Quadrature Down Convertor

AEC Project | Spring2021

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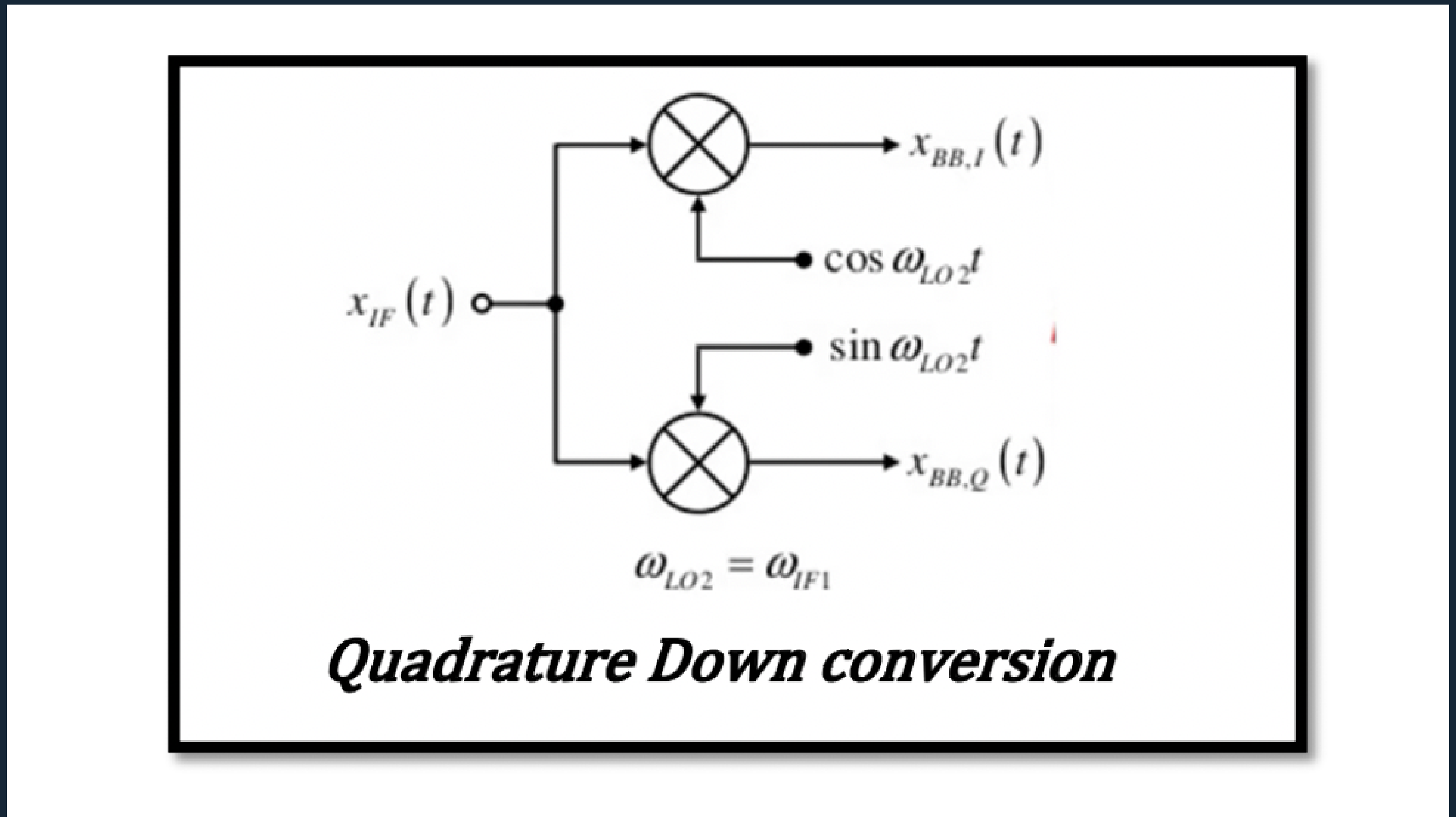

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Quadrature Oscillator

Its function

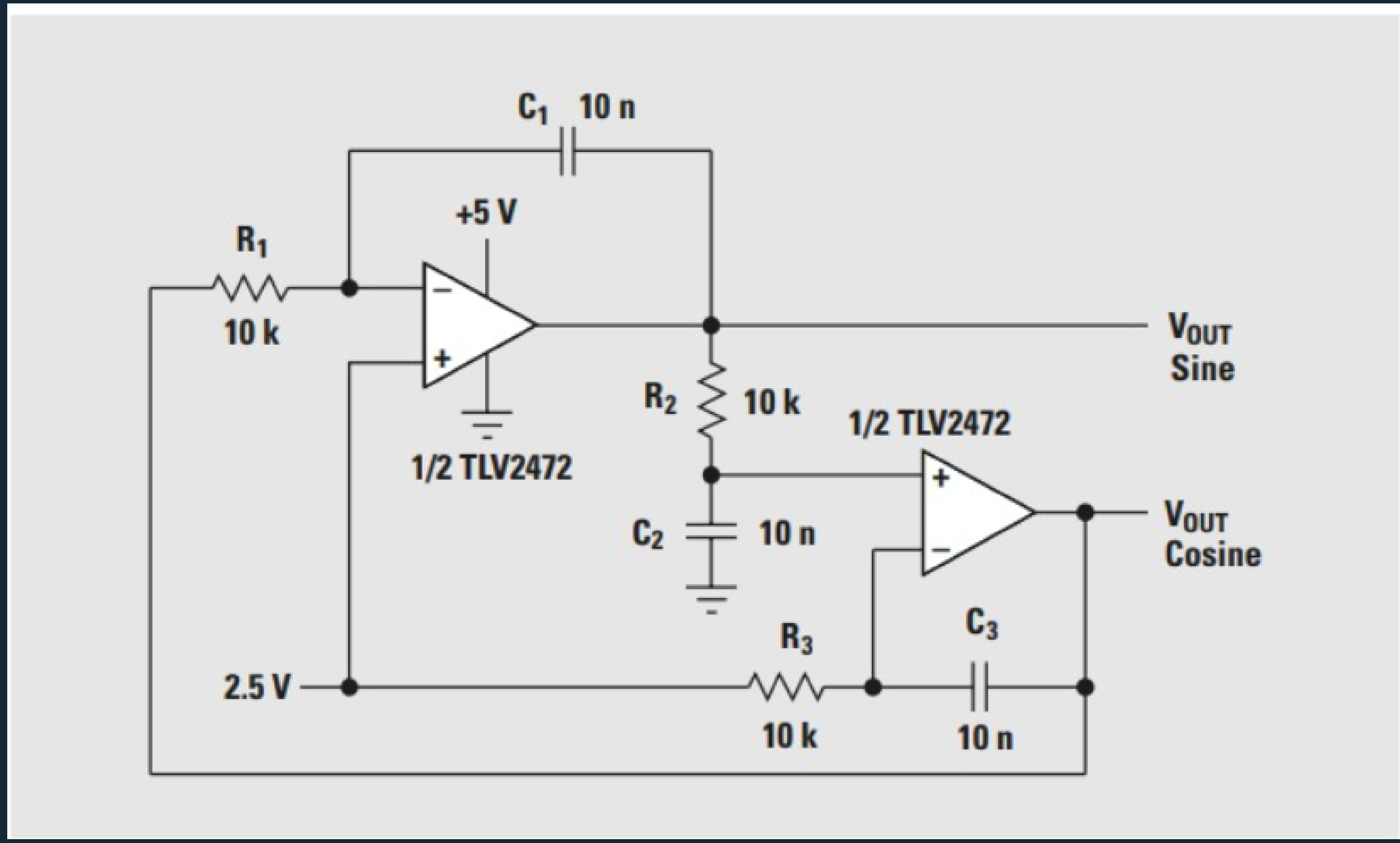
It generates two sinusoidal signals of certain frequency with a phase difference of 90°

Circuit Diagram and Components

2 **UA741** OP-AMPs

Resistors

Capacitors



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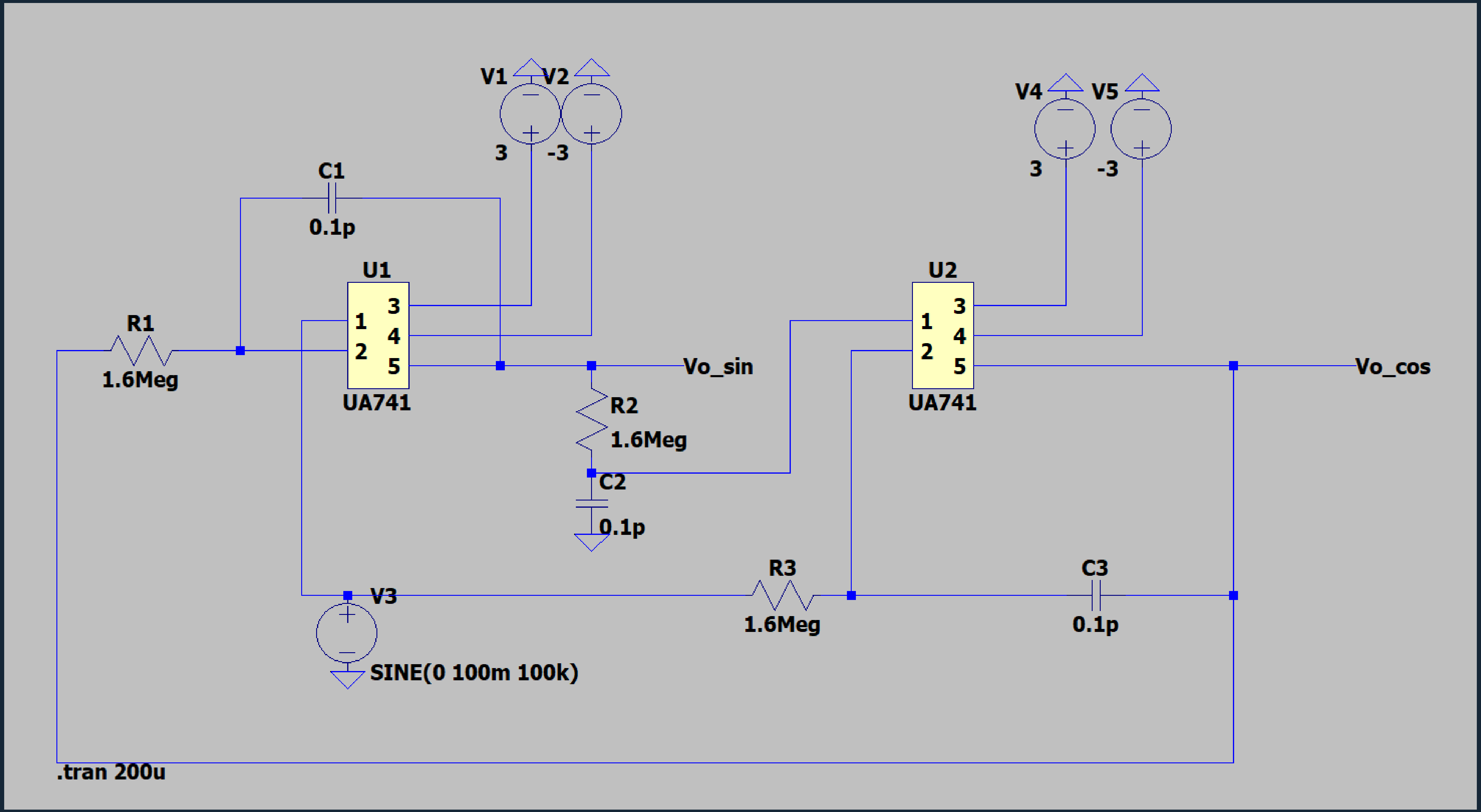
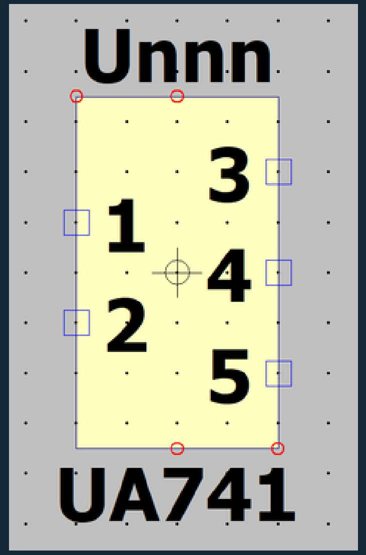
Quadrature Oscillator

LT-Spice Circuit



pindiagram of ua741



- 1 - V(+)
- 2 - V(-)
- 3 - Vdd
- 4 - Vss
- 5 - Vout

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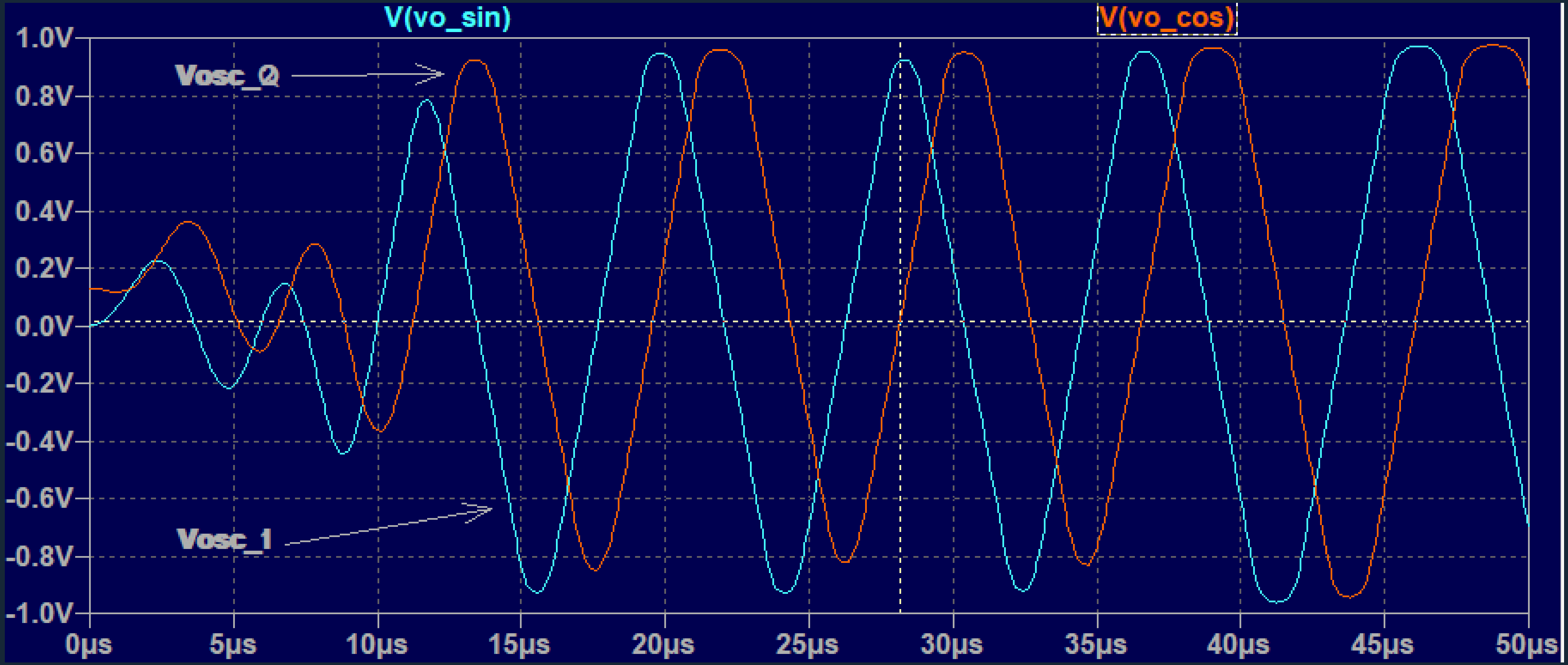
Quadrature Oscillator

LT-Spice Simulation Results



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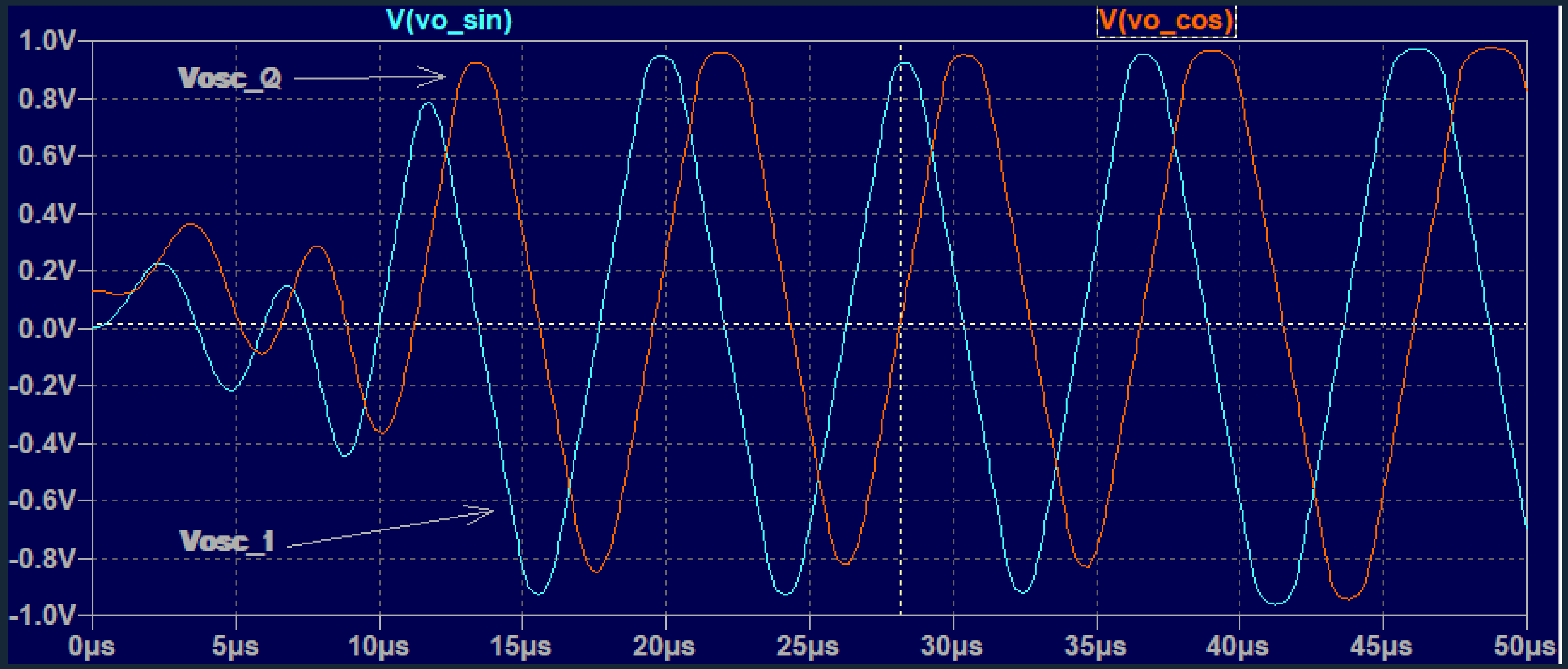
Quadrature Oscillator

LT-Spice Simulation Results

- Only the noise signal is used to generate the outputs
- Amplitude of both the outputs are almost same (~0.9V)
- Frequency is same as that of the noise signal
- Phase difference b/w the the two outputs is around 90°



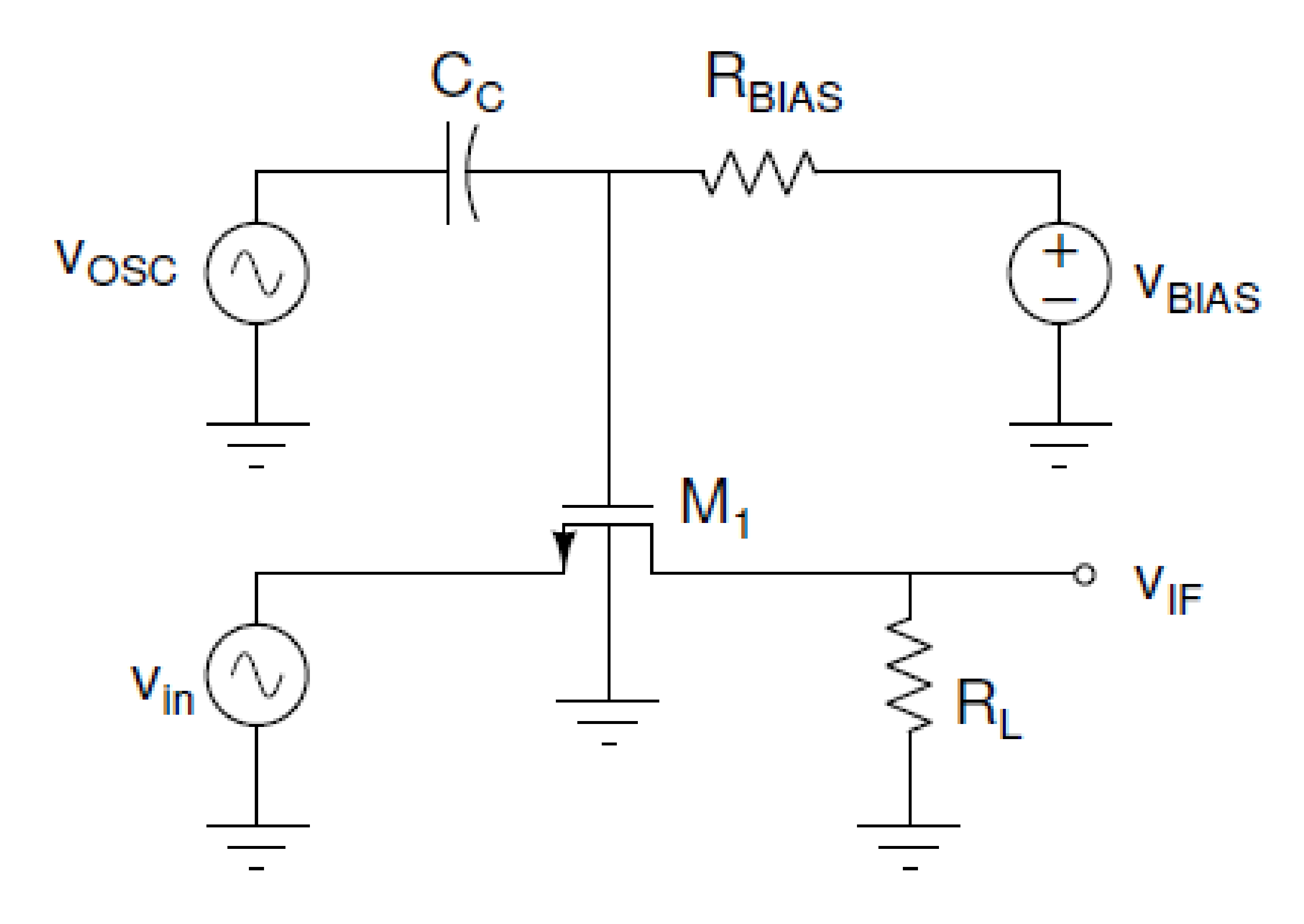
2 Mixer Circuit (Switch Design)

Its function

It multiplies two sinusoidal input signals to give the output signal

Circuit Diagram and Components

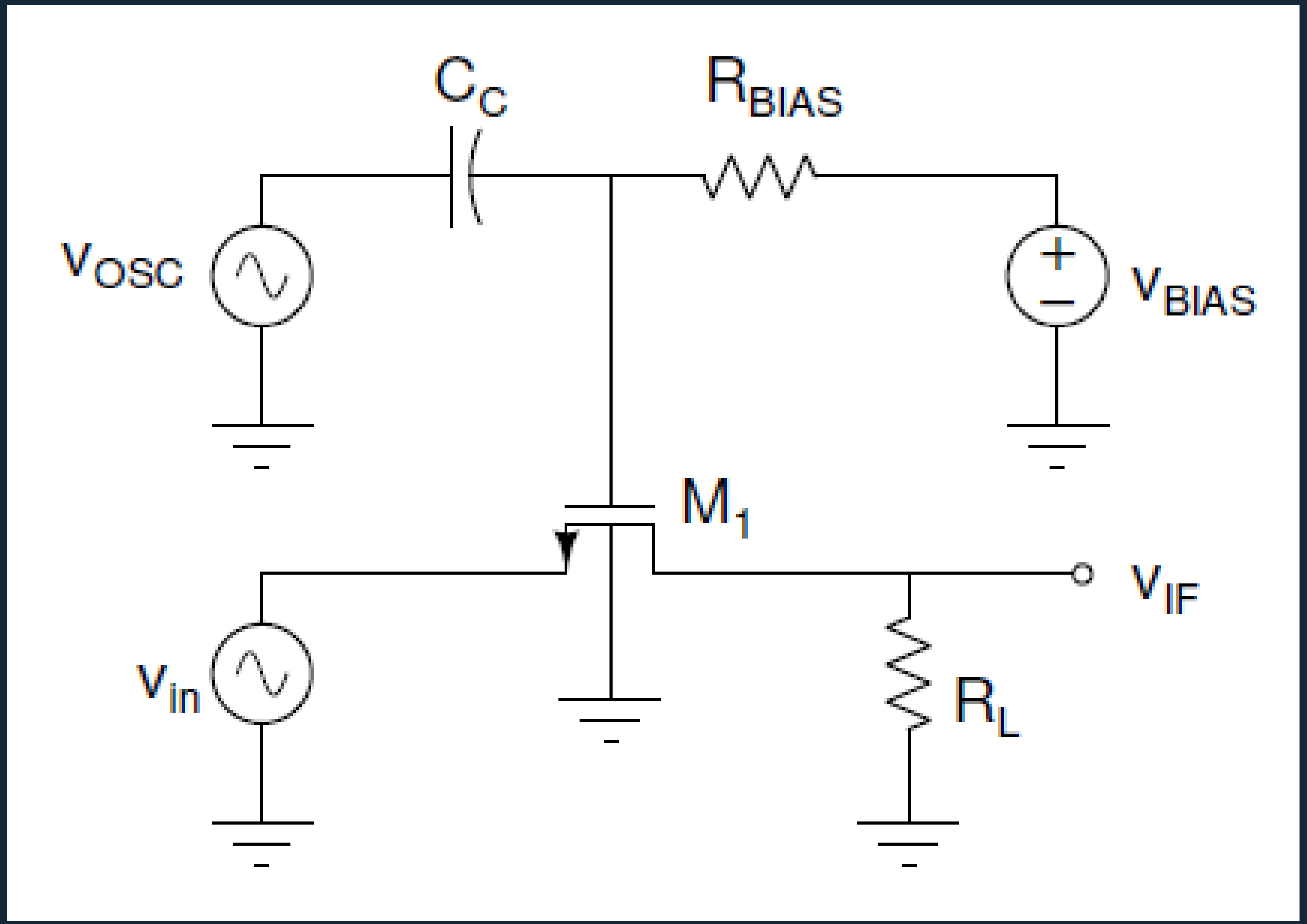
- **1 NMOS**
- Resistor Rc and bias resistor
- Capacitor Cc



2 Mixer Circuit (Switch Design)

Functioning

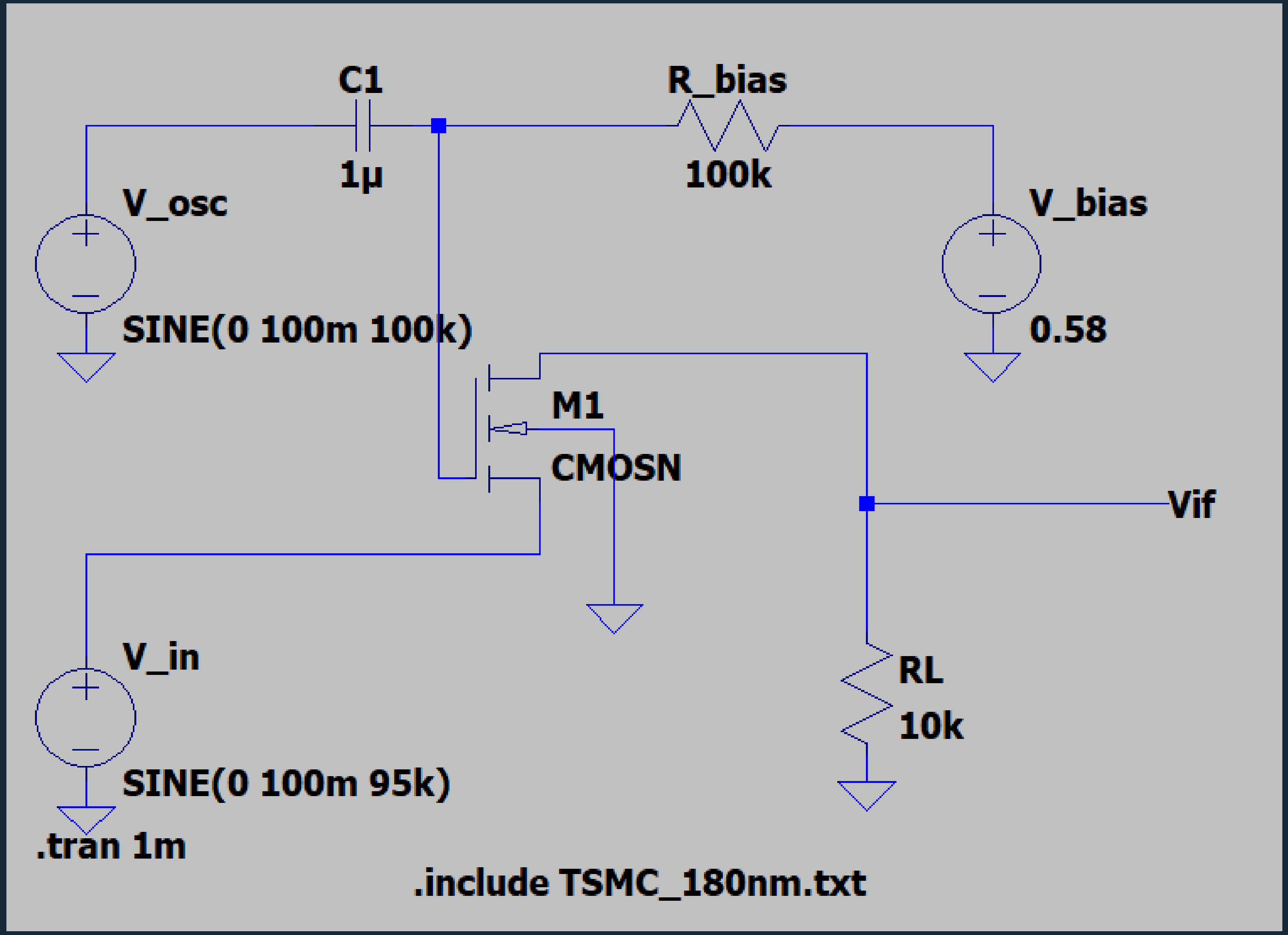
- V (bias) is given to be around V(T) so that the circuit switches on and off as per the sinusoidal signal
- Cc blocks the AC component from Vosc in DC analysis
- R(bias) blocks the DC component of V(bias) from interfering in AC analysis



Circuit Diagram

2 Mixer Circuit (Switch Design)

LT-Spice Circuit



NMOS Parameters

Monolithic MOSFET - M1

Model Name:	CMOSN
Length(L):	0.09u
Width(W):	1.8u
Drain Area(AD):	0.81p
Source Area(AS):	0.81p
Drain Perimeter(PD):	4.5u
Source Perimeter(PS):	4.5u
No. Parallel Devices(M):	

OK

Cancel

2 Mixer Circuit (Switch Design)

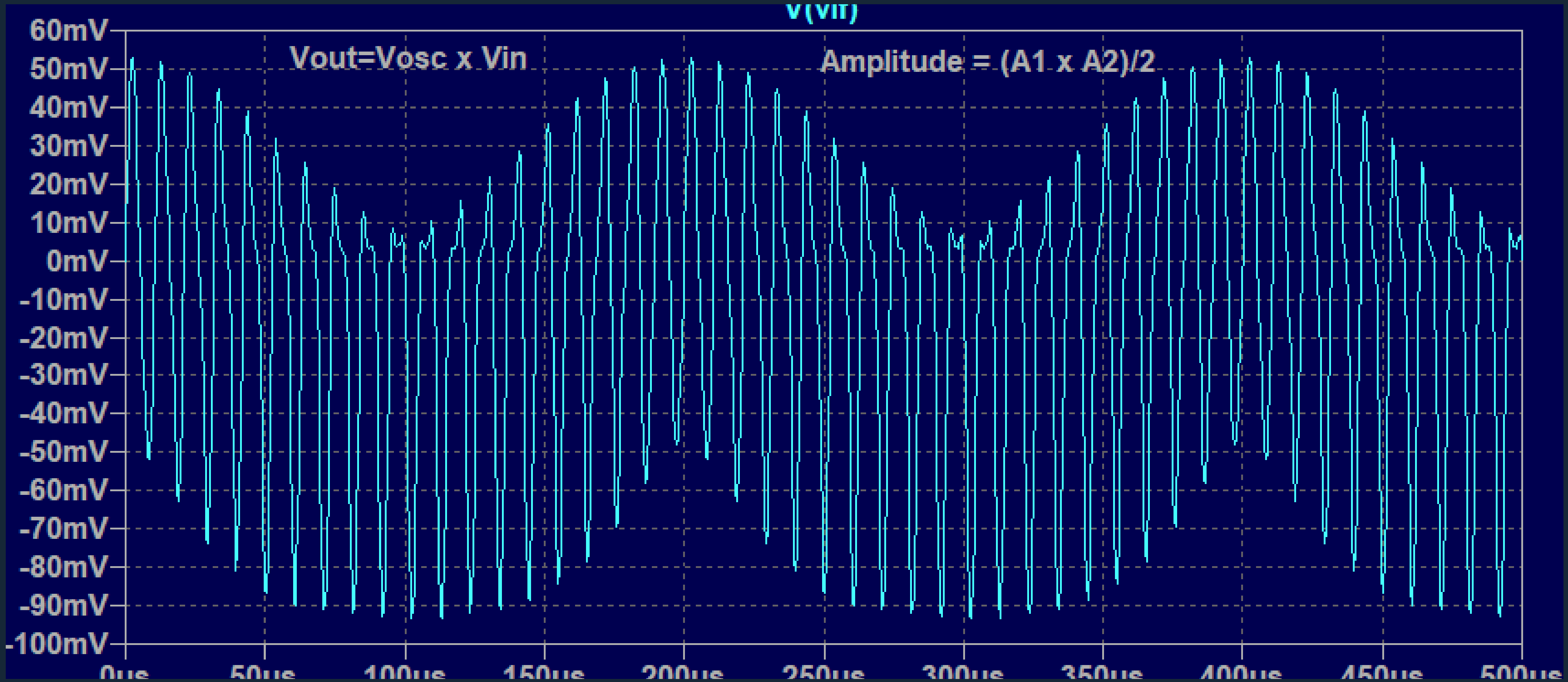
LT-Spice Simulations

$V_{out} = V_{osc} \times V_{in}$

- R(load) = 10kΩ
- Cc= 1μF
- R(bias) = 100kΩ

$V_{in} = 0.1\sin(2\pi f1\ t)$

$V_{osc} = 0.1\sin(2\pi f2\ t)$

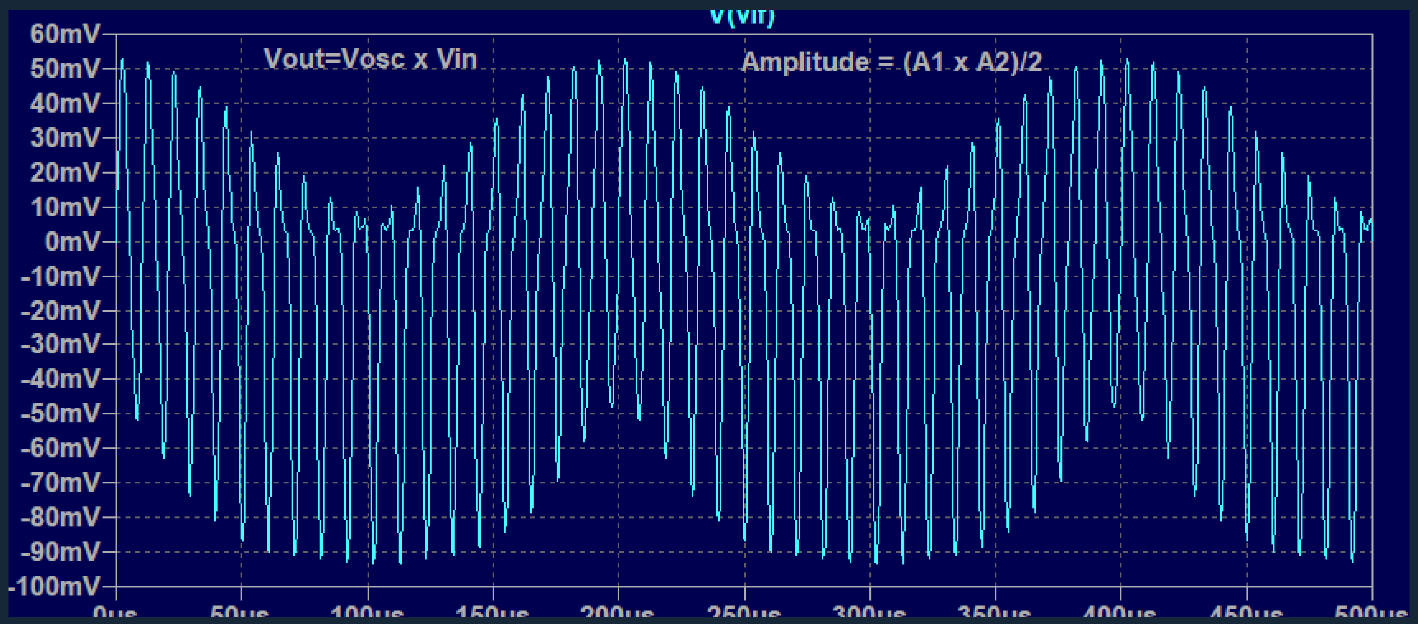


2 Mixer Circuit (Switch Design)

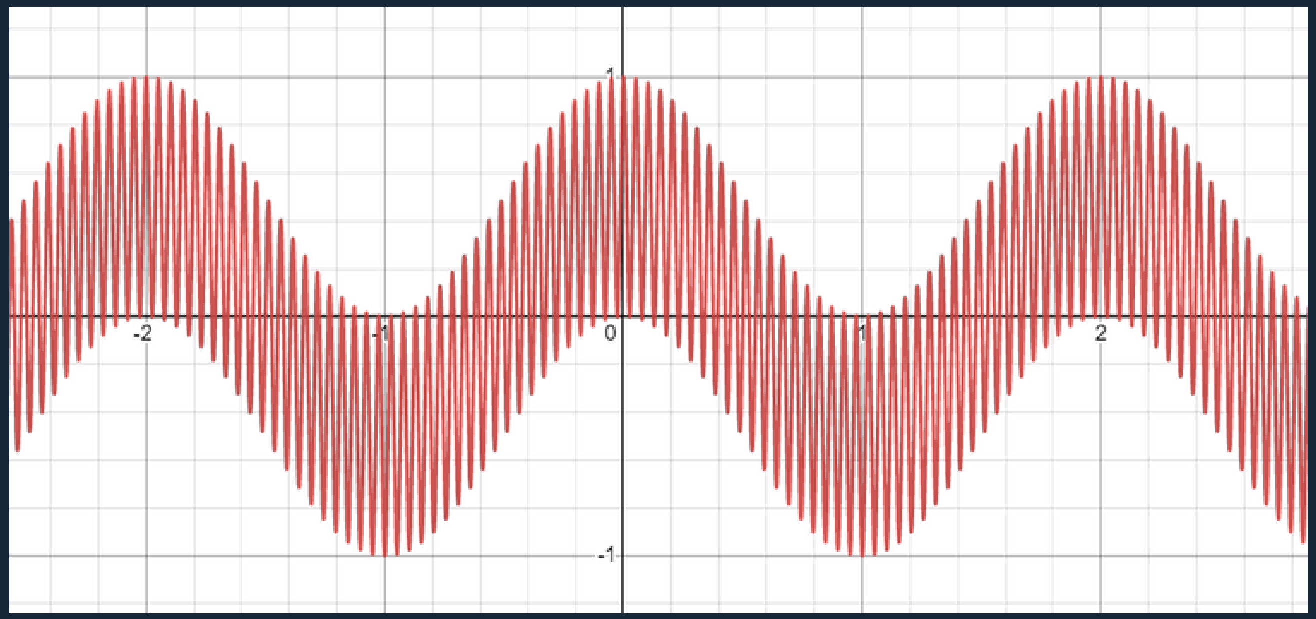
LT-Spice Simulations

$$v_{IF_I} = v_{in} \times v_{OSC_I} = \frac{A_1 A_2}{2}\left(cos(\omega_{in}t - \omega_{OSC}t) + cos(\omega_{in}t + \omega_{OSC}t)\right)$$

$$v_{IF_Q} = v_{in} \times v_{OSC_Q} = \frac{A_1 A_2}{2}\left(sin(\omega_{in}t + \omega_{OSC}t) - sin(\omega_{in}t - \omega_{OSC}t)\right)$$



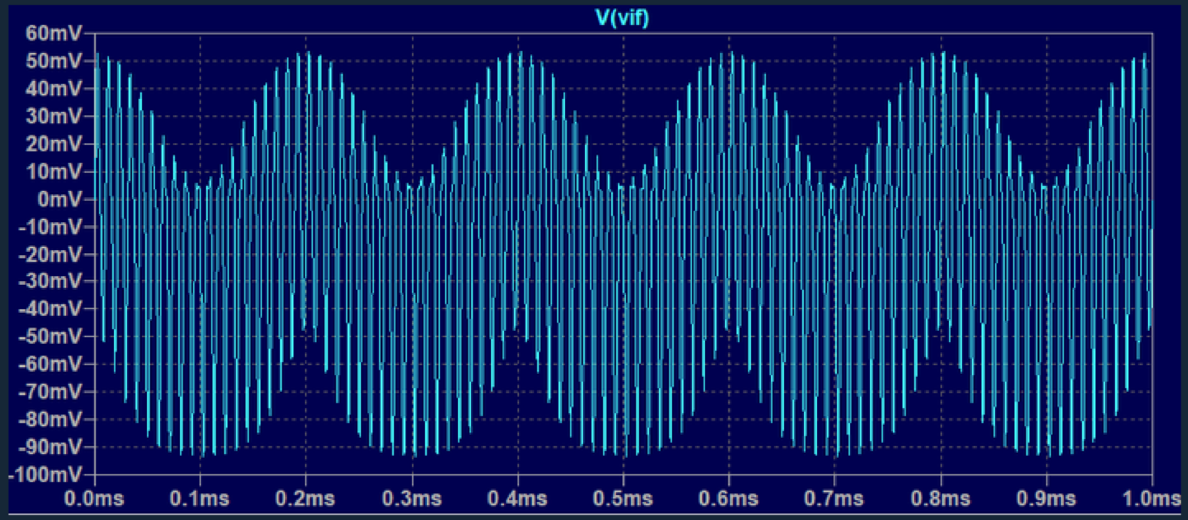
Obtained Waveform



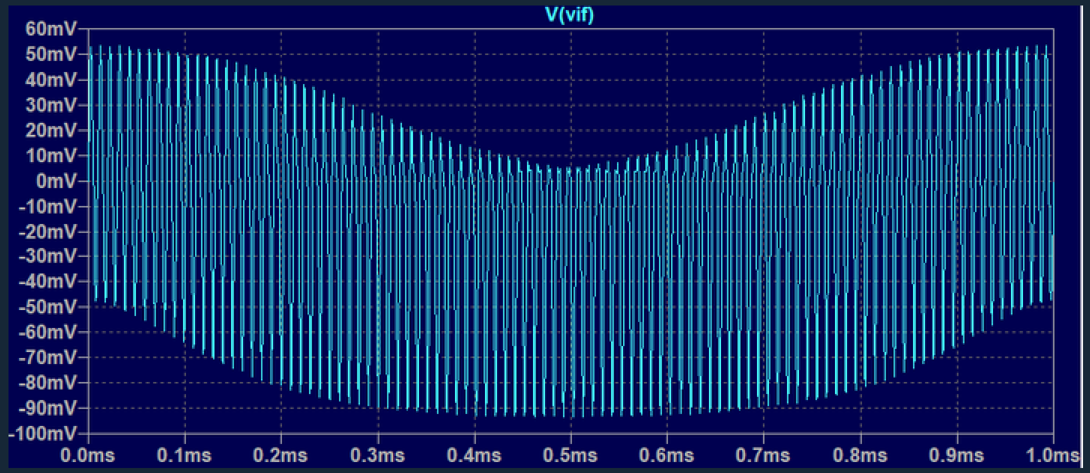
Theoretical Waveform

2 Mixer Circuit (Switch Design)

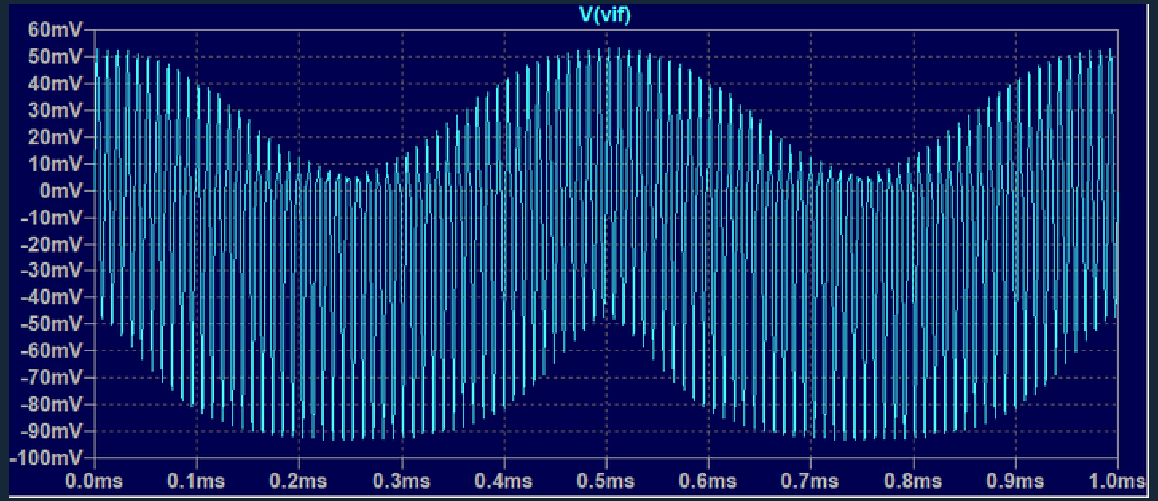
LT-Spice Simulations for various frequencies



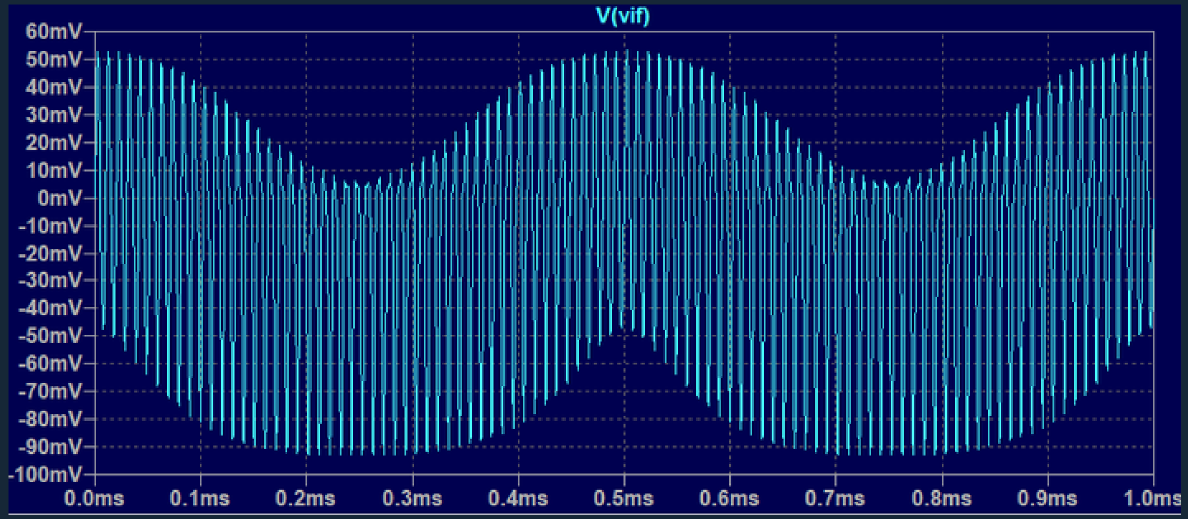
fin = 95kHz



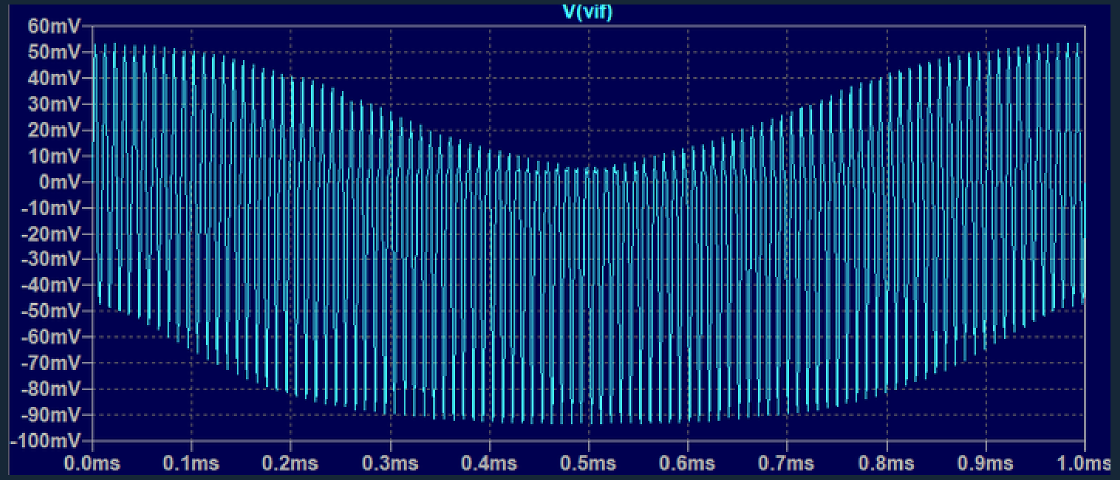
fin = 98kHz



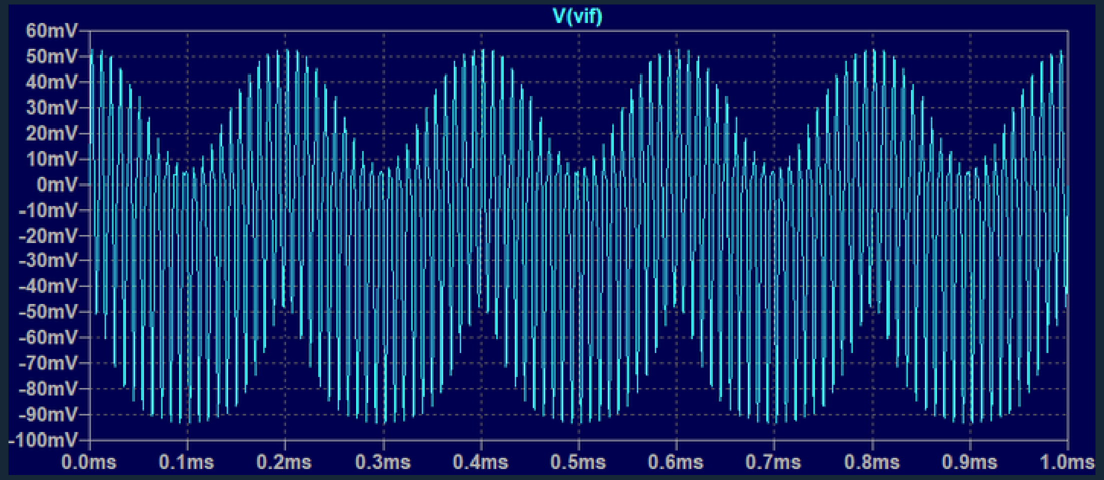
fin = 99kHz



fin = 101kHz



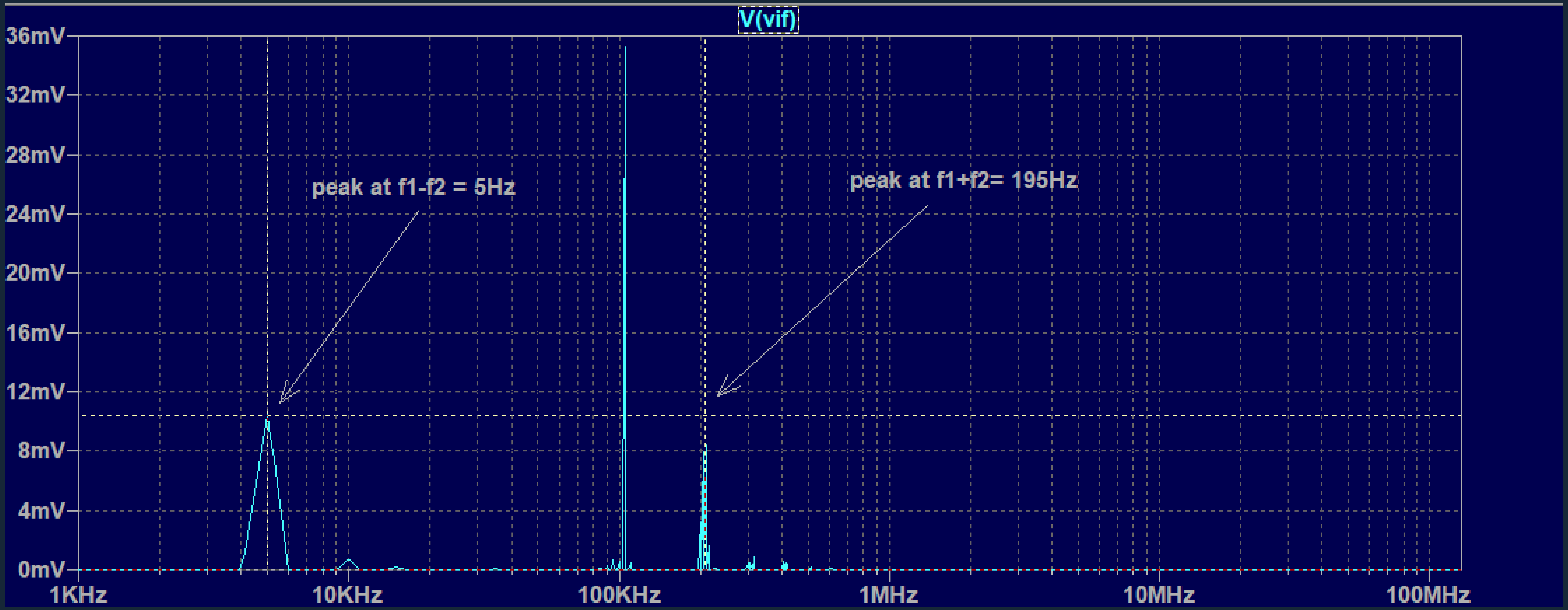
fin = 102kHz



fin = 105kHz

2 Mixer Circuit (Switch Design)

LT-Spice Simulations for FFT



3 Low-Pass Filter

Its function

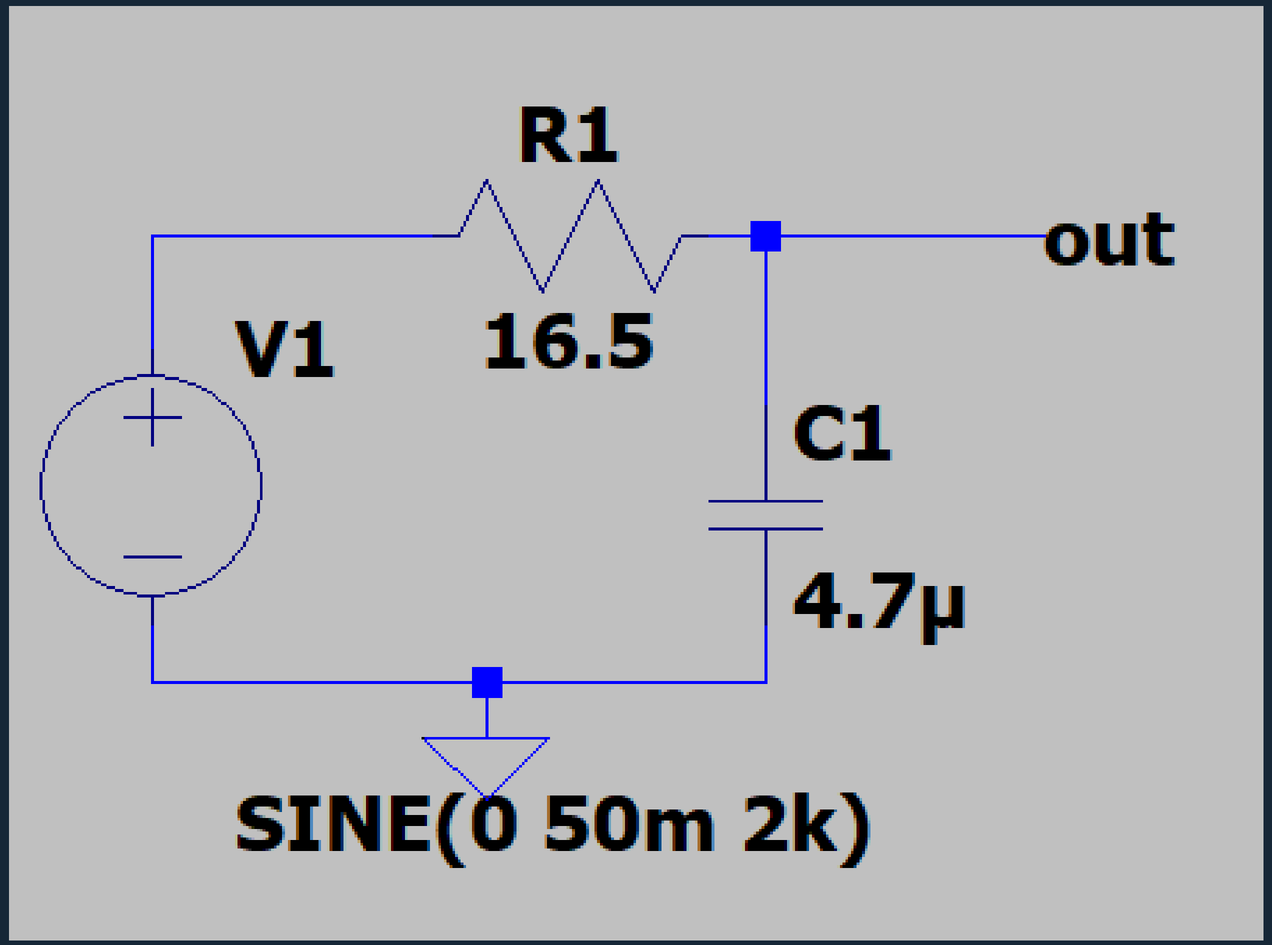
It filters out the high frequency components of the input signal based on value of RC

Circuit Diagram and Components

- Resistor R = 16.5 Ω
- Capacitor C = 4.7μF

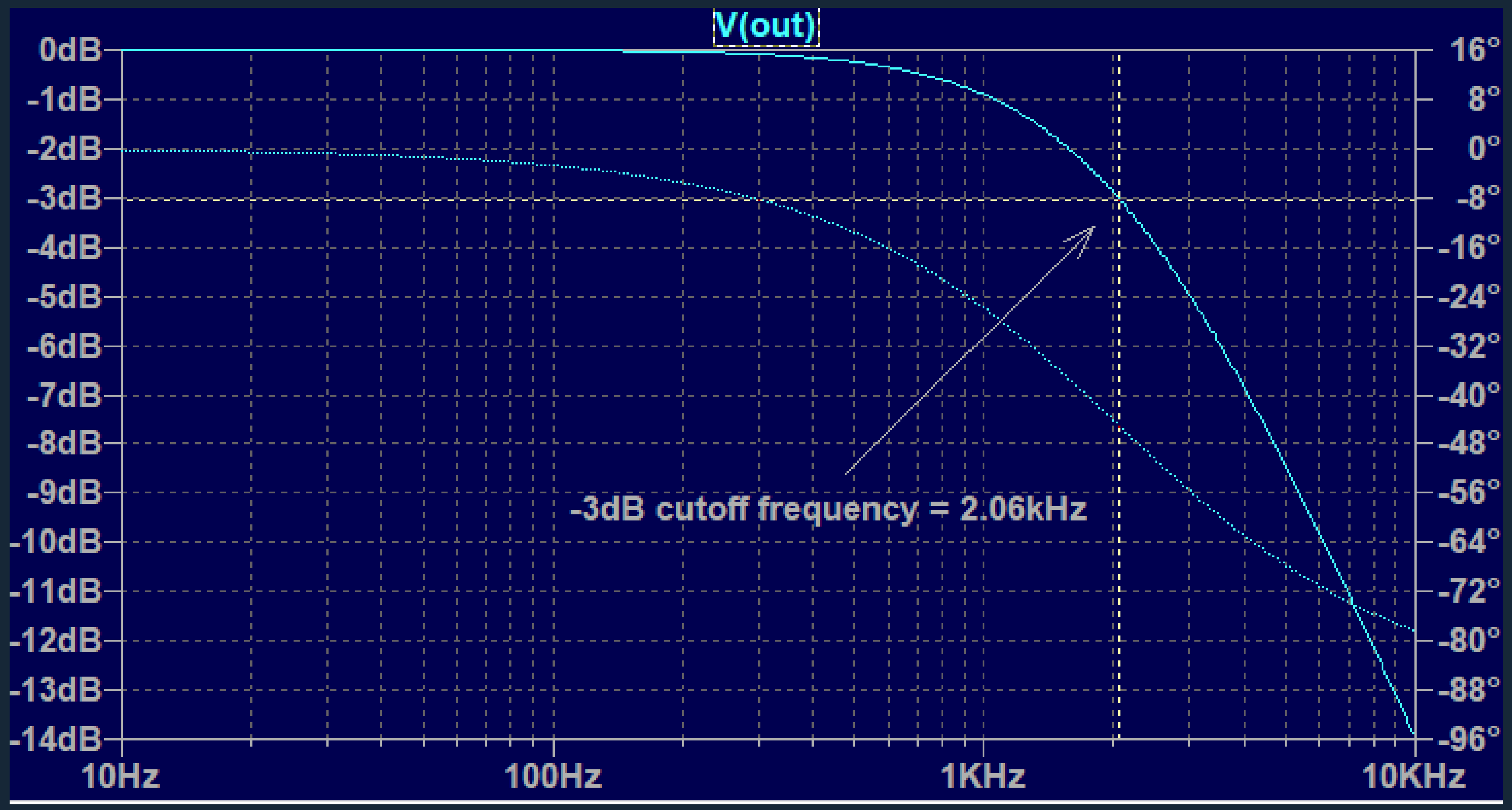
-3dB frequency = 1 / (2πRC) = 2kHz

cutoff = 1 / (2πRC) = 1000000/487 = 2.053 kHz

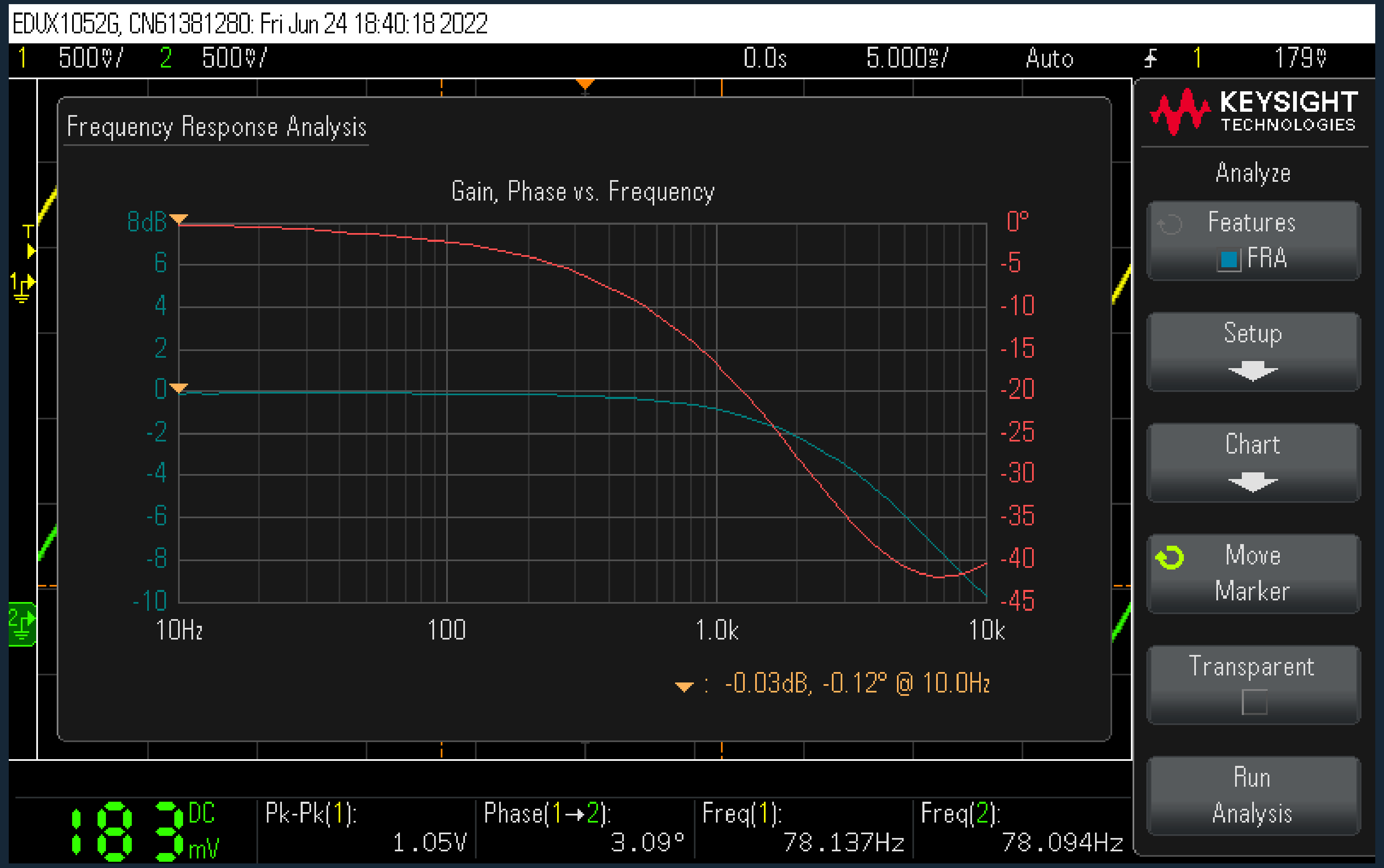


3 Low-Pass Filter (Bode-Plot for RC Low Pass filter)

LT-Spice Simulations



DSO output



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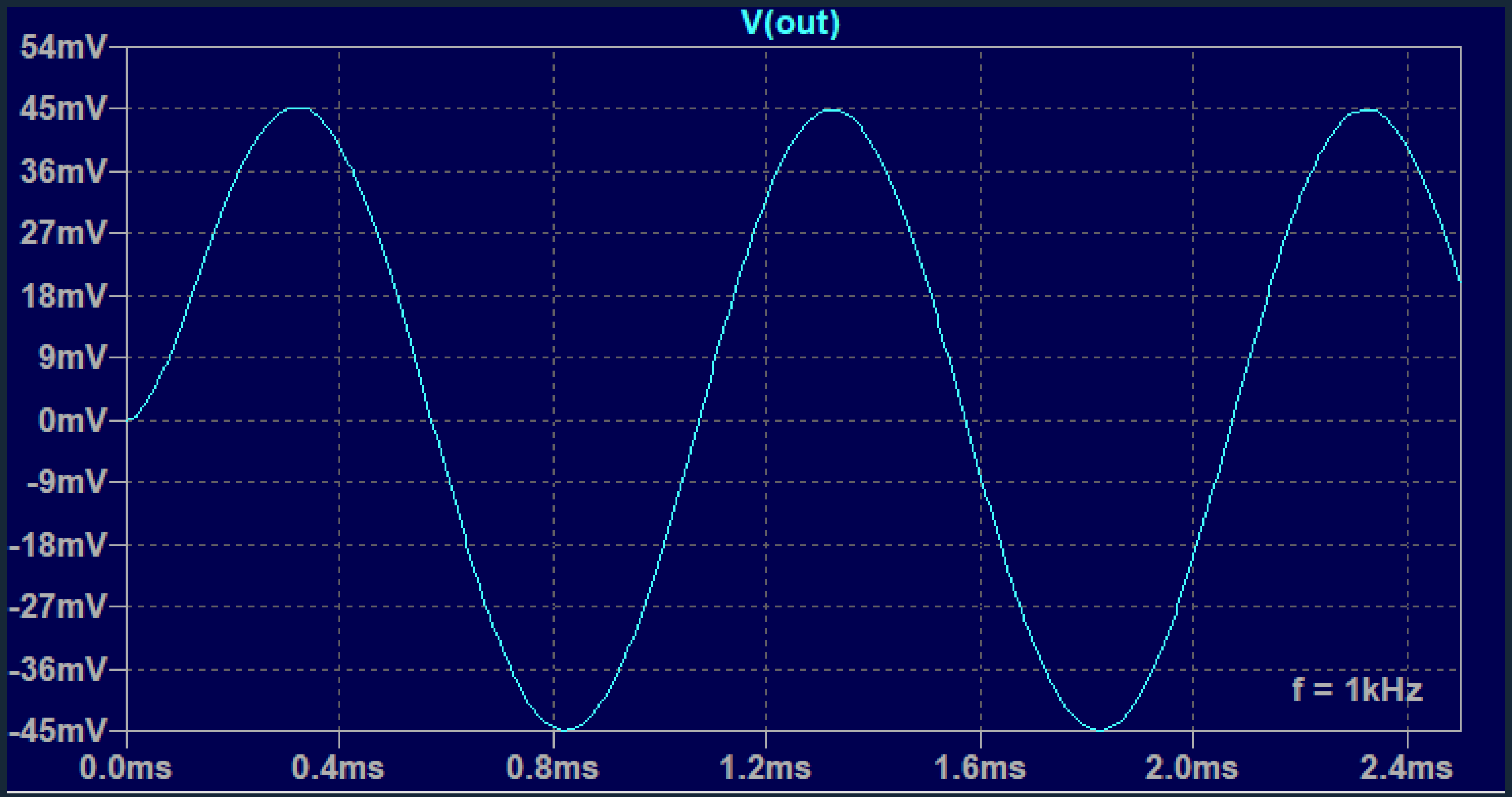
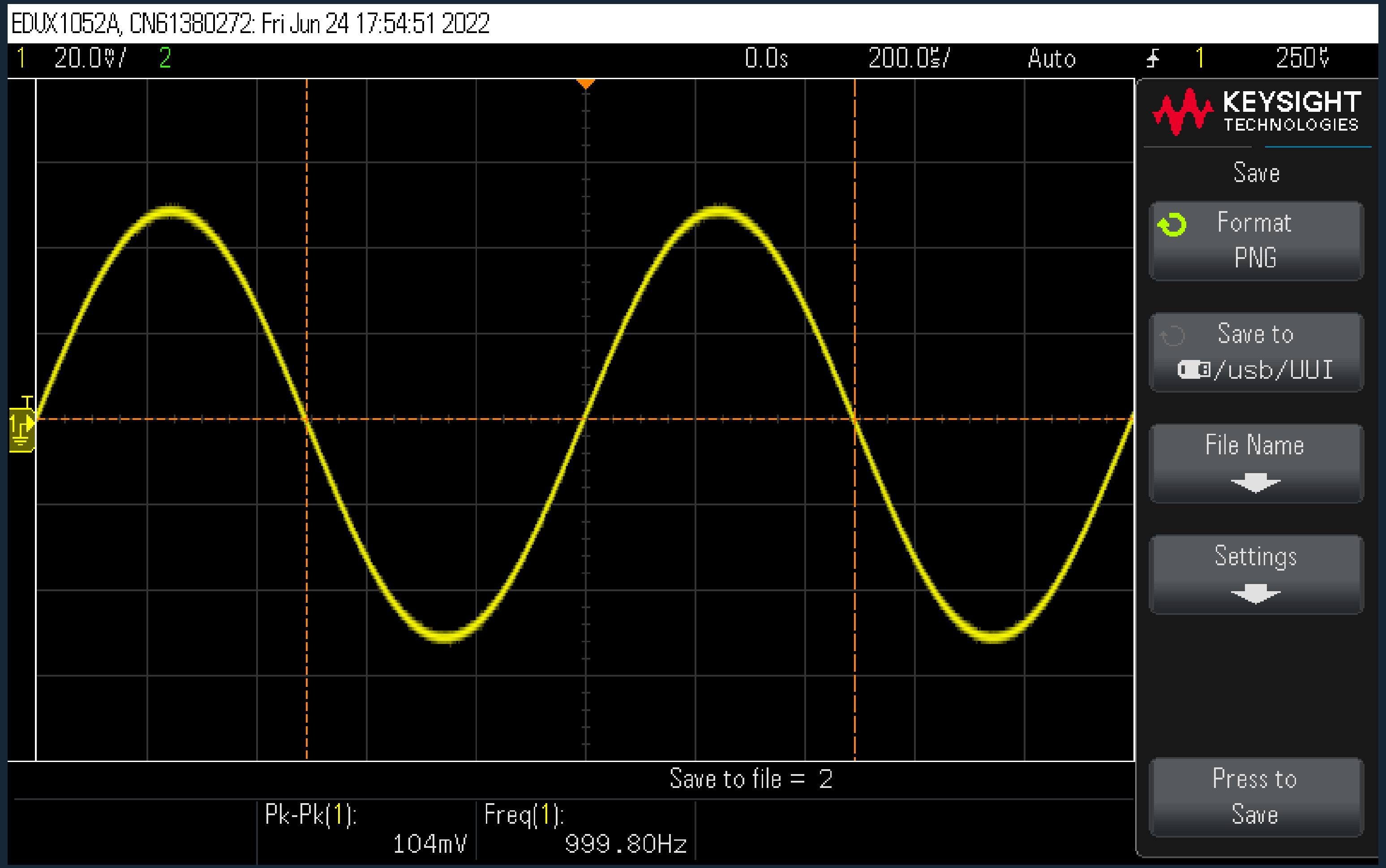
Low-Pass Filter

LT-Spice Simulations



Vpp = 90mV

DSO output

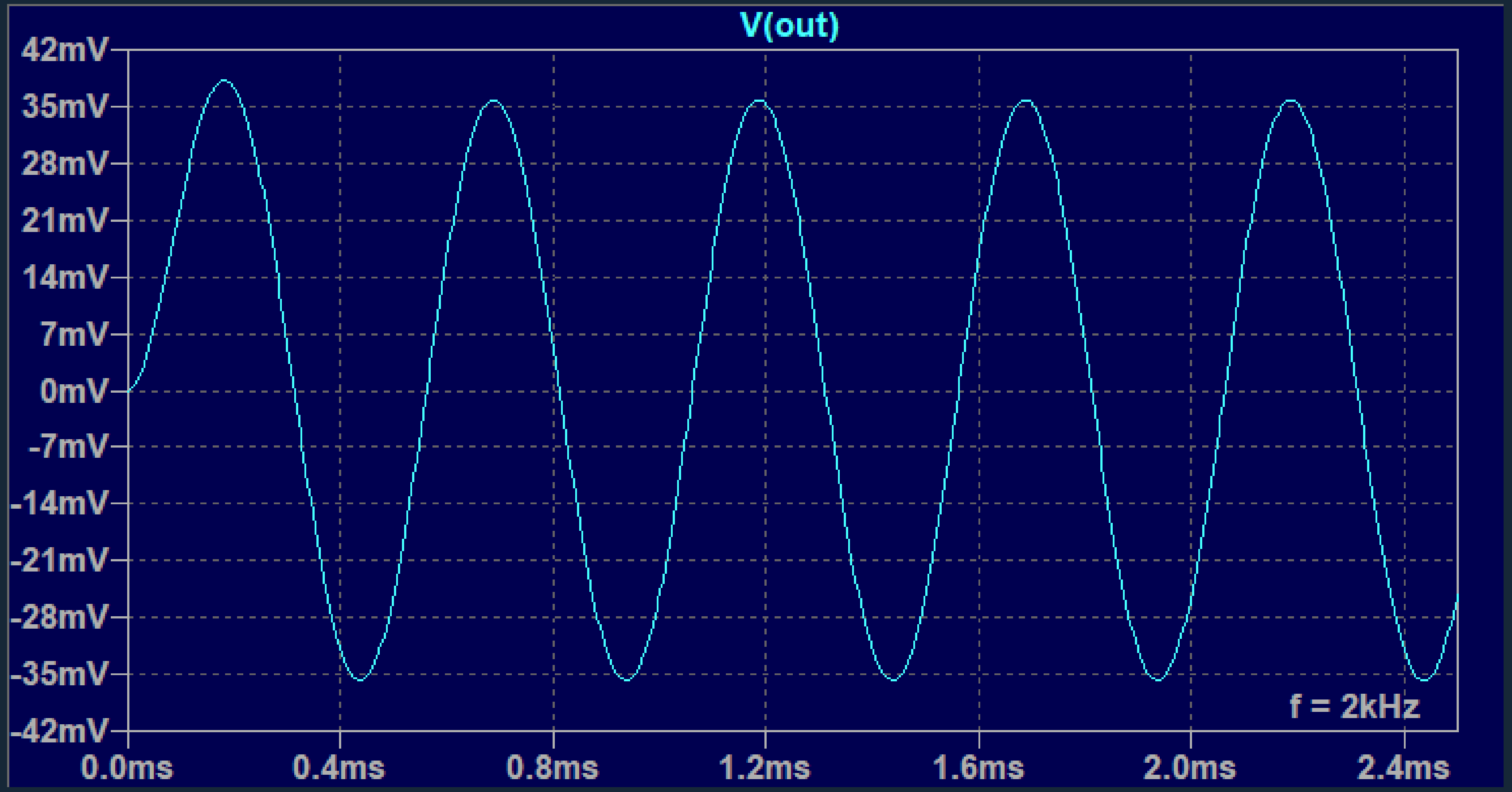


Vpp = 104mV

(Transient Response Vpp = 100mv f = 1kHz)

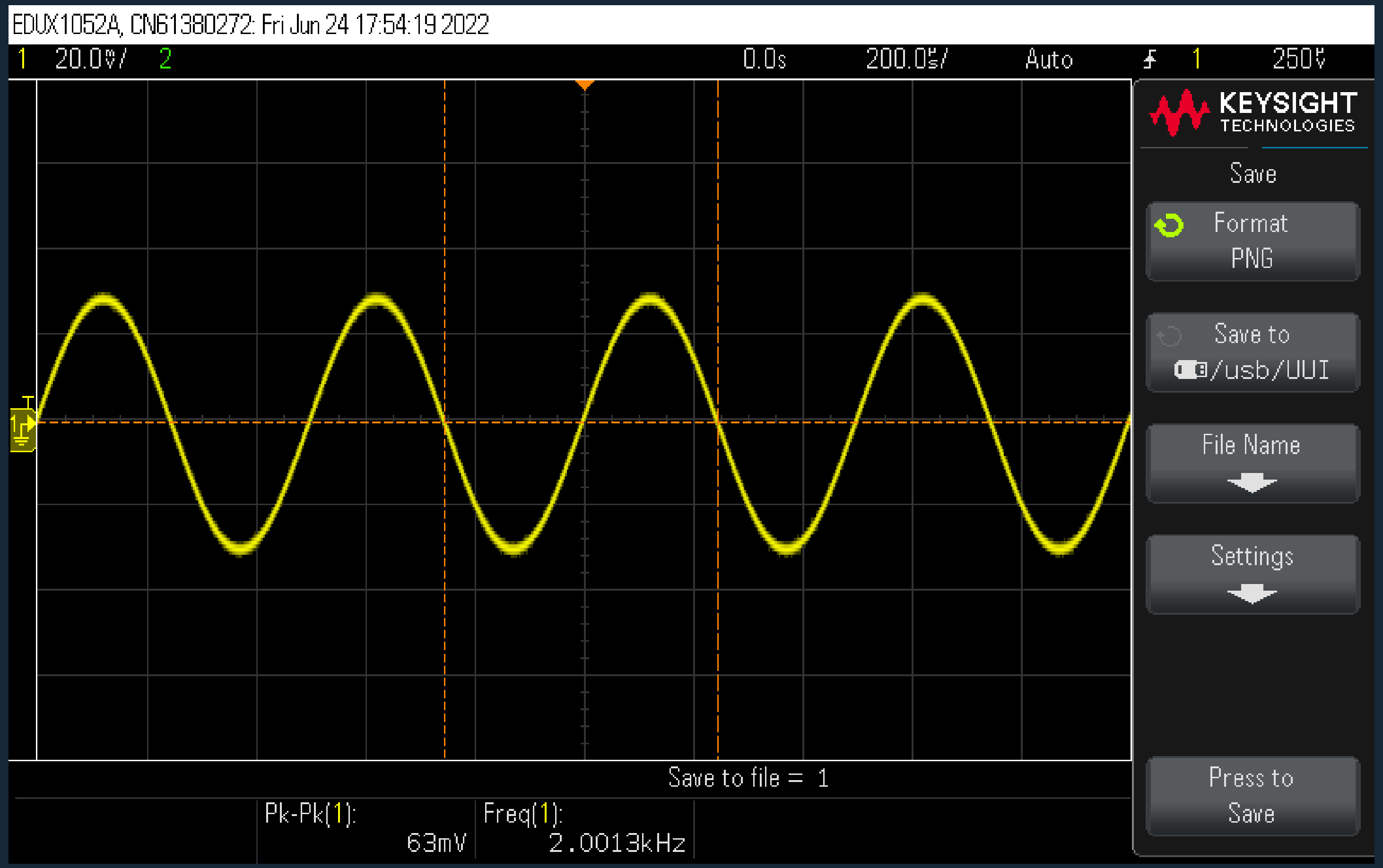
3 Low-Pass Filter

LT-Spice Simulations



Vpp = 71mV

DSO output

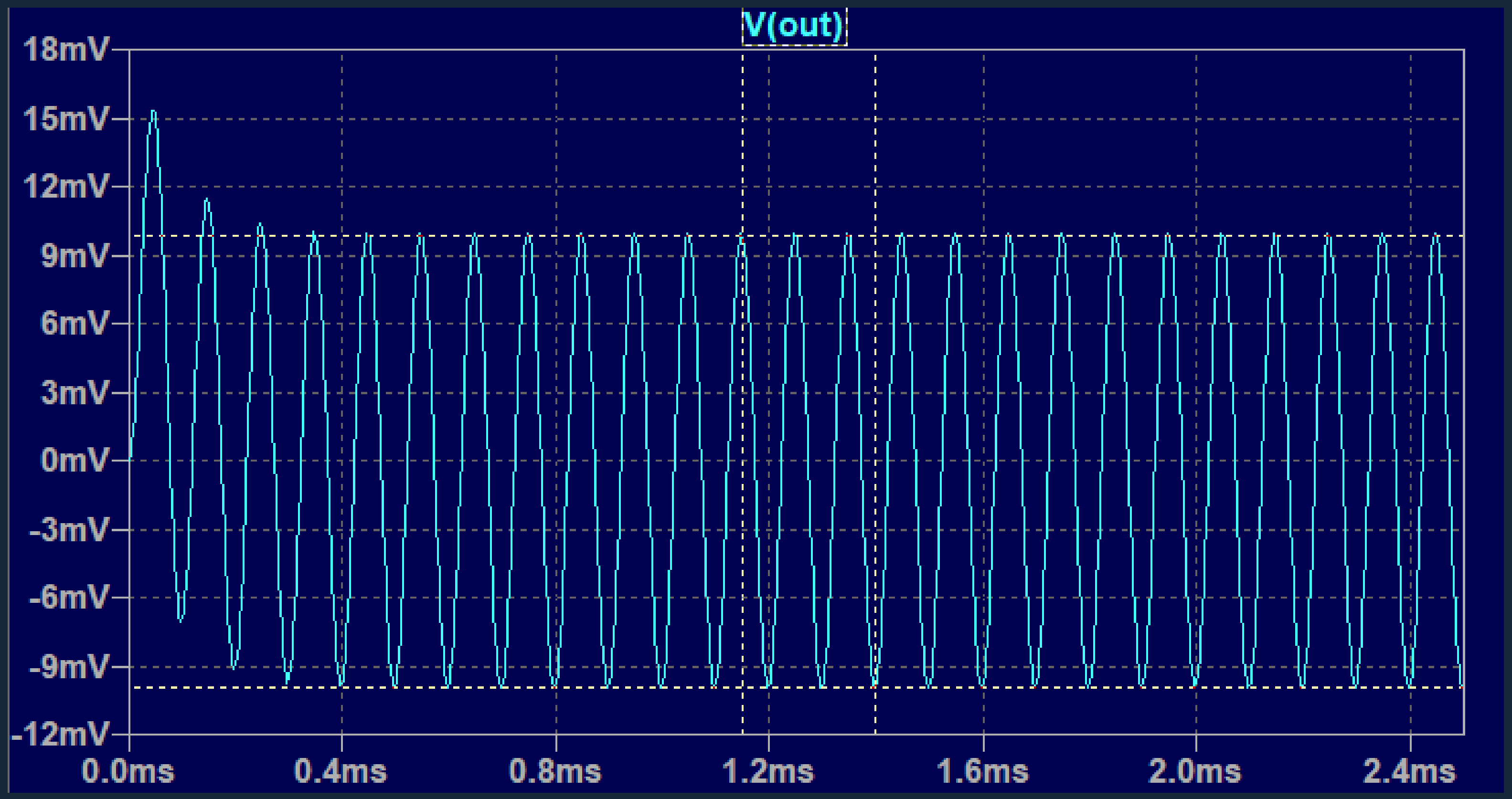


Vpp = 63mV

(Transient Response Vpp = 100mv f = 2kHz)

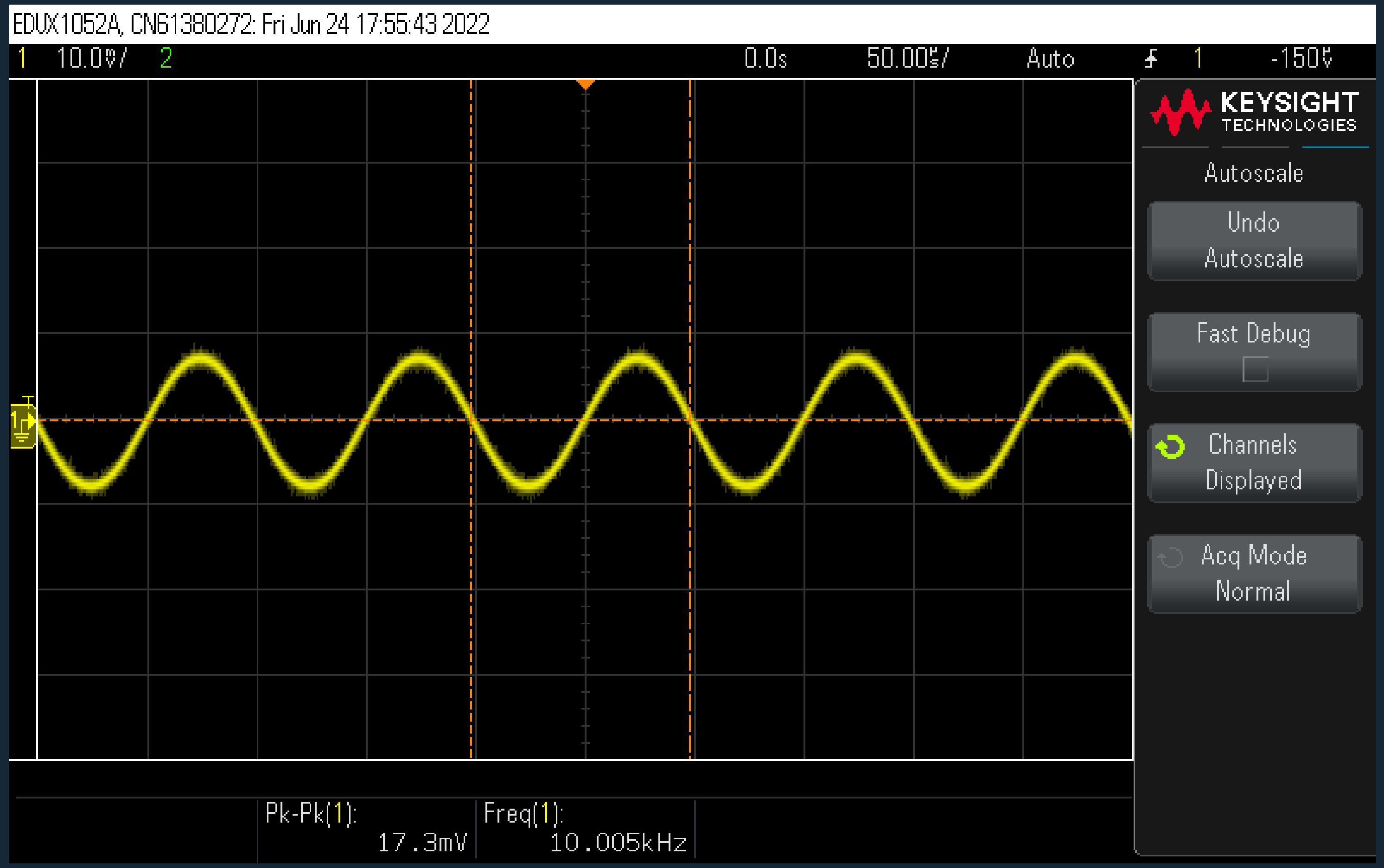
3 Low-Pass Filter

LT-Spice Simulations



Vpp = 20mV

DSO output



Vpp = 17mV

(Transient Response Vpp = 100mv f = 10kHz)

Thankyou