Recording Devices

- Analog recorders store the continuously changing information as a direct one to one analog of the original.
- Digital recorders convert the analog signal into discrete values, a binary code of ones and zeros.
Analog Recorders

Examples:

- Phonograph Disk Cutting Lathe
- Reel to Reel Tape Recorder
- Cassette Tape Recorder
Reel to Reel Tape

Supply Reel

Take-up Reel

Tension Arm

Idler Roller

Pinch Roller

Tension Arm

Capstan
Analog Tape Calibration

Electrical Calibration

• Analog tape machines have to be calibrated so the noise, distortion and frequency response characteristics of the tape are optimized.

Playback Calibration

• Test Tapes which have a series of sine wave tones at calibrated levels are used for Playback frequency response calibration.

Record Calibration

• After the playback calibration is completed the tape being used is biased for it’s specific tape type.
Magnetic Analog Tape Track Formats

- **Stereo Cassette Tape (1/8")**
  - Outer Diameter: 0.035
  - Core Diameter: 0.021

- **Full Track (1/4")**
  - Outer Diameter: 0.240

- **Stereo Half-Track (1/4")**
  - Outer Diameter: 0.080
  - Core Diameter: 0.156

- **Stereo Quarter Track (1/4")**
  - Outer Diameter: 0.043
  - Core Diameter: 0.136

- **Four Track (1/2")**
  - Outer Diameter: 0.070
  - Core Diameter: 0.130

- **Eight Track (1")**
  - Outer Diameter: 0.130
  - Core Diameter: 0.070

- **Twenty-Four Track (2")**
  - Outer Diameter: 0.084
  - Core Diameter: 0.037
Studer 827 Mulitrack
Analog Tape Biasing

Bias:
A high frequency tone combined with the audio signal sent to the record head to improve the distortion and noise characteristics of the tape.

Tape Transfer Characteristics
Without Bias

Tape Transfer Characteristics
With Bias
So the tape can be set to playback correctly on other tape machines, a series of sine wave tones at 1000 Hz, 10,000 Hz & 100 Hz are recorded at 0 VU on the master tape.

These tones are played back on the other reel to reel machine and adjusted so that all tones playback equally. (0 VU)

This assures correct tonal balance on playback.
Important Information to Include on the Reel to Reel Box

- Track Format (half track, quarter track etc.)
- Tape speed (3 3/4, 7 1/2, 15, 30 IPS (inches per second))
- Heads or Tails Out (ready to play or needs to be rewound)
- Mono, Stereo, Quad etc.
- Test Tone information (tones frequencies, recording level)
- Noise reduction (if any) (i.e.: Dolby A, Dolby SR, DBX etc.)
Print-Through

Sound on one layer of tape imposes a copy on an adjacent layer making a echo.

If the tape is heads out the echo is a pre-echo and is heard before the sound.

If the tape is tails out the echo is a post-echo and is heard after the sound making the echo much less audible.
Analog Master tapes should always be stored tails out (need to be rewound before playing) because:

- Assures a flat winding of the tape which protects the tape from edge damage.
- Reduces the audibility of Print-Thru.
Digital Audio Media

A Few Digital Audio Media Formats

**Tape Formats**
- D.A.T. or Digital Audio Tape
- Reel to Reel - DASH

**Video Tape Formats**
- a. 1610
- b. 1630
- c. DA-88 (Hi-8 mm)
- d. ADAT (S-VHS)

**Magnetic Formats**
- Mini disks
- Computer hard drive

**Optical Formats**
- DVD (Digital Video Disk)
- Compact Disks
- Blu-Ray

**Other Formats**
- Compact Flash
- Memory Stick
Digital Recording Coding

- The same information is recorded on digital machines as their analog counterparts, only the method of encoding that information on the media differs.

- The analog sound information is coded into digital words by an analog to digital converter.

- The standard word length or bit depth for CD’s is 16 bit. The more bits there are in a digital system the more values of amplitude or volume can be represented which increases the dynamic range capabilities of the system.

- The analog wave amplitude is divided into many small samples each represented by a digital word. This information is then stored on the media.

- On playback the digital information is converted back to analog using a digital to analog converter.

- The sampling rate determines the highest frequency that can be recorded. The higher the sampling rate the greater the frequency response. For CD’s the sampling rate is 44.1 KHz.
Digital Conversion

Analog to Digital Converter “A to D”

Storage Media

Digital to Analog Converter “D to A”

Recording

Storage

Playback
Sample Rate & Bit Depth

- Increasing the sample rate increases the highest frequency that can be recorded.

  A sample rate of 40,000 samples/seconds records frequencies up to 20,000 Hz.

  A sample rate of 96,000 samples/seconds records frequencies up to 48,000 Hz.

- The greater the number of bits the better the dynamic range capability. (more numbers to represent amplitude changes).

  Dynamic range for 16 bit is 96 db, for 20 bit is 120 db & for 24 bit is 144 db. (theoretical)

  The best actual bit resolution available with today’s Analog to Digital converters is about 21 bits.

**Bit Depth**

- 8-bit word = 256 steps
- 16-bit word = 65,536 steps
- 20-bit word = 1,048,576 steps
- 24-bit word = 16,777,216 steps

**Sampling Rate**

- Lower Sampling Rate
- Higher Sampling Rate
Bit Depth & Sample Rate Example

16 bit Word Example
65,536 Amplitude Values (green lines)

Sample Rate = 44100 samples per second (blue lines)

Binary Value
100000000000

Amplitude
32,768

Sample Rate
1/44000 sec

65,536
Analog vs. Digital Distortion

- When digital recorders are sent too much level the result is a severely distorted “clipped” wave.

- When analog recorders are sent to much level the result is “soft clipping” which generally sounds more pleasing than hard clipping.
Advantages of Digital Recordings

1. Identical “clone” copies when transferring digital to digital.
2. Interfaces to computer easily.
3. Very accurate, stable time base. (stable pitch)
4. Can provide high quality recording quality.

But, just because it’s digital doesn’t mean it sounds better.
Disadvantages of Digital Recordings

- **Hard Clipping**: When it overloads, the resulting distortion is much more obvious and sounds much worse than analog tape distortion.

- **Data Loss**: If too much data is lost, there is no sound.

- **Poor Quality Converters**: Poor quality Analog to Digital & Digital to Analog converters make the sound harsh & brittle.
Multi-track Recording

• **What:** Multi-track Recording is the process of recording different instruments or groups of instruments on separate tracks so that they may be balanced and processed separately at a later time. Sometimes these tracks are recorded at different times by the use of overdubbing.

• **Why:** Multi-track Overdubbing provides more quality control over the final product.

• **How:** The tape is divided into bands (analog tracks) that can be recorded on separately allowing different instruments to be recorded at different times.
A Typical Multi-track Sequence

- Record basic tracks instruments (usually rhythmic foundation, often with a click or metronome track).
- Record overdubs (solos, vocals, string, pads etc.)
- Mix down. (2 track stereo, 5.1 surround etc.)
- Mastering (final processing of entire mix for release on CD, DVD etc.)
Advantages of Multi-track Overdubbing
Recording Verses Live Recording

1. All instruments do not have to be recorded at the same time.
2. Much better control of sound & performance quality.
   a. Punching IN / OUT.
   b. Multiple takes on different tracks.
   c. More options in processing.
3. Remixing: The ability to do more than one mix.
4. More overall control of mix levels & effects.
MITSUBISHI X-850
1" 32 TRACK DIGITAL RECORDER
(old/obsolete tape based machine)
ALESIS ADAT 8 Tracks Digital on S-VHS Tape (almost obsolete)
8 Tracks Digital on Hi-8 Video Tape (almost obsolete)
Dedicated Computer Hard Drive Recorder
Tascam DV-RA 1000
Compact Flash Portable Digital Recorder
Fostex Pro FR-2

Lexar Professional CompactFlash™
with Write Acceleration
2GB 80x Speed Wa
Dedicated Computer Hard Drive Recorder IZ Radar 24
Protools HD 4 DAW

Hardware

Software