1. Process of putting information onto a high-frequency carrier for transmission.

2. The frequency that is used to "carry" the intelligence.

3. to provide separate carriers for different intelligence
   the difficulty of transmitting signal at very low frequencies

4. amplitude, frequency, and phase

5. MF - 300kHz to 3MHz
   HF - 3 to 3- MHz
   VHF - 30 to 300MHz
   UHF - 300 MHz to 3GHz
   SHF - 3 to 30 GHz

6. $$dB\mu V = 20\log\frac{.4\mu V}{1\mu V} = -\mathbf{7.95}$$

7. $$10\,dBm = 20\log\frac{V}{.774}$$
$$[\log^{-1}(.5)][.774] = V = \mathbf{2.45\,V}$$

8. $$P = \frac{V^2}{R}$$
$$\frac{P_{out}}{P_{in}} = 15 = \frac{(V_{out})^2/R}{(V_{in})^2/R}$$
$$\frac{V_{out}}{V_{in}} = \sqrt{15} = \mathbf{3.87}$$

9. $$(a)\;\; dBm = 10\log\frac{1}{.001} = \mathbf{30\,dBm}$$
$$(b)\;\; dBm = 10\log\frac{.001}{.001} = \mathbf{0\,dBm}$$
$$(c)\;\; dBm = 10\log\frac{.0001}{.001} = -\mathbf{10\,dBm}$$
$$(d)\;\; dBm = 10\log\frac{25\times10^{-6}}{.001} = -\mathbf{16\,dBm}$$

10. $$(a)\;\; 38dBm = 10\,\log\frac{P}{.001} \quad P = \mathbf{6.3W}$$

$$(b)\quad 10\log\frac{6.3}{1} = \mathbf{8\,dBW}$$

11.

$$-70\,dBm = 20\log\frac{V}{.774}$$
$$\therefore V = \mathbf{.245\,mV}$$

12. $$dBmV = 20\log\frac{50\,\mu V}{1\,\mu V} = \mathbf{34\,dB\mu V}$$

13. $$dBm = 20\log\frac{2.15V}{.774\,V} = \mathbf{8.86\,dBm(600)}$$

14. $$dBm = 20\log\frac{2.15}{.2236} = \mathbf{19.66\ dBm(50)}$$

15. any undesired voltages or currents that end up appearing in a circuit

16. external noise - noise in a received radio signal that has been introduced by the transmitting medium
internal noise - noise in a radio signal introduced by the receiver

17. man-made noise, atmospheric noise, space noise

18.

$$\begin{aligned}e_{noise} &= (4kT\Delta f R)^{1/2}\\ &= 4\times1.38\times10^{-23}(273+27)\times10^{6}\times10^{6})^{1/2}\\ &= (16.56\times10^{-9})^{1/2}\\ &= 128.7\times10^{-6}\\ &= \mathbf{128.7\,\mu V\,rms}\end{aligned}$$

19.

$$e_{noise} = (4kT\Delta fR)^{1/2}$$
$$240\mu V/75 = (4\times1.38\times10^{-23}\times(273+27)\times10^{5}\times R)^{1/2}$$
$$3.2\times10^{-6} = (1.711\times10^{-15}R)^{1/2}$$
$$(3.2\times10^{-6})^2 = (1.711\times10^{-15}R)$$

$$R = \frac{10.24\times10^{-12}}{1.711\times10^{-15}}$$

$$R = \mathbf{5.985\,k\Omega}$$

At 25 kHz bandwidth,

$$e/75 = (4\times1.38\times10^{-23}\times310\times25\times10^{3}\times5.985\times10^{3})^{1/2}$$
$$e_{noise} = \mathbf{120\,\mu V}$$

20. low-noise resistor - a resistor that exhibits low levels of thermal noise

21. 128.7 uV/1 Mohm equals approximately 129 pico amps
The noise current increases with the increase in temperature

22.

$$\frac{e^2{}_n}{\Delta f} = kTR = (1.6x10^{-20})(20x10^3) = 3.2x10^{-16}$$

$$e_n = 20\mu V \therefore \Delta f = 1.25\,MHz$$

23. $$\frac{S}{N} = \frac{signal\ power}{noise\ power}$$

$$= \frac{(4V)^2/\acute{R}}{(0.48V)^2/\acute{R}} = \mathbf{69.44}$$

$$S/N(db) = 10\ \log_{10} S/N$$

$$= 10\ \log_{10} 69.44$$
$$= \ \mathbf{18.42}\,\boldsymbol{dB}$$

24. $$\boldsymbol{NF} = 10\ \log_{10} \frac{S_i/N_i}{S_o/N_o}$$

$$= 10\ \log_{10} \frac{110}{69.44} \ = \ \mathbf{1.998}\,\boldsymbol{dB}$$

$$NR = \frac{110}{69.44} = \mathbf{1.584}$$

25.

$$\boldsymbol{NF} = 10\ \log_{10} \frac{S_i}{N_i} - 10\ \log_{10} \frac{S_o}{N_o}$$

$$6\,dB = 25\,dB - 10\ \log \frac{S_o}{N_o}$$

$$S/N\ dB = 10\ \log \frac{S_o}{N_o} = 25dB - 6dB = \mathbf{19}\boldsymbol{dB}$$

$$S_o/N_o\ as\ a\ ratio\ =\ 10^{19/10} = 10^{1.9} = \mathbf{79.4}$$

26.

$$NR = 5 + \frac{10-1}{50} + \frac{10-1}{50x1000} = 5.18$$

$$NF = 10\log NR = 10\log 5.18 = \mathbf{7.143\mathit{dB}}$$

27.

$$NR_1 = antilog\ NF_1 = antilog\ 2.4\,dB = 1.74$$
$$NR_2 = antilog 6.5\,dB = 4.47$$
$$P_{G_1} = antilog\,8\,dB = 6.31$$
$$P_{G_2} = antilog\,40\,dB = 10{,}000$$
$$\therefore NR = 1.74 + \frac{4.47-1}{6}.31 = \mathbf{2.29} \qquad \therefore NF = 10\log 2.29 = \mathbf{3.6\,\mathit{dB}}$$
$$P_{noise\ input} = kT\,\Delta f$$
$$= 1.38\times10^{-23}\times300\times\frac{\pi}{2}\times150\times10^{3} = \mathbf{9.75\times10^{-16}\mathit{W}}$$

$$e_{noise\ input} = (4\ R\ P^{1/2}_{noise\ input} = \mathbf{19.8\,\mu\mathit{V}}$$

$$NR = \frac{S_i/N_i}{S_i/N_i}\ and\ \frac{S_o}{S_i} = P_G = 10{,}000\times6.31 = 63{,}100$$
$$\therefore 2.29 = \frac{1}{63{,}100}\times\frac{N_o}{N_i} = \frac{N_o}{63{,}100\times9.75\times10^{-16}}$$
$$N_o = 2.29\times9.75\times10^{-16}\times63{,}100 = \mathbf{1.41\times10^{-10}\mathit{W}}$$
$$P = \frac{V^2}{R} \therefore e_{noise\ output} = (N_o\times R)^{1/2}$$
$$= (1.41\times10^{-10}\times300)^{1/2} = \mathbf{0.206\,\mathit{mV}}$$

28.

$$N = kT\,\Delta f = 1.38\times10^{-23}\times(25+30+60)\times2\times10^{6} = \mathbf{3.17\times10^{-15}\,\mathit{W}}$$

$$NR = T_{eq}/T_0 + 1 = 60/290 + 1 = \mathbf{1.21}$$

$$NF = 10\log NR = 10\log 1.21 = \mathbf{0.817\,\mathit{dB}}$$

29.

$$SINAD = 10\log\frac{S+N+D}{N+D} = 10\log\frac{15.7}{0.015} = 30.19\,dB$$

30. The ratio of the signal + noise + distortion power out to the output signal + noise power,

31.

$P_n = kT\,\Delta f$
$= 1.38\times10^{-23}\times(45+35)\times5\times10^{6} = \mathbf{5.52\times10^{-15}}\boldsymbol{W}$

32. $S/N = 100$
$S = 100\times5.52\times10^{-15}W = \mathbf{5.52\times10^{-13}}\boldsymbol{W}$

33.

$NR = 20I_{dc}R = 20\times0.3\,mA\times300\,\Omega = 1.8$

$NF = 10\log 1.8 = \mathbf{2.55}\,\boldsymbol{dB}$

$T_{eq} = T_0(NR-1) = 290(1.8-1) = \mathbf{232}\,\boldsymbol{K}$

34. A diode is used to generate a reference noise. The signal level of the device under test is then matched to the diode's level. Equation 1-19 is then used to obtain the noise ratio.

35. DUT - Device Under Test

36. the noise signal is connected to both channels of a dual trace oscilloscope. The vertical position is adjusted until the dark band between the traces disappears. The resulting separation in the signals (according to the scope channel settings) is twice the rms noise.

37. information theory - concerned with the optimization of transmitted information

38. Hartley's Law - information that can be transmitted is proportional to the product of the bandwidth times the time of transmission, This means that the greater the bandwidth the more information that can be transmitted.

39. harmonic - it is a multiple of the fundamental frequency

40.

$7\times360\,kHz = \mathbf{2{,}520}\,\boldsymbol{kHz}$

41. the square wave contains many harmonic frequencies, the sine wave just contains the fundamental frequency.

42. use Figure 1-12 as a reference. The period and the harmonics will change because of the 2kHz sine wave signal.

43. Fourier Analysis - method of representing complex repetitive waveforms by sinusoidal components

44. Refer to Figure 1-13

45.

$$v = \frac{8V}{\pi^2}[\cos\omega t + \frac{1}{9}\cos 3\,\omega t + \frac{1}{25}\cos 5\,\omega t]$$

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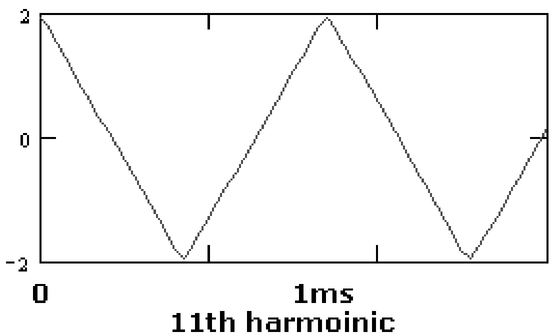
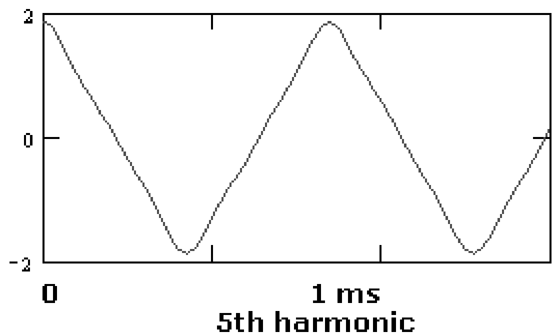




46.

(*a*) $10\,ks/s$

(*b*) $750\,Hz$

47.

(*a*) $37.5\,kHz, 62.5\,kHz$

(*b*) *The period off the square wave is* $80\,\mu s$.
$f = \frac{1}{T} = \frac{1}{80\times10^{-6}} = 12.5\,kHz$. *Also, the first harmonic in the FET spectrum is at* $12.5\,kHz$

48. Inductors - store energy in the surrounding magnetic field
capacitor - stores energy between the plates
(Q) quality factor - ratio of the energy stored to the energy lost

49. resonance - when $X_C = X_L$

50.

$$f = 100\,MHz \quad L = 6mH \quad R = 1.2k$$

$$Q = \frac{\omega L}{R} = \frac{2\pi(100\,MHz)(6x\,10^{-3})}{1.2x10^{3}} = 3.14x\,10^{3}$$

$$D = \frac{1}{Q} = 0.318x\,10^{-3}$$

51.

$$f = 100\,MHz \quad C = .001\mu F \quad R = .7x\,10^{6}$$

$$Q = \frac{\omega C}{G} = \frac{2\pi(100x\,10^{-6}}{\frac{1}{.7x10^{-6}}} = 4.398x\,10^{5} \qquad D = \frac{1}{Q} = 2.27x\,10^{-6}$$

52.

At 100 *MHz*

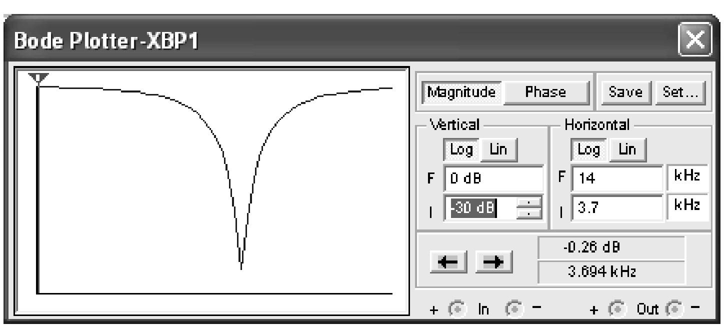
$$\begin{aligned} Z_{ind} &= R + jX_L \\ &= 1.2\times10^{3}\times j2\pi\times10^{8}\times6\times10^{-3} \\ &= 1.2\times10^{3}\times j37.7\times10^{5} \simeq \boldsymbol{j37.7\times10^{5}} \end{aligned}$$

$$\begin{aligned} Z_{cap} &= R \| -jX_C \\ &= 0.7\times10^{6} \| -j\frac{1}{2\pi\times10^{8}\times0.001\times10^{-6}} \\ &\approx 0.7\times10^{6} \| -j1.592\,\Omega \end{aligned}$$

$$\begin{aligned} Z_{TOT} &= Z_{ind} + Z_{\cap} \\ &= j37.7\times10^{5} - j1.592\,\Omega \simeq \mathbf{37.7\ M\Omega} \end{aligned}$$

$$f_r = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\pi(6\times10^{-3}\times0.001\times10^{-6})^{1/2}} = \mathbf{65\,kHz} \quad At\ f_r,\ Z \simeq R_{ind} = \mathbf{1200\,\Omega}$$

53. At 4KHz , e out ~ 0.96V at 6KHz e out ~ 0.8V



54. see Fig. 1-17

55. as Q increases the filter becomes more selective
the limiting factor is the resistance factor (see equation 1-21)

56.

$$Q = \frac{f_r}{BW} = \frac{10.7\times 10^6}{200\times 10^3} = \mathbf{53.5}$$

57.

$$f_r = \frac{1}{2\pi\sqrt{LC}} \;=\; 10.7\times 10^6 = \frac{1}{2\pi(L\times 0.1\times 10^{-9})^{1/2}}$$

$$\therefore\; L = \mathbf{2.21\mu H}$$

$$Q = \frac{X_L}{R} = \frac{2\pi\times 10.7\times 10^6\times 2.21\times 10^{-6}}{R} = 53.5$$

$$\uparrow \; from\; Prob. 51$$

$$R = \frac{2\pi\times 10.7\times 10^6\times 2.21\times 10^{-6}}{53.5} = \mathbf{2.78\;\Omega}$$

58.

$$Z_{res} = Q^2R = 60^2\times 5\;\Omega = \mathbf{18\;k\Omega}$$

59.

$$f_r = \frac{1}{2\pi\sqrt{LC}} \;=\; \frac{1}{2\pi(27\times 10^{-3}\times 0.68\times 10^{-6})^{1/2}} \;=\; \mathbf{1175 Hz}$$

$$Q = \frac{X_L}{R} = \frac{2\pi\times 7{,}148\times 10^3\times 27\times 10^{-3}}{4} = \mathbf{49.8}$$

$$Z_{\max} = Q^2R = (49.8)^2\times 4\;\Omega = \mathbf{23.6\;Hz}$$

$$BW = \frac{f_r}{Q} = \frac{1{,}175\;Hz}{49.8} = \mathbf{23.6\;Hz}$$

$$f_{lc} \simeq f_r - \frac{BW}{2} \;=\; 1{,}175 - \frac{23.59}{2} \;\simeq\; \mathbf{1163\;Hz}$$

$$f_{hc} \simeq f_r + \frac{BW}{2} \;\simeq\; \mathbf{1187\;Hz}$$

60. constant-k filters - capacitance and inductive reactive resistance made equal to some constant k.
m-derived filters - use a tuned circuit in the filter to provide nearly infinite attenuation at a specific frequency

61. above 100 MHz - use LC
below 100 MHz - use RC

62. at high frequencies the leads exhibit stray inductance and capacitance

63. number of RC or LC sections in a filter
Note: There is also a mathematical relationship for filters that uses the poles term in filter circuits.

64. they use a constant-k value for the inductive and capacitive reactance values

65. see Figures 1-23 and 1-24.

66. The capacitor in series with the inductor swamps out the transistor's internal capacitances thereby negating transistor variation and increasing stability.

67. A Pierce crystal oscillator is provided in Fig. 1-27. The crystal has a fixed resonant frequency.

68.

There are 2.592×10^{6} *second per month* $(60\times60\times24\times30)$

$$\therefore \pm 15\, s/month$$

$$= \pm\ \frac{15}{2.592\times10^{6}}$$

$$= \pm\ 5.787\times10^{-6} = \pm\ \mathbf{5.787}\ \boldsymbol{ppm}$$

69. Symptoms, Signal Tracing and Injection, Voltage and Resistance Measurements Substitution or check the AC connection, check fuses, check input/output connections, ask yourself if you forgot something also, check visual inspection and all of your senses, check power supplies, verify input and output signals

70. Good components can get damaged in the substitution process.

71. Voltages will cause incorrect resistance measurements. The power must be turned off and the component isolated.

72. complete failures, intermittent faults, poor system performance, induced failures

73. When tracing through a multiple stage circuit for a fault.

74. a distorted sine wave or a flat line

75. at series resonance the crystal should have a low resistance
at parallel resonance the crystal will have a high resistance

76. the answer should include at least two of the following issues
- limitation of the electronics (eg. noise)
- the bandwidth limitation of the communications channel

77.

$$Assume\ T = 27^oC$$

$$At\ the\ input,\ e_{noise} = (4kT\Delta f R)^{1/2}$$

$$= (4\times 1.38x10^{-23}(273+27)\times 200\times 10^3\times 2\times 10^3)^{1/2} = \mathbf{2.574\mu V}$$

$$\therefore \frac{S_i}{N_i} = \frac{(1mV)^2}{(2.574V)} = 150.9\times 10^3$$

$$NF = 10\log\frac{S_i/N_i}{S_o/N_o}$$

$$\frac{S_i/N_i}{S_o/N_o} = antilog\ 5/10 = 3.162$$

$$\therefore \frac{150.8\times 10^3}{S_o/N_o} = 3.162$$

$$S_o/N_o = 47.73\times 10^3$$

$$S_o = 1mV\times 100 = 100mV$$

$$\therefore (N_o)^2 = \frac{100mV)^2}{47.73x10^3} \qquad N_o = \mathbf{458\mu V}$$

78. Noise temperature measurements are more common and these are based more on the system rather than the device.

79. This is verified when an oscillator won't maintain oscillations. The level of positive feedback might need to be adjusted for proper operation.