Quizzes

This Thursday, in both classes (220 and 222).

Measuring Power in Decibels

Since decibels compare powers, they cannot be used directly to measure a single power. You can't measure a power of 25 watts directly in decibels.

If you compare a power value (like 25W) against a reference power (1W) then you can use decibels. When this is done, then the reference value is appended to the decibel symbol to give a measurement of **dBW** (decibels compared to one watt). In this example, it would be 14 dBW. 10 * log(P2/P1) = 10 * ln(P2/P1) / ln(10) = 14.

Thus a power of 25W becomes a power of 14 dBW because it is 14 dB greater than 1W. 25 W is *not* 14 dB – it must be expressed as 14 dBW.

Decibels are a unit-less ratio.

Another value commonly used as a comparison power is 1 milliwatt and the unit is **dBm**. 10 * log (power/0.001). 10 * log(25/(10^{-3})) = 44 dBm. Notice the 30 dB difference between dBW and dBm; this expresses the difference between watts and milliwatts. One watt is 1000 milliwatts, or 10^3 milliwatts, which is a difference of 30 dB. Often used in low power radio transmitters or telephony.

A power of 23 dBm means a power level that is 23 dB greater than 1 mW, or 200 times greater than 1 mW, or a power of 200 mW.

VU

Many professional audio systems have signal level meters calibrated in dBm. They are often called **Volume Units** or **Vu**s.

DBA (A for Audible)

When sound levels are being measured, the power density (watts per square meter) of the sound is often measured in dBA. The reference power level is the power density of the quietest sound that the human ear can detect under perfect conditions. The reference level is 0 dBA. Very loud sounds have powers around 100 dBA while aircraft engines may exceed 130 dBA; peace and quiet comes in at 40 dBA. Sound levels are often reported in some number of decibels when they usually mean dBA.

What Exactly Is A Log?

In mathematics, the **logarithm** functions are the inverses of the exponential functions.

If x is b to the power y, $x = b^y$, we also say that y is the logarithm of x in base b (meaning y is the power we have to raise b to, in order to get x), and we write $\log_b x = y$. For instance, $\log_{10} 100 = 2$ (since $10^2 = 100$) and $\log_2 8 = 3$ (since $2^3 = 8$).

Changing Log Bases

$\log_2 100 = \log_{10} 100 / \log_{10} 2$

Logarithms and Exponents

Exponential Form	Logarithmic Form
$2^3 = 8$	$\log_2 8 = 3$
$4^2 = 16$	$\log_4 16 = 2$
$5^0 = 1$	$\log_5 1 = 0$

Logarithm Rules

$\log A + \log B = \log (AB)$

$\log A^k = k \log A$

$y = \log x$ --> $x = 10^y$

$y = \log_e x$ --> $x = e^y$

Voltage and Power

power (watts) = I * E = current * voltage = (volt/resistance) * voltage = V^2 / R

The power is proportional to the square of the volt.

For power, dB = 10 log (output power / input power).

For voltage, dB = 20 log (output signal / input signal).

Video Signal

0 Hz to 4.5 MHz +/- 0.5 dB. What is the reference here? 1 MHz for video, 1 kHz for audio. Not just found by taking the highest power and the lowest power within this range, and ensuring the difference between these is not more than 1.0 dB. This means that whatever is the power level at 1 MHz that you measure, the power that you measure at any other frequency within this video range will not be more than +/- 0.5 dB from that power level.

Usage of dB in Equipment Specifications

3 dB is quite a variation. A consumer amplifier rated at 100 watts +/- 3 dB will go from 50 watts to 200 watts. A rating of +/- 0.5 dB or +/- 0.1 dB is a more serious, professional rating.

Another place used is in filters. For example, 3 dB down at a specific frequency is a typical measurement of a filter.

Force 1 MHz to be at 1 volt; this makes it simpler to measure everything.

If have 1 volt at 1 MHz, can vary between 1.06 volts and 0.94 volts. 1.06 is the antilog of 0.5 dB. 20 * log (1.06 / 1) = 20 * log (1 / .94) ~= 0.5

dBr

A dB scale which gives the relative power relation between a measured power strength and a suitable reference signal's power strength. It is suitable to indicate difference as opposed to an actual power strength. The scale follows the relation dBr = 10 * $\log_{10}$ Pm/Pr

Pm = power measured at the output of the system Pr = power of a suitable input (reference) signal to the system.

dBspl

A dB scale for acoustical sound pressure being referenced to 10 uPa (micro Pascal). It is useful for acoustical sound pressure measurements. Speakers are rated in dBspl.

dBu

A dB scale where the reference power is replaced with a reference voltage (approximately 0.775 V) which will give an effect of 1 mW over a 600 ohm resistance. This unit is used in television transmission and audio. Audio's termination is 600 ohms, video's termination is 75 ohms.

dBV

A dB scale similar to dBu but differs in the sense that it will reference to exactly 1 V instead of a derived voltage (as in the dBu case).

Example

A transmitter has an output power of 20 watts. What is its output power in dBW? Power = 10 log Po/Pr = 10 log 20/1 = 13 dBW.

In communications we sometimes use dB in relation to 1 Hz bandwidth (dBHz), temperature in Kelvin above absolute zero (dBK), and the gain of an antenna referenced to an isotropic (truly omni-directional) antenna (dBi).

Self-test Questions

1. An amplifier increases the power of a signal by 50 times. In decibels, this is:

a) 500 dB

b) 17 dB

c) 50 dB

d) -17 dB

2. An amplifier increases the power of a signal from 100 microwatts at the input to 25 watts at the output. This is a gain of:

   a. 54 dB

b. -6 dB

c. 140,000 dB

d. 5.4 dB

d. An antenna has a gain of 23 dB. This is equivalent to a numerical gain of:

?

?

?

?

A cable has an attenuation of 6 dB. This means that the power passing through the cable is reduced by a factor of: 6, 4, 106, 0.6

A power level of 16 dBW is the same as: 16W, 40W, 1.6 MW, 4 kW

When expressed in dBW, a power of 5 W is: 7 dBW, 5 dBW, 105 dBW, 50 dBW

A power level of 700 mW when expressed in dBm is equal to: 700 dBm, 70 dBm, 28 dBm, 56 dBm.

A signal of level 20 dBm, when amplified by a factor 10, would become a signal of level: 30 dBm, 200 dBm, 2 dBm, 10 dBm.

A signal of power 50 microwatts when measured:

A signal of 6 dBm is passed through an amplifier with a gain of 20 dB, along a cable with a loss of 6 dB, through a connector with a loss of 1 dB, along a second cable with a loss of 4 dB and then through a second amplifier with a gain of 16 dB. The final level of the signal will be: 31 dBm, 25 dB, -5 dB, 42 dBm.

Break

Theory of Tape Recorders after break.

Transports

The tape tension control

During play-back, a certain tape tension is required to provide good head contact with the tape.

During spooling, a certain tape tension is required to ensure safe running of the tape and to provide a good tape “pack”.

During spooling and braking the tape tension must be kept in safe limits to prevent over-stressing and stretching of the tape.

Brake Systems

Holding Brakes

The holding brakes are always mechanical. These hold the tape still after the tape is stopped. Pro decks do not use mechanical brakes to stop the tape. They consist of a brake drum mounted on the spooling axis, and a spring-loaded brake ribbon which produces friction.

Diagram 1.

Some machines use brake shoes instead of a ribbon.

The brakes are disengaged (off) during run (playback and record modes) and during fast wind (fast forward or rewind). Achieved by solenoids which pull the brake ribbons away from the brake drums. Brakes disengaged by turning on a solenoid; if power lost, brakes will apply (pulled in by springs). This ensures that the tape comes to a smooth stop in case of power failure.

Motor drives reels directly. 3600 rpm at top speed (60 Hz).

In normal operation we don't use these brakes. Never have to replace them since they get used so infrequently.

Spooling Tension

During fast forward or rewind the tape tensions have to meet:

Acceleration: the take-up motor should accelerate as fast as possible. At same time, stress on tape during acceleration should remain within safe limits.

The take-up motor torque has to be controlled by the take-up tension sensor.

Reel to reel tape recorder has supply reel (source) and take-up reel (destination).

Take-up arm monitoring how much stress on the tape. Moves if tape is looser or tighter. There is a switch that will turn off the tape recorder when the tape runs out.

Steady Winding

Supply reel motor provides reverse torque to provide certain tape tension. Tension not so high to reduce spooling speed, should be high enough to produce a densely wound pack on the take-up spool, especially when open reels are used.

Supply motor torque has to be controlled by supply tension sensor.

Deceleration

During fast wind, when stop button pressed, tape come to complete standstill quickly without straining tape. In some machines achieved with brakes only. Other machines spool motors used for braking by applying reverse torque. Torque of supply motor increased, take-up motor switched off. Supply motor torque controlled by supply tension sensor to optimum values.

Tape motion sensor required to detect when tape comes to standstill to switch off motors and apply the mechanical brakes.

Speed sensor

Diagram 3. As wheels rotate, the dots open and close the aperture. LED and laser light. Generates square wave when tape moving. Know that the tape has stopped when slightly go into reverse.

Dynamic braking: braking with the force of the motor. This is what is used in professional recorders.

Tape Motion Sensors

Give info about whether tape is moving and in which direction, for.

One. When braking motor-assisted, tape transport control must switch off spooling motor currents and apply mechanical brakes after tape has come to a standstill.

Two. When switching from wind to play directly, the tape transport contro will brake the tape first. Only after the tape motion sensor has reported full standstill of the tape will the pressure roller (pinch roller) engage with the capstan, and machine switches to play mode.

Capstan responsible for accurate speed of tape, pulls tape along.

Pressure roller is rubber, can safely pinch tape between it and capstan. Only used in play and record. In rewind/fast forward, pinch roller disengaged.

Three. The tape counter must know whether to count forward or backward.

Tape stand still detected:

One. A detector (light barrier on an idler or reel motor) detects no motion of the tape

Two. A direction detector detects a change of motion detection of spooling motors or tape. The moment when the tape changes direction the tape is assumed to be at a stand-still.

Use optical rather than reed contact now.

The drag switch fitted below the supply and take-up reel. Has permanent magnet at the end, dragged to or away from a reed contact by the rotation of the spool motor. Reed switches are magnetically controlled. Magnet pushes one contact against the other.

Functions initiated by tape transport control circuit. Now done by digital logic. Then, was relay logic. One of drag switches is always closed. Which one depends on direction of tape motion.

Control logic uses information from these drag-switches.

Example. Machine in Fast forward. Play pressed. Power-assisted braking starts with high power on left motor until tape still and just starts backward. Detected by drag switches. Braking ended and machine switches to play.

Reversing reed conditions indicates tape motion ended.

Left side switch informs counter of tape direction.

Tape-driven idler between capstan and take-up spool has four blades attached. These blades reflect IR light from two reflection light barriers. When blades rotate, light reflections interrupted.

Light barriers positioned at distance equal to half width of reflector blades. Signals from light barriers always 90 degrees out of phase as idler rotates. Depending on rotation direction, #1 leads #2 or vice versa. Determines tape direction.

#2 used to give MOVE indication. Circuit puts move signal to low if no more pulses.

Play Tension

Near heads, tape should have constant tension. Else, would lose fidelity because the tape would be varying distance from heads. Maintains tape-head contact pressure. Only tape tension will press tape onto head. Stretches tape a bit, then releases the stretch.

Pressure pads not used on professional recorders (an older technology). Are a felt pad. Likely to cause undue and uneven head-wear and other problems.

Constant tape tension will also keep slip which is the result of the tape slipping (usually backward, sometimes forward) between capstan and pressure roller to a minimum. However, should be fairly constant, within 10%, over whole length of one large tape spool.

Ideally, take-up tension and supply tension should be approximately equal and constant, so that capstan moves tape but does not pull it. Easily tested by holding back the pinch roller in the play mode. Tape should then easily be moved back and forth, but should neither speed forward nor be held back strongly.

Devices used to sense/measure tape tension on supply and take-up sides. Usually sensing levers: spring loaded, displaced by tape. Tape tension controlled by position of these levers.

Signal from levers may be:

- purely mechanical, operating brake for left spool and variable friction clutch on right (cheesy)
- change in resistance
- change of light intensity
- change of RF coupling
- change in core position in the coil of a discriminator

Several ways how correct tape tension set:

- mechanically by brake drum and ribbon linked to the sensor level
- powering both spooling motors, whereby voltage on motors depends on sensor position
- tension before capstan can be set by feeding a controlled amount of DC to AC supply motor (not too many AC motors today, though); the DC acts like an eddy current brake

Tape Tension Forward Regulation

Some tape machines don't use a tape tension feedback system, but use a control system that computes required reel torque to achieve constant tape tension. To do so, need to reduce reel torque as spool diameter decreases. Done in today's recorders. Because rotational speed of supply or take-up reels inversely proportional to spool diameter, rotation speed used to compute required reel torque.

For this purpose, the spooling motors carry **tachometer systems**. Motor speed used to compute required motor current. Higher reel speeds will result in lower motor torque.

Tape Tension Measurements

Tape tensions must be regularly measured in line with manufacturer's specifications to maintain constant quality tape transport. Tape tensions measured with spring balances.

Supply Tension

Spool (empty reel) put to supply spooling motor, tape threaded through left side, tape tension sensor idlers. Spring balances (fish scales) connected to end of tape. While machine in play mode, tape pulled slowly steadily from supply reel while force on spring balance is read. Measure with full and empty reel to see if there are differences. About 8 ounces.

Take-up Tension

Basically same thing. Tape must not pass through capstan. Spool put on tape-up motor, tape threaded through right side tape, tension sensor, and idlers.

End up with a balance when pull off capstan and pinch roller. Tape won't pull to one reel or the other. Use a test tape, since hook the hook of the spring balance through the tape.

If have specs of 8 ounces from supply reel and 3 ounces from take-up reel, total is 11 ounces tension on the head. Some manufacturers have 8 ounces on each side.