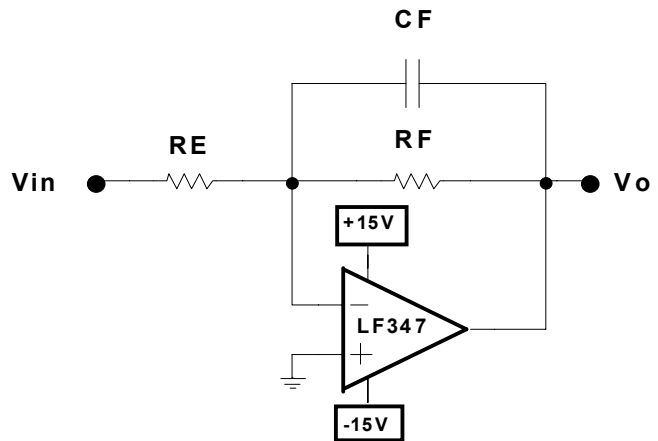


INTEGRATOR CIRCUIT AND APPLICATIONS

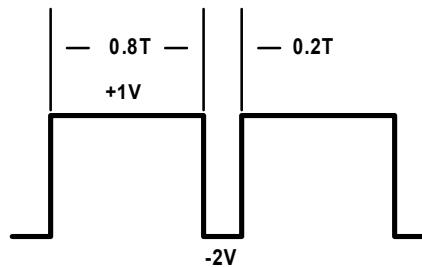
PART 1 BASIC INTEGRATOR

PRE-LAB

#	R_E	C_F	R_F
1	10K	3.30e-07	15k
2	12K	3.30e-07	15k
3	15K	3.30e-07	15k
4	18K	3.30e-07	15k
5	22K	3.30e-07	15k
6	27K	3.30e-07	15k
7	10K	3.30e-07	22K
8	12K	3.30e-07	22K
9	15K	3.30e-07	22K
10	18K	3.30e-07	22K
11	22K	3.30e-07	22K
12	27K	3.30e-07	22K



1. Draw O/P waveform with respect to V_{in} shown for frequencies of 50 Hz, 100 Hz, 1 kHz and 10 kHz - label waveforms with AC and DC values as well as PW and SW.



2. If V_{in} is a 4 V_{pp} squarewave with a 30% duty cycle, calculate the frequency of V_{in} that will produce $V_o = 0.5 V_{pp}$

3. If V_{in} is a 4 V_{pp} triangular wave with a frequency of 4 kHz, draw the expected O/P waveform with respect to V_{in} .

LAB

Verify all waveforms predicted in the pre-lab with Microcap and explain any major discrepancies. For step 1 of pre-lab, ensure that you include 50 Hz and 100 Hz in the measurements to observe the behavior of the integrator when it does not integrate: draw the "unexpected" waveforms and explain them – measure the time constant of V_o for the 50 Hz and 100 Hz cases and verify that $\tau = R_F C_F$. V_{in} is not integrated when the period of V_{in} is not much smaller than $\tau = R_F C_F$.

Include all μ Cap simulations in your lab report.

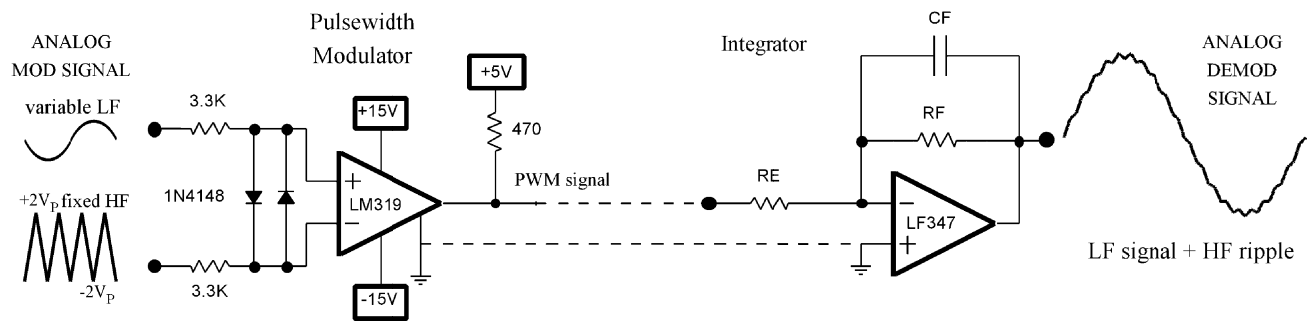
POST-LAB

Compare all pre-lab waveforms/values to the μ Cap results, highlight discrepancies and explain. Include all μ Cap simulations in report and answer all questions in lab procedure.

PART 2 INTEGRATOR PULSEWIDTH DEMODULATOR

#	F_{tri}	$F_{in\ max}$	R_F	C_F	R_E	#	F_{tri}	$F_{in\ max}$	R_F	C_F	R_E
	(Hz)	(Hz)					(Hz)	(Hz)			
1	40000	500	10000	33 nF	10000	7	52000	500	10000	33 nF	10000
2	42000	500	10000	33 nF	12000	8	54000	500	10000	33 nF	12000
3	44000	500	10000	33 nF	15000	9	56000	500	10000	33 nF	15000
4	46000	500	10000	33 nF	18000	10	58000	500	10000	33 nF	18000
5	48000	500	10000	33 nF	22000	11	60000	500	10000	33 nF	22000
6	50000	500	10000	33 nF	27000	12	62000	500	10000	33 nF	27000

PW Modulator with Active Integrator



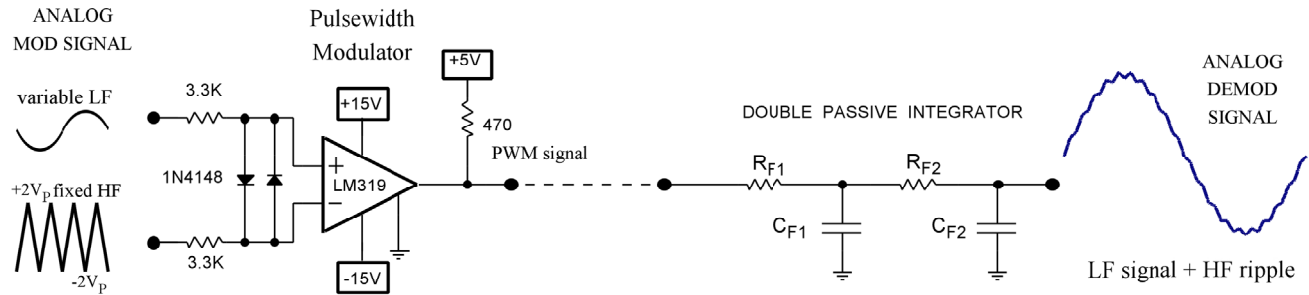
PRE-LAB

- Determine the maximum triangular ripple voltage at the O/P of the integrator – this occurs at 50% duty cycle of the PWM signal. Assume 0.5V low saturation voltage for LM319 and calculate the exact high level taking into account the loading effect of R_E .
- If the analog modulation signal is 2 V_{pp} and has 0V DC, determine the minimum and maximum duty cycle of the PWM signal and the corresponding ripple voltages at the integrator O/P. What is the worst case % ripple of the integrator O/P?

LAB

- Verify step 1 of the pre-lab by grounding the analog modulation input and observing the integrator input and output on the oscilloscope. Why is there a DC component at the integrator O/P? Calculate it theoretically.
- Apply a 2V_{pp} sinewave at 100 Hz to the mod input and verify step 2 of the pre-lab by observing the integrator input and output on the oscilloscope – record waveforms, label all relevant values.
- Vary the amplitude of the modulation input (sinewave) up and down while observing it along with the integrator output on the scope. Explain what happens and explain why the performance of the integrator is not good for low amplitude signals.
- Now keep the mod input amplitude at 2V_{pp} while observing it along with the integrator output on the scope. Explain what happens and measure record the frequency at which the integrator O/P is down by 3 dB – this the cutoff frequency of the integrator which is also a low-pass filter.

PW Modulator with Double Passive Integrator



PRE-LAB

1. Determine the maximum double integrator output ripple – this occurs again for a 50% input square wave. Assume the same PW modulator frequency and the same C_F and R_F values that you were assigned for the active integrator (in part 2, see page 2).

$$\Delta V_{C_{F1}}(PP) = \frac{1}{R_{F1}C_{F1}} \int_{t_1}^{t_2} V_{in}(AC) dt \quad \Delta V_{C_{F2}}(PP) = \frac{1}{R_{F2}C_{F2}} \int_{t_1}^{t_2} V_{C_{F1}}(AC) dt \quad \text{if } F \gg \frac{10}{2\pi R_F C_F}$$

LAB

1. Ground the mod input of the PW modulator and observe the ripple waveforms across C_{F1} and C_{F2} on the scope, record the waveforms and label them with pp ripple and DC voltage. Compare to pre-lab values.
2. Apply a $2V_{pp}$ sine wave modulation signal at 100 Hz and observe the integrator O/P on the scope along with the mod signal. Vary the mod signal amplitude from 0 to $2V_{pp}$ and observe the performance of the double integrator. What is the minimum amplitude of V_{mod} below which the % ripple of the integrator O/P is unacceptable – say 10% ripple?
3. Measure the cutoff frequency of the double integrator by increasing F_{mod} until the integrator O/P is down 3 dB – record the frequency and compare to the active integrator cutoff frequency, which is better, explain.

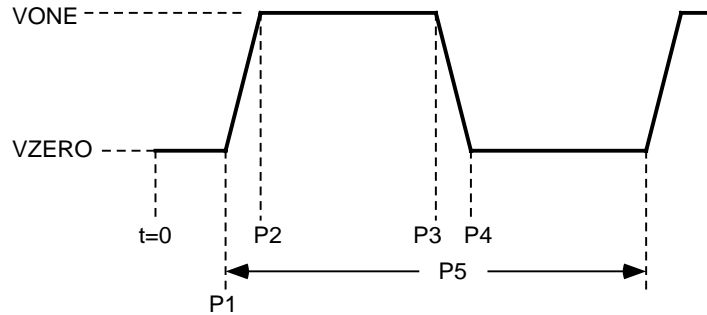
EDITING THE PULSE SOURCE

SQUARE WAVE

To edit the pulse source parameters, double-clicking the source symbol in the "select" mode and use the following values:

VONE=5V VZERO=-5V P1=0 P2=1n P3=1m P4=1m+1n P5=2m

The above parameters define a 10V_{pp} 500 Hz squarewave with 1ns rise and fall times and 50% duty cycle. The parameters of the pulse source are defined on the waveform shown below.



TRIANGULAR WAVE

VONE=0.15V VZERO=-0.15V P1=0 P2=1m P3=1m P4=2m P5=2m

The above parameters define a 500 Hz triangular wave with A 0,3 V_{PP} amplitude.

