10K**	**7RES 10K 8PIN**	**770-81-R10KP-ND**
RN3-6	**4**	**100**	**4RES 100 8PIN**	**770-83-R100P-ND**

Capacitors

REF. DESIG.	**QTY.**	**VALUE**	**COMMENTS**	**DIGIKEY PART NO.**

C1,C2 C11,C24	4	10 uF	Electrolytic, 25V	493-1372-ND
C3-5,C8,C9				
C16,C18-23				
C25-30	18	100 nF	Metal Poly	495-1103-ND
C6,C7,C12	3	100 uF	Electrolytic, 35V	P5165-ND
C10	1	10 nF	Metal Poly	478-3403-ND
C13	1	47 nF	Metal Poly	478-3381-ND
C14	1	330 nF	Metal Poly	P4959-ND
C17	1	4.7 uF	Electrolytic, 160V	493-1160-ND
C15	1	100 pF	CERM CAP	P4849-ND

Multi-Turn Trimmer Potentiometers

REF. DESIG.	QTY.	VALUE	COMMENTS	DIGIKEY PART NO.
R17	1	10K	25 TURN, TOP ADJ.	490-2875-ND

Semiconductors

REF. DESIG.	QTY.	VALUE	COMMENTS	DIGIKEY PART NO.
D1-D8	8	BAT43	DIODE, SCHTK	497-2492-1-ND
D9-D14	6	1N4148	DIODE, Si	1N4148FS-ND
U1	1	XC95108-15	CPLD	122-1460-ND
U2	1	LM7805CT	5V REGULATOR	LM7805CT-ND
U3	1	MXO45HS-2C-10M0000	10 MHz OSC.	CTX-163-ND
U4	1	DAC0800LCN	DAC, 8 BIT	DAC0800LCN-ND

U5	1	TL074	QUAD OP-AMP	296-1777-5-ND
U6	1	ADC0804LCN	8 BIT ADC	ADC0804LCN-ND
U7	1	TL072	DUAL OP-AMP	296-1775-5-ND
U8	1	74HC573	OCTAL LATCH	MM74HC573N-ND
Q1	1	2N3904	TRANSISTOR,NPN	2N3904FS-ND
Q2	1	2N3906	TRANSISTOR ,PNP	2N3906FS-ND

Connector Headers

REF. DESIG.	QTY.	VALUE	COMMENTS	DIGIKEY PART NO.
J1,J6,J12	** SEE NOTE		CONN HEADER .100 SINGL STR 36POS	S1032E-36-ND
J2,J4,J7	3		HEADER, 8POS	WM4206-ND
J3	1		HEADER, 4POS	WM4202-ND
J5	1		HEADER, 3POS	WM4201-ND
J8,J9	2		HEADER, 10POS	WM4208-ND
J10,J11	2		HEADER, 6POS	WM4204-ND

NOTE ** 36 PIN HEADER STRIP, BREAK APART FOR DESIRED PIN COUNT (J1 = 6 PINS J6 = 3 PINS J12 = 2 PINS)

Connector Housings

REF. DESIG.	QTY.	VALUE	COMMENTS	DIGIKEY PART NO.
J2,J4,J7	3		HOUSING, 8POS	WM2607-ND
J3	1		HOUSING, 4POS	WM2603-ND

J5	**1**		**HOUSING, 3POS**	**WM2602-ND**
J8,J9	**2**		**HOUSING, 10POS**	**WM2609-ND**
J10,J11	**2**		**HOUSING, 6POS**	**WM2605-ND**

Crimp Terminals

REF. DESIG.	QTY.	VALUE	COMMENTS	DIGIKEY PART NO.
NA	**65**		**CRIMP TERM.**	**WM1114-ND**

Shunt & Heatsink

REF. DESIG.	QTY.	VALUE	COMMENTS	DIGIKEY PART NO.
NA	**2**		**CONN JUMPER SHORTING**	**S9001-ND**
NA	**1**	**TO-220**	**HEAT SINK**	**HS366-ND**

<u> Use thermal grease type Digikey P/N 345-1006-ND or equivalent with heat sink.</u>**

Sockets

REF. DESIG.	QTY.	VALUE	COMMENTS	DIGIKEY PART NO.
N/A	**1**		**CONN SOCKET PLCC 84POS THRU HOLE**	**ED90011-ND**
N/A	**1**		**SOCKET IC OPEN FRAME 8POS .3"**	**3M5461-ND**

N/A	**1**	**SOCKET IC OPEN FRAME 14POS .3"**	**3M5462-ND**
N/A	**1**	**SOCKET IC OPEN FRAME 16POS .3"**	**3M5463-ND**
N/A	**2**	**SOCKET IC OPEN FRAME 20POS .3"**	**3M5465-ND**

Figure 9 Illustrates the IKC parts layout and all schematics and interconnects on the following pages. Below is the IKC board attributes to aid in selecting the correct standoffs and mounting your board into a chassis.

IKC PCB Mechanical Specifications

Board Dimensions: L 5.5” (139.7 mm) W 3.0” (83.8 mm)
Hole Center to Center Spacing: 5.2” (132.1 mm), 2.7” (68.6 mm)
Hole Size: 0.125” (1/8”) (3.2 mm)
Hole Pad Size: 0.25” (1/2”) (6.4 mm)

IKC PCB Board Attributes

Layers: 2
Green Solder Mask: Solder Side / Component Side
Silkscreen Color: White
Material: Fiberglass FR4
Copper Weight: 2 OZ.

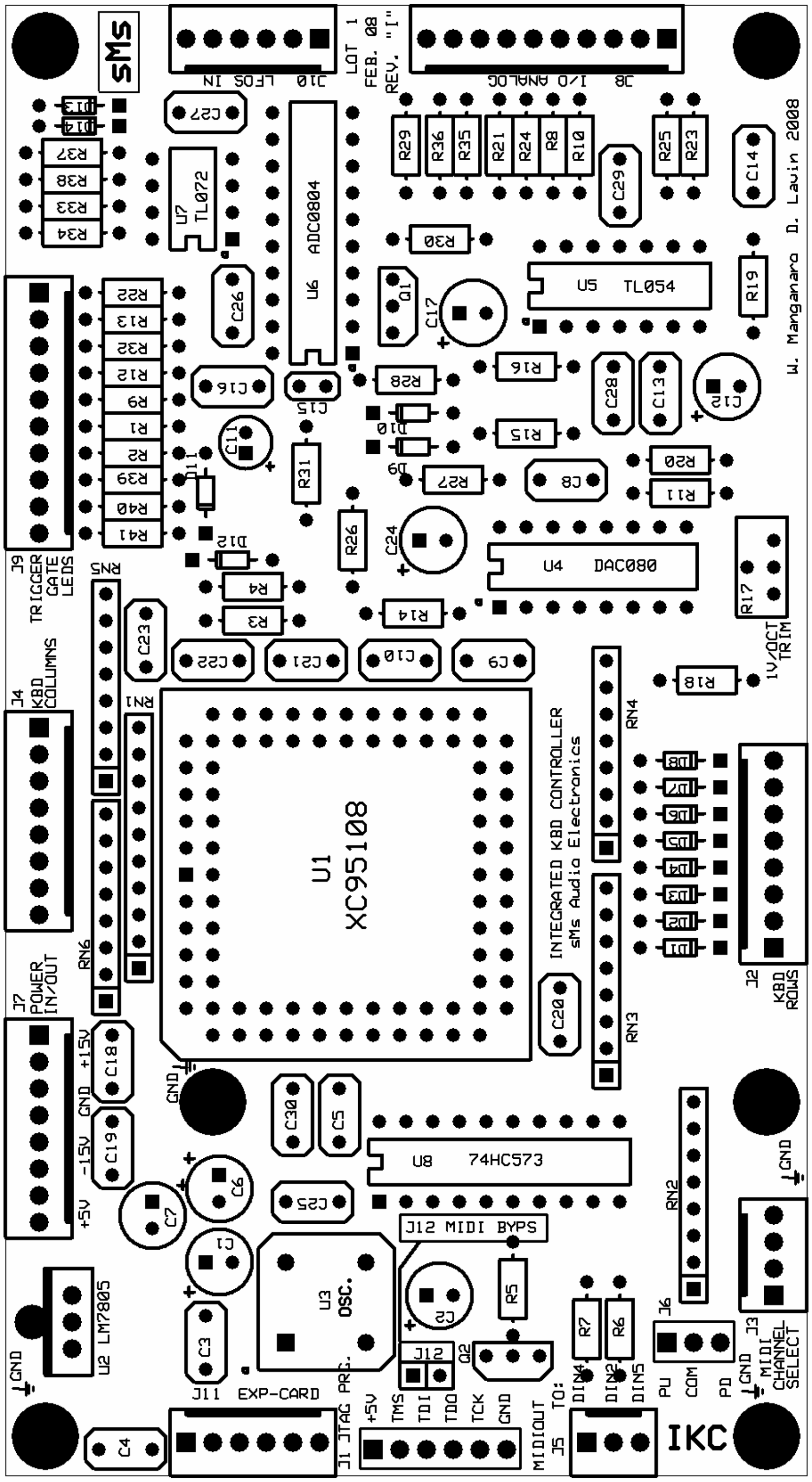
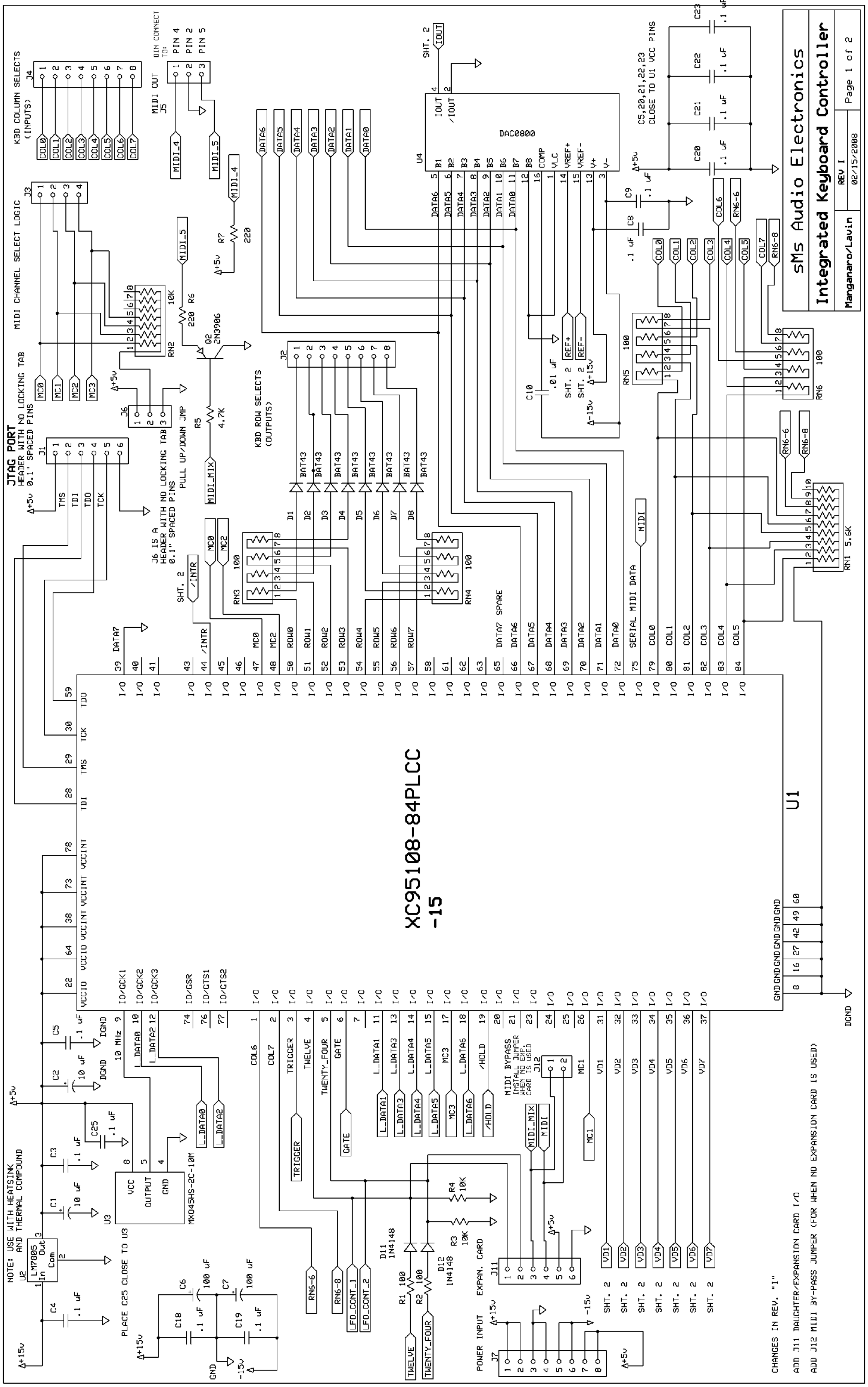
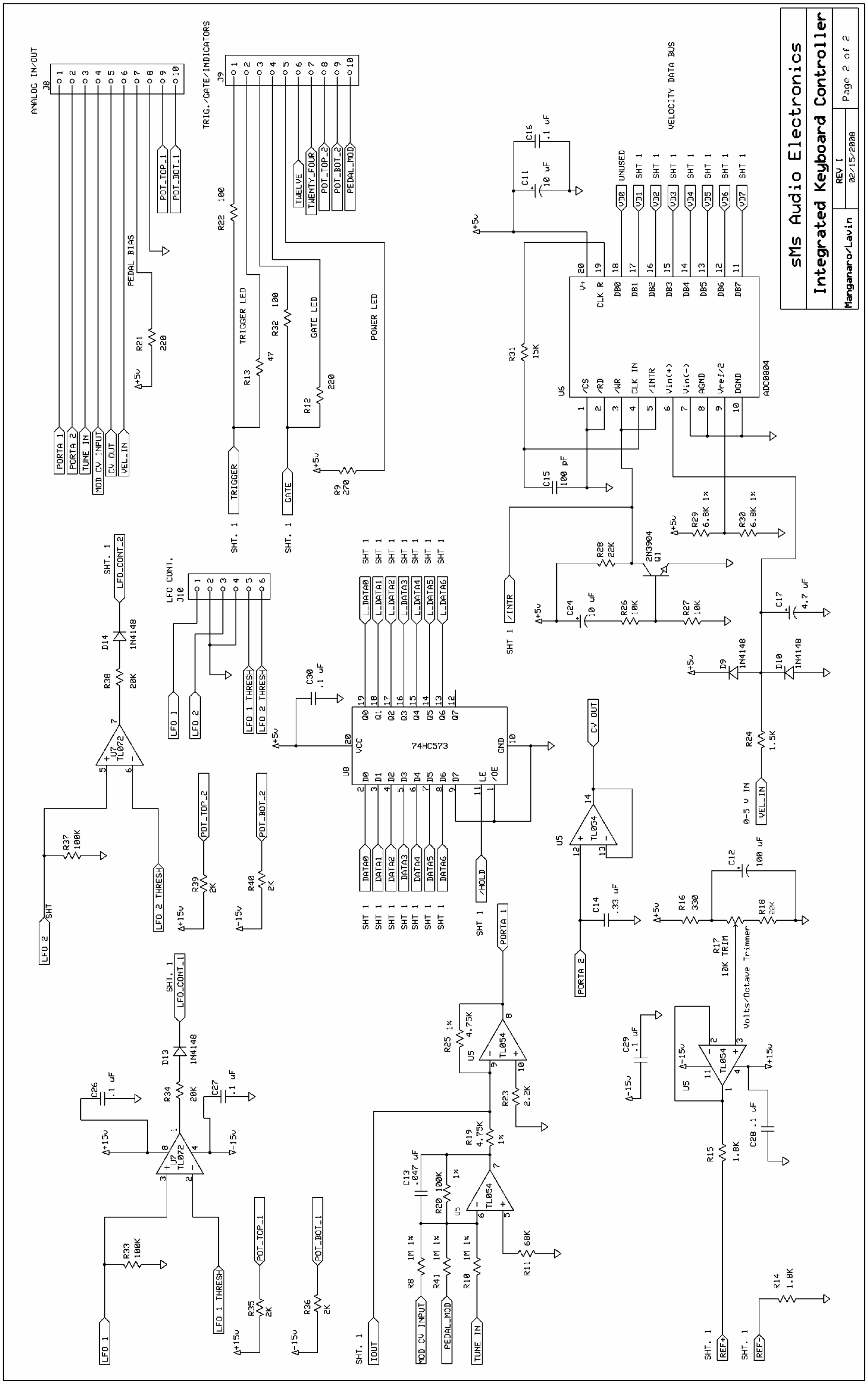
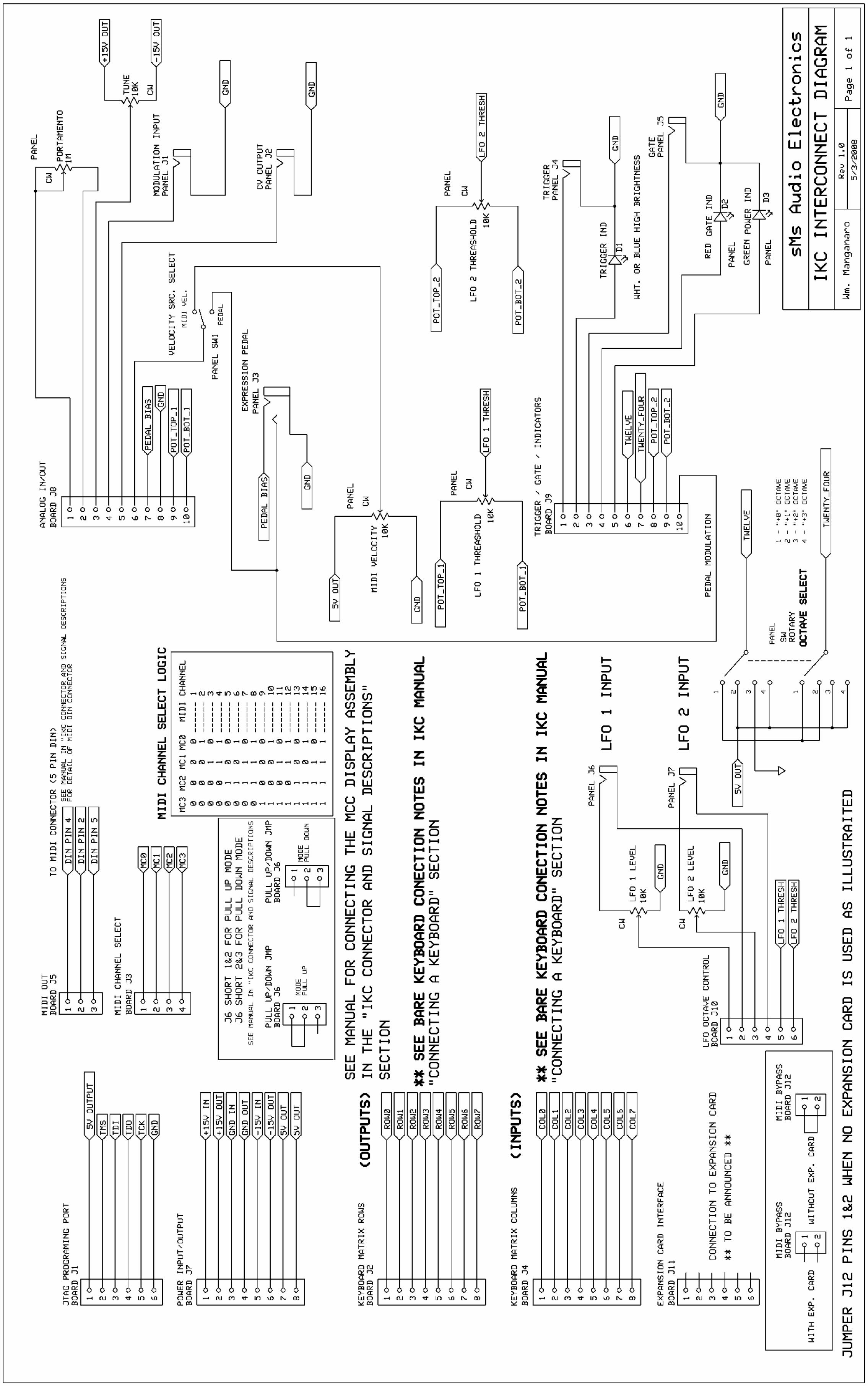


Figure 9 IKC Parts Layout Diagram & Schematics


sMs Audio Electronics
Integrated Keyboard Controller
REV I
Page 1 of 2
Manganaro/Lavin
02/15/2008
XC95108-84PLCC
-15
U1
DAC0800
JTAG PORT
CHANGES IN REV. "I"
ADD J11 DAUGHTER/EXPANSION CARD I/O
ADD J12 MIDI BY-PASS JUMPER (FOR WHEN NO EXPANSION CARD IS USED)


sMs Audio Electronics
Integrated Keyboard Controller
Manganaro/Lavin
REV I
02/15/2008
Page 2 of 2


sMs Audio Electronics
IKC INTERCONNECT DIAGRAM
Wm. Manganaro
Rev 1.0
5/3/2008
Page 1 of 1
MIDI CHANNEL SELECT LOGIC
SEE MANUAL FOR CONNECTING THE MCC DISPLAY ASSEMBLY IN THE "IKC CONNECTOR AND SIGNAL DESCRIPTIONS" SECTION
** SEE BARE KEYBOARD CONECTION NOTES IN IKC MANUAL "CONNECTING A KEYBOARD" SECTION
(OUTPUTS)
(INPUTS)
LFO 1 INPUT
LFO 2 INPUT
OCTAVE SELECT
JUMPER J12 PINS 1&2 WHEN NO EXPANSION CARD IS USED AS ILLUSTRAITED

IKC Board Construction

This section is where the IKC will be constructed. Each component group shall be mounted and soldered to the board. A convenient checklist is provided for each component group to minimize error and to keep track of what you have done.

The IKC circuit board build is designed for experienced electronics hobbyists and builders so a tutorial on soldering will not be included in this document. If you need information on these subjects, there is plenty of information on the Internet on how to solder and equip your electronics workbench.

Your IKC board is shipped ready to solder and no special cleaning is required.

Install all resistors on the IKC first. The fixed resistors and potentiometer are highlighted in purple on figure 10. Install those first. The resistor networks are highlighted in yellow and should be installed next.

<u>NOTE: if this document is in black and white only, then these components will appear shaded.</u>

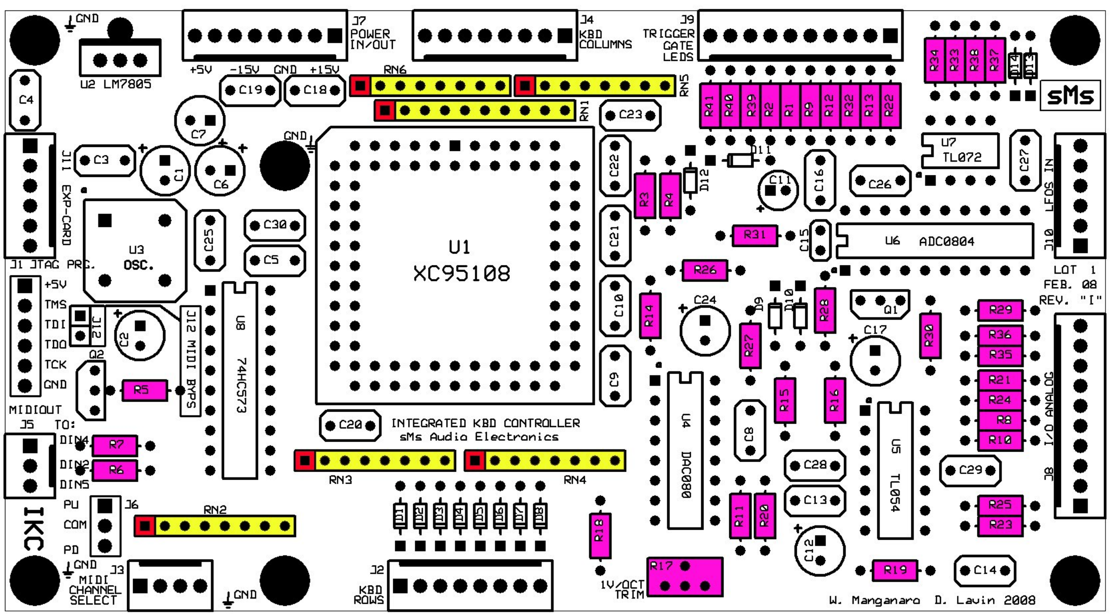


Figure 10 Fixed Resistor Placements

<u>Fixed Resistor Install Checklist (All resistors are 5% unless specified otherwise)</u>

R1	100	_____
R2	100	_____
R3	10K	_____
R4	10K	_____
R5	4.7K	_____

R6	220	______
R7	220	______
R8	1M 1%	______
R9	270	______
R10	1M 1%	______
R11	68K	______
R12	220	______
R13	47	______
R14	1.8K	______
R15	1.8K	______
R16	330	______
R17	10K TRIM	______
R18	22K	______
R19	4.75K 1%	______
R20	100K 1%	______
R21	220	______
R22	100	______
R23	2.2K	______
R24	1.5K	______
R25	4.75K 1%	______
R26	10K	______
R27	10K	______
R28	22K	______
R29	6.8K 1%	______
R30	6.8K 1%	______
R31	15K	______
R32	100	______
R33	100K	______
R34	20K	______
R35	2K	______
R36	2K	______
R37	100K	______
R38	20K	______
R39	2K	______
R40	2K	______
R41	1M 1%	______

Resistor Network Install Checklist

IMPORTANT: Take note of pin 1 orientation on the resistor network package indicated by a white DOT and should be lined up with the red indication, or darker shade if in B&W, on the IKC circuit board layout in figure 10

RN1	5.6K	______
RN2	10K	______
RN3	100	______

RN4	100	______
RN5	100	______
RN6	100	______

Install all the ceramic capacitors shown highlighted in blue on figure 11.

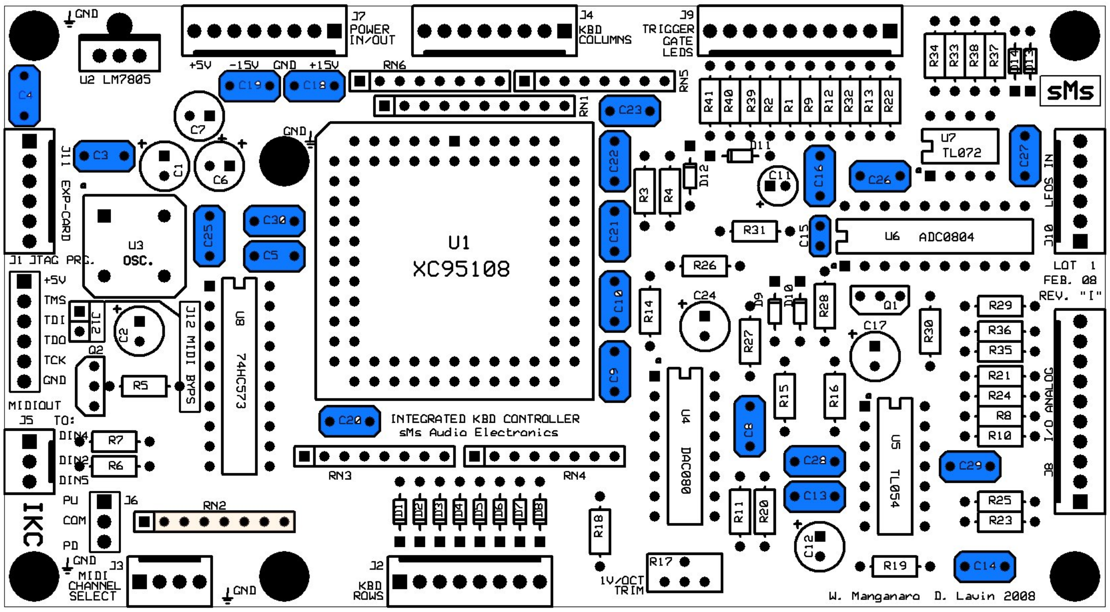


Figure 11 Ceramic Capacitor Placements

<u>Ceramic Capacitor Install Checklist</u>

C3	.1 uF	______
C4	.1 uF	______
C5	.1 uF	______
C8	.1 uF	______
C9	.1 uF	______
C10	.01 uF	______
C13	.047 uF	______
C14	.33 uF	______
C15	100 pF	______
C16	.1 uF	______
C18	.1 uF	______
C19	.1 uF	______
C20	.1 uF	______
C21	.1 uF	______
C22	.1 uF	______
C23	.1 uF	______
C25	.1 uF	______

C26	.1 uF	_____
C27	.1 uF	_____
C28	.1 uF	_____
C29	.1 uF	_____
C30	.1 uF	_____

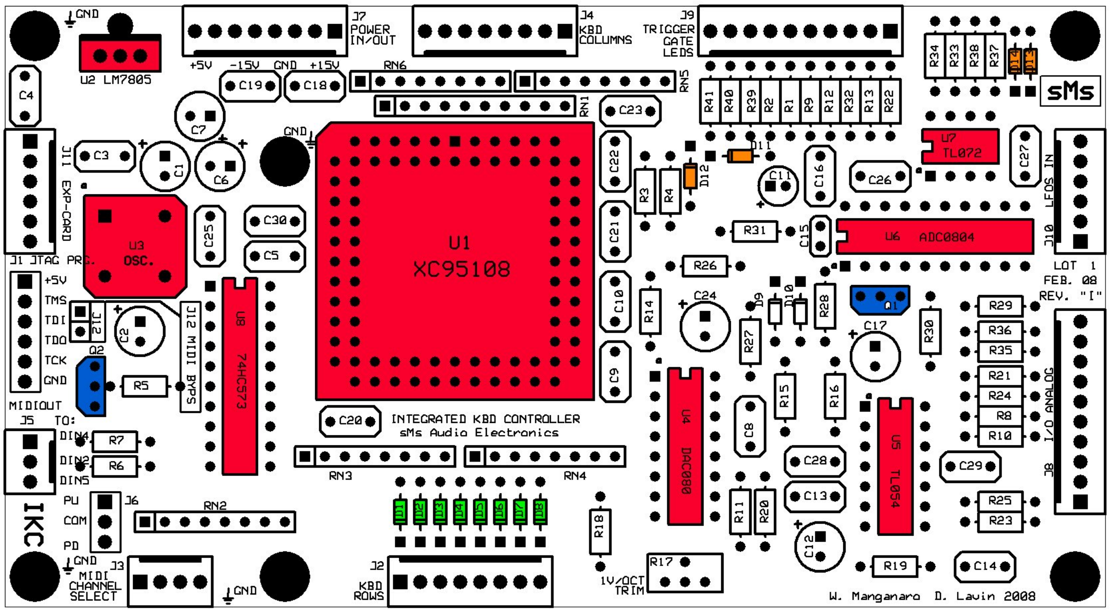


Figure 12 Diodes, Transistors, Regulator, and Socket Placements

Install Signal Diodes highlighted in green and orange in figure 12

Diode Install Checklist

D1	BAT43	_____
D2	BAT43	_____
D3	BAT43	_____
D4	BAT43	_____
D5	BAT43	_____
D6	BAT43	_____
D7	BAT43	_____
D8	BAT43	_____
D9	1N4148	_____
D10	1N4148	_____
D11	1N4148	_____
D12	1N4148	_____
D13	1N4148	_____
D14	1N4148	_____

Install the transistors with their correct orientation highlighted in blue. Take note of the flat side of the transistor package.

Transistor Install Checklist

Q1	2N3904	_____
Q2	2N3906	_____

Place a thin layer of heat sink compound to the back of U2 regulator IC then insert this into the heat sink. No hardware is necessary to mount the regulator to the heat sink. Do not use too much compound as only a very thin layer is required. It should not ooze out excessively when inserting the regulator with compound applied into the heat sink.

Referencing figure 12 on previous page again, Install voltage regulator and oscillator highlighted in red on left side of board. The oscillator package has tiny built in standoffs so you don’t need to worry about package clearance with the board’s surface.

Semiconductor Install Checklist

U2	LM7805	_____
U3	MXO45HS-2C-10M	_____

Install all IC sockets. The IC references and IC types are listed in the checklist. The IC’s are highlighted in red in figure 12 on the previous page.

IC Socket Install Checklist

U1	XC95108-84PLCC	_____
U4	DAC0800	_____
U5	TL054	_____
U6	ADC0804	_____
U7	TL072	_____
U8	74HC573	_____

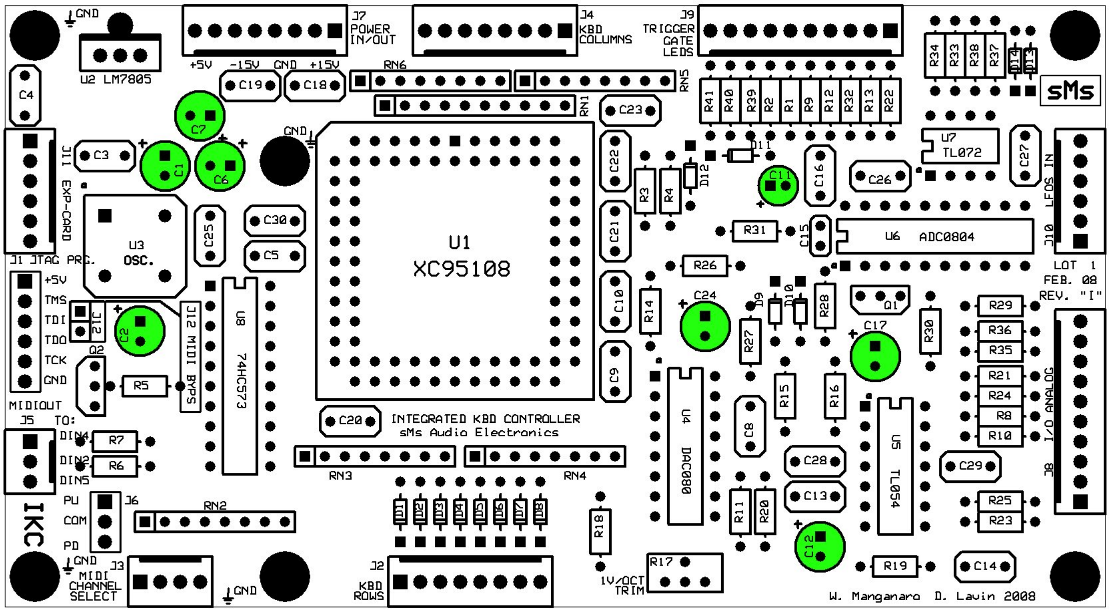


Figure 13 Electrolytic Capacitor Placements

Install all electrolytic capacitors highlighted in green on figure 13. Observe all polarities as damage will occur when power is applied to reversed biased electrolytic capacitors.

<u>Electrolytic Capacitor Install Checklist</u>

C1	10 uF	_____
C2	10 uF	_____
C6	100 uF	_____
C7	100 uF	_____
C11	10 uF	_____
C12	100 uF	_____
C17	4.7 uF	_____
C24	10 uF	_____

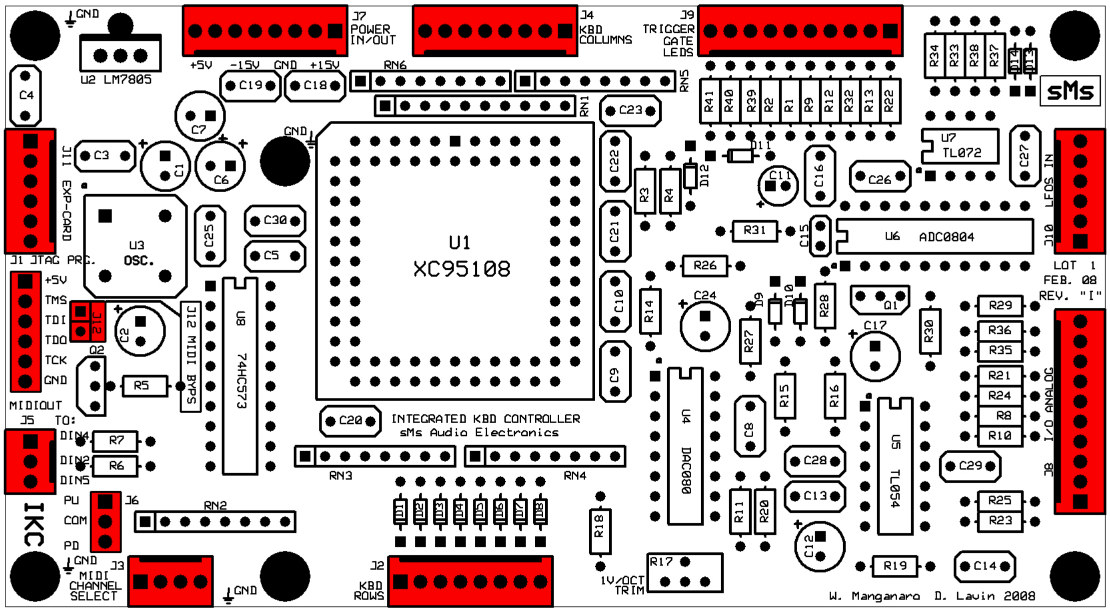


Figure 14 Molex Connector Placements

Installing the J1, J6, and J12 headers involves the breaking apart of the following part to the correct number of positions and soldering them to your IKC

CONN HEADER .100 SPACED SINGLE STRIP 36POS PN S1032E-36-ND

Break a 6 position section for J1, a 3 position section for J6 and a 2 position section for J12. Install into the PCB on the components side in their respective locations shown in figure 14 with longer lead toward the board.

<u>Jumper / Header Install Checklist</u>

J1 _____
J6 _____
J12 _____

Place a shorting jumper, Digikey PN S9001-ND, on J12 to allow the MIDI data to pass to the output. Place another jumper across COM and PD on J6 if using the MCC display board or driving the MIDI address inputs into J3 from a logic device or microcontroller. If using switches, then place a jumper across the COM and PU pin on J6 to provide a pull up voltage and ground reference for the switches. In some instances though, the pull down connection may be required depending on the type of switches you use such as thumbwheel types.

Install the rest of the Molex connectors highlighted in red on figure 14. The locking tabs are located toward the inside of the board as illustrated.

<u>Molex Connector Header Install Checklist</u>

J2 ______
J3 ______
J4 ______
J5 ______
J7 ______
J8 ______
J9 ______
J10 ______
J11 ______

This concludes the placement and soldering of the components on the IKC board. The Molex connectors should be the last things installed. Recheck to make sure no components or IC sockets have been omitted. Next, be sure to clean all the flux off all the solder joints using flux remover or alcohol and use a brush on the difficult areas. Be sure to test a small amount of solvent on a small area of the board to be sure no plastic parts will melt or deform but I find all flux removers do not damage components. sMs uses "Pure-Tronics Flux Remover", manufactured by T.A. Emerald Industries shown in figure 15, a company that specializes in high quality aerosol cleaning products for advanced applications. It works well and does not damage any PCB components. It is best to clean the flux off the board as soon as you can. The longer you wait, the harder it is to remove the flux. Follow all the directions on the container closely and you will get very good results. The flux remover can be found at "All Electronics" web store and at the time of this writing, a 13 OZ. can was $6.35 USD. The link for their web page is shown below. Just go to the chemicals section of their site to purchase this flux remover.

http://www.allelectronics.com/index.php

Figure 15 T.A. Emerald Industries Cleaning Products

After the board is cleaned and inspected, it is time to install the IC's. First, I find a lead straightening tool, like the one shown in figure 16, really comes in handy before inserting all DIP IC's. DIP IC pins are usually spaced wider than the spacing of the pins on sockets, which makes it very difficult to insert the IC's without bending leads. If you have this tool, place each IC in this lead straightener tool to put a nice right angle on all the pins.

Figure 16 DIP LEAD FORMER

If you do not have a tool, alternately place each side of the DIP IC against a flat, hard, surface and push down to give the pins more of a right angle. Once the board is cleaned, dry, and all the IC leads are formed, carefully install the IC’s in their respective sockets. Be careful to observe all IC polarities. When installing the CPLD, place the IC in the socket with the correct orientation and apply pressure in the middle of the IC and make sure it firmly and evenly seats (snaps into place) in the 84-pin socket. You will not be able to install the IC in the wrong orientation. Now inspect the entire board for soldering workmanship and accurate parts placement. Check that all electrolytic capacitor polarities are correct and make sure no solder bridges exist between pads. Using an ohmmeter, make sure that all the DC voltage supplies are not shorted to ground. Double check the placement of the U2 voltage regulator. Make sure sufficient topside solder (component side) exists on all components where visible. When you are absolutely sure the board has been constructed properly with ALL the correct parts in place and that no shorts exist, it is ready for application of power and programming of the CPLD device as described in the next section.

IKC CPLD Chip Programming

The programming of the CPLD device on the IKC is performed with software available from Xilinx called iMPACT. This software is available for free and located on their website as an individual, standalone, application or as part of their "Webpack ISE" design software. It is recommended that the standalone programming component be downloaded and installed on your computer. If you decide that you do not want to program the CPLD yourself, you can purchase a programmed part from sMs Audio Electronics. To download iMPACT or Webpack ISE, go to the following link and create a login account with Xilinx and download the software.

http://www.xilinx.com/ise/logic_design_prod/webpack.htm

Configuration is the process of loading design-specific information into one or more FPGA, PROM, or CPLD devices to define the functional operations of the logical blocks, their interconnections, and the chip I/O. The configuration file for the IKC CPLD contains all the device configuration data to define its function and will reside in the CPLD's flash memory indefinitely until reprogrammed. When using iMPACT, you must have one of the following cables, Parallel Cable IV or a MultiLINX cable. Alternately, a web link is shown below that takes you to "Rena Electronics" product page that sells a downloader cable that will work with iMPACT.

http://www.renaelectronics.com/product_x_cable.htm

You must, however, have a parallel printer port on your computer to work with the Rena cable. Remember to always match the cable type you choose to the interface type available on your PC. Usually one of these three interfaces is used: USB (Universal Serial Bus), parallel printer port, or COM Port (RS232 Port). It is increasingly harder to find modern PC's with parallel printer ports or COM ports and thus a USB interface programmer cable would be your best choice. This will insure that you can use it for years to come.

Getting power connected to your IKC to facilitate programming:

It's time to connect the IKC J7 to your power source in order to program the configuration code into the CPLD. You will need to build a suitable cable assembly to connect to J7 POWER I/O if you have not done so already. **Reference the building cables portion of this document before proceeding**. Make the power cable leads long enough to reach your power source so that when the IKC is in its final location the same cable can be reused. The connector will accept +15V, -15V and will output +5 volts on pins 7 and 8. The +15, and –15 volts will be output on pins 2 and 6 respectively. Be careful not to short these outputs together when programming your board. Pay attention to pin numbering to avoid damage to the IKC. The table below is the IKC J7 pin assignments. After the wires are attached to the crimp terminals and inserted into to the J7 housing, strip and identify all flying leads that will connect to your power supply using a small piece of masking tape. Place tape on the ends of any unused leads to insulate them.

IKC J7 Power I/O Pin Assignments:

J7 [1]: +15 VDC INPUT	**(To supply)**
J7 [2]: +15 VDC OUTPUT	**(insulate with masking or clear tape)**
J7 [3]: GROUND	**(To supply)**
J7 [4]: GROUND	**(To supply)**
J7 [5]: -15 VDC INPUT	**(To supply)**
J7 [6]: -15 VDC OUTPUT	**(insulate with masking or clear tape)**
J7 [7]: 5 VDC OUTPUT	**(insulate with masking or clear tape)**
J7 [8]: 5 VDC OUTPUT	**(insulate with masking or clear tape)**

When done wiring, connect the cable housing to J7 header on the IKC with no power on. Now, turn your supply ON and set each output for +15 and –15 volts DC with a voltmeter. Turn the supply OFF and connect the marked flying leads from J7 to the power supply terminals.

Boundary-Scan Configuration Mode

Boundary Scan Configuration mode allows you to perform Boundary Scan Operations on any chain of JTAG compliant devices. The chain can consist of both Xilinx and non-Xilinx devices, but only the BYPASS and HIGHZ operations will be available for a non-Xilinx device.

To perform operations, the cable must be connected to the JTAG pins, TDI, TCK, TMS, TDO,+5V, and GND of the cable to the IKC board. If not, connect them now then turn the power supply to ON. The IKC JTAG port is shown in figure 17 for reference. The boundary scan chain that is created in the software must match the device on the board. On the IKC, there would be only one device in the chain and a single XC95108 CPLD device will be identified when iMPACT is executed.

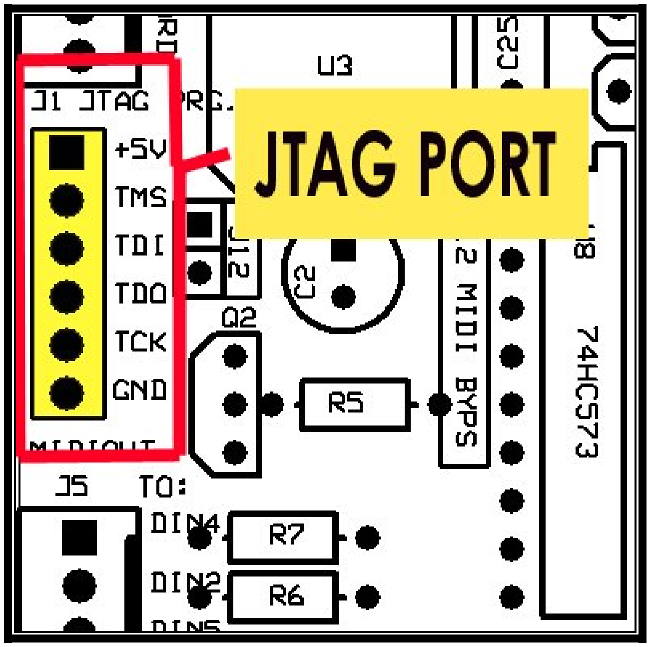


Figure 17 IKC JTAG Port.

Execute the iMPACT program. A process wizard will prompt you to select an operation mode shown in figure 18. Select the Configure Devices radio button then select NEXT. The Configure Devices wizard appears as in figure 19. Select Boundary Scan mode as shown in figure 19.

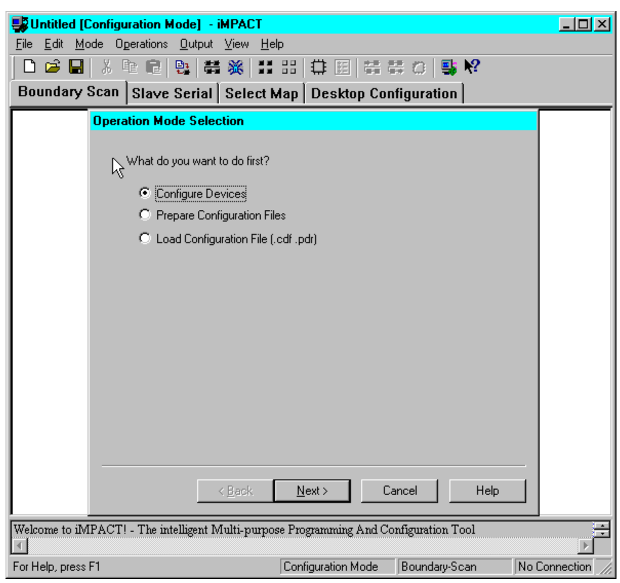


Figure 18 Initial Window When Opening iMPACT stand-alone

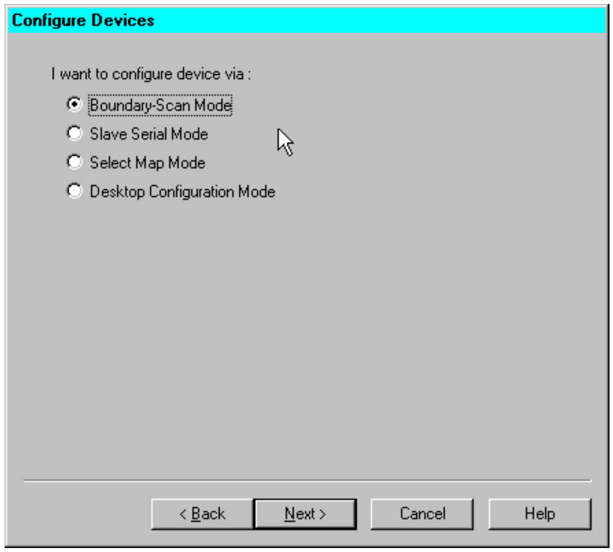


Figure 19 Configure Devices Wizard

Connecting to a Cable

A connection to a cable must be established by iMPACT before operations can be performed on a device. If a connection has not been established, attempting to perform any cable operation, such as Programming the CPLD, will cause iMPACT to attempt to auto detect the cable. An alternate method would be to right-click on a blank portion of the iMPACT window and select either **Cable Auto Connect** or **Cable Setup**.

Cable Auto Connect will force the software to search every port for a connection. Cable Setup allows the user to select the cable and the port to which the cable is connected. The following in figure 20 shows the dialog box when a cable connection fails.

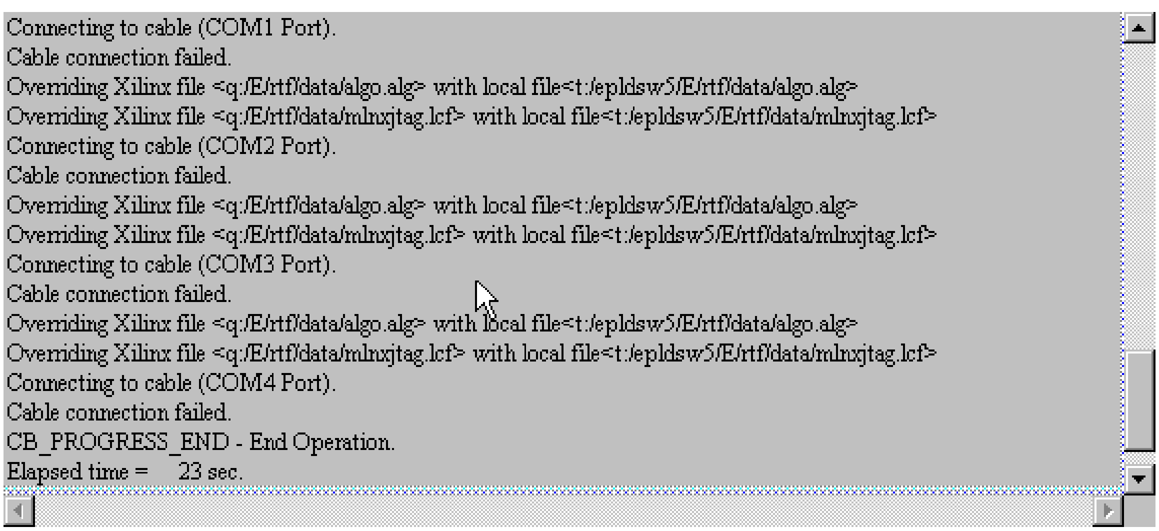


Figure 20 Failed Attempts to Establish Cable Connection

NOTE: If a cable is connected to the machine and the cable auto detection fails, use the following steps to debug.

1. Verify that the VCC and GND pins of the cable are connected to VCC and GND on the IKC board and make sure that the power supply for the board is turned on.

2. If a connection was previously established with another cable or if the configuration mode has changed, terminate the previous connection by selecting **Output →Cable Disconnect** from the menu at the top of the iMPACT window.

3. Try performing a cable reset by selecting **Output →Cable Reset**.

4. Check the connection to the port on the computer and try another port if possible.

5. Shut down the software and reopen it.

6. Verify that the drivers for the cables were installed. Open the fileset.txt file that is located in the directory where the software was installed. The following lines should be in this file:

<Date of install> <Time> <Year>:: summary=MultiLINX Cable Driver
<Date of install> <Time> <Year>:: summary=Parallel Cable III Driver

If these lines are not present, the drivers were not installed. They can be installed by reinstalling the software or by installing the Webpack Programmer.

Automatically Creating the Chain (Preferred Method for IKC Programming)

To automatically create the chain, right-click on an empty space in the iMPACT window and select initialize chain. iMPACT will pass data through the devices and automatically identify the size and composition of the Boundary Scan chain. Any supported Xilinx device will be recognized and labeled and any other device will be labeled as unknown. iMPACT will then highlight each device in the chain and prompt you for a configuration file. For the IKC, the file is called “keyscan_Vx.x.jed” Where “x.x” is the latest file version. This file can reside in any directory of your choice and is located in the root directory of your CD-ROM.

Programming Operation

Next, right click on the CPLD device in the chain. This will bring up a window with all of the available options. Figure 21 below shows the available options for a XC9500 device that has a JEDEC file associated with it. We are primarily interested in the PROGRAM option.

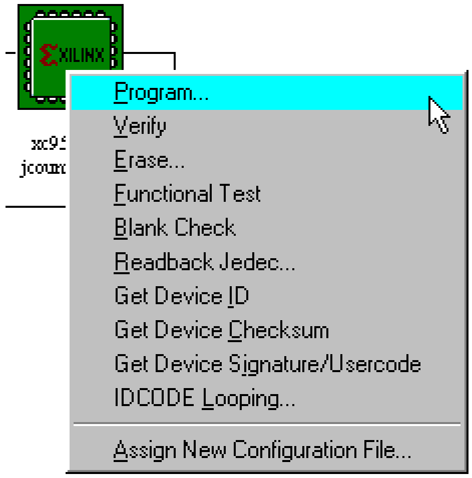


Figure 21 Available Boundary Scan Operations for an XC95108 device

Right click on the XC95108 and then left click on Program, the Program Option Window will appear as in figure 22. Select the options “ERASE BEFORE PROGRAMMING” and “VERIFY”.

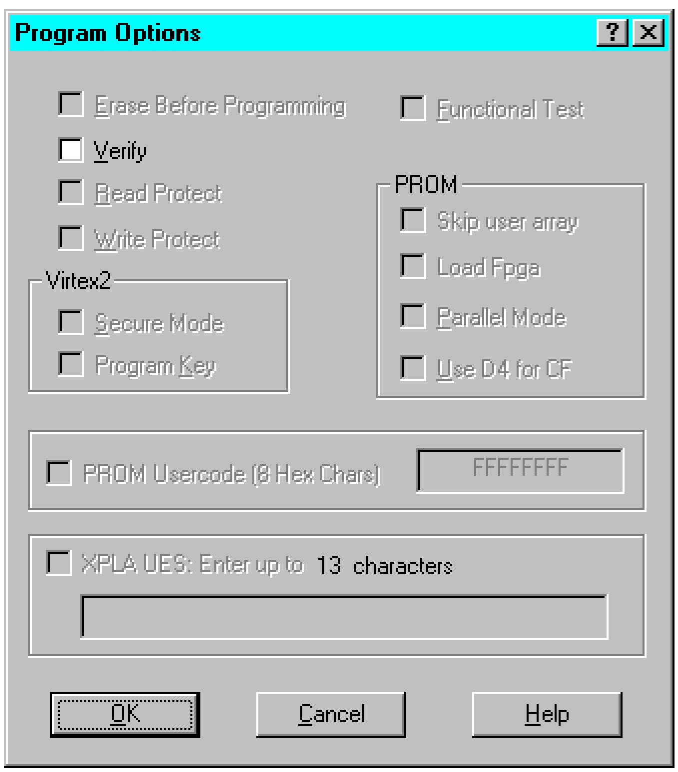


Figure 22 Program Options dialog box

After clicking on OK in the program options dialog box, the Program operation will begin and an operation status window will appear shown below in figure 23. At the same time, the log window will report all of the operations being performed.

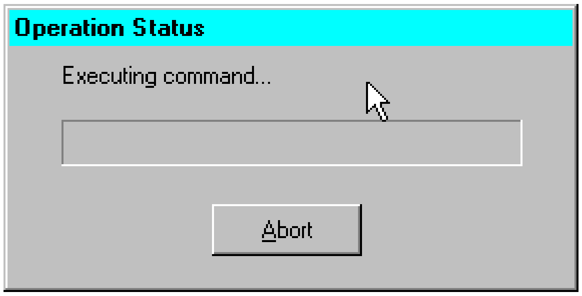


Figure 23 Operation Status

When the Program operation completes, a large blue message will appear showing that Programming Succeeded (DEVICE IN CHAIN WILL BE XC95108) as shown in figure 24.

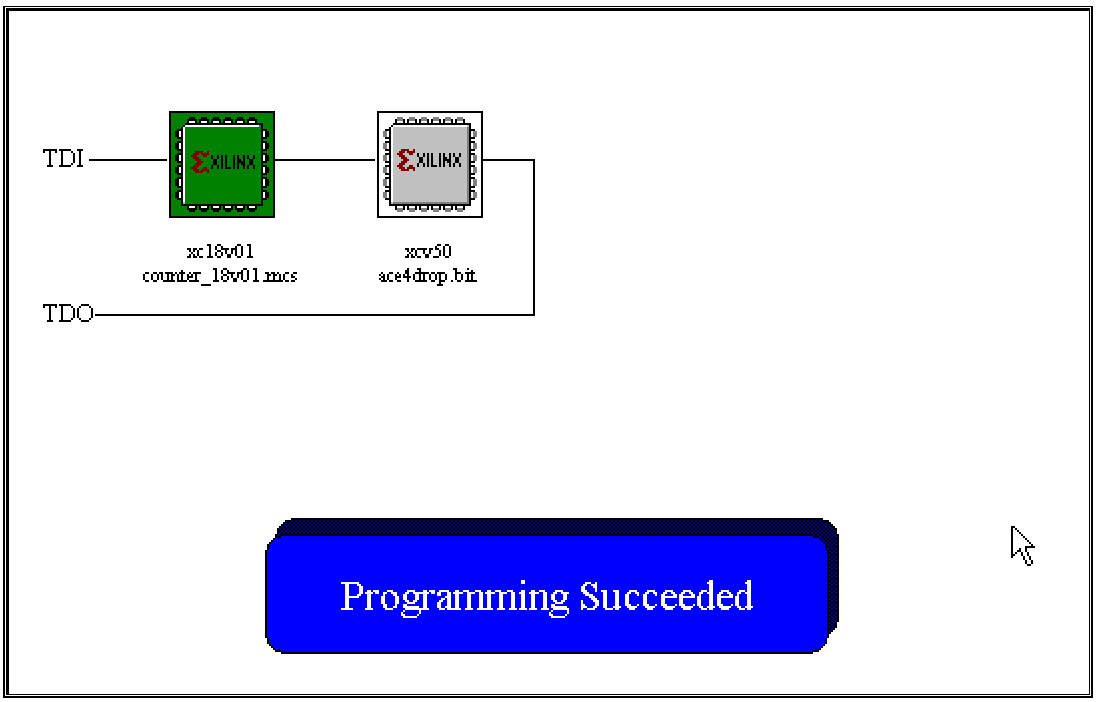


Figure 24 Program Succeeded Prompt

The log window, in figure 25, will also show that the programming completed successfully and will show all of the operations that were performed

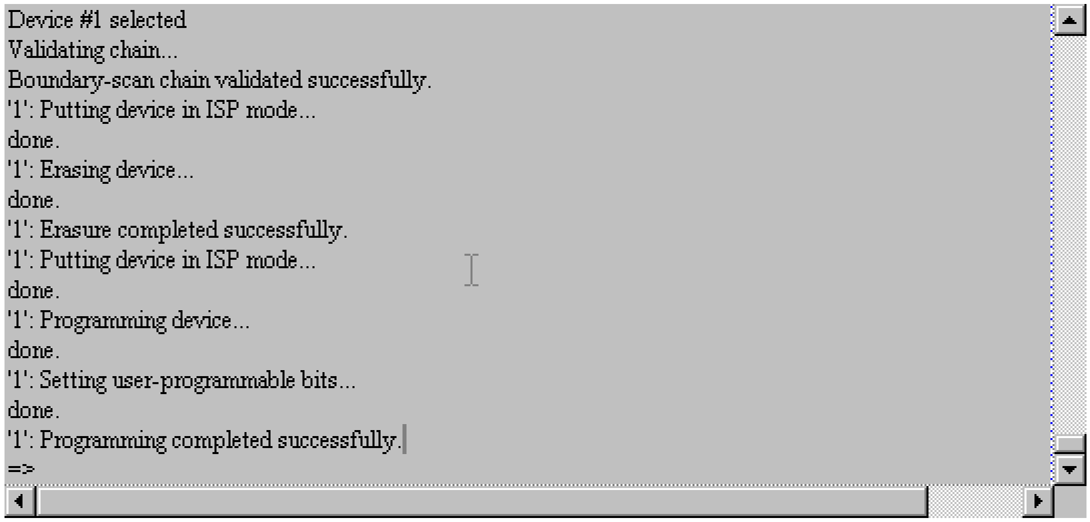


Figure 25 Log window showing successful configuration of the CPLD

After you are done programming your CPLD, turn the power supply OFF and remove the downloader cable connections from the IKC JTAG port. You may close the iMPACT program now. The next time you apply power to the IKC it will begin to function immediately.

The IKC is now ready to be integrated into a keyboard system of your own custom design. Now that you have your IKC main board ready, **please read the two connecting keyboard sections and the MCC section carefully as this will help immensely in integrating the IKC into a keyboard system.** Also, read the section on building cables as this will also provide some great guidelines on building the interconnections to your IKC. Reference the table of contents at the beginning of this document for all these important areas to read. Your IKC parts kit provides all the necessary headers, housings and crimp terminals to build such cables except for the wire. If you did not purchase a parts kit, the parts list will list all the parts you will need and includes all Digikey parts numbers for your convenience.

Plan your work carefully asking yourself how many octaves you want, how the front panel will be laid out, what material the front panel should be, will you be fabricating it, what type of enclosure do you want, what material the enclosure should be, where should all the connections go such as which ones will be on the rear of the enclosure. These are all very important questions to ask yourself. While on the subject of enclosures, it might be wise to construct the keyboard enclosure out of lighter weight material such as a light weight wood or even aluminum if you plan on traveling with it and playing live. Nobody likes to lug heavy gear! Use the interconnect diagram as a guide and remember you can modify what you need in order to meet your criteria. You might want to add multiple outputs for the CV, GATE and TRIGGER signals so you can drive multiple destinations.

Connecting the IKC to a “Fatar” Keyboard

In addition to many other keyboards and switch arrangements, the IKC was also designed to be compatible with Fatar’s line of **FAST TOUCH TP/7BA** synthesizer keyboards. They are economic keyboards that are available in various configurations of 25, 37, 44, 49, 61 unweighted keys with dynamic or monophonic bubble contacts. They are made of tough durable plastic and are lightweight. A side view of the assembly is shown below in figure 26.

Figure 26 Fatar Synthesizer Keyboard Assembly

To purchase a keyboard, please visit “Analog Haven’s” web link below. They are usually in stock and they deliver fast.

http://www.analoguehaven.com/doepfer/mke/

The following is not a detailed method to connect the keyboard but rather more of a general guideline for interconnection. Your methods may vary. The IKC connects to the keyboards matrix via the IKC J2 and J4 headers. Also, shown below, is the interconnection between the five-octave keyboard and the IKC. The keyboard uses two cables with small outline 16 position AMP “Micromatch” connectors on each end. Cut *only one* connector housing on each of the two cables, as these are not compatible with the IKC board headers. Separate each wire in the ribbon cable up to approximately three inches, and strip the insulation off the wire ends that you will need. Place an ID on each wire so that you know where to place them in the 8-pin Molex housing. Unused wires are cut back and insulated on their ends so that they will not short. Usually a small piece of shrink sleeve will do. Wire your interconnecting harnesses in accordance with the “IKC to Fatar Keyboard Interconnection” diagram shown in figure 27. Pay attention to the cable dimensions so the cable will lay in your chassis assembly between the keyboard and the IKC leaving enough slack so that the harness is no stressed.

J2

[1] ROW0: Output driving (T0) ROW0 of connected keyboard assembly.

[2] ROW1: Output driving (T1) ROW1 of connected keyboard assembly.
[3] ROW2: Output driving (T2) ROW2 of connected keyboard assembly.
[4] ROW3: Output driving (T3) ROW3 of connected keyboard assembly.
[5] ROW4: Output driving (T4) ROW4 of connected keyboard assembly.
[6] ROW5: Output driving (T5) ROW5 of connected keyboard assembly.
[7] ROW6: Output driving (T6) ROW6 of connected keyboard assembly.
[8] ROW7: Output driving (T7) ROW7 of connected keyboard assembly.

J4

[1] COL0: Input from MK0 of connected keyboard assembly.
[2] COL1: Input from MK1 of connected keyboard assembly.
[3] COL2: Input from MK2 of connected keyboard assembly.
[4] COL3 Input from MK3 of connected keyboard assembly.
[5] COL4: Input from MK4 of connected keyboard assembly.
[6] COL5: Input from MK5 of connected keyboard assembly.
[7] COL6: Input from MK6 of connected keyboard assembly.
[8] COL7: Input from MK7 of connected keyboard assembly.

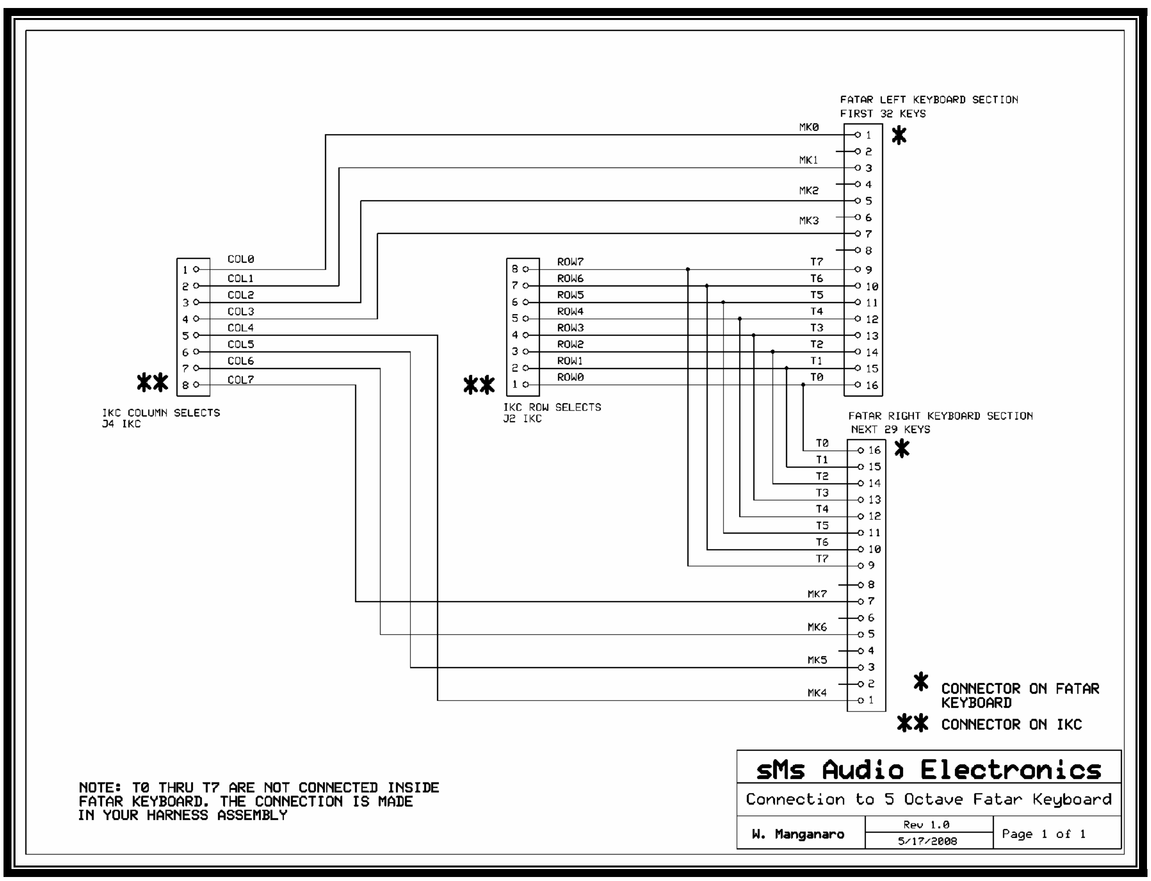


Figure 27 IKC to Fatar Keyboard Interconnection

Guidelines When Connecting to Other Keyboards

The diagram in figure 28 on the next page shows an example of how to connect an array of switches to your IKC. Here, there are a total of 64 connected, the maximum allowed. If less switches are needed, then always start with switch 1 and add as many as you need up to 64. The IKC will scan from switch 1 and continue up to the 64th than start over and scan switch 1. The lowest switch actuated has priority over a higher switch actuation thus if switch 2 is pressed and held and switch 4 is pressed, the IKC will not recognize switch 4 until switch 2 is released. This is called low key priority. The "ROW" and "COL" signals in the diagram connect to the IKC J2 and J4 respectively. The suggested switch types are normally open, momentary pushbutton types of good quality. This allows you to use your IKC as a custom MIDI controller for your laptop computer to trigger events within your sequencing software from an external switch box. With the octave selection set to "1", or no offset, each number switch corresponds directly to the note number minus one sent over the MIDI OUTPUT connection. If you select an offset of "3" octaves, you get an additional 36 note commands (the last 36 switches) for a total of 100 unique trigger events! Switches 29 thru 64 then send note numbers 63 thru 99.

Seeing this arrangement also gives you a good idea on how to add keyboards from other manufacturers. The switches represent the key switches of a any connecting keyboard. Take note of how the rows and columns are bussed together also. Beware of keyboards with internal diodes as they may prevent the row signal from getting to a column due to a reverse bias diode condition thus blocking the signal from ever getting to the intended column. Generally speaking, the ROW outputs should never connect to diode cathodes within a keyboard as the row signal is active high pulse and will get blocked. Some keyboards may need modification when used with the IKC by bypassing the internal diodes. The bottom line to all of this is that the switches in any keyboard MUST be connected as you see them in the diagram. It's OK if there are series diodes in the ROW lines of your keyboard as long as the anode gets connected to the ROW output of the IKC. The series row diodes used in the IKC are low loss type so another diode in the signal path will not affect the IKC operation. In fact, the Fatar uses a series diode in the T0 thru T7 input lines.

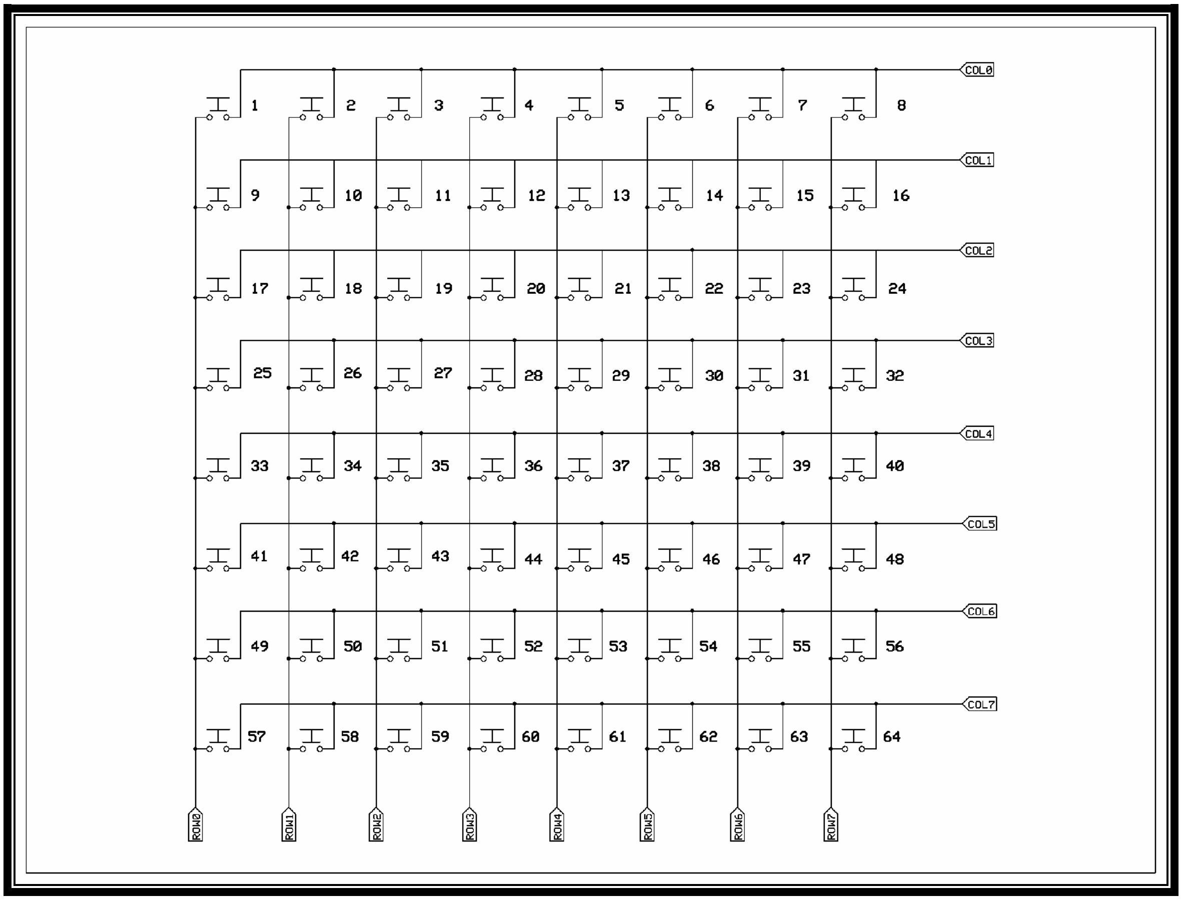


Figure 28 Switch Connections to Form a Matrix

A fine example of a DIY keyboard constructed by Dan Lavin is shown in figure 29. One of the most striking features is the home brew enclosure build by Dan and his father-in-law, is its rich looking cherry finish. The panel design has extra space for extra features the IKC daughter card will offer. Here is what Dan had to say about the construction of the enclosure for his keyboard.

"There is no correct way to make a keyboard cabinet. I've made four now with my father and father-in-law (because they were better than I at wood cabinetry) and each one is a different design. The important thing is to design from the inside out and take measurements by actually placing control panels, wheels and printed circuit boards by the keyboard. I leave about 0.25"/6mm on each end of the keys for play as you don't want the keys rubbing against the cabinet. For the IKC, I found 4.75"/121mm to be the distance needed behind the keyboard to place the printed circuit board and have some room to run wires. I used cherry wood for the top and sides with plywood (optionally pine) for the base since the base is never seen. All panels were 0.75"/19mm thick. Construction is glue with nails (pneumatic gun used). The nails are not important...they just hold the panels together until the glue is dry. Be sure to use good wood glue. The top of my IKC is screwed onto the base, but all my other keyboards used hinges.

A dark cherry or mahogany stain was used on the bare wood pieces (after lots of sanding) and several layers of clear polyurethane were applied for protection. The control panel is actually a temporary one as I plan to make a permanent one after the MIDI daughercard is added. The panel was designed with “Front Panel Designer” software and printed out onto card stock, then glued to a piece of 1/8”/3.2mm plywood available from most local hobby stores. A few layers of clear polyurethane were applied for protection. I used a 3-way multiple for the CV out to control 2 VCO's and a VCF and 2-way multiples for the gate and trigger signals to control 2 ADSR's which is my normal modular set-up. The keyboard was a US$10 Ebay special Casio CA-100 which is a 4 octave keyboard. The keyboard encoding matrix was actually not a multiple of 8 and I don't remember exactly but I seem to remember something like 2 separate matrices with a base 7. Well, regardless, the keyboard needs to be turned into a base 8 matrix so with 49 keys, it becomes a 8 X 7 (8 X 6 = 48 + 1 extra key) matrix. I used a Dremel cutting tool to break some traces and 30 gauge wire-wrap wires to create new traces. This was probably the least fun of the whole project. It took me a good afternoon to complete (between normal household chores).”

Great work Dan and certainly some good tips on how to approach your keyboard build! Of course, there are many other materials from which to make you keyboard and you can even go as far as to build one from clear plastics for a really cool inside view. It’s up to your imagination on how your keyboard will look.

Figure 29 Dan Lavin’s Home Brew Design using “IKC” and “MCC” Assemblies

IKC Calibration

This is a good time to calibrate the IKC for 1V/Octave operation. You will need to reference your parts layout and interconnect for this calibration. The calibration of the IKC will require an accurate digital voltmeter. Most modern 3 ½ digit models will do fine for the job. You will also need a non-metallic potentiometer adjustment tool to adjust R17 “1V/Oct TRIM”. If you are very careful, you can use a jeweler’s screwdriver but it’s not recommended as any slips can cause permanent damage to your IKC.

By now it is assumed you have connected a keyboard matrix and wired your entire front panel potentiometers, jacks and indicators according to the interconnect diagram or a modified one of you own design. If not, you will not be able to align the IKC according to these instructions and will have to find an alternate method to the one being described in this text. Below in figure 30 is an illustration showing the location of the R17 calibration pot located next to J2 ROW connector.

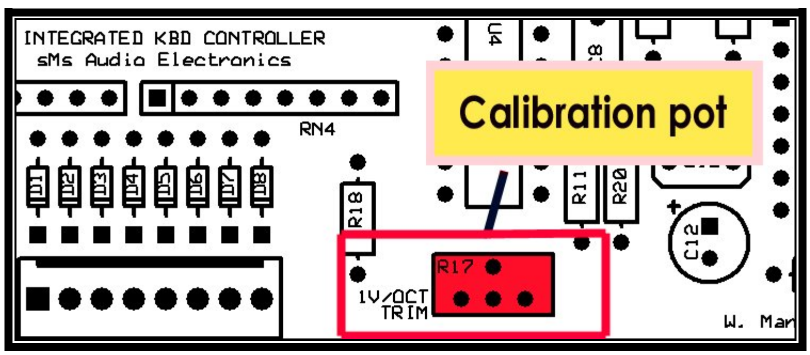


Figure 30 IKC Calibration Potentiometer

Turn the power ON and let stand for at least 15 minutes at room ambient temperature to let the analog portion of the IKC settle to their final values. In preparation, turn LFO 1 and 2 THRESHOLD potentiometers fully clockwise so that they do not interfere with the calibration. Remove any input to the LFO 1 & 2 input jacks. Turn the PORTAMENTO potentiometer potentiometer fully counter-clockwise. Turn the OCTAVE SELECT rotary switch to the “1” or zero octave position. Momentarily depress the leftmost key on your keyboard to zero the DAC on the IKC.

Measure and take note of the voltage at the CV jack on your panel or, alternately, measure directly at U5-14 operational amplifier, CV OUTPUT, being careful not to slip with your probe. This voltage should be at or near 0.0 VDC. After noting the voltage, turn the OCTAVE SELECT rotary switch to position “4” or the three octave setting. Measure and take note of the voltage at the CV jack on your panel or measure directly at U5-14. Adjust R17 so that the voltage at this point is 3.0 volts higher than when the octave selector was in position “1”. Go back and forth between these rotary switch settings and make sure you achieve this 3.0-volt span. The voltage at the CV output with the selector at position “1” should yield a voltage of about 0 volts, give or take a few millvolts. After you’re done, verify that every successive key you press on your keyboard will yield an increase of 83.33 millvolts starting from the leftmost key. The CV will increase by this amount as you ascend up the scale and should never decrease. If it does, there is a wiring issue in your keyboard to IKC harness. If you choose, you can check the every twelve keys pressed and thus will yield an increase of 1.0 volt conforming to the 1V/Octave standard for voltage controlled synthesis equipment. Next, you can check intermediate positions of the octave shift rotary switch to make sure it yields a 1V change for each position. Each higher position will yield a 1 volt higher reading. If everything went well, your IKC is now calibrated. Congratulations, you now have yourself a useful precision instrument!

MIDI Channel Changer (MCC)

The MCC is a small 2" x 2" high quality circuit board assembly that contains two 0.5" "eye catching", high contrast, blue LED digital displays with all the necessary logic for MIDI channel selection on the IKC board and display of MIDI channel. The single chip design lowers cost by incorporating the entire switch debounce, clock, decode, counting, and display driver logic in a single IC package. The MCC outline drawing is shown below in figure 31. NOTE: Some versions will not have X1, C3 and C4 populated on the board.

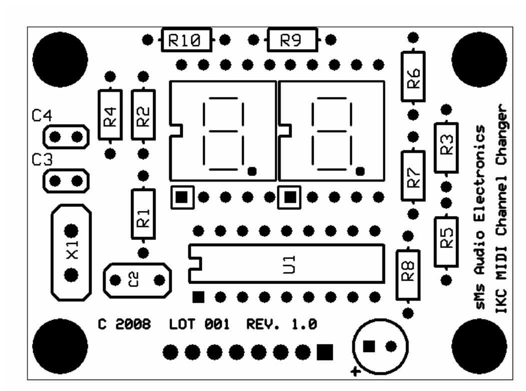


Figure 31 MCC Board Assembly

The module will provide the 4-bit TTL compatible MIDI channel address required by the IKC as well as display the MIDI channel number from 1 thru 16.

MCC PCB Mechanical Specifications

Board Dimensions: L 2.2" (55.9 mm) W 1.6" (40.6 mm)
Hole Center to Center Spacing: 1.9" (48.3 mm), 1.3" (33 mm)
Hole Size: 0.125" (1/8") (3.2 mm)
Hole Pad Size: 0.25" (1/2") (6.4 mm)

MCC PCB Board Attributes

Layers: 2
Green Solder Mask: Solder Side / Component Side
Silkscreen Color: White
Material: Fiberglass FR4
Copper Weight: 2 OZ.

The photo below in figure 32 shows the size comparison between the MCC and IKC circuit board.

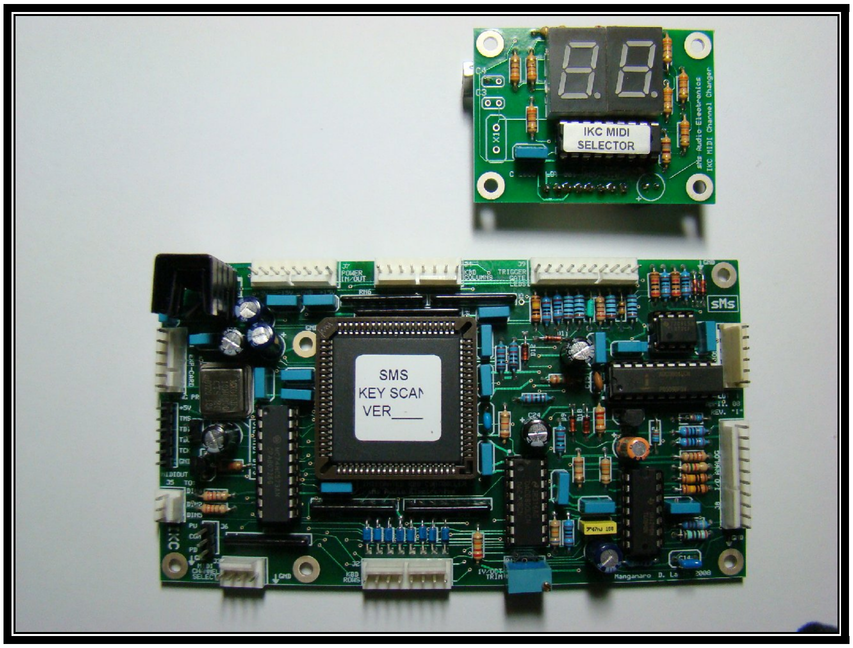


Figure 32 MCC and IKC Shown Together

The MCC provides an easy off the shelf solution that integrates perfectly with the IKC or can be used with any other MIDI retrofit or new project that could benefit from a "more modern solution" channel display and digital selection which eliminates DIP, Rotary, or any other mechanical methods. It has (4) 0.125" mounting holes to mount to your enclosure's front panel and an 8-pin female interface header on the back of the board for connection to the IKC.

MCC Interconnection Diagram

Shown below in figure 33 is the connection between the MCC and the IKC. The IKC power connector, J7, pin 8 is a 5-volt output that you can use to power the MCC as shown. In addition to this interconnection, be sure to place a shunt between pins "COM" and "PD" (Pull Down) on J6 header of the IKC board as shown below in figure 34. This places a 10K resistor from each CPLD input to ground. The diagram also shows the J3 input connector to which the MCC connects.

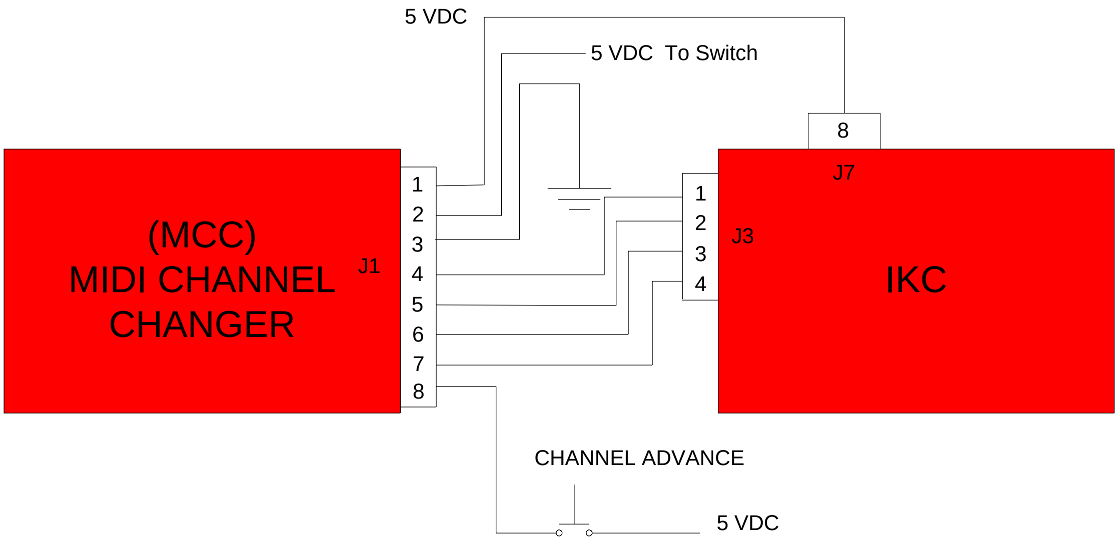


Figure 33 MCC to IKC Connections

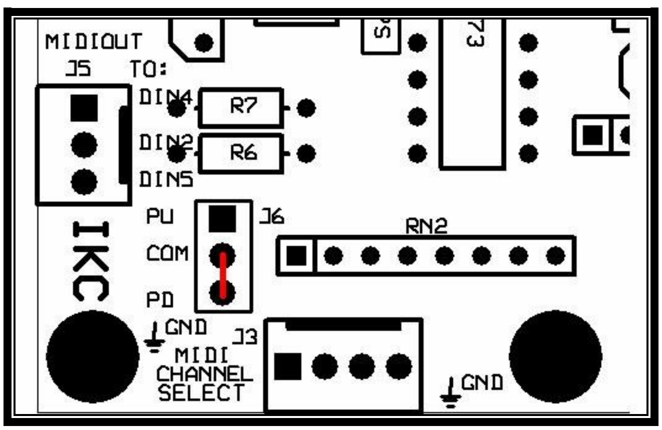


Figure 34 JUMPER POSITION WHEN USING MCC

After all the connections are made and verified, it is time to apply power. When the MCC/IKC units are first turned on, the MCC channel will default to a display of "1" and channel "1" will be selected on the IKC. Each time the "CHANNEL ADVANCE" pushbutton is depressed, the channel display will advance by "1" as well as the channel selected on the IKC. Holding the pushbutton down will not auto advance the channel. The maximum channel count is 16 as defined by the MIDI standard. At channel 16, pressing the pushbutton once more will cause the unit to wrap around back to channel 1 and continue in this counting fashion. The last channel number displayed will be lost when power is removed and will default back to "1" when power is reapplied. The MCC units come programmed, built, and tested and ready immediately for use. Cable assembly kits are available in 12" lengths from sMs Audio Electronics.

Building the Cables for the IKC

When constructing your keyboard and integrating the IKC into it, three main reasons why you should use the cable components that came with your IKC kit should be considered.

(1) Final Assembly of an IKC based keyboard is made much easier. If one is to hardwire the connections, the wires must be soldered to both the front panel and the PCB assembly. This involves point-to-point wiring which involves a considerable amount of effort over building the cables and wiring them to the front panel.

(2) Servicing/trouble-shooting the IKC is made easier – the panel can be easily disconnected and re-connected to and from the PCB.

(3) Its easier to organize the wiring in a methodical manner, which leads to a neater, no “rats nest” build.

This is not to say that building the cables cannot introduce problems – the cables must be built with care so they do not themselves create problems with intermittent connections.

Soldering the wires to the board and performing point to point wiring is really an option that should not be considered.

Parts Used In the Cables

Each cable is comprised of three elements:

The housing, which is a shell that the cables are “plugged into and which connects to the proper connector on the PCBs. There are different types of headers used in the IKC , they differ by the number of wires they will accommodate. The header pins are crimped or soldered **or** crimped **and** soldered to the ends of the wires, depending on your chosen technique. Generally 22 gauge or 24 gauge braided wire is required. Do not use solid core wire.

Housings and Pins

First of all, one must be aware that the housings will plug into the PCB headers in only one direction – this ensures the wire that is to attach to pin 1 of the PCB connector is the correct wire. So, you must become aware which “hole” in your housing will mate with pin 1. On the back of the PCB, you will notice that each connector has a square pad to designate pin 1 of the connector. The connector is keyed so that the housing can only be plugged in with one orientation. In other words, the header is keyed so that the housing, which has a mating “key” will plug into it. On the housing, the key is a ridge running along the edge of the “bottom of the housing”.

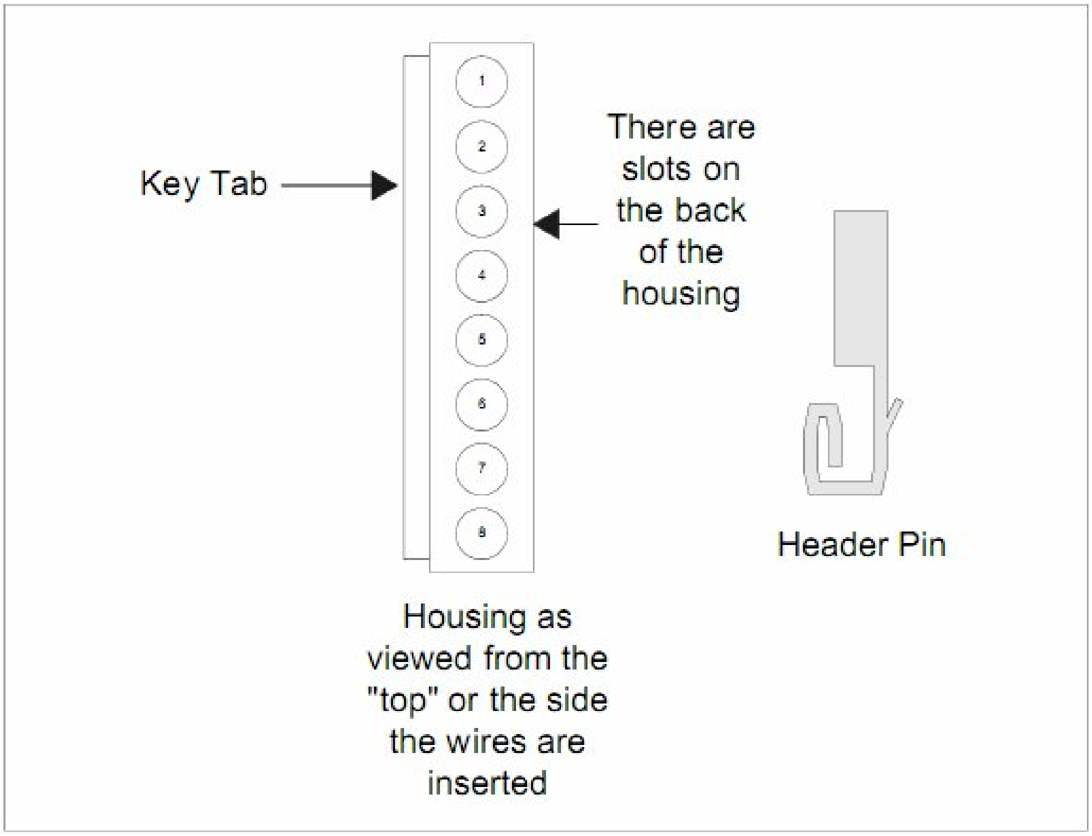


Figure 35 Housings and Header Pins

On the opposite side of the housing is a slot for each "hole" or terminal in the housing. These slots run along the bottom. The header pins, which attach to the ends of the wire, have a small tab that protrudes from the "back" of the pin. This small tab acts as sort of a fish hook and will "catch" in this slot when it is inserted into the housing.

Attaching the Pins to the Wires

The header pins attach to the ends of the wires, and are then inserted into the housing. The pins have a couple of tabs at the top that are intended to be crimped, or folded over the insulation of the wire. The end of the wire is stripped and tinned, about ¼" from the end of the wire. This stripped and tinned part is to extend down so the "loop" of the header pin compresses down onto the bare wire when the wire and pin are inserted into the housing.

Crimping tools can be expensive, though fairly inexpensive types that resemble a pair of wire cutters are available. In lieu of a crimping tool, many people will fold the tabs over the bare wire and put a *small* amount of solder there to hold it in place (a large "blob" of solder may prevent the header pin from fitting into the housing). Generally, during the

IKC proto build process, it was found that the small amount of solder made a much more reliable connection.

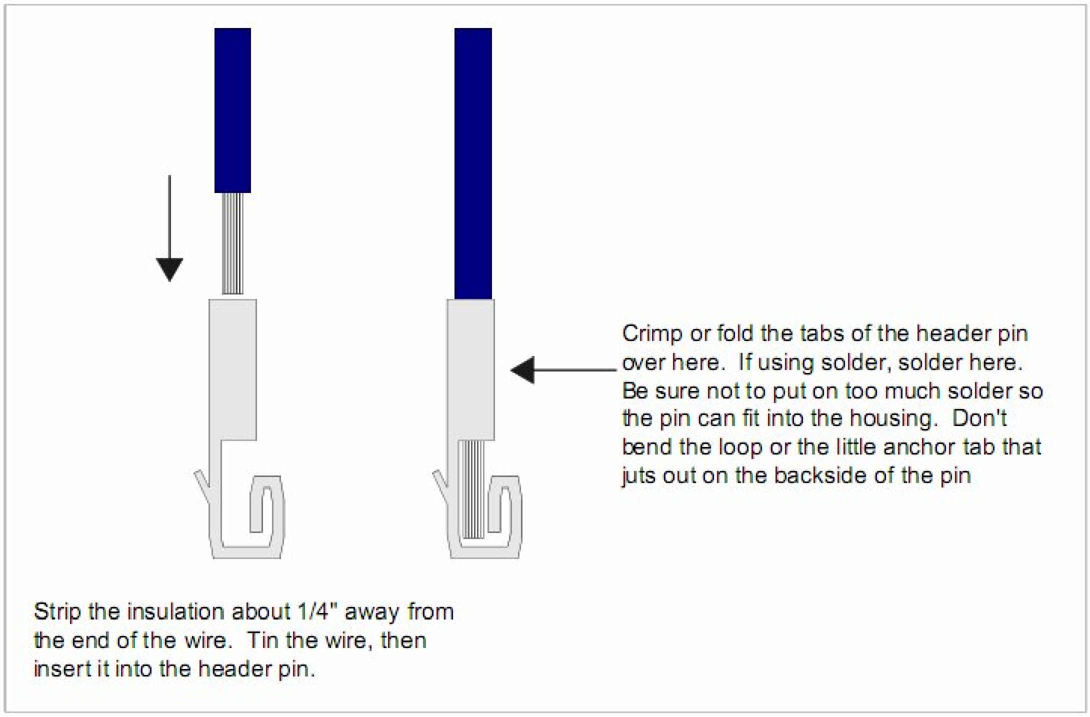


Figure 36 Putting The Header Pins On Wires

It's a very good idea, if at all possible, to use a number of different colors of wire when building the cables. This helps you to determine very quickly which wire is pin 1, which wire is pin 2, etc. Otherwise, it's very easy to become confused which wire is which, and this can lead to errors when soldering the free ends of the cables to the front panel. Also, make sure you provide plenty of length for the wires. By now, you've probably figured out how you're going to mount the IKC PCB in your keyboard chassis. Making the wires longer than what you think may be needed allows you to measure them out by physically stretching them to where your boards will be and ensuring they will indeed reach before you actually do solder them to the front panel. You can break the job down into separate tasks. For example, you can go through task of stripping all of the wires needed and attaching the pins. Then you can task yourself with inserting the wire/terminal pin into the housings, and then you can task yourself with creating a neat looking cable by either wire-tying the cable wires together, or twisting the wires around each other to create a twisted-pair type thing. However, this last task may need to wait until after you've soldered the cables to the front panel – for now, it may be best to put a nice little twist-tie "collar" onto the cables just above the housing once the cable is assembled. When you strip the wires, it's not a bad idea to strip just a tiny bit of the wire off the end that will connect to the panel. You can then use this exposed bit to attach a DMM or continuity checker to it and make sure your wire has continuity from the pin to the end of the wire. A little care at these early stages can save a lot of headache at the final assembly and test stage of building your keyboard.

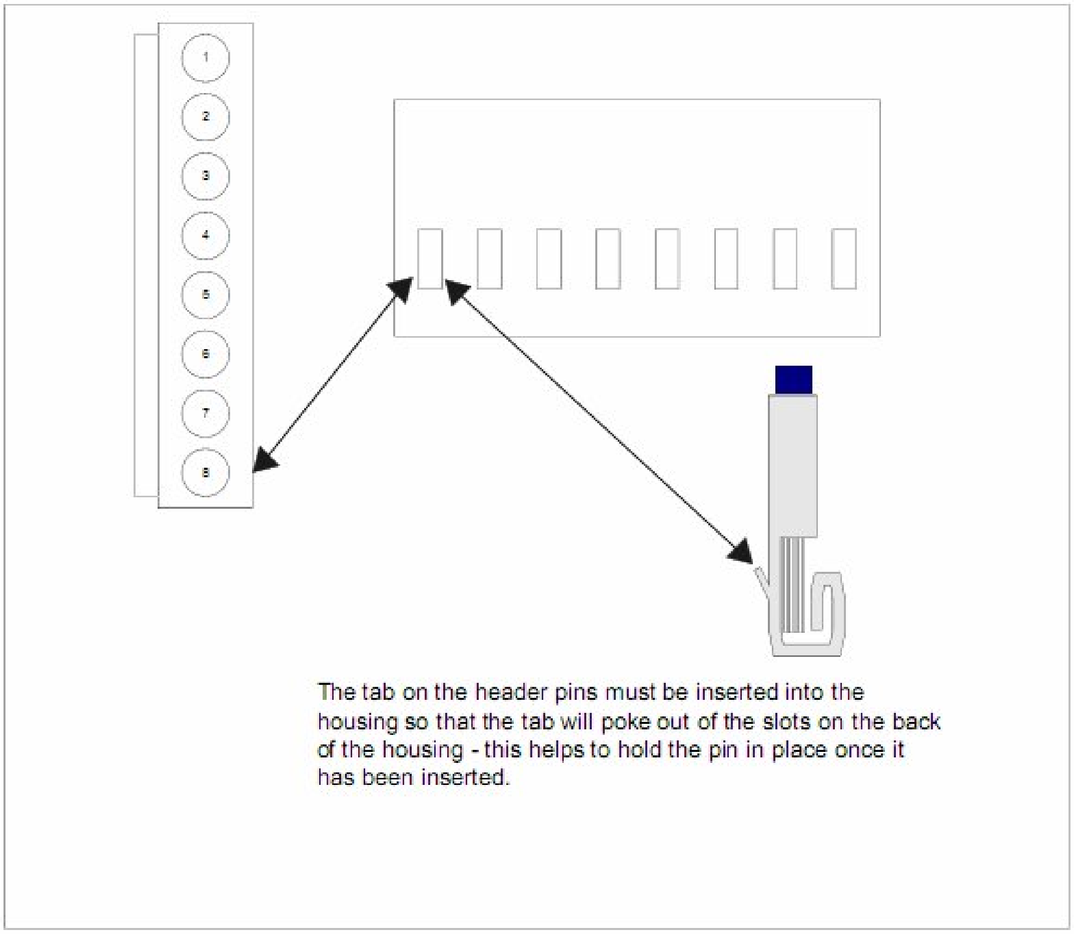


Figure 37 Pins Orientation Before Insertion Into the Housing

Once you’ve got the terminal pins attached to your wires, you can insert them into the housings. When you insert the pins into the housing, make sure that little barb on the back of the pin is oriented towards the side of the housing that has the small “window” in it – the barb is designed to “catch” in that window like a hook in the mouth of a fish, and make it harder to yank it out at a later date. When the pins are inserted into the housings, there should be the sensation of a soft “click” – this is a good sign that you’ve done a good job getting the pins on the ends of the wires.

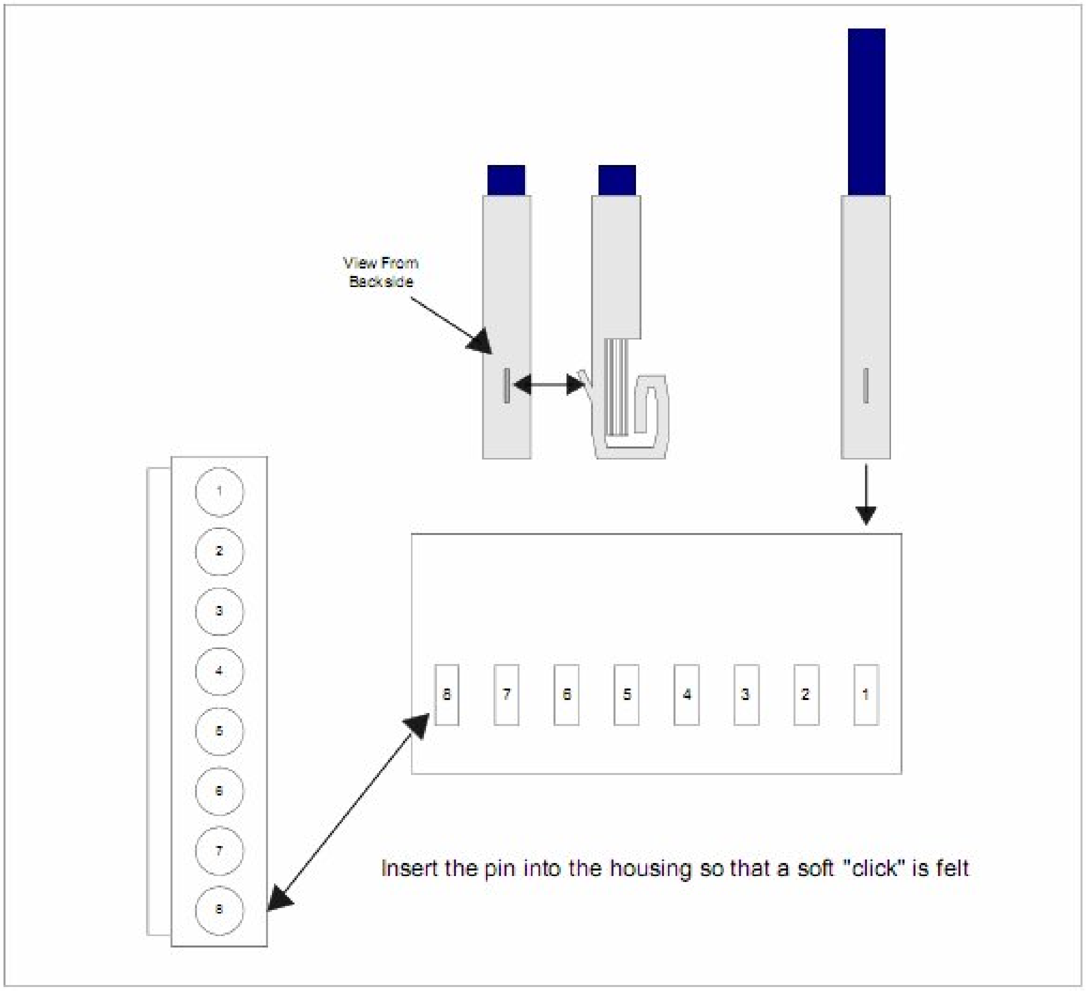


Figure 38 Inserting Pins Into the Housing

Remember that "loop" on the pin must not be crushed or misshapen – it is intended to compress down over the wire, making a good connection, and also provides a certain amount of tension that helps hold the pin in the housing. And, again, too much solder (if you put solder on) or solder in the wrong place can inhibit the actual installation of the pin into the housing.

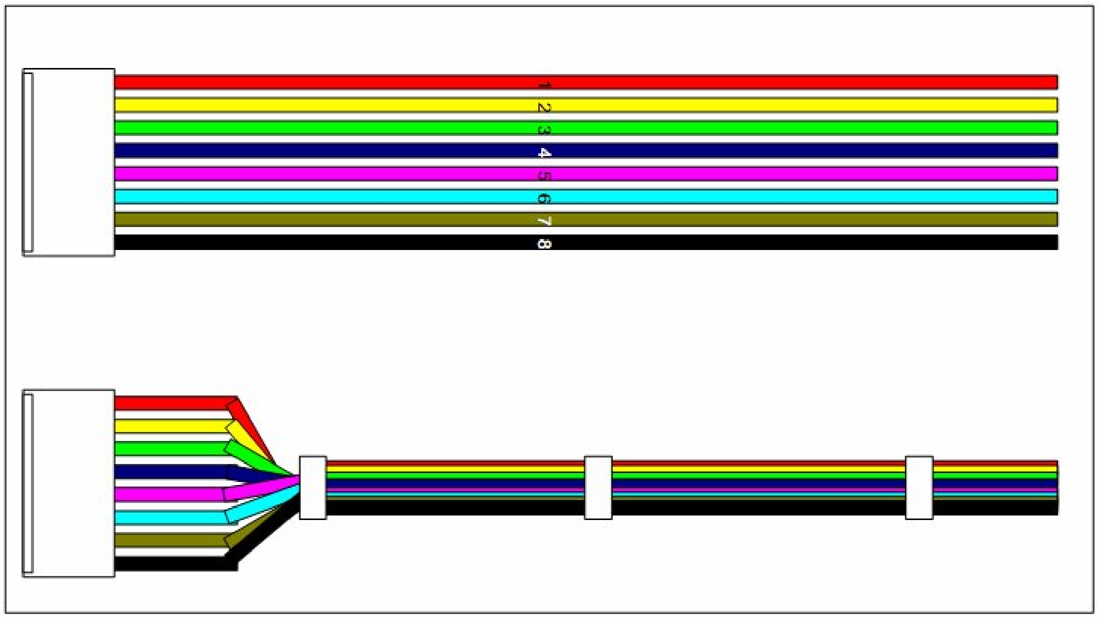


Figure 39 Assembled Cables

Once you've got all the wires into the housing, you can put a small collar onto the wires just above the housing. You may not want to add more at this time, because your wires will need to "fan out" in order to connect the all the disparate points they will connect to. Once you've built your cables, you will find that soldering them to your panel is a real cinch – very easy, and all the real work will be behind you.

The following are all the IKC and MCC board dimensions that you will need to know to drill your holes for your panel. This should answer where the holes should go and how large a diameter the holes need to be.

Some final words by the author:

I wish you luck with your keyboard build and hope that it will become a useful tool in your music creation, and, a tool from which you learned a great deal from. After you build your keyboard and have success, or even some failures along the way, it will give you a great sense of pride that you have created something from virtually nothing. That is the magic of engineering things. By bringing bits and pieces together to form an instrument as pragmatic and complex as this, and, use it in your studio or during live performances is a priceless feeling. I would also like to once again thank Dan Lavin, my friend and colleague in the "Great Lakes" area of the US, for his assistance in the IKC project. His prototype testing, technical advice, keyboard building, and IKC printed circuit board design were a valuable service and certainly made the IKC a better product. It would have certainly been a slower go without him. Thanks Dan! Please e-mail any comments you may have about your IKC, MCC, and the keyboard you create using these products.

Bill Manganaro thex@optonline.net [sMs Audio Electronics]

Bibliography:

The reference that follows is certainly no formal bibliography by academic standards but it gets its point across adequately. The format is a bit unorthodox for a purpose. It highlights books, articles, and products that have had great influence on the IKC project and by creating the projects foundation. The format that follows is a reference is stated and then its influence on the project follows.

1. Thomas Henry's Book: "Build a Better Music Synthesizer" – [Digital Keyboard Section] – "Inspiration for the 'analog' portion and the foundation of the digital design of the IKC"

2. John Simonton's Book: "Friendly Stories about Computers and Synthesizers" – "Basis of keyboard encoding and exponential control sections. Basic inspiration for the DAC output design and perhaps even Thomas Henry's original digital keyboard."

3. Kirk Austin's Polyphony, April 1984 Issue, "Remotely Midi" (Remote Midi Keyboard) –"Inspiration for using the ADC0804, 8 bit, analog to digital converter IC in the project."

4. Electronic Musician, September 1989 Issue, "Pocket Midi Controller" – "Inspiration for the technique employed to develop the MIDI hardware output serializer embedded into the IKC CPLD device."

5. Blacet Technology, VCO 2100 (www.blacet.com) –"Inspiration for the octave jumping circuits."