The ever growing digital era is here now, has been for a long, long time, and it’s here to stay. To help with circuit design and combat faults this probe will be dubbed a mere “MUST Have!”. The MKII probe teamed up with the Windows software which is not only high in function & easy to use, you may find that this project is much, much, more than just a super charged, highly sophisticated logic probe. You may in fact find that it has other uses such as remote data logging. With little or no modification a vast array of other uses could be dreamt up. The on-board 2KB serial EEPROM allows for fast multiple 10mS writes. Taking a closer look at how the system works, you will notice that on the front of the unit there are four menu LED’s, four push buttons along with a common cathode 7 segment display. In stand alone mode, the unit allows us to measure VCC & pulse width values. During which time the “Program” LED is lit. Measured valid logic highs that meet your settings are displayed as a “1” on the 7 segment display. Whilst valid lows show “0”. We can at any time press the “Mem” button on the front of the unit so that the measured VCC level can be recorded internally to the EEPROM. Pressing “Mem” causes an “E” to be shown on the display. On the other hand, if it’s a pulse width value that we are after then it’s just a case of pressing the “Pulse” button. The unit then sits back and waits for a pulse to arrive, measures it, saves it, shows “P” on the display to indicate success!. All in one hit. It can be a single shot or continuous train, positive or negative going. This function is good for about 10mS to 20uS, in 10uS increments. Which makes it useful but limited. 50Hz to 25Khz. Within that range it’s extremely accurate & decisive. This function operates in a real time fashion when using the Windows software. You’ll like it.

CIRCUIT EXPLANATION

As with all electronic circuits it’s best to try and break it down into as many sections as possible. I think this rule applies not only for interrupting other peoples work but also for when designing your own. The power supply section of any schematic is a good place to start and this is where I shall begin. The probe may powered from a variety of different sources including AC or DC. There is a required 18V rail used so this means that the minimum level of DC voltage required is going to be about 20V. Taking into consideration that there’s a bridge rectifier that’s going to give us a loss of about 1.2V regardless as to if it’s AC or DC used. As far as power sources for the unit go, I feel the wisest move would be to use a 12VAC source. 12VAC rated plug packs normally supply a slightly higher than rated level when less than the maximum amount of current is drawn. A 12VAC plug pack with a current output of 500mA should allow for at least 15VAC to be applied to the bridge rectifier. After filtering via a 470uF electrolytic capacitor this gives us a DC rail of about 21V. The heat sink is a must if you intend on using the unit with higher levels of a supply source. Even with 12VAC for the sake of a dollar or so it’s a wise investment. A reversed biased zener diode, ZD1, along with a 470Ω resistor provide us with our 18VDC rail that is used to power IC4, LM358 dual operational amplifier. Here’s how this simple regulator works. The golden rule with zener regulators is that the actual zener needs 5mA to maintain regulation. The zener is biased via the 470Ω resistor which limits the current and as a result gives us 18V between the cathode side and ground. Calculating the value of the resistor for current limiting is as easy as this: RZ = (VDD - VZ) / IT. Where as RZ being the required resistor and VDD the supply voltage & VZ the break down voltage of the zener diode. But before we can do any sort of calculation we need to know the amount of current required. Always add on top 5mA to the maximum required amount. To see how much current is used in this zener regulator circuit we can use the following formula: (VDD - VZ) / 470Ω, (21 - 18) / 470 = 6.38mA. This assumes that a 12VAC plug pack is used. IC2 which a LM7805 voltage regulator provides a 5V rail for the PIC micro along with all of the LED’s. Power consumption is modest and reflects on the small number of filtering / decoupling capacitors used. No power LED has been included due to the fact that there’s always going to be at least one of the menu LED’s on whilst the unit has power applied to it. If only logic circuits operating at less than say 6.5V are to be measured, battery power could be implemented quite easily. Change the value of the zener to say 8V1, reduce it’s resistor to say 150Ω & power it from 9V battery. Team it up with a notebook & your set!.

Moving down the schematic, directly below the power supply section, we are now faced with the input section that connects to the physical logic probe that you will hold in your hand for taking samples in circuits. This real world probe first makes contact with a 560pF capacitor and 100K resistor. The 560pF capacitor shunts unwanted hash and results in the probes sensitivity being dramatically reduced. The two 100pF capacitors that are connected between the 100K resistor provide us with two functions. Firstly the combined 100K resistor along with the 100pF capacitor going to ground form a low pass filter. Attenuation starts to begin at around 15KHz. This is the -3db corner frequency. This configuration along with the other 100pF capacitor provides a small amount of further hysteresis. You will note that there are a number of small signal diode's used. D2 & D3 that are connected after the 100K resistor provide IC4a with over voltage protection by means of clamping. Here's how it works. Both diode's are normally reversed biased when the measured VCC is within specs. But, if say for example 20VDC is applied to the probe then D2 will become forward biased and conduct. This is due to the fact that it's anode side is at a level of 0.6V greater than it's cathode that is connected to the 18V rail. As a result clamping the incoming VCC to 18.6V. Now, if the incoming voltage is 0.6V below ground then D3 will conduct to ensure that it goes no further than 0.6V below ground. The other remaining four provide us with the same function but on a different level. Pin 1 of IC4a could swing as high as 16V. It's true that the PIC does have internal diode clamping protection on most of its ports. But I have encountered some major software lockup's when applying relatively higher voltages to the inputs. I'm not entirely sure what the story is. But having said that, I feel that this arrangement ensures for much better protection for the PIC. I have had fewer dramas when using voltages up to about 12VDC at the inputs with PIC16f84a's. The 16f877a doesn't seem to like much higher than it's supply. Anyhow, what's 4¢ worth of diode's.

A 1MΩ resistor connected between the 18V rail and the output of IC4a is used to persuade it swing to the supply rail a bit quicker. Not a great deal is reflected through the use of this resistor but, it does help a bit. If you want to make the probe a tad bit less sensitive then a lower value could be opted for. Increasing the value of the 100K will also help. Although I feel that most people will be happy with the chosen values for most applications. Increasing the value of the 1MΩ below about 470K will result in a loss of bottom end measurement. Not much, but a little bit.
At further close inspection of the schematic you will see that the other half of the LM358 operational amplifier is used to measure pulse width. This arrangement for the use of an additional buffer is required since we don't want any sort of scaling applied. IC4a has it's output scaled to about 3:1 as set by VR1. This is necessary so that we obtain VCC readings up to 15.25VDC from the PICs on-chip ADC which has a full scale deflection of 5V. This is 4.8mV per step. After scaling, we now have acquired a step size of 15mV. Thus (0 - 15.25)V is now the FSD, full scale deflection. AN0 on the PIC is only really concerned with seeing scaled down VCC levels whilst RE0 has it's interests in measuring the width of a pulse anywhere between 10mS to 20uS. RE0 too has over voltage protection included. Located directly below the probe input circuitry is the RS232 serial interface that involves IC3 and it's associated 10uF capacitors. This IC is essential a buffer & line level converter. Where as the signal coming from the PC is of too high an amplitude to connect directly to the micro and the signal coming out of the micro is of too low an amplitude for the PC. This IC also allows for desired signal buffering and data inversion as well. RC6 & RC7 on the PIC are used for serial data transmission.

Turning towards the right hand side of the schematic we are now presented with the bulk of the goodies that hang off the microcontroller. Most noticeably at first glance would be the common cathode 7 segment display which occupies all of port B. Eight 330Ω current limiting resistors provide the display with about 9.6mA of current. While decreasing the brightness of the display can be achieved by simply increasing their value, it's not recommended that the display be made to operate much brighter. As the display is nice & bright enough already. The display is very efficient and with the increase in too much more current you may find that a few segments start drop off over time.

PARTS LISTING

RESISTORS 0.25 1%

1	2K2Ω	**4**	100KΩ
2	4K7Ω	**12**	330Ω
1	470Ω	**2**	180KΩ

CAPACITORS

3	100nF MKT	**6**	10uF Electro
1	470uF Electro	**2**	22pF Ceramic
2	100pF	**1**	560pF

SEMICONDUCTORS

5 IN4001 Power diode's
6 IN914 Signal diode's
1 18V Zener diode
4 3mm Red LED's
1 Common Cathode 7 Segment Display
1 BC548 NPN Transistors Q1

1 LM358 Dual OP Amp IC4
1 LM7805 Voltage Regulator IC2
2 24LC16B Serial EEPROM IC5
1 MAX232 Serial Data Buffer IC3
1 PIC16f877a Micro With DSLP.hex IC1

1 2.5mm DC Socket PC Mount
2 8 Pin IC Sockets
1 16 Pin IC Sockets
1 40 Pin IC Socket
2 PC Pins
2 10 Way PC Mount Headers & Connectors
2 4 Way PC Mount Headers & Connectors
4 2 Way PC Mount Headers & Connectors
4 Push Buttons Switches PC Mount

1 PCB Mount Buzzer
1 Toggle Switch SPDT
1 100K Horizontal Trim Pot VR1
1 4MHz Crystal
2 Panel Mount Banana Sockets, Red & Black
1 Measuring Probe Tip
1 Crocodile Clip “Black”
1 D9 Female PCB Mount Socket
1 D9 Male Socket
1 D9 Female Socket
2 D9 Back Shells

1 30CM 15 Way IDC Cable
1 30CM Red Hook Up For Probe Tip
1 30CM Black Hook Up For Croc Clip.
1 Metre 4 Core Cable.
1 30CM Tin Copper Wire For Links
1 ABS Case 140 x 110 x 35mm, + Front Label
1 Main PCB Measuring 130 x 82 mm
1 Display PCB Measuring 130 x 29 mm
1 12AC Plug Pack @500mA

SPECIFICATIONS

Operating Voltage Range: (20 - 30)VDC, (12 - 24)VAC
Operating Temperature: Proto Tested In Room Conditions
Main PCB Dimensions: 130 x 82mm
Display PCB Dimensions: 130 x 28mm

Current Consumption

Stand Alone With Probe Floating: 34mA
Stand Alone With Probe Sampling: 75.8mA

PC Mode With Probe Floating: 38.5mA
PC Mode With Probe Sampling: 80mA

Power Consumption

Minimum: 680mW
Maximim: 1.65W

Data Storage

2KB Serial EEPROM
Max: 888 VCC Samples
Max: 128 Pulse Width Samples

Logic Acquisition Elements

(0 - 15)V - CMOS
5V - TTL Logic Familys

Logic Measurements

10 BIT VCC (0 - 15)VDC, 15mV Resolution
Valid BIT Digits, 1’s & 0’s
Pulse Width (10mS - 20us), 10uS Resolution

User Interface

Push Button LED Driven Menu
Windows Graphical User Interface

Communications Interface

Serial RS232
2,400 Baud, Inverted