I2C Interface for QL Emulators Part 8

In the first three parts of this series we have looked at the principles of the I2C bus and some the devices that can be used. Such as parallel and AD/DA interfaces, RTC (Real Time Clock), RAM (Random Access Memory) and a digital potentiometer.
In the forth part of this series I showed how to use the PCF8574 parallel device to drive a LCD display.

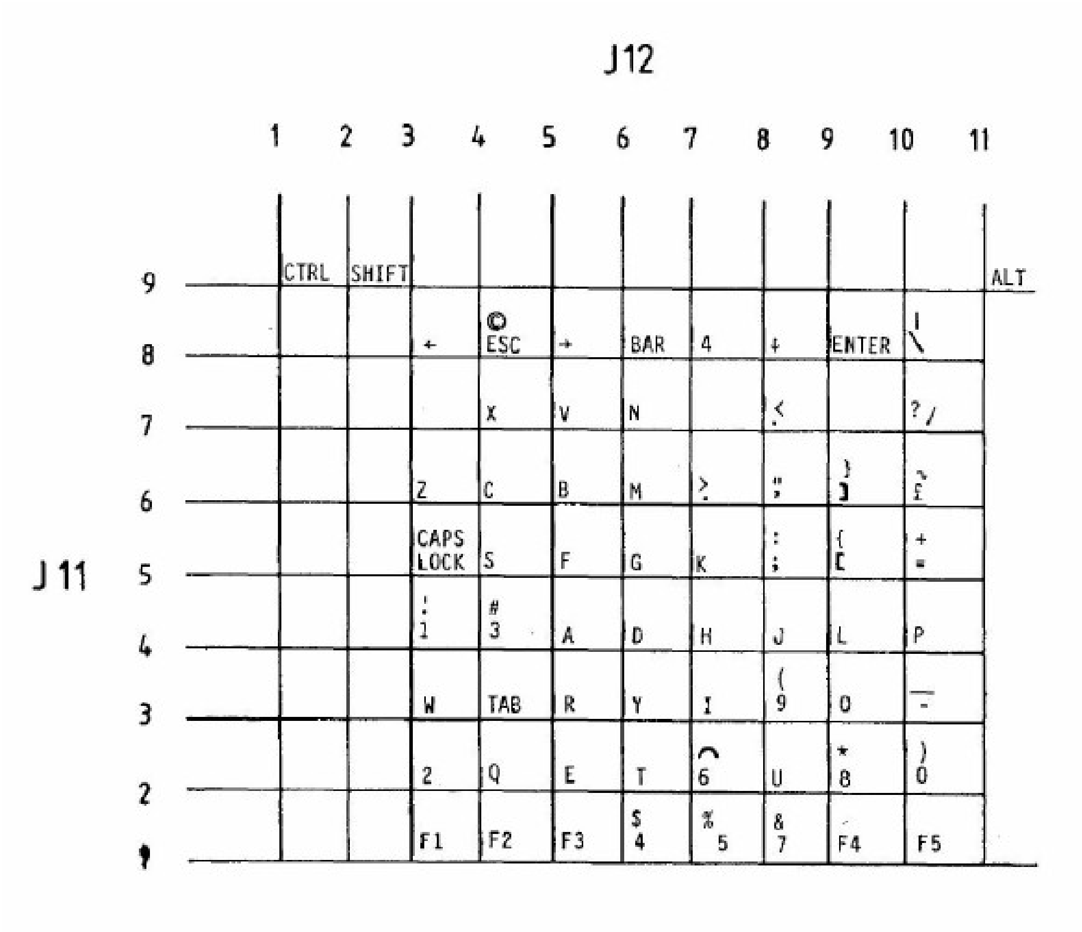
This time will we look a further practical use for the PCF8574 parallel device and the PCF8591P analogue to digital and digital to analogue converter device that we looked at in part two (QLToday Vol 16, Issue 1, page 26) of this series.

The application in this article is to control a device that does not have remote control input. But does have a keyboard. My example is a Sony ICF2001 radio, but principles used could be use for any device that does have a scanning keyboard. My example does mean delving into the device to be controlled. If you are not confident in doing this then don’t. You will also need the service manual for the device you wish to control. However, all is not lost, as I will show. Also in this case with the ICF2001 Radio I will be using the AD/DA PCF8591 so we can also get a return from the radio of the signal strength indicator.

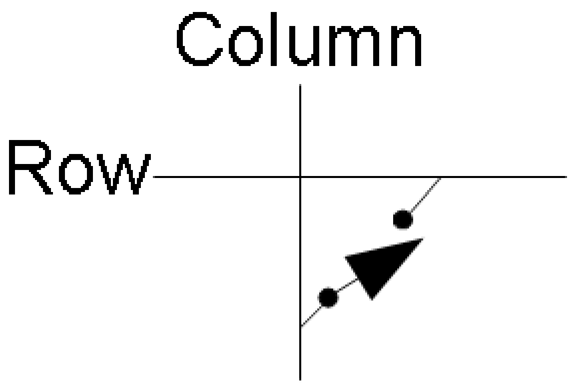
As an addition for those interested in my last article about using the computers parallel port, then again the principles in this article can still be used. Also the serial to parallel controller I described in Vol 12, Issue 3 issue of QLToday could be used. Since in it basic form we just need one eight bit port. However this will just control the radio (or other device you may wish to control), there is no way of getting a return analogue or digital signal back to the computer. Well that is not entirely true, you could use the oscilloscope project I described in Volume 14, issue 4 of QLToday page 32. So using the oscilloscope boards as an A/D converter, which will provide data back to the computer via a serial port.

Going back to the I2C solution which is the focus of this article, other I2C devices could be used such as the RTC (Real Time Clock) for time stamping receiving logs for example. So as always, I hope this give you ideas for your own applications.

So why scanning keyboards? Having two wires for each key on a keyboard is not very efficient way of working. So the wiring can be simplified by arranging the wiring into row and columns as shown below:-



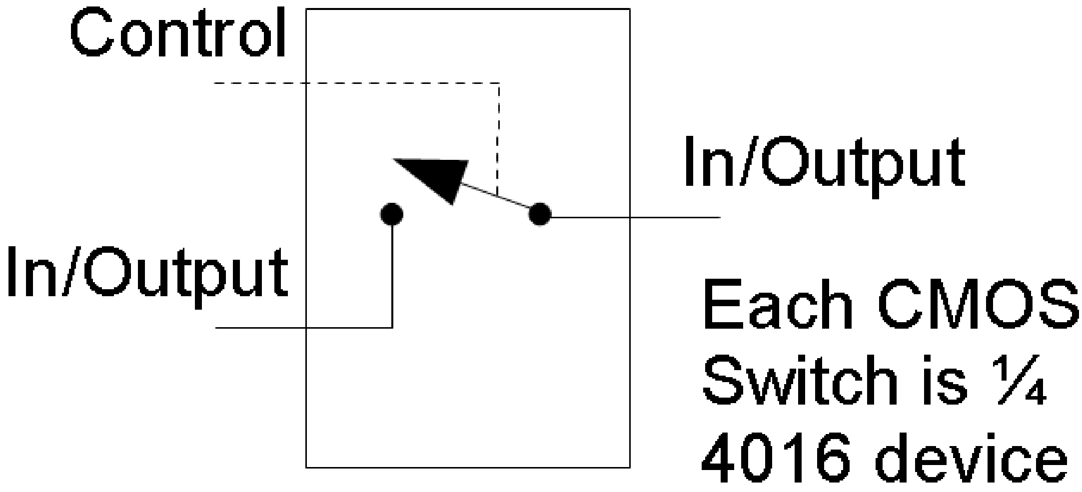
In fact this diagram is of the Black Box QL keyboard. At each crossing of a row and column there is a switch, which is a key of the keyboard. As shown below.



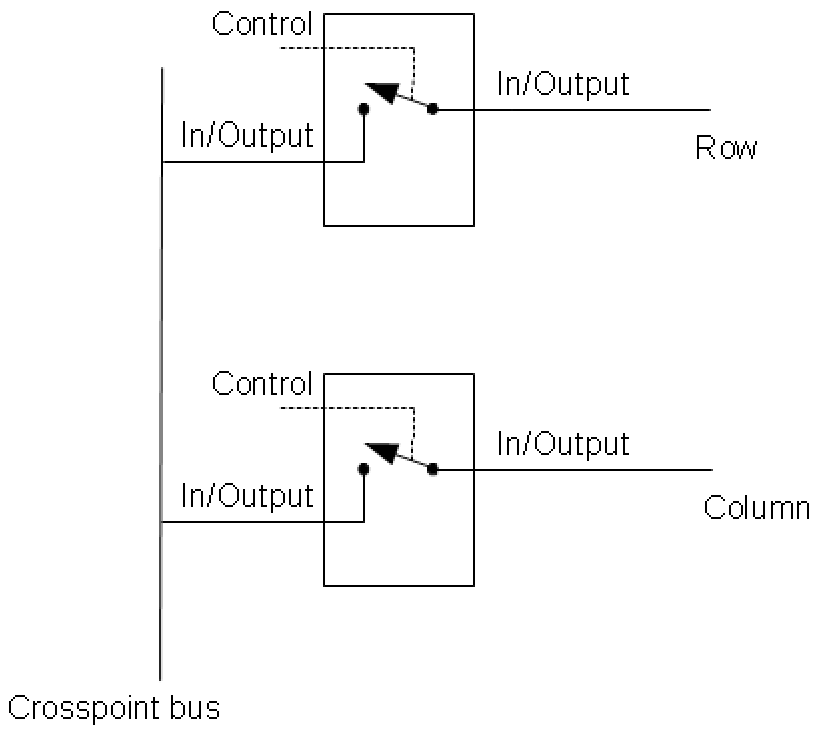
As you can see there are 65 keys on a QL keyboard, which would need at least 66 wires, one for each key plus say ground, however by using the scanning keyboard with row and columns only 20 wires are required.

So how does this work ? The columns are feed with a pulse, sequentially, only one column is pulsed at a time. As a key/switch is closed that pulse is sent to a row. So with a given pulse to a column and the key/switch closed to a given row selects the key required.

So what is needed is to replicate the keys/switches with electronics switches. This can be done by using, CD4016 quad bi-lateral switch integrated circuits. A representation of this device is shown below.



So there is no need for an excessive number of these devices, they have been arranged that one switch is required for each row and one switch for each column. There is a switch bus, so any two switches create the required crosspoint.

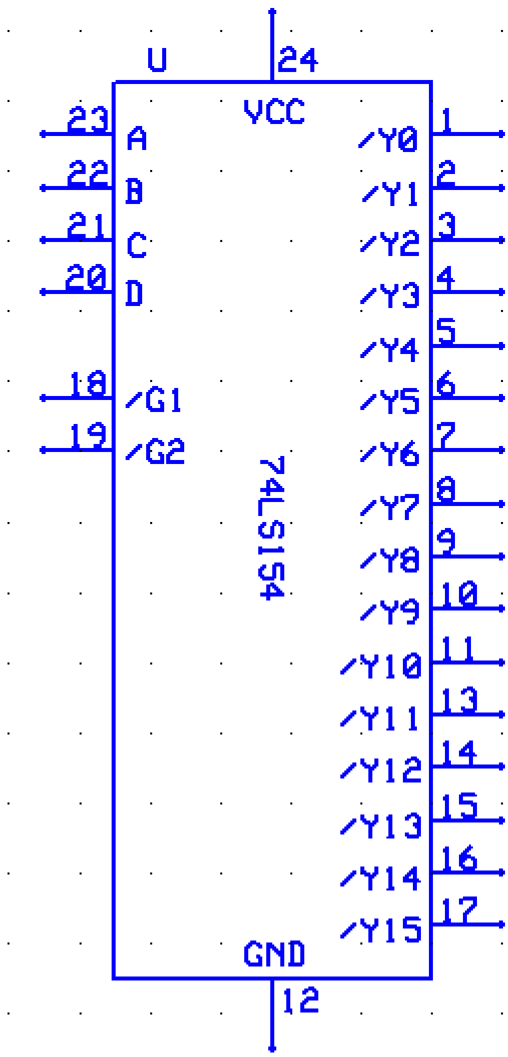


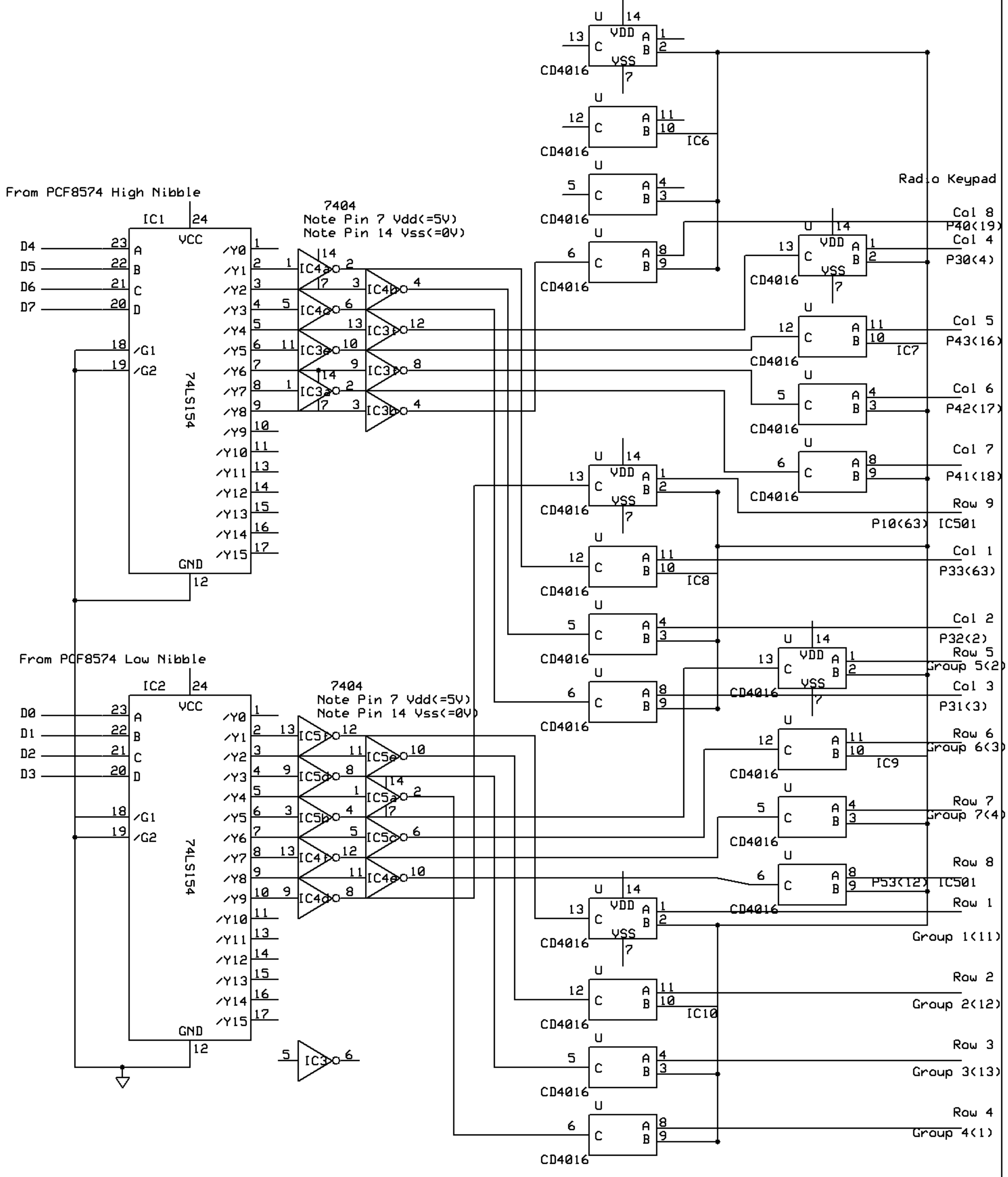
The control of these crosspoints comes from two 74154's, these are four bit BCD to 16 output decoders. So for any four bit word presented to the BCD inputs, will product one active low output. The truth table for the 74154 is shown below.

In							Outputs														
G1	G2	D	C	B	A	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
L	L	L	L	L	L	L	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H
L	L	L	L	L	H	H	L	H	H	H	H	H	H	H	H	H	H	H	H	H	H
L	L	L	L	H	L	H	H	L	H	H	H	H	H	H	H	H	H	H	H	H	H
L	L	L	L	H	H	H	H	H	L	H	H	H	H	H	H	H	H	H	H	H	H
L	L	L	H	L	L	H	H	H	H	L	H	H	H	H	H	H	H	H	H	H	H
L	L	L	H	L	H	H	H	H	H	H	L	H	H	H	H	H	H	H	H	H	H
L	L	L	H	H	L	H	H	H	H	H	H	L	H	H	H	H	H	H	H	H	H
L	L	L	H	H	H	H	H	H	H	H	H	H	L	H	H	H	H	H	H	H	H
L	L	H	L	L	L	H	H	H	H	H	H	H	H	L	H	H	H	H	H	H	H
L	L	H	L	L	H	H	H	H	H	H	H	H	H	H	L	H	H	H	H	H	H
L	L	H	L	H	L	H	H	H	H	H	H	H	H	H	H	L	H	H	H	H	H
L	L	H	L	H	H	H	H	H	H	H	H	H	H	H	H	H	L	H	H	H	H
L	L	H	H	L	L	H	H	H	H	H	H	H	H	H	H	H	H	L	H	H	H
L	L	H	H	L	H	H	H	H	H	H	H	H	H	H	H	H	H	H	L	H	H
L	L	H	H	H	L	H	H	H	H	H	H	H	H	H	H	H	H	H	H	L	H
L	L	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	L
L	H	X	X	X	X	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H
H	L	X	X	X	X	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H
H	H	X	X	X	X	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H
H=																					

The pinouts for this device are shown below, to make the above table a little clearer.

Two of these device are used, one for rows and the other for the columns. This has been arranged as two four bit nibbles, the low nibble i.e. the first four bit of the 8 bit port is for rows, the higher four bits is for the columns. This means since each device can only provide one output as a time, rows and columns cannot be shorted out. Or put another way, there is no chance of two crosspoints being selected at any one time. So a built in safety device. This does mean any functions of the device you are controlling requires two buttons/key to be pressed at the same time then this will not work. In fact the ICF2001 radio does need two buttons pressed at the same time to enter frequencies into the 'Memory Presets'. I will come back to this point. Now since the output of these 74LS154 is active low, the outputs need to be inverted, hence the 7404 inverter devices, each device has 6 inverters. So the complete circuit diagram looks complicated, but is in fact the same circuit just multiplied for the number of rows and columns required. In my case of driving the Sony ICF2001D radio, 9 rows and 8 columns. Hence 17 4016 switch elements, with 17 inverters. This number can be adjusted to whatever your requirement is, up to a maximum of 16 rows and 16 columns. Or put another way 256 keys are possible. The complete circuit of the interface is shown below. What is not shown is the 8 bit port, which could either be from a I2C parallel device (see part one of this series, QLToday Vol 15, Issue 4, page 24) or PAR port described in QLToday Vol 16, Issue 4, or the Serial controller Vol 12, Issue 3 issue of QLToday.





Ian Burkinshaw

Sony ICF-2001 Interface

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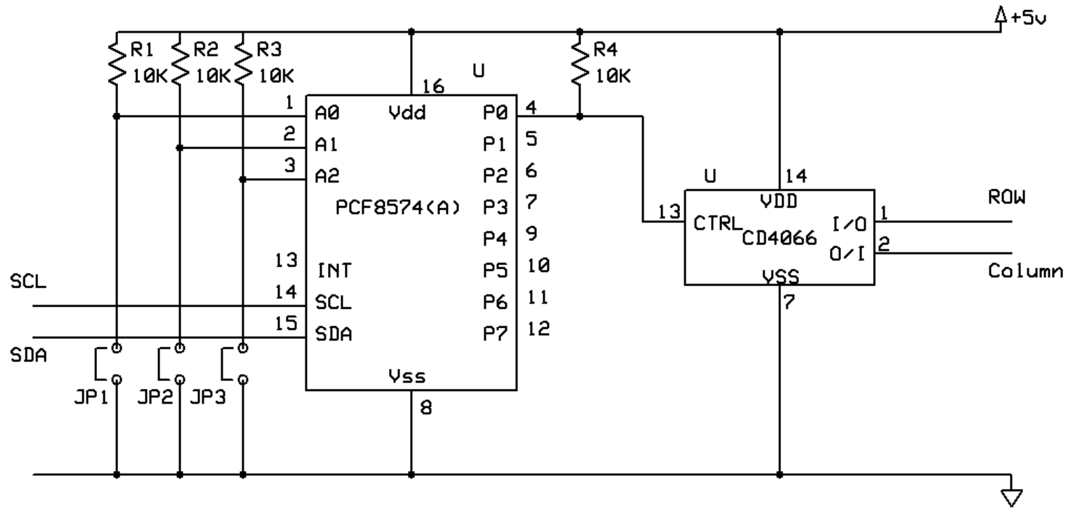
So you can see from the table below for my Sony ICF2001D Radio application, If you send the number 98 the column, P42 and row, Group 2 means the “EXCUTE” key has been pressed.

Key											
			P40	P41	P42	P43	P30	P31	P32	P33	IC501
	IC Pin Num's		(19)	(18)	(17)	(16)	(4)	(3)	(2)	(64)	High Nibble, these represent the columns
Group 1	(11)	IC503	0	1	2	3	4	5	6	7	
			129	113	97	81	65	49	33	17	
Group 2	(12)	IC503	8	9	EXCUTE	0 Min	15 Min	30 Min			
			130	114	98	82	66	50	34	18	
Group 3	(13)	IC503	A1	A2	A3	A4	A5	A6	A7	A8	
			131	115	99	83	67	51	35	19	
Group 4	(1)	IC503	B1	B2	B3	B4	B5	B6	B7	B8	
			132	116	100	84	68	52	36	20	
Group 5	(2)	IC503	C1	C2	C3	C4	C5	C6	C7	C8	
			133	117	101	85	69	53	37	21	
Group 6	(3)	IC503	D1	D2	D3	D4	D5	D6	D7	D8	
			134	118	102	86	70	54	38	22	
Group 7	(4)	IC503	AIR	FM	AM	WIDE	NARROW	SYNC	USB	LSB/CW	
			135	119	103	87	71	55	39	23	
P53	(12)	IC501	PT1	PT2	PT3	PT4	SHIFT	SKIP	ENTER		
			136	120	104	88	72	56	40	24	
P10	(63)	IC501	SCAN START STOP	MEMORY SCAN START STOP	Not Used	Not used	LIGHT	PRESET TIME SET	SLEEP		
Low Nibble, The ICF2001			137	121	105	89	73	57	41	25	

Now for those who do not want to delve inside the device you wish to control then there is a second way, however this does require a lot of mechanical work, which I will let you work out for yourself. You still use the 74LS154 decoders and the 7404 inverters. But now use the ULN2803A that was used in part 1 in this series (QLToday Vol 15, Issue 4, Page 24. But in place of the LED’s now have small solenoids. The Common Free Wheeling Diodes on pin 10 does need to be connected to the 5V supply rail, otherwise the back EMF from the solenoids will blow the chip up. You have been warned. The solenoids then press the required keys with no electrical connection to the device to be controlled. There is a limitation here and that is the number of outputs from the 74LS154’s will only give 32 outputs. But that may be enough for your application.

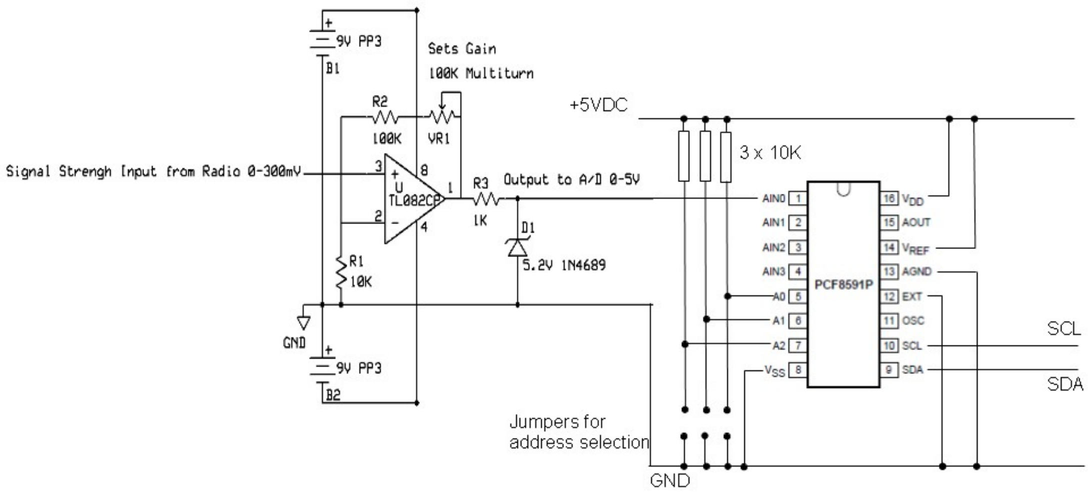
Also the 74154 can be used as a form of port expander, since with two chips you get 32 outputs. However do take into account that only one active low per device at a time. So you can have only two active lows across the two chips. Of course if you only requires a smaller number of outputs then a single chip can be used.
So what to do if you need to “press” two keys at the same time. Now in my example of the ICF2001 radio, there is only one function were this is required the entry into the

"Preset Memories", when the Enter key and a Memory key need to be pressed at the same time. Here I use a second PCF8574(A) set to a different address to the first device. Which in turn drives a single element of a 4016 switch as shown below.



So connect the CD4016 to the required row and column and with the fact it is driven from a separate parallel device mean there is independent control of the this switch so we can "Press" two keys at the same time. By the way you can use either CD4016 or CD4066 devices they are the same for this type of application.

That deals with the hardware to control the Radio in my example, now how about the Signal Strength Meter. Here the PCF8591P in analogue to digital mode is used.



The voltage range for the signal strength from the radio is fairly small 0 to 300mV. The signal strength voltage is obtained from pin 2 on the IC401 within the radio. You will need the service manual to find this. Now the PCF8591P needs to made to respond to this small voltage range. This is where R1, R2 and R3 in the original circuit in, Vol 16, Issue 1 QLToday, come in. These three resistors make up a voltage divider, which set the minimum and maximum voltages on the input pin to give a digital output range of 0 to 255. However in this case with only 300mV available on the input is out the range the PCF8591 can deal with. About 1V in the lower limit. So

I have added a DC(voltage) amplifier, which amplifies the low input voltage to a level which is more acceptable to the PCF8591. In this case 0 to 5V. I have added a preset to be able to adjust the gain of this amplifier. To make things simple I power this amplifier with two PP3 type batteries, you can power this from other sources if you wish, but you do need a positive and negative supply of between +/-9 volts and +/-15 volts. This will not work from a signal power rail. To adjust the gain, tune the radio into a strong signal so the meter on the radio is fully driven. Now with software reading the PCF8591, again see the original article about the AD to DA chip, adjust the preset until the number returned falls just below 255. It is as simple as that.

So that deals with the hardware for this project, next time I will look at the software. I will also included some of my graphical listings for such things as LED's, needle type meters and seven segment LED display so you can have these types of display on your QL. These can be used for all sorts of projects, both hardware and software based so should be of interest to both hardware and software developers.

References

http://www.byvac.com/bv3/index.php?route=product/product&product_id=88
(Please note, I used the original V1 of the BV4221, ByVac now supply V2 which also has a SPI interface. The commands are the same, so the programs listed in the article should still work.)

http://www.byvac.com/bv3/index.php?route=product/category&path=44

Sony ICF2001D User and Service Manuals
http://groups.yahoo.com/group/icf2010/

Computer-controlled radio receiver system
Electronics & Wireless World, December 1985, page 42

PCF8574(A) Data Sheet
http://www.nxp.com/documents/data_sheet/PCF8574.pdf
http://focus.ti.com/lit/ds/symlink/pcf8574.pdf

PCF8591 Data Sheet
http://www.nxp.com/documents/data_sheet/PCF8591.pdf

DS1307 RTC (Real Time Clock)
http://datasheets.maxim-ic.com/en/ds/DS1307.pdf

I2C Tutorials
http://www.robot-electronics.co.uk/acatalog/I2C_Tutorial.html
http://www.i2c.byvac.com/ar_foundation.php

TF Services I2C manual
http://www.dilwyn.me.uk/docs/manuals/index.html