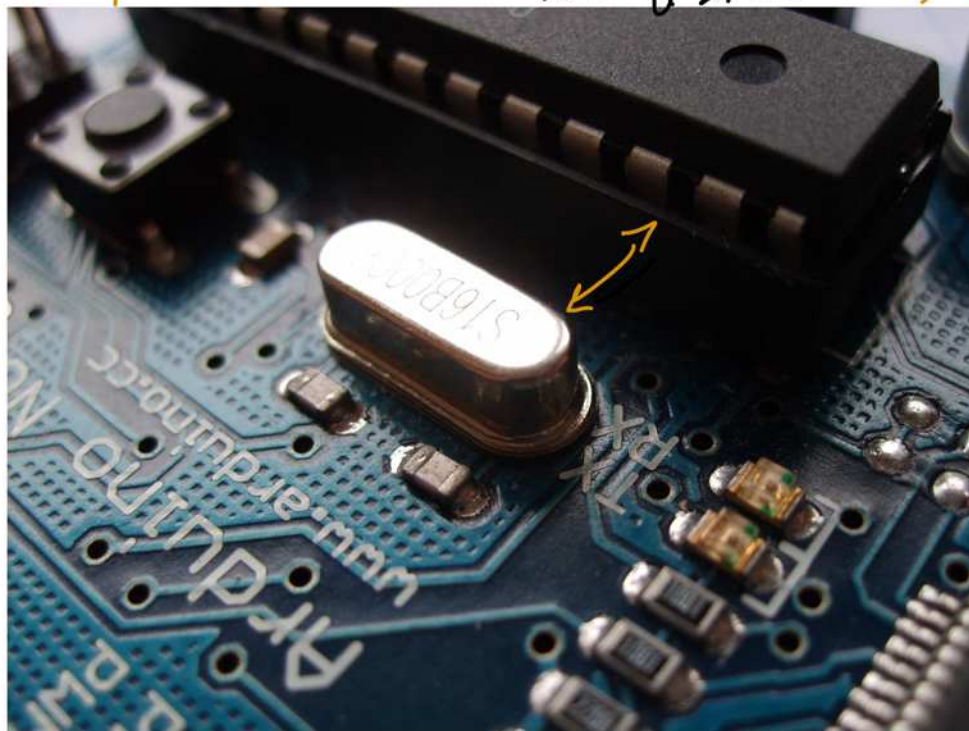Arduino uno

ATmega328

$f_{out} = 500 \, Hz \; , \; f_{CLK} = 8 \, MHz$

$$f_{out} = \frac{f_{CLK}}{N \cdot (1 + Top)}$$
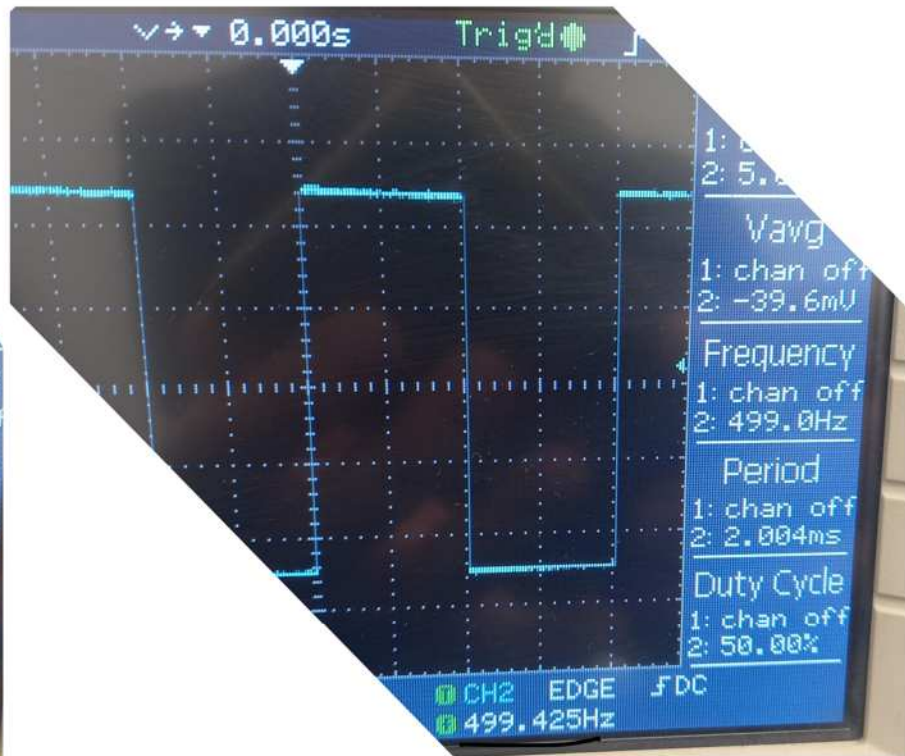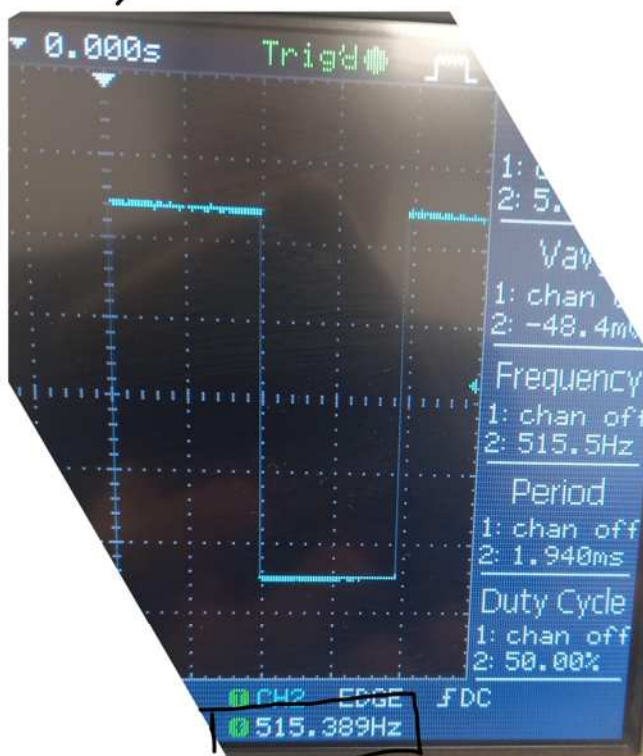
$N = 1 - 8 - 64 - 256 - 1024$

$$500 = \frac{8 \times 10^6}{N(1 + Top)}$$

$\boxed{N = 64}$, $\boxed{Top = 0 \times F9}$

Internal

External

$f_{int} = 515.389 \, Hz \implies$

$f_{ext} = 499.425 \, Hz \implies$

$\dfrac{515.389 - 500}{500} \times 100 \implies \boxed{err \approx 3\%}$

$\dfrac{500 - 499.425}{500} \times 100 \implies \boxed{err \approx 0.1\%}$

$$f_n = \frac{1}{2\pi\sqrt{LC}}$$

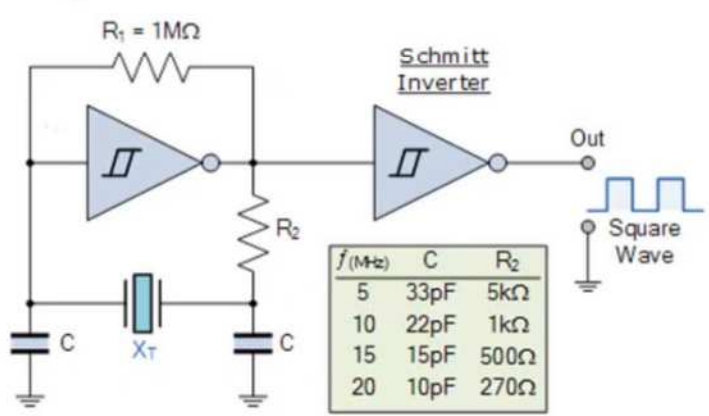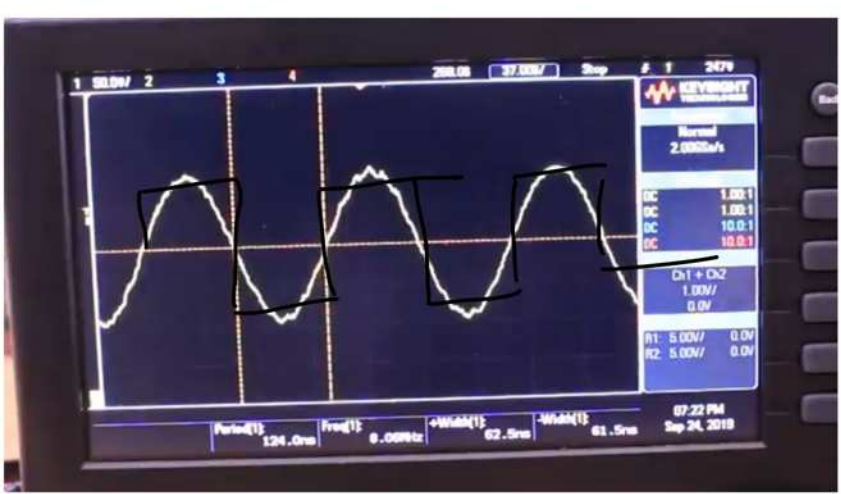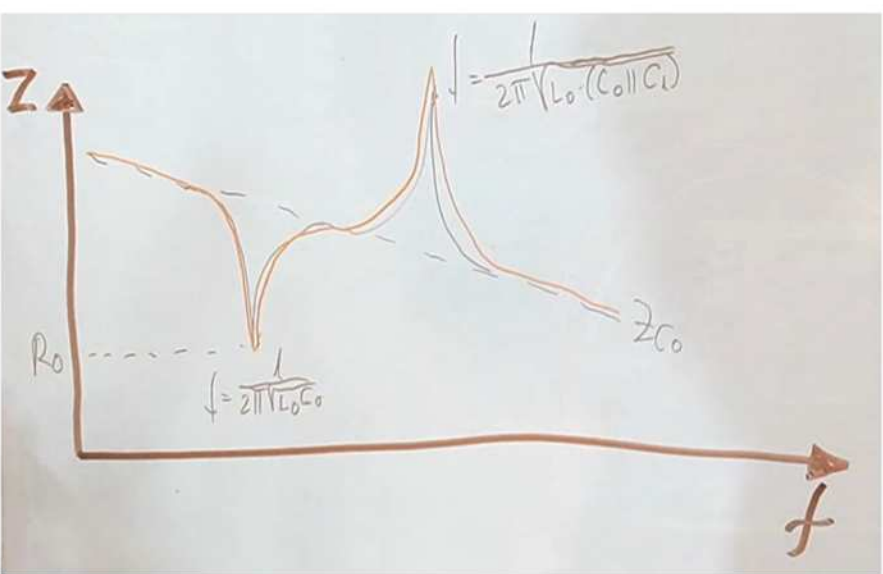$$= \frac{1}{2 \times 3.14 \sqrt{10 \times 10^{-6} \times 22.33 \times 10^{-6}}} \cong 10650\ HZ$$

$$X_C = X_L \implies \frac{1}{2\pi f C} = 2\pi f L$$

$$\implies 4\pi^2 f^2 C L = 1 \implies f_R^2 = \frac{1}{4\pi^2 LC} \implies$$

$$f_R = \frac{1}{2\pi\sqrt{LC}}$$

$$f_R = 10650\ HZ$$

quartz)لایه طلا روی

(metalized) لایه نیکل روی

(E32K)

Equivalent circuit: R_s, L_s, C_s, C_p

$1pF \lesssim C_p \lesssim 7pf$

$mH \lesssim L_s \lesssim H$

$C_s \propto \ell f$ $f = 1\cdot^{-15} f$

R_s

$$f = \frac{1}{2\pi\sqrt{L_0 \cdot (C_0 \| C_i)}}$$

$$f = \frac{1}{2\pi\sqrt{L_0 C_0}}$$

Z, Z_{C_0}, R_0, f

$R_1 = 1M\Omega$

Schmitt Inverter

Out

Square Wave

f (MHz)	C	R_2
5	33pF	5kΩ
10	22pF	1kΩ
15	15pF	500Ω
20	10pF	270Ω

X_T

$$60 \, \frac{sec}{min} \times 60 \, \frac{min}{hour} \times 24 \, \frac{hours}{day} = 86400 \, \frac{sec}{day}$$

$$1\% \qquad \frac{1}{100}(86400) = 864 \, \frac{sec}{day} = 14min + 24sec \, /day$$

Typical oscillator 100PPM

PPM: part per million (10^6)

$$86400 \times 100 \times 10^{-6} = 8.64 \, \frac{sec}{day}$$

$$8.64 \, \frac{sec}{day} \times 30 \, \frac{day}{month} = 259.2$$

$$= 4min + 19sec \, /month$$

نبض الشارع

watch oscillator 20PPM

$$86400 \times 20 \times 10^{-6} = 1.728 \, \frac{sec}{day}$$

$$1.728 \, \frac{sec}{day} \times 30 \, \frac{day}{month} = 51.83 \, \frac{sec}{month}$$

$$51.85 \, \frac{sec}{month} \times 12 \, \frac{month}{ear} = 622.08 \, \frac{sec}{ear}$$

$$= 10min + 22sec \, /year$$

TCXO = Temperature Compensated Crystal oscillator 1PPM

$$86400 \times 1 \times 10^{-6} = 0.0864 \frac{sec}{day}$$

$$0.0864 \times 30 \frac{day}{month} = 2.592 \frac{sec}{month}$$

$$2.592 \times 12 \frac{month}{year} = 31.104 \frac{sec}{year}$$

OCXO = oven Controlled Crystal oscillator 1PPB

$$86400 \times 1 \times 10^{-9} = 86.4 \frac{us}{day} \times 30 \frac{day}{month}$$

$$= 2.529 \frac{ms}{month} \times 12 \frac{month}{year} = 31.104 \frac{ms}{year}$$

$$32.15 \frac{year}{1sec}$$

Rubidium 0.001 PPB

$$86400 \times 0.001 \times 10^{-9} = 86.4 \frac{ns}{Hz} \times 30 \frac{day}{month}$$

$$= 2.529 \frac{us}{month} \times 12 \frac{month}{year} = 31.104 \frac{us}{year}$$

$$32150 \frac{year}{1sec}$$

Cesium $\qquad$ 0.0001 PPB

$86400 \times 0.0001 \times 10^{-9} = 8.64 \frac{ns}{day} \times 30 \frac{day}{month}$

$= 252.9 \frac{ns}{month} \times 12 \frac{month}{year} = 3.1104 \frac{us}{year}$

$\Rightarrow 321502 \frac{year}{1 sec}$

Atomic Clock $\qquad$ اتمی ساعت

$CFE = -0.042(25-t)^2 \qquad t: operating\ temp\ (°C)$

$\hookrightarrow$ Real Time Clock frequency error (PPM)

$25°C$
$100 PPM$

$\begin{cases} 86400 \times 100 \times 10^{-6} = 8.64 \frac{sec}{day} \\ 8.64 \frac{sec}{day} \times 30 \frac{day}{month} = 259.2 \\ = 4 min + 19 sec / month \end{cases}$

$25 + 10 = 35°$
$\downarrow$
$104.2 PPM$

$CFE = -0.042(25-35)^2 = -4.2 PPM$

$86400 \times 104.2 \times 10^{6} \simeq 9 \frac{sec}{day} \times 30 \frac{day}{month}$

$= 270 \frac{sec}{month} = 4 min + 30 sec / month$

$+ 11 sec$