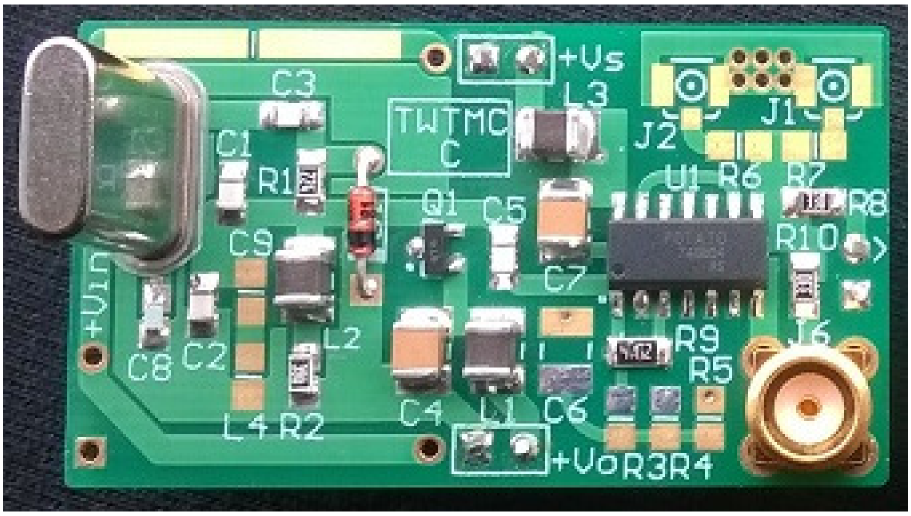
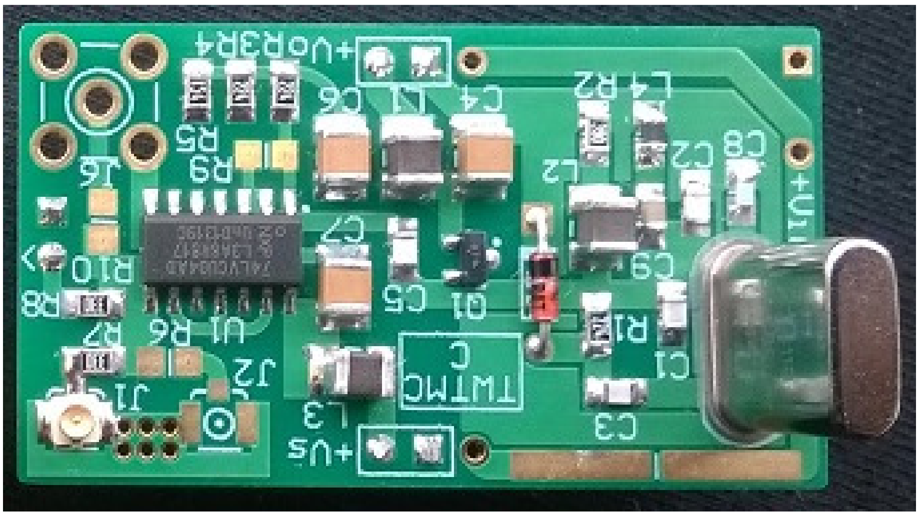
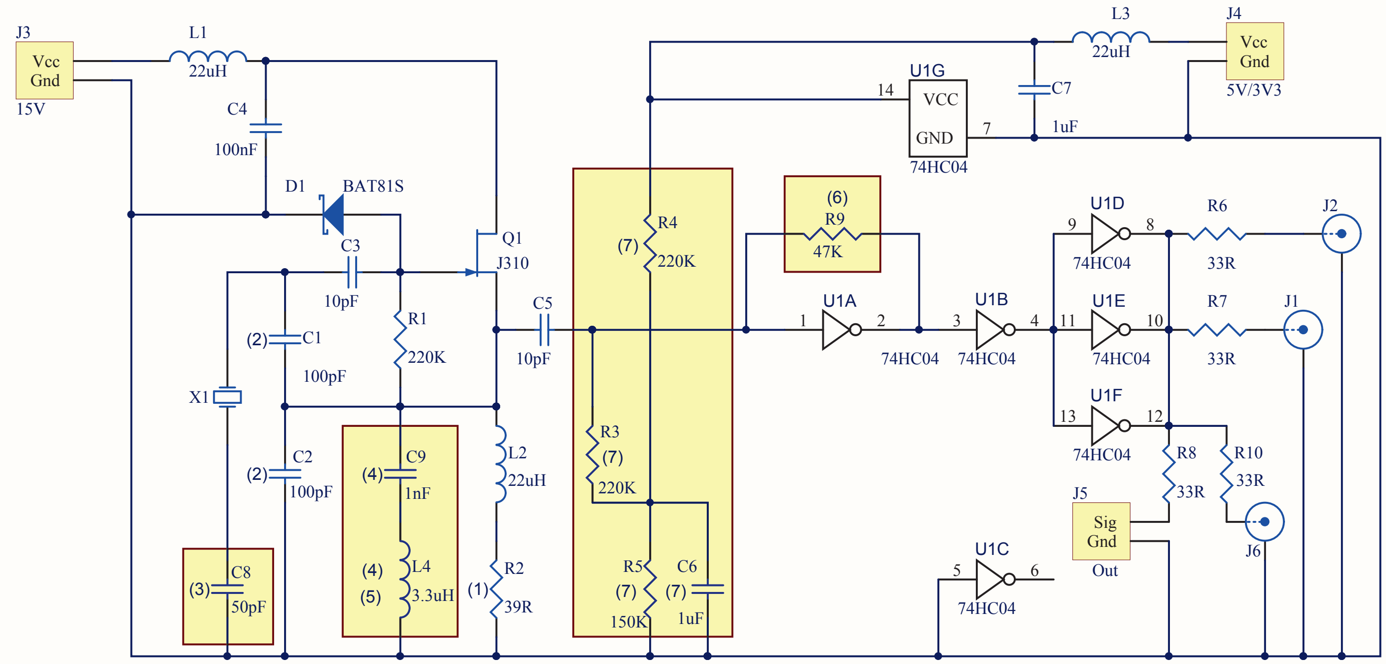
The Well Tempered Master Clock

TWTMC-C





Colpitts-Clapp crystal oscillator



(1) Adjust for 18-20 mA without crystal

(2) C1 = C2 >= 1000 / f0-f3rd-f5th

(3) 50/100pF for measurement only, 0R0 for audio digital application

(4) overtone crystal only

(5) 3rd overtone L4 = 1 / (6.28 * (>f0)) ^2 * C2 in Henry

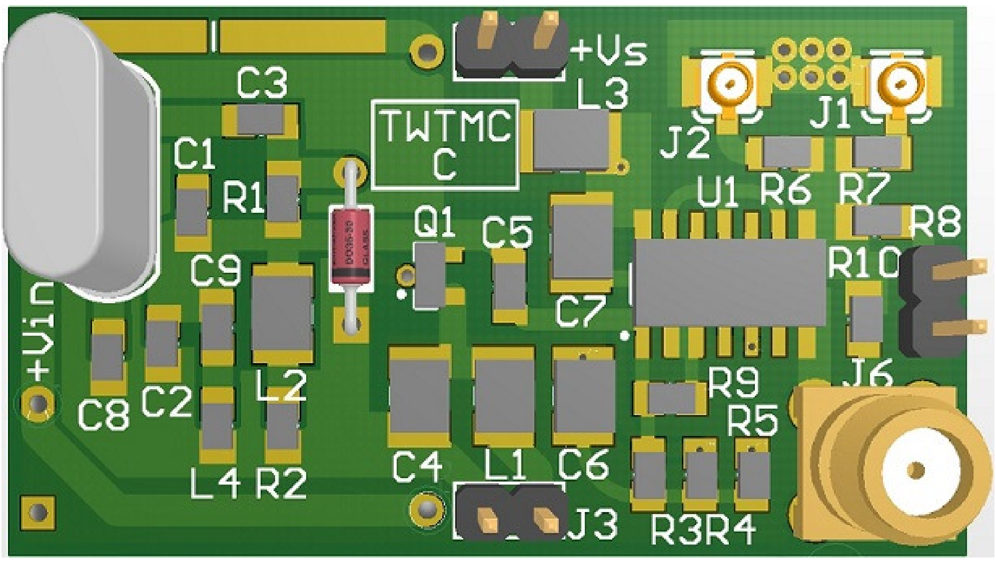
(5) 5th overtone L4 = 1 / (6.28 * (>f3rd)) ^2 * C2 in Henry

(6) slicer 1st option 50% duty cycle

(7) slicer 2nd option

Title	TWTMC-C	
Size A4	Number 1	Revision 4
Date: 24/05/2016		Sheet 1 of 1
File: C:\Users\..\TWTMC-C.SchDoc		Drawn By: Andrea Mori

PCB layout


C3
+Vs
L3
TWTMC
C
C1
R1
J2
J1
U1
R6
R7
R8
Q1
C5
C9
C7
R10
+Vin
C8
C2
L2
J6
R9
R5
L4
R2
C4
L1
C6
J3
R3R4

BOM

Label	Item	Pkg.	Manufacturer	Manufacturer part	Supplier	Supplier part	Q.ty	Note
C1 C2								(2) C1 = C2 = 1000 / f0
C3 C5	10pF C0G/NP0	0805	Kemet	C0805C100J5GACTU	Mouser	80-C0805C100J5G	2	
C4	100nF 100V X7R	1210	AVX	12101C104KAT2A	Mouser	581-12101C104KAT2A	1	
C6								(11) squarer 2nd option
C7	1uF 100V X7R	1210	AVX	12101C105KAT2A	Mouser	581-12101C105KAT2A	1	
C8								(3) 50/100pF for measurement only, 0R0 for digital audio application
C9								(9) 3rd overtone crystal only
R1	220K 1/10W	0805	Susumu	RR1220P-224-D	Mouser	754-RR1220P-224D	1	
R2								(1) Adjust 18-20 mA without crystal
R3 R4								(11) slicer 2nd option
R5								(11) slicer 2nd option
R6 R7 R8 R10								(4) Q.ty dependent on used outputs
R9								(12) squarer 1st option 50% duty cycle
L1 L2 L3	22uH	1210	Taiyo Yuden	CBC3225T220MR	Mouser	963-CBC3225T220MR	3	
L4								(10) 3rd overtone crystal only
X1								(5) Select for desired clock frequency
D1	BAT81	DO-35	Vishay Semi	BAT81S-TR	Mouser	78-BAT81S	1	
Q1	J310	SOT-23	On Semi	MMBFJ310LT1G	Mouser	863-MMBFJ310LT1G	1	
U1								(6) Select for desired output voltage
J1 J2								(7) Q.ty dependent on used outputs
J5								(8) Header output
J6	SMA connector	-	Molex	73391-0070	Mouser	538-73391-0070	1	SMA output
	Crystal insulator		Bivar	CI-192-028	Mouser	749-CI-192-028	1	

(1)

Starting value	39R 1/10W	0805	Susumu	RR1220Q-390-D	Mouser	754-RR1220Q-390D	1	

(2)								
11.2896 MHz	100pF C0G/NP0	0805	AVX	08051A101FAT2A	Mouser	581-08051A101FAT2A	2	
12.288 MHz	100pF C0G/NP0	0805	AVX	08051A101FAT2A	Mouser	581-08051A101FAT2A	2	
22.5792 MHz	56pF C0G/NP0	0805	AVX	08052U560GAT2A	Mouser	581-08052U560G	2	
24.576 MHz	56pF C0G/NP0	0805	AVX	08052U560GAT2A	Mouser	581-08052U560G	2	
5.6448 MHz	200pF C0G/NP0	0805	AVX	08051A201GAT2A	Mouser	581-08051A201GAT2A	2	
6.144 MHz	200pF C0G/NP0	0805	AVX	08051A201GAT2A	Mouser	581-08051A201GAT2A	2	
16.9344 MHz	75pF C0G/NP0	0805	AVX	08055A750FAT2A	Mouser	581-08055A750FAT2A	2	
33.8688 MHz	33pF C0G/NP0	0805	AVX	08051A330FAT2A	Mouser	581-08051A330F	2	
33.8688 MHz	33pF silver mica	0805	Cornell	MC08FA330J-TF	Mouser	598-MC08FA330J-TF	2	upgrade to silver mica capacitor
45.1584 MHz	22pF C0G/NP0	0805	AVX	08055A220FAT2A	Mouser	581-08055A220FAT2A	2	
45.1584 MHz	22pF silver mica	0805	Cornell	MC08EA220J-TF	Mouser	598-MC08EA220J-TF	2	upgrade to silver mica capacitor
49.152 MHz	18pF C0G/NP0	0805	AVX	08051A180GAT2A	Mouser	581-08051A180GAT2A	2	
49.152 MHz	18pF silver mica	0805	Cornell	MC08EA180J-F	Mouser	598-MC08EA180J-F	2	upgrade to silver mica capacitor

(3)								
Measurement	50pF	0603	AVX	06035A500JAT2A	Mouser	581-06035A500JAT2A	1	
Final app.	0R0	0603	Vishay/B.	MCT06030Z0000ZP500	Mouser	594-MCT06030Z0000ZP5	1	

(4)								
1 output	33R 1/10W	0805	Susumu	RR1220Q-330-D	Mouser	754-RR1220Q-330D	1	
2 outputs	33R 1/10W	0805	Susumu	RR1220Q-330-D	Mouser	754-RR1220Q-330D	2	
3 outputs	33R 1/10W	0805	Susumu	RR1220Q-330-D	Mouser	754-RR1220Q-330D	3	
4 outputs	33R 1/10W	0805	Susumu	RR1220Q-330-D	Mouser	754-RR1220Q-330D	4	

(5)								
11.2896 MHz	AT-cut 11.2896 MHz	HC-43/U	Laptech	XT4117 LP4412	Custom	Custom	1	
12.288 MHz	AT-cut 12.288 MHz	HC-43/U	Laptech	XT4332 LP4412	Custom	Custom	1	
22.5792 MHz	AT-cut 22.5792 MHz	HC-43/U	Laptech	XT4273 LP4412	Custom	Custom	1	
24.576 MHz	AT-cut 24.576 MHz	HC-43/U	Laptech	XT4274 LP4412	Custom	Custom	1	
25.0000 MHz	AT-cut 25.0000 MHz	HC-43/U	Laptech	XT4334 LP4412	Custom	Custom	1	
5.6448 MHz	AT-cut 5.6448 MHz	HC-43/U	Laptech	XT4272 LP4412	Custom	Custom	1	
6.144 MHz	AT-cut 6.144 MHz	HC-43/U	Laptech	XT4304 LP4412	Custom	Custom	1	
16.9344 MHz	AT-cut 16.9344 MHz	HC-43/U	Laptech	XT4333 LP4412	Custom	Custom	1	
33.8688 MHz	AT-cut 33.8688 MHz	HC-43/U	Laptech	XT4118 LP4412	Custom	Custom	1	3rd overtone
45.1584 MHz	AT-cut 45.1584 MHz	HC-43/U	Laptech	XT4275 LP4412	Custom	Custom	1	3rd overtone
49.152 MHz	AT-cut 49.152 MHz	HC-43/U	Laptech	XT4276 LP4412	Custom	Custom	1	3rd overtone

(6)								
5V	74VHC04	SOIC-14	On Semi	MC74VHCU04DR2G	Mouser	863-MC74VHCU04DR2G	1	
3V3	74LVC04	SOIC-14	NXP Semi	74LVCU04AD,118	Mouser	771-LVCU04AD118	1	
3V3	74GU04	SOIC-14	Potato Semi	PO74GU04A	Potato	PO74GU04A	1	

(7)								
1 u.fl. Output	u.fl. Connector		Hirose	U.FL-R-SMT(10)	Mouser	798-U.FL-R-SMT10	1	
2 u.fl. Output	u.fl. Connector		Hirose	U.FL-R-SMT(10)	Mouser	798-U.FL-R-SMT10	2	

(8)

Vertical	2 pin header r.a.		AMP	826631-2	Mouser	571-826631-2	1	
Horizontal	2 pin header		AMP	826646-2	Mouser	571-826646-2	1	

(9)								
Fundamental	None	-	-	-	-	-	-	
33.8688 MHz	1nF C0G/NP0	0805	Kemet	C0805C102J5GACTU	Mouser	80-C0805C102J5G	1	
45.1584 MHz	1nF C0G/NP0	0805	Kemet	C0805C102J5GACTU	Mouser	80-C0805C102J5G	1	
49.152 MHz	1nF C0G/NP0	0805	Kemet	C0805C102J5GACTU	Mouser	80-C0805C102J5G	1	

(10)								
Fundamental	None	-	-	-	-	-	-	
33.8688 MHz	3.3uH	0805	TDK	MLZ2012A3R3W	Mouser	810-MLZ2012A3R3W	1	
45.1584 MHz	2.7uH	0805	TDK	MLF2012A2R7K	Mouser	810-MLF2012A2R7K	1	
49.152 MHz	2.7uH	0805	TDK	MLF2012A2R7K	Mouser	810-MLF2012A2R7K	1	

(11)								
C6	1uF 100V X7R	1210	AVX	12101C105KAT2A	Mouser	581-12101C105KAT2A	1	
R3 R4	220K 1/10W	0805	Susumu	RR1220P-224-D	Mouser	754-RR1220P-224D	2	
R5 - 5V	180K 1/10W	0805	Susumu	RR1220P-184-D	Mouser	754-RR1220P-184D	1	
R5 - 3V3	150K 1/10W	0805	Susumu	RR1220P-154-D	Mouser	754-RR1220P-154D	1	

(12)								
R9	47K 1/10W	0805	Susumu	RR1220P-473-D	Mouser	754-RR1220P-473D	1	

Assembly guide

The TWTMC-C is a Colpitts-Clapp crystal oscillator suitable for digital audio.

The board works with fundamental and overtone crystals, and can be used for frequencies from 5 MHz up to 50 MHz.

It needs 2 external power supplies: +15V and +3V3/+5V, depending on the desired output voltage.

The are two options to convert sine wave to TTL, starting from a C-MOS inverter.

The board provides 4 outputs with different connectors: 1 x SMA, 2 x u.fl, 1 x pin strip.

Some component values depend on the crystal operating mode and on the chosen frequency. The following table shows the values of the components for each frequency.

Frequency	Mode	C1-C2	C9	L4
5.6448 MHz	fundamental	200 pF	none	none
6.144 MHz	fundamental	200 pF	none	none
11.2896 MHz	fundamental	100 pF	none	none
12.288 MHz	fundamental	100 pF	none	none
16.9344 MHz	fundamental	75 pF	none	none
22.5792 MHz	fundamental	56 pF	none	none
24.576 MHz	fundamental	56 pF	none	none
25.0000 MHz	fundamental	56 pF	none	none
33.8688 MHz	3rd	33 pF	1 nF	3.3 uH
45.1584 MHz	3rd	22 pf	1 nF	2.7 uH
49.152 MHz	3rd	18 pF	1 nF	2.7 uH

Firstly place the following components: C1, C2, C3, C4, C5, R1, L1, L2, D1 and Q1.

Solder a jumper (0R0) in place of C8.

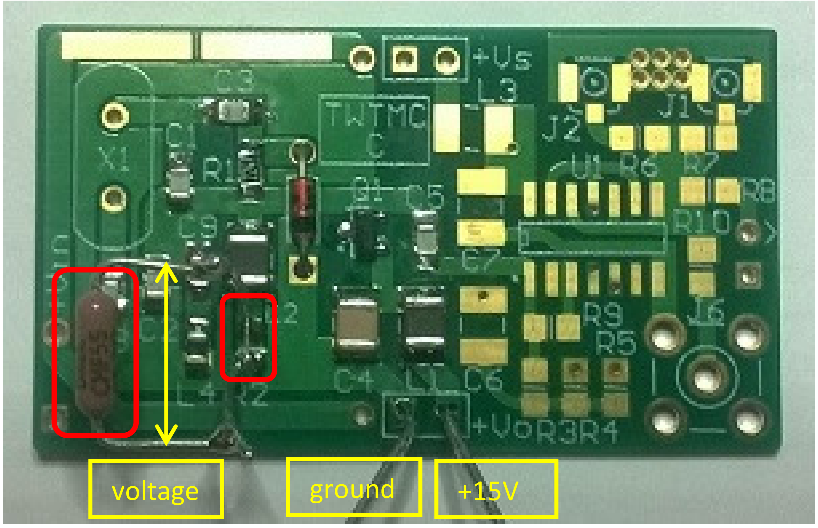
If you are building an overtone oscillator (33.8688 MHz to 49.152 MHz), place C9 and L4 following the above table.

Now you have to adjust the jfet bias current, choosing the right value for component R2. In most cases 39R is the right value for R2 to get 18-20 mA bias current. Anyway the bias current depends on jfet IDSS, so a little adjustment could be needed.

Solder two solid wire (component terminals do the job) on R2 pads.

For the moment don't solder the crystal.

Start soldering a 39R resistor across the solid wire, as in the following picture.



Now apply +15V as in the above picture.

With a DMM measure the voltage across R2 resistor.

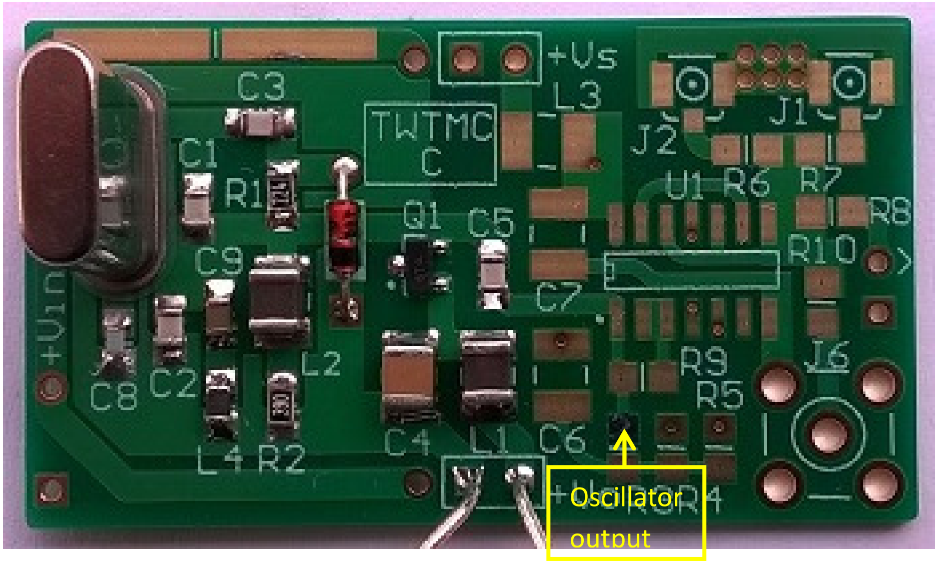
Since the bias current to reach is 18-20 mA, by the Ohm law, you should measure a voltage between 702 mV (39R * 0.018mA) and 780 mV (39R * 0.020mA) across the 39R resistor.
If the measured voltage is out of the above range the 39R resistor have to be replaced with another one of different value. If the voltage measured exceeds 780 mV, the value of R2 have to be increased, otherwise it should be decreased.
Once R2 has been replaced the voltage across it have to be measured again. The measured voltage must be in the range calculated starting from the new R2 value, using the Ohm law:

lower limit in Volt = R2 in ohm * 0.018 A
upper limit in Volt = R2 in ohm * 0.020 A

Once the right value for R2 is found, you can de-solder the test resistor and the solid wires, replacing them with a suitable SMD component.

Now you can solder the crystal. **Remember to insert the appropriate insulator between the crystal and the board** (see BOM).

If you own an oscilloscope, you can apply +15V power supply and test the sine waveform. Keep in mind that if you are not using an active probe the waveform could be attenuated because the probe is loading the oscillator. Set the probe to 10X, if possible.



Place and solder the following components: L3, C7, U1.

Select the sine to square option you desire, following this table:

Option	Type	Components	Duty cycle
1	Self-bias	R9	50%
2	Voltage divider	R3-R4-R5-C6	Configurable

Components listed in the BOM for the second option give around 50% duty cycle, but you can vary their values to get different duty cycle.

Warning. If you are planning to use this oscillator with TWTMC-D&D daughter board, using its feature "power off oscillator" (when the oscillator is not in use), you should select the second slicer option, avoiding to leave U1 input floating. If you desire anyway to use the first option, you should solder also R3 and R5 (they will work as pull-down resistor).

Finally one or more output (up to 4) connectors have to be chosen within the possible options. See the following table:

Label	Connector type	Resistor
J1	u.fl	R7
J2	u.fl	R6
J5 (> on board)	pin strip	R8
J6	SMA	R10

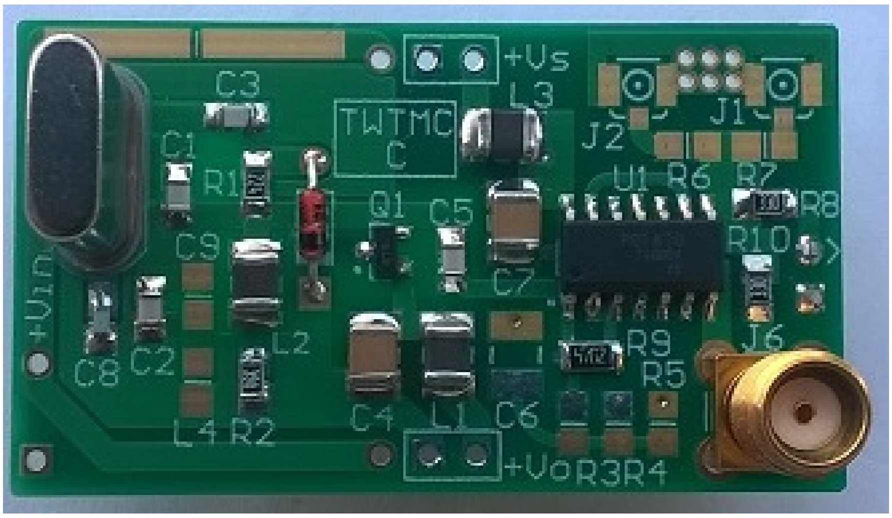
Solder connectors and its output resistors.

Solder J3 and J4 pin strip connector for power supply. If you are planning to use external regulators fed by a single DC supply, you have to solder also the connector at the leftbottom corner of the board. The 2 pads at the left-top side are provided to insert a voltage drop resistor, in case the 3V3/5V regulator needs a lower input DC voltage. Otherwise you have to place a jumper (0R0).

If you own an oscilloscope you can check the output waveform. Keep in mind that to display correctly a square wave you need an oscilloscope with high bandwidth and a good probe. As a rule of thumb you can assume a bandwidth at least 9 times larger than the square wave frequency to be displayed. Otherwise you will get a distorted representation.

The crystal oscillator reach its best performance after several weeks of intensive use.

Finished fundamental oscillator board.



Finished overtone oscillator board.