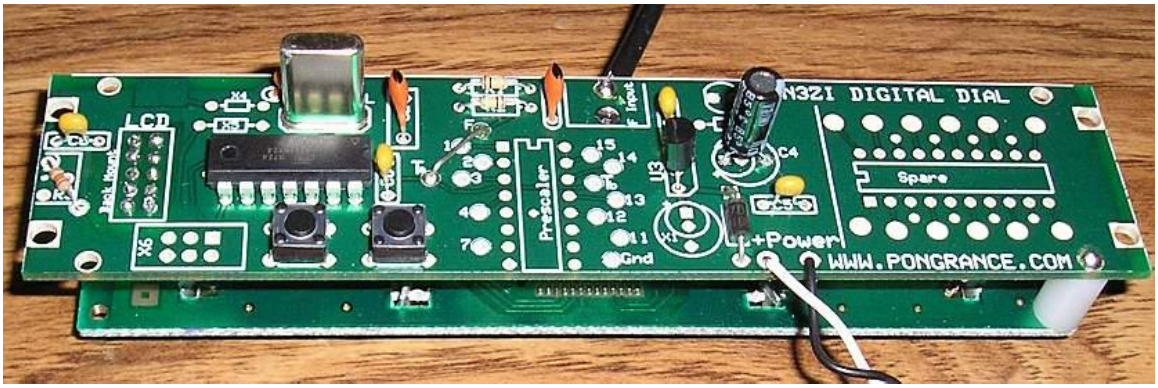
N3ZI Digital Dial
Full Kit Manual

Rev 1.4 15 Feb 2009



Full Kit photo (shown without prescaler chip installed)

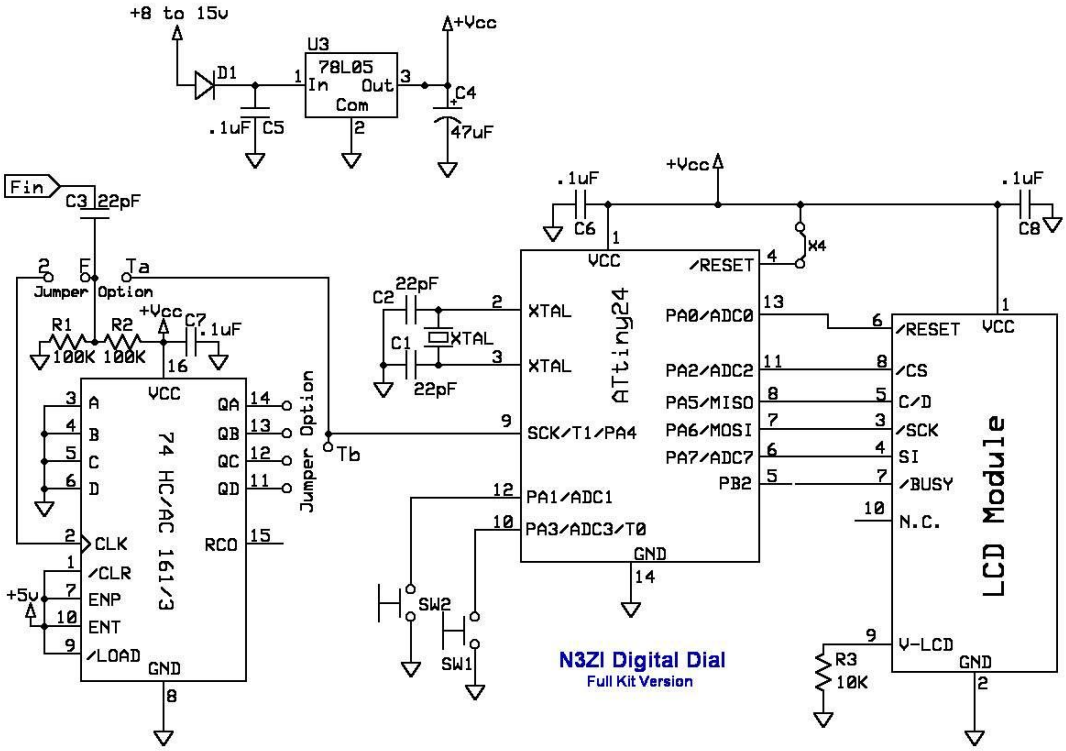
FULL Kit Components			
Item	**Qty**	**Designator**	**Part Color/Marking**
PCB	1		
LCD Display	1		
Prescaler	1	Prescaler	16 Pin Dip, 74HC163
Microprocessor	1	Microprocessor	14 Pin Dip, ATTINY24
XTAL	1	XTAL	
Caps, 22pF	3	C1,C2,C3	Orange - 22
Caps, 0.1 Uf	4	C5,C6,C7,C8	Blue or Yellow - 104
Resistors, 100K	2	R1,R2	Brown-Black-Yellow
Resistor, 10K	1	R3	Brown-Black-Orange
Switch	2	SW1, SW2	
Voltage Reg 78L05	1	U3	To92 - 78L05ACZ
Electrolytic Cap	1	C4	Radial - 47uf 25v
Diode	1	D1	1N4003
RCA Jack	1	F input	

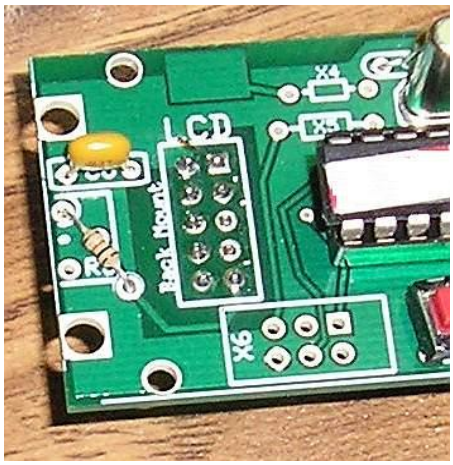
You should start by soldering all of the passive components in the circuit board, followed by the voltage regulator. Leave the two IC's and the LCD module uninstalled for the time being. Double check your work, and apply power. Check the voltage at pin 1 of the microprocessor and pin 16 of the prescaler, you should see very close to 5.0 volts there. Sometimes the color of parts shipped may change from time to time.

Once you've verified that the regulator is working, disconnect power, and solder the Microprocessor and Prescaler IC (if you are using one). You can use sockets for these, but my experience is that IC sockets can cause problems, so I recommend that you solder the IC's directly into the PCB. In general as a starting point I recommend that you use the prescaler and

select the Div/2 option which means you will want to solder jumpers from “F” to “2”, and from “Tb” to “14” You kit includes and RCA jack. You can use this or just solder coax into the input holes.

Lastly solder the LCD module in place. Solder insulated wires from each position in the 10 pin area from the PCB to the LCD module. Use about 1-2 inches of wire, and this will allow you to fold the two boards apart to get to the back of the PCB if you need to make changes. You should not use a header that’s soldered on both ends, that makes it too difficult to get the boards apart to fix any problems. There are some suggestions on my web site if you want to use connectors http://www.pongrance.com/dd-pcb-lcd.html



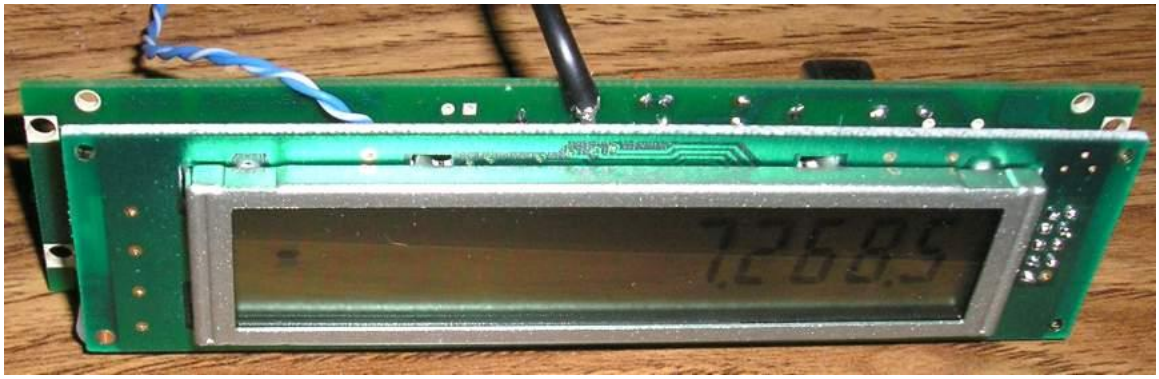


The first photo shows the assembled counter without a prescaler chip. The PCB is stacked with the LCD module, which is face down on the desk in that photo.

Just a note about the switches, if you want to use different, or remotely mounted switches. There are 4 holes on the PCB for each switch, the upper left is the active signal, the lower right is grounded, the other 2 are not connected.

In the photo the 22pF capacitors are the orange caps, the 0.1 uF caps are yellow. Note that R3 is mounted diagonally, you can see in at the far left side of the PCB in the photo.

The LCD Module and the PCB have 4 matching holes. They are rather small for hardware, so I added two holes on the ends which accept 4-40 hardware. 14 Gauge solid wire fits in the LCD module holes and the boards can be made into a solid stack by using holes and spacers. All the holes are plated through so you can solder the 14 gauge wire in place. The electrical connection to the LCD module is made with 10 holes (2 rows of 5) on the right hand side of the photo. The wiring is straight through, and I recommend insulated solid wire, which also provides for some mechanical support. If you are planning to change things from time to time, you probably should use insulated stranded wire that is ~2 inches long so you can separate the two boards.



Note that there is an additional ground hole for C4, the electrolytic capacitor. This is so it's easy to use a capacitor with 2mm or 5mm spacing. You will also note that there is another space for an electrolytic capacitor (Not supplied) in this area called X1. This is electrically in parallel with C5 and can be installed if you want. This will allow you to use an AC power source since D1 and X1 form a half wave rectifier. A 9 VAC wall wart worked fine for me.

Prescaler chip:

Your kit is supplied with a 74HC163 or equivalent Prescaler chip, although others can be used. Jumpers are provided for a number of different Divide by rations, but in general a Div by 8 setting should be used. This will give you a counter that will work from 1MHz to 45MHz. You will need to solder in two jumpers, "F" to "2" and "Tb" to "12" During the setup routine you should set the timebase factor to 8. Your counter will refresh approximately 6 times per second.

If you need a faster update rate, or want to operate above 45MHz, or below 1MHz, please refer to the appendix entitled "advanced prescaler options."

Initial Set Up:

When you first power up the counter, a date code should appear for about 2 seconds, then the frequency reading will show. If there is no input, then the IF frequency will be displayed.

If that all looks ok, turn it off, hold one of the push buttons down, and apply power. The date code will appear and stay there until you release the pushbutton.

The first step is setting the timebase factor. The default is 1. Just do nothing to keep the default, and it will move to the next step in 5 seconds. The way the setup works, is the buttons increase and decrease the number displayed. Once you've gotten to the value you want. Simply release all the buttons and after about 5 seconds it will proceed to the next step. If

you've installed the prescaler chip as above and soldered the appropriate jumpers for divide by 8 operation as stated above. Then change this setting to "8" This factor simply slows the timebase down by that factor. When you set it to 8 it causes the counter to count the input 8 times over, thus canceling out the effect of your input divider. Of course this also slows the update rate by the same factor. Decrementing beyond 0 will make it negative, be careful not to accidentally enter a negative value for the timebase factor.

The next step is for setting the decimal point position. 12.345.6 will be displayed. Pressing either button sequences the decimal points through the possible positions. The default is with the decimal point between the 1st and second digits. You can also turn them off. The position is strictly cosmetic, but the readout can be quite confusing if they are set wrong. Stick with the default, except for some special cases.

The next parameter is the IF frequency. The way the setup works, is the buttons increase and decrease the number displayed. Once you've gotten to the value you want, simply release all the buttons and after about 3 seconds it will proceed to the next step. Holding a button down continuously will change the value at an accelerating rate. If the value is negative, a minus sign will appear at the far left on the display. If your radio uses a subtractive frequency plan, you need to enter the IF as a negative number. Your unit will likely be shipped with an IF of +11.000.0 If your radio has a subtractive freq scheme (i.e. a 7MHz radio with 4Mhz VFO and a 11Mhz IF.) , then you have to change the IF to –11.000.0 To do this you just keep reducing the IF value by holding the button down, eventually it will go to zero and the minus sign comes on, and you keep going. It takes about 90 seconds to go from +11 to –11 MHz. Once you are close, release the button, and use the buttons to tweak it in. The change speed slows the instant the button is released. After your satisfied, just release both buttons, and after 5 seconds of no buttons being pressed, the values will be saved in EEPROM. Next time you power up these values will be used.

If you want to use it as a frequency counter, just set the IF to 0. If you are not sure of your IF frequency, set it to zero, then use the device as a frequency counter to measure your radio's BFO frequency. Then go through the setup again using that value for the IF.

Calibration:

With the 74HC163 prescaler the input sensitivity is 100mV RMS (~300mV peak to peak) meaning your VFO signal must be above this level. The maximum input signal level is equal to your power supply voltage. The maximum is 5v peak to peak (1.8v RMS) There are clamp diodes on the input of the microprocessor which will absorb some excess voltage, but if you overdrive it too much, such as directly with a transmitter, it will be permanently damaged. Even a 1 watt QRP rig puts out 20v peak to peak, which will cause damage.

Once you get it hooked up to your radio's VFO, you may want a fine tweak of the IF, to compensate for a variety of errors, including the frequency error in the crystal. Generally these are less than 1 Khz.

Tune your radio to a known frequency, observe the readout, and compute the error by subtracting the readout value from the expected frequency. Then go through the set-up again, and change your IF setting by exactly that amount. Calibrating this way eliminates the need for a trimmer capacitor in the xtal oscillator circuit. If you want you could use a 50pf trimmer in place of one of the 22pf capacitors, and using that to tweak the crystal oscillator to exactly 13.435MHz. But this isn't necessary. There is also a mathematical parameter inside the

software related to the oscillator frequency. In my first version of the software there was a setup step which allowed the user to change this. But I found that this was just too confusing, so I removed it. It's easier to simply tweak the IF setting to calibrate.

Other Considerations

Anti jitter logic. The S/W is designed so that the last digit will not jitter between two values. Even if you purposely set your VFO on the edge of two readings, it won't jitter. Now if your VFO is very unstable, then you may see some jitter. In essence you have 1 LSD (Least Significant Digit) of hysteresis in the counter.

The readout may show a negative sign, which can be ignored under normal operation. But basically if your radio has a frequency plan that causes the VFO frequency to move in the opposite direction of the operating frequency a minus sign will be shown.

The LCD module has mounting holes in the corners. They are rather small, but I have found that #14 wire fits through nicely, and they are plated so you can solder the wire in place. They match up with similar holes in the PCB. Alternatively, you could drill them out (at your own risk) or get some very small mounting hardware. The PCB has 2 holes on each side on the ends which protrude beyond the LCD module. You can use 4-40 mounting hardware in these holes.

The S/W was written in 'C' using an optimizing compiler. The program memory is full, at last count there were just a few unused bytes. The lock bit in the device is set, so you cannot copy the code. You can however, erase the chip, but you will then lose the code, and I'm not planning on releasing the S/W. However, if you are experienced at programming these micro's and have some ideas, please email me and we can work something out. n3zi@pongrance.com

Appendix 1, Advanced Prescaler Options.

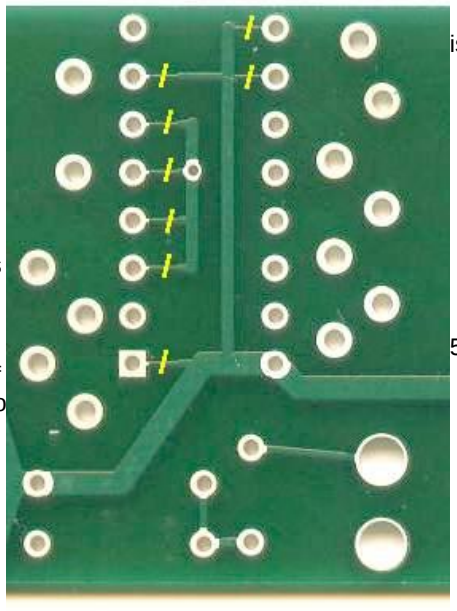
This design supports a number of different prescaler (divider) chips. If you VFO is at 5.5MHz or below you do not need a preselector and this counter will work better without one. If your VFO is between 5 and 45MHz, you should use a 74HC161 prescaler. If your VFO is above 25Mhz, then you can use a 74AC161 prescaler. But do not use the 74AC161 prescaler with a VFO below 20 MHz. I should note that the 74xC163 counters are identical in this application and can be substituted.

Maximum VFO Frequency	Recommended prescaler Chip	Timebase Factor	Div/ by mode	Jumpers
5.5 MHz	NONE	1 or 10	NONE	Jumper F to Ta
11 MHz	74HC161	2 or 20	Div/2	Jumper F to 2, Tb to 14
25Mhz	74HC161	4 or 40	Div/4	Jumper F to 2, Tb to 13
45 MHz	74HC161, or 74AC161	8 or 80	Div .8	Jumper F to 2, Tb to 12
100 MHz	74AC161	16	Div / 16	Jumper F to 2, Tb to 11

At first glance you might just select the highest setting, Div/16. This will work over the widest frequency range, but the counter update will be rather slow. And the 74AC parts are a little touchy at low frequencies, so they should be preceded by an external Schmidt trigger if you want to use the counter over a very wide frequency range. When using the higher of the two stated “timebase” factors, you will need to move the decimal point over one place, and your resolution will be 10Hz. Note that the higher the timebase factor the slower the counter update. With a timebase factor of 1 the counter will update 50 times a second. With a factor of 16 it updates 3 times a second, 80 gets you one update every 2 seconds.

There are some cases where you might want a Div/10 prescaler.

The schematics below are examples of a Divide by 10 prescaler. In the first one I'm using a 74HC4017, which can only be configured as a Div / 10. Theoretically this will allow operation up to 55MHz, but the HC4017 only guaranteed to clock up to 25-30MHz, but there are "typical" specifications which range from 40 to 70MHz, depending on the manufacturer. NXP (Phillips) has the best specs, if they are also best in the real world I don't know. Mine ran fine up to 50MHz which is the highest my equipment would allow me to test. You'll have to run everything at 5volts if you are shooting for high speed.



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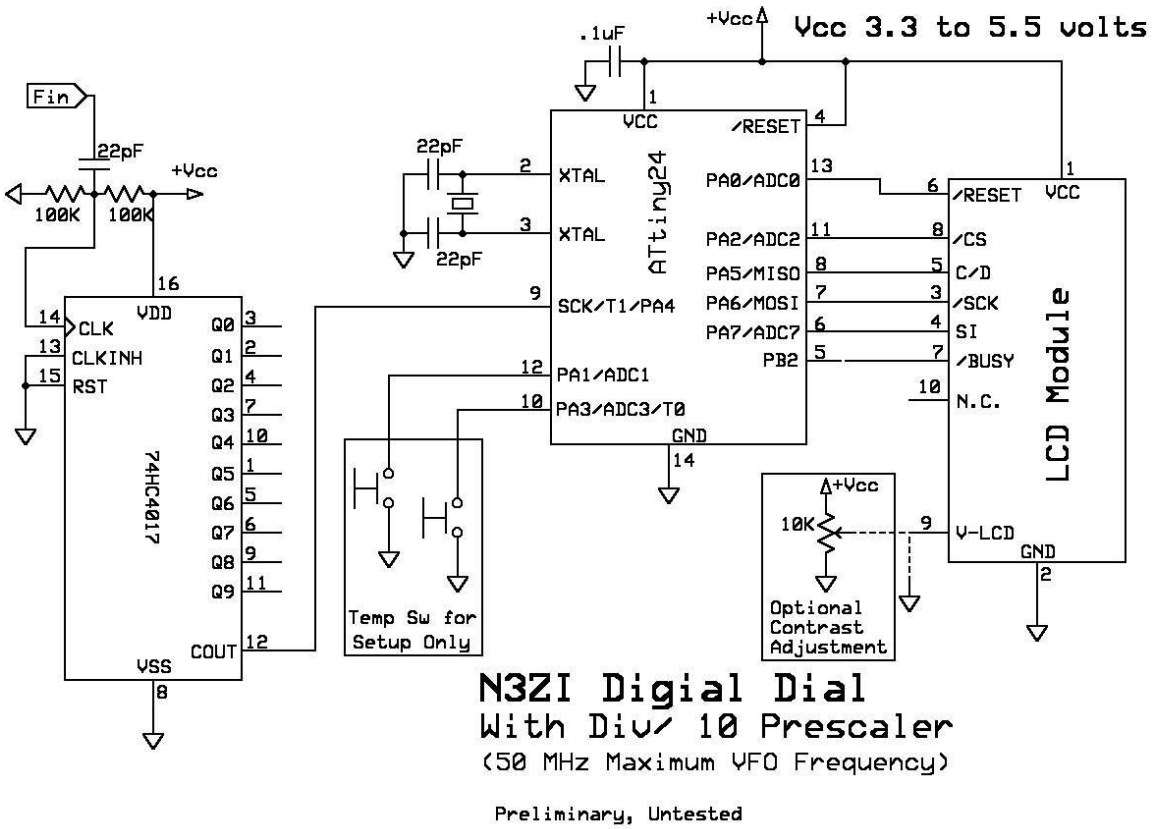
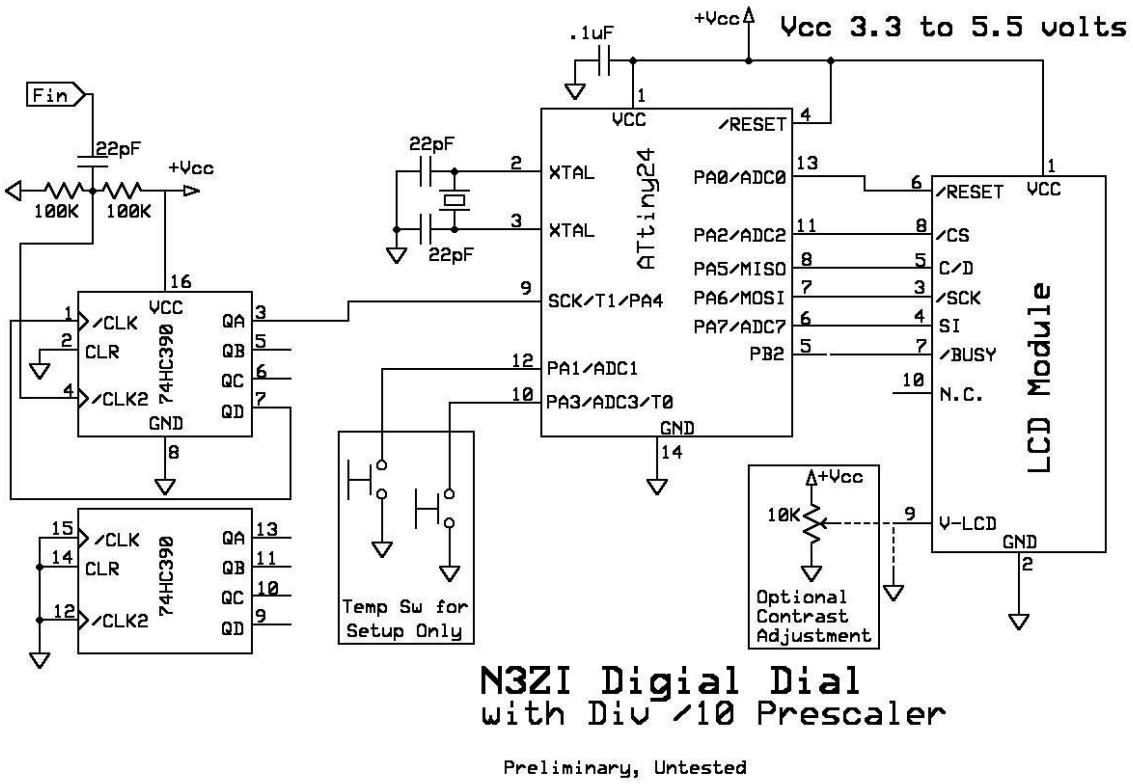
When using this mode, the update rate will be 5 times a second, which is really rather slow for VFO use. But since this one uses a Divide by 10, several interesting changes can be made by fiddling with the decimal points. You can change to resolution to 1 KHz and then it will update at 50 times a second. (timebase factor=1, decimal points to the far right) But if you are looking for precision, change the "timebase factor" in the setup to 100, and set the decimal point 2 digits from the left, and you will have a counter with 10Hz resolution, but the update rate will be very slow.

In order to use the 74HC4013, or the 74HC390, you will need to cut 8 jumpers on the back of the board. The PCB was designed to make it easy to cut these. The pins you need to connect to for both chips are brought out to labeled jumper holes. The photo to the rightshows the back of the board, with yellow slashes over the traces you need to cut.



This is the same Div /10 prescaler, but using a 74HC390 chip. In my testing these parts don't reliably clock up to 50MHz, but seem OK in up to the 30 to 45 MHz area.

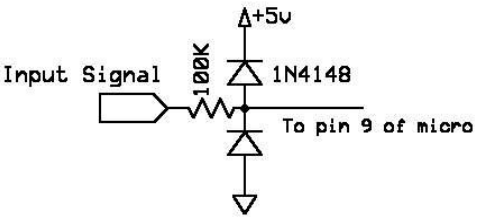


Low Frequency Applications (Under 1 MHz)

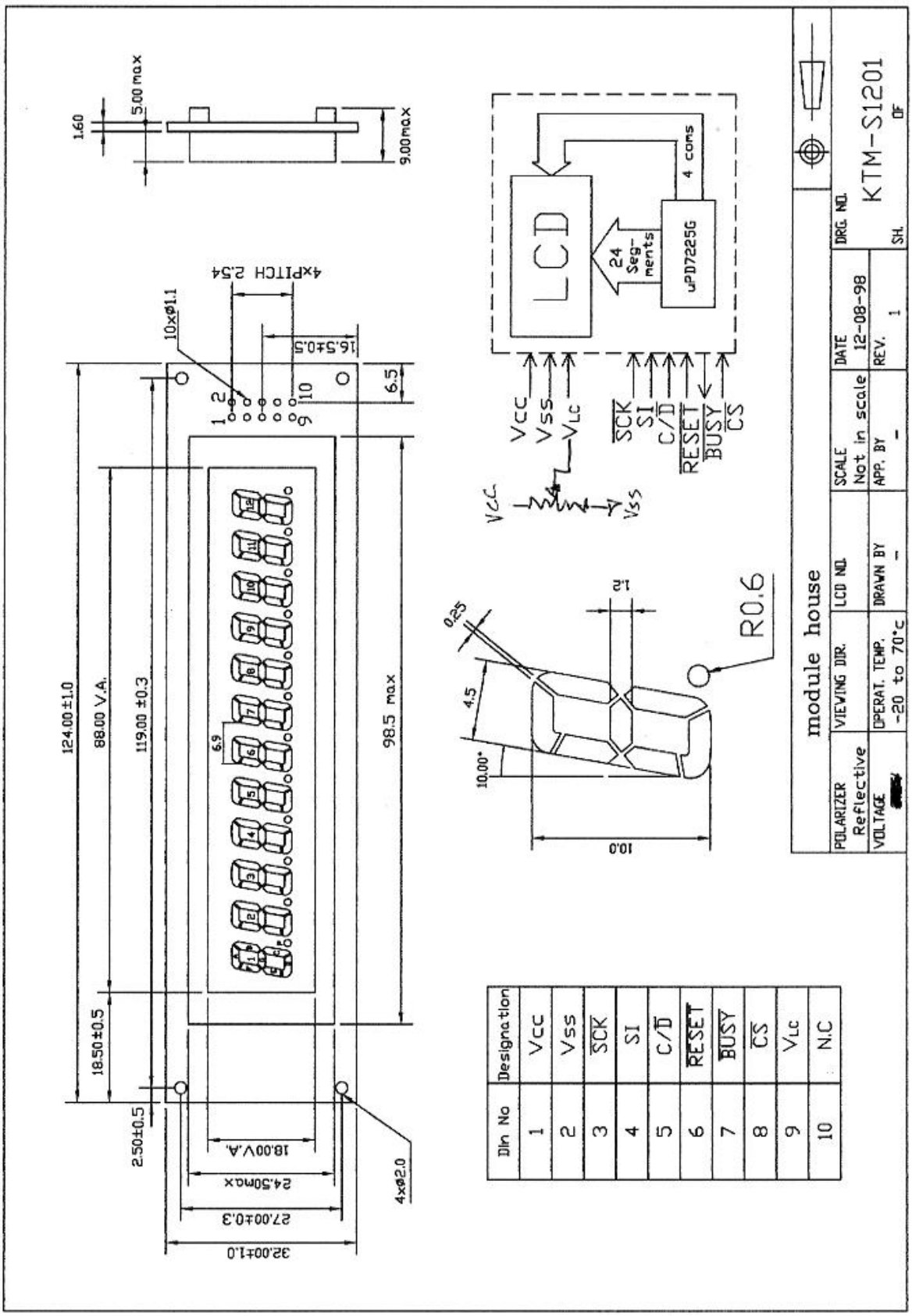
My digital dial was designed for Radio Frequency Applications, but I have had quite a few persons interested in using it for low frequency applications. And for the most part it has been used successfully for audio and low frequencies.

Some minor tweaks are required. The input coupling network has a 22pF coupling capacitor, this network rolls off below 1Mhz and shouldn't be used below that frequency. Certainly you can change C1 to a 1000pF capacitor which will work down to 10KHz. But if you want to go very low in frequency you really should use DC coupling. Assuming that the voltage swing of your source is between 500mV and 5V peak to peak, the following circuit should work fine.

This circuit will also provide a level of protection for over voltage and under voltage. But the ground for the signal source and the frequency counter should be tied together. But the signal will need to swing across 2.5 volts to be counted.



For low frequencies you do not need the prescaler, if you've already installed it you can bypasss it by jumpering from “Ta” to “F”. Set the prescale factor to 100, turn off the decimal points, and set the IF to 0.0. This will give you 1 Hz resolution but a rather slow update rate (once ever 2 seconds) For a faster update rate use a prescale factor of 10, then your resolution will be 10Hz, and you will update 5 times per second.



Dim No	Designation
1	Vcc
2	Vss
3	SCK
4	SI
5	C/D
6	RESET
7	BUSY
8	CS
9	Vlc
10	N.C