Exercise #1: Raw Data and Error Estimate

Part A: Spectrum of Carrier Sinusoidal Signal and Baseband Signal

A1-Spectrum of carrier signal (carrier generator is connected to CH 1)

f_c = 25 kHz; A_c = 4V

Power Spectrum of Sinusoidal Carrier signal [V_{rms}]

Frequency [kHz]					25.00				
1) Theoretical (rms)					2.828				
2) Measured (rms)					2.66				
3) Error					=.06				

f_m = 1 kHz; Am + DC = +4V + 0V

Power Spectrum of baseband signal [V_{rms}]

Frequency [kHz]	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00
1) Theoretical (rms)	3.64	0	1.2	0	0.72	0	0.52	0	0.4
2) Measured (rms)	3.64	0	1.17	0	0.67	0	0.43	0	0.29
3) Error (%)	0	0	.03	0	.07	0	.17	0	.28

Part B: Transmitted Carrier AM Signal With Square Wave Baseband

f_c = 25 kHz; A_c = 4V

f_m = 1.000 kHz; A_m = 4V (i = 100%); DC $shift_{resulting}$ = +4V

Power Spectrum of DSBTC modulated signal [V_{rms}]

Frequency [kHz]	21.00	22.00	23.00	24.00	25.00	26.00	27.00	28.00	29.00
1) Theoretical ($K_{AM} = 1$)	0	2.399	0	7.19	11.31	7.19	0	2.399	0
2) Measured ($K_{AM} \neq 1$)	0.01	0.18	0.01	0.54	0.85	0.57	0.02	0.18	0.01
3) Measured Multiplied K_{AM}	0	2.28	0	6.83	10.75	7.21	0	2.28	0
Error (V). 1) – 3)	0	.119	0	.36	.56	-.02	0	.119	0

$K_{AM.Average} = \frac{K_p + K_V}{2} = 12.645$

Uncertainty of Baseband Amplitude Measurement (express as percentage) $\underline{\pm 0.04V}$ 1.4%

Theoretical power of DSBTC AM signal ($K_{AM} = 1$) 256 W_T

$W_M\ power\ =$ 1.78 W

256 W_T : 1.78 W_M = K^2

Value of $K_{AM.(P)}$ calculated from power

$K_P = \sqrt{K^2}$ = 11.99

Theoretical Value of modulated signal

Carrier spectrum

11.31 V_T

Measured Value of modulated signal

Carrier spectrum

0.85 V_M

$K_{AM.V}$ calculated : from spectrum V_T : V_M

K_V= 13.3

Bandwidth (EBW) of Signal (measured) 1.8 kHZ

$K_{AM.Average.} =$ $\frac{K_p + K_V}{2}$ = 12.65

Sampling Error (from LabVIEW) $\underline{\pm 0.04\ V}$

Power (Theoretical) = $\frac{1}{2} * \frac{((A_m+DC)*A_C)^2}{(\sqrt{2})^2}$

Part C: Suppressed Carrier AM Signal with Squared Wave Baseband

DSBSC AM signal:

f_c = 25 kHz; f_m = 1.000 kHz; $DC\ (shift)_{resulting}$ = 0V

A_C = A_m = 4V

Theoretical Power

$\frac{(A_m * A_c)^2}{(\sqrt{2})^2}$ 128 W

Bandwidth (EBW) 5.4 kHz

Sampling Error $\underline{\pm .02V}$

(From LabVIEW)

Measured Power $P_{exp}(\ 0.952)\ * K^2\ (134.45)$ = $\underline{128}\ P_{Theor}$

Power Spectrum of DSBSC baseband signal [V_{rms}]

Frequency [kHz]	21.00	22.00	23.00	24.00	25.00	26.00	27.00	28.00	29.00
1) Theoretical (rms)	0	0.21	0	0.53	0	0.53	0	0.21	0
2) Measured (rms)	0.01	0.17	0.02	0.58	0.04	0.62	0.01	0.17	0.01
3) Error (%)	0	.19	0	.09	0	.17	0	.19	0

Part D: FM Signal With square waveform Baseband

$FM\ with\ k_f = 1$

$f_c = 25\ kHz; A_c = 4V; A_m = 2.94\ V; f_m = 1.000\ kHz$

Value of K_{FM} = $2\pi * 340 \pm 5$

Calculate A_m value to get k_f = 1,

$K_f = \frac{K_{FM} * A_m}{2\pi * f_m} = 1$ A_m = 2.94 V

Power Spectrum of modulated signal [V_{rms}]

Frequency [kHz]	21.00	22.00	23.00	24.00	25.00	26.00	27.00	28.00	29.00
Measured (rms) ($k_f = 1$)	0.08	0.01	0.57	1.35	1.72	1.43	0.61	0.01	0.12

Amplitude Modulation and Frequency Modulation

CS M117 Laboratory Exercise 1

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Observation

Experiment 1 explored the effects of modulating a carrier waveform by a baseband signal in terms of amplitude, phase, and frequency. We measured both the power spectrum and bandwidths of the resulting signals. Finally, we saw the different shapes of amplitude, power, and frequency-modulated (AM, PM, and FM) signals in the time domain.

Our experimental values were relatively close to our theoretical values for the most part. However, in some cases, such as measuring the power spectrum of the baseband signal and DSBSC baseband signal, percentage error changes along the frequency axis. In other words, error seems to increase for rms values farther from the maximum rms value. This may be the result of a fluctuating generated frequency, inaccurate DC offset, or maybe because it is harder to read smaller rms values accurately. As for the remainder of the lab, power requirements and effective bandwidth seem to be measured accurately enough.

Goals and Results

#	Main Goals	Results with error
1	Find the shape of the AM, PM and FM signals in time domain for rectangular baseband signals with sinusoidal carrier	The resulting waveform and power spectrum signals in time domain for both rectangular and sinusoidal can be seen in the printed graphs A2 and A1, respectively.
2	Find the effective bandwidth (EBW) of AM, PM and FM signals and estimate the power requirements for APM, PM and FM	For AM transmitted, suppressed, and FM signals, the EBW values were approximately 1.8 kHz, 2 kHz, and 5.4 kHz, respectively. Power values for AM transmitted and suppressed were approximately 1.78 W and 0.952 W.
3	Find the power spectrum of AM, PM and FM signals and their bandwidth (EBW)	AM transmitted and suppressed signals were relatively accurate in expected power spectrum values, with less than 10% error for most rms values (except rms values far away from the max rms). Similarly, the FM power spectrum appeared to be consistent and symmetric with our calculations. EBW values are also on the generated graphs.
4	Compare the obtained results of FM signals with AM signals; make conclusion about required bandwidth (EBW) and power	When comparing the values of FM and AM, we see that the bandwidths (EBW) are about the same, but FM has more prominent power spectrum peaks and has higher values of required power.
5	Find how your measured data of modulated signal are close to the theoretical	Our measured data of the modulated signals is relatively close to expected theoretical values. The less accurate rms values that had greater error could be attributed to unstable generated frequencies. Overall, experimental values reflected our theoretical calculations in bandwidth and power as well.