The FCL_X meter, a meter of frequency, capacitance, inductance and Crystal

Any of your friend or SWL told you that he want a FCL meter? Here is that interesting project which helps us to measure over a wide range Frequency also Inductance and Capacitance of electronic components and resonant frequency of Crystals with high accuracy, with the cost of an ordinary frequency counter. About this project, it is not my design, not my program and nothing & nothing. I am just introducing an interesting project on the web to you all. Here I assembled it and found working nicely and helpful, so thought to publish it here. But anyhow I have added a little more facilities in the software and wiring to make it user friendly, more compact & helpful to a home brewer. The basic design you can download from http://members.optusnet.com.au/frankwinter. The construction possesses minimum sizes say about 2.5cm x 8cm" x 12cm, less weight and components that allow to use our operations on roofs, support and in field conditions.

Characteristics

1) **AUTO RANGE** selection for Capacitance and inductance with 1/100 resolution.
2) **AUTO SELF-CALIBRATION** at power ON to avoid problems with stray Capacitance and inductance of test probe & PCB tracks.
3) Measuring frequency limit extended from units of a Hz, up to 30 MHz
4) Nearly 2% accuracy.
5) **THE MODE "C"** can be selected after calibration by pressing S1 to "C" and unit displays "Capacitance" XXXX xF.
6) **THE MODE "L"** becomes active at pressed S1 to "L". The input in a mode of double calibration (for inductance more than 10mh) occurs at any change of position S5, thus besides inductance the own capacity of the measuring inductance that can be very useful is also displayed. On the display it is displayed "Inductance" XXXX xH.
7) **THE MODE "F"** is for measuring input frequency from an external source and **mode "X"** is for measuring Crystal resonant frequencies which is very useful to select Crystals required for Ladder filter and other things, and we can take the unit to the shop itself for selecting our X'-tals.
8) Minimum components and only one selection switch which helps to assemble to unit easily.

Disadvantage:- The error increases with growth of active resistance; for compensation of influence of own "parasitic" capacity there is a function of correction of indications and mappings of value of this capacity. For small-sized spools with the big active resistance (more than 20 Ohm) and closed magnetic loop without a split the error essentially increases.

A principle of operation

In a mode of the frequency meter the instrument works on widely known method of measurement as the PIC-micro controller counts the number of oscillations, in unit of time and displays on an LCD. For measuring crystal resonant frequency, the crystals are put in an oscillator and the oscillator frequency is measured. It is very useful to have this feature to select Crystals of same frequency for ladder filter and similar purpose.

At measurement inductance and capacitance the instrument works by the resonant principle and is described here briefly. The measured unit switches on in a tank circuit with the known parameters, included in the measuring generator. On change of generated frequency under the well-known formula f=1/4?2LC required value settles up. For definition of own parameters of an outline the known additional capacity is connected to it, under the same formula inductance of an outline and his capacity, including constructive are calculated.

The given method with reference to operations has the essential disadvantage consisting in increase of an error at measurement big (more than 10mh) inductance with significant own capacity (ie; stray capacitance). Instrument readings can be in that case overestimated at 2-10 time. Function of definition of own "parasitic" capacity and recalculation of inductance is applied for elimination of this disadvantage by the author within the registry. For this purpose calibration is carried out at the on-line measured inductance. Further there is a calculation and mapping of "correct" inductance and its "own" capacity, which accuracy of measurement about 2 to 10 %. The given method also is not ideal because of allocation of "own" capacity between measured and measuring inductance that noticeably appears at their commensurable values. If measured inductance more than 10mh, i.e. In 100 times more a measuring spool of the generator (100 µh here) this influence is insignificant.

Schematic diagram, Details and a construction

The electrical circuitry of the instrument is shown on **fig _1**. In the circuit it is possible to select the following main sites: the measuring generator on U1, the entry amplifier of mode F on T2, the commutator of signals on U2, the block of measurement and indication on U3 and LCD, and also the crystal measuring oscillator wired around T4.

The LC measuring generator is wired on chip-comparator **LM311**. The given circuit has well proved as the generator of frequency around 800KHz, providing on an output a signal close to a meander. For support of stable indications the generator demands coordinated on a resistance and stable load.

The hearts of the generator are measuring spool L1 and capacitor C12, and also standard capacitor C13 switched by the micro controller. Depending on operating mode L1 it is connected to plugs JK1 serially or in a parallel way. Output from the generator passes through untying resistor R11 acts on commutator U2 CD4066. Transistor T1 collects signals from external source and amplifies it and feeded to an input of CD4066. The output from U3 reaches to the RF amplifier wired around T5. The circuit for this is a simple RF amplifier which is necessary to amplify the input signal.

The leading role in the instrument belongs to micro controller U3 PIC16F84A from the manufacturing company Micro-Chip. The given micro controller enjoys the huge and deserved popularity for designers thanking not only to good technical parameters and the small price, but also a simplicity in programming The signal from transistor T3 is directly on-line to the trigger of Schmidt included in the micro controller. The result of calculations is output on the alphanumeric display with interface HD44780.

Selection of modes is carried out by a 3 Pole 4 Way switch S7 and will be in detail described below. The given other switches are for the calibration of the unit. Transistor T2 switched by the micro controller is used to energize the relay for connecting standard capacitor C13 to the measuring generator. The transistor T3 and D4 is for the indication of the battery state. The circuit helps to display a “!” on the display if battery is low.

Use good quality glass epoxy PCB for the unit. I think not much explanation is required about assembling of the circuit. Any way let me say, use good quality Inductors, Capacitors not the ordinary disc capacitors and resistors. It can be from say companies like

Philips or so for the unit, which helps you to achieve a commercial quality instrument. Use good quality sockets for all the 3 IC's. One gold colored metal coated sockets are available in some shops. Try to get that one. Reduce wiring length inside the unit which helps to reduce stray capacitance and inductance. Mode selection switch SW7 is a 3 Pole 4 Way sliding band switch type and the other 4 switches SW3 to SW5 are small 4pin micro switches fitted on the PCB itself as once the instrument is calibrated for installed components, these switches don't have much functions. Switch SW2 is a SPST switch for double Calibration of the unit against own Capacitance of higher valued inductances ie; more than 10mH. Switch SW1 is also a micro switch for Calibration of the unit against its stray Capacitance and inductance of components, and PCB tracks & test jacks. Switches SW1, SW2 & SW7 can be fitted on the body of the box. If you are using the Given PCB layout, all this switches is on the PCB itself and after assembling the unit will be small and will look like a Multi meter. Moreover the **GIVEN PCB USES 2Nos OF 2POLE 4WAY SWITCHES AS THIS SWITCH WAS EAZY TO GET FROM MARKET THAN 3POLE 4WAY AT MY END.**

U3 - PIC16F84A is pre programmed and is the most popular microchip chip. With some correction of the program probably usage more "advanced" PIC16F628A, having twice the big memory of programs and speed up to 5 million operations a second.

In the authoring instrument the display is Hitachi HD44780 alphanumeric 2line X 16 characters in string. Special attention has to give to choose relay K1. First of all, it should work confidently at power of 4,5 volt. Second, the resistance of the closed contacts should be minimum, but no more than 0,5 Ohm. Many small-sized relay with consumption at 5-15mA from import telephone sets have a resistance about 2-4 Ohm that is inadmissible in this case. So for this purpose, don't destroy the poor SWL's DX telephone sets which they given to you for service. Use a very small good quality relay which offers minimum contact resistance and if you feel difficulty in getting 5V relay, you can use 12V relay with one of its coil end connected to the unregulated 12V power line. Circuit is shown with 12V relay and is connected to 12V line. PCB is having provision to use either 12V or 5V relay. Use R2 if using 12V relay and R3 if using 5V relay. **NEVER USE BOTH RESISTORS**.

The major unit on which quality accuracy and stability of indications of LC meter depends, spool L1, C9, C12, C13, R4 to R11. The L1 should possess maximum good quality and minimum own capacity. Ordinary inductors with inductance 100-125 μH are not bad here to work.

To capacitor C9, C12, C13, C22, C25 require rather high quality especially on thermo-stability. C12 can be of capacity 510 to 680pF. Same should be C13, but in limits 820 to 2200pF. The capacitor C9 should be 10uF 25V **Tantalum** Capacitor.

Testing & Calibration:-

1. The current of consumption should not exceed 20mA in any mode (except for the moment of operation of the relay).
2. Resistor **R29** installs a desirable image contrast for LCD. Keep the common point of this preset near to ground first later you may adjust.
3. Check for any short circuit and put all the IC's in the socket. Keep the Selector switch in position for measuring capacitor, then switch on the power supply. The voltage at out put of Regulator ic and the PIC 16F84 should not exceed 5V.
4. The unit enters to the **mode of self-calibration** against Stray capacitance and inductance. The unit displays "calibrating" and after few seconds it displays "OK'. Now your meter should show 0.00pF and unit is ready for measuring L & C. If you pres S6 for a while the unit will repeat the same function.

5. For measuring Frequency, put S1 for frequency measurement. Adjust the Trimmer C18 connected to the Crystal of Pic pin 15 & 16 for correct reading. Display shows "Frequency" XX, XXX . xxx MHz. Use possible standard sources of frequency like hybrid quartz generators from radio or mobile phones (12,8IMHz, 14,85MHz) or, as a last resort, computer 14,318IMHz etc.
6. Further it is necessary to go in a mode of installation of constants for correct indication of the measured capacitance and inductance value. There are two constants to be installed. Constant X1 and Constant X2. Constant X1 is installed numerically equal value of capacitor C4 in Pico-farads and here it is 1000 by default. Constant X2 is for correcting inductance value and here it is 1.000 by default. We have to adjust this value for getting correct inductance value. For the further calibration it is necessary to have a set (1-3 pieces) capacitors and inductance with known values (accuracy better 1 % is desirable). Self-calibration of the instrument should pass in view of constructive capacity of clips.
7. **Mode of installation of constants.** This mode is necessary for getting correct value of Inductance and Capacitance and this procedure required only at the beginning. The meter actually compares the new value of capacitor or inductor to be measured with the value already we have in the oscillator and displays its value accordingly. So for this we have to enter the installed values of constants in the EEPROM of micro controller. For this, switch off your meter and keep your meter in the position “C” ie; for measuring Capacitance then press SW5 and switch it ON. Meter displays the Constant X1 or X2 according to the current state of SW2. Change the current state of SW2 with SW5 pressed to get either X1 or X2 and then leave SW2 and SW5. Press SW3 or SW4 to change the value up or down. X1 is equal to the numeric value of C4 in PF and here its default value is 1000. Constant X2 is for inductance and its value is 1.000 by default. First change X1 up or down. Then just change the state of SW2. This saves the new value of constant to EEPROM. Then the meter automatically goes to CALIBRATION AND then to capacitance measuring mode. Then press the calibrate button once again if required and when ready measure a known value of C with your meter. Follow the same procedure for getting the correct value for X1 so that when we measure a capacitance the display shows the correct value. Follow the same procedure for Changing Constant X2 so that the unit shows correct Inductance value. Note that record in EEPROM occurs only at manipulations with SW2.

This much is required for you to assemble the unit I hope. You can download the details of construction and software from http://www.hamradioindia.org or E-mail me at vu3wij@yahoo.com or shaji@hamradioindia.org for a copy. Feel the power and accuracy of your newly constructed FXL_X meter and hope to meet all you on air.

73’s

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