ECE313 Music & Engineering
Electric Guitars & Basses

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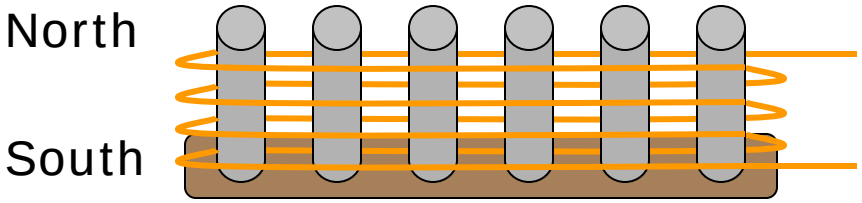
Basic Parts

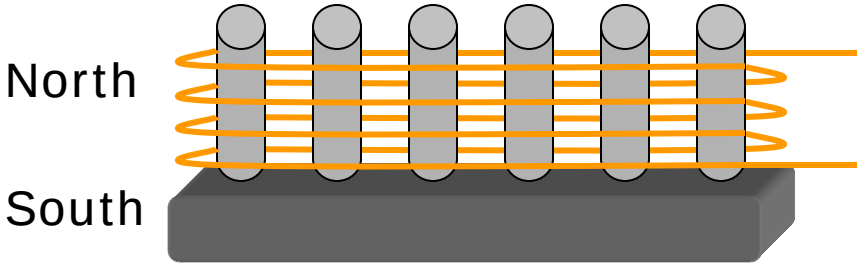
- Physical
  - Neck
    - Tuners
    - Nut (possibly locking)
    - Fingerboard board
      - Frets (typically 21 – 24)
      - Fret markers (3,5,7,9,12,15,17 19,21,24)
  - Body
    - Bridge
      - Saddles
      - Variants
        - » Fixed (Stop tail, tele style)
        - » Whammy bar (standard, 2 point, Floyd Rose, Kahler, Bigsby)
    - Body shape
      - Single Cutaway
      - Dual Cutaway
      - Other

Electronics

- Electrical
  - Pickups
    - Single Coil
      - Strat
      - Tele
      - P90
    - Humbucker
      - 4 wires
  - Switches
    - 1 pole 2 throw with bridging
    - 2 pole 3 throw with and without bridging
    - 4 pole 5 throw – Super Switch

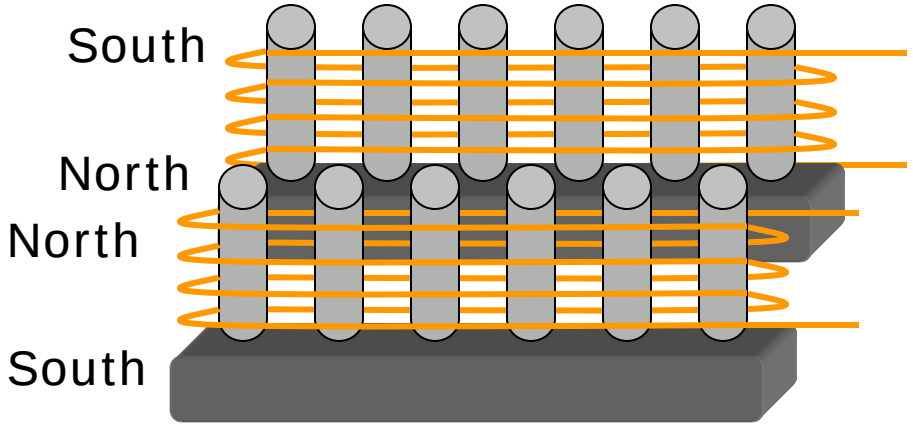
Pickups





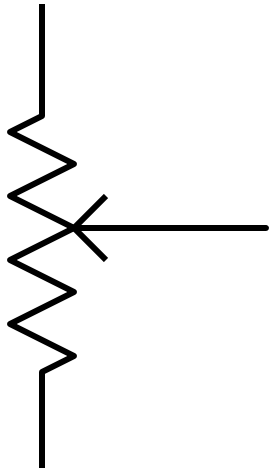
- The Fundamental guitar pickup is
  - Source of magnetism
    - 1 magnet under 6 fero-magnetic pole pieces
    - 6 magnettic pole pieces
  - A coil of wire
    - Usually several thousand turns of wire
    - The more turns
      - The hotter the output signal
      - The more higher frequency components lost.

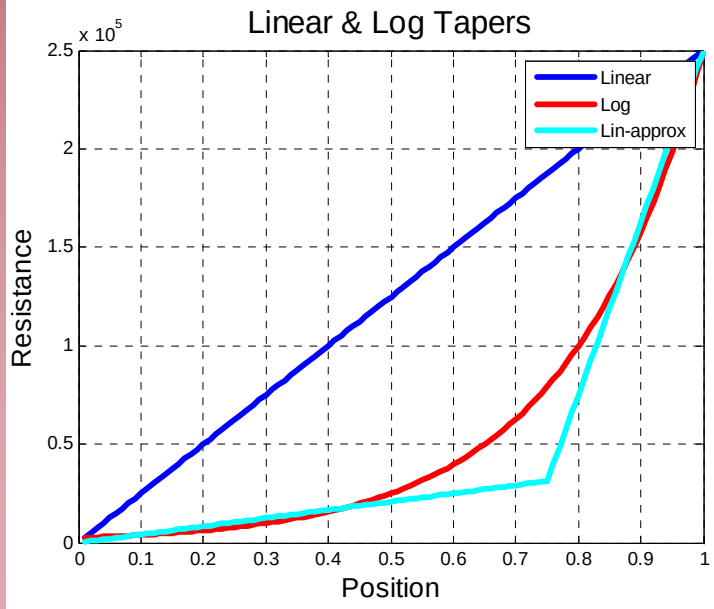
Humbuckers



- In 1955 Seth Lover invented the Humbucker for Gibson
- It combines 2 coils with reversed magnetic fields and reversed windings.
- When added correctly, the two picked up guitar strings (one from each coil) will add in phase, but the hum from the 60Hz noise will add out of phase and be cancelled.
- The original humbuckers were called PAF humbuckers because of the sticker they carried.
  - PAF = Patent Applied For
  - The patent was granted.
  - PAF and Patent sticker Gibson humbuckers are very sought after and very expensive

Potentiometers

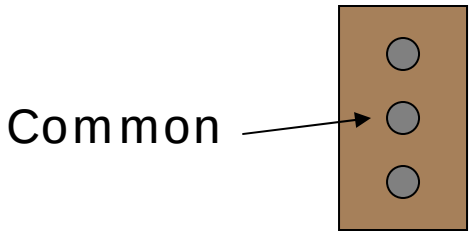




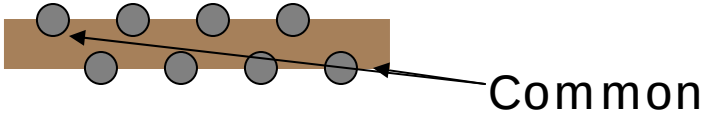
- Electric Guitars use between 2 and 4 potentiometers as volume and tone controls.
- The volume controls are typically log taper pots configured as voltage dividers.
- The tone controls are usually log taper, and are simply used as a variable resistance.
- Variations occur with linear taper devices used as a pan pot or a more dramatic tone control

Switches

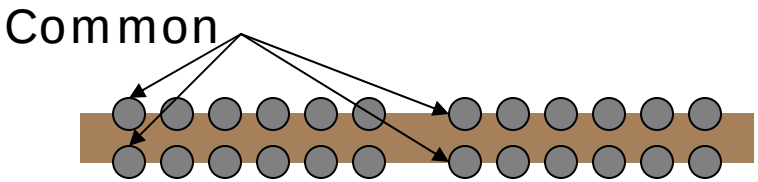
1P2T w/ B



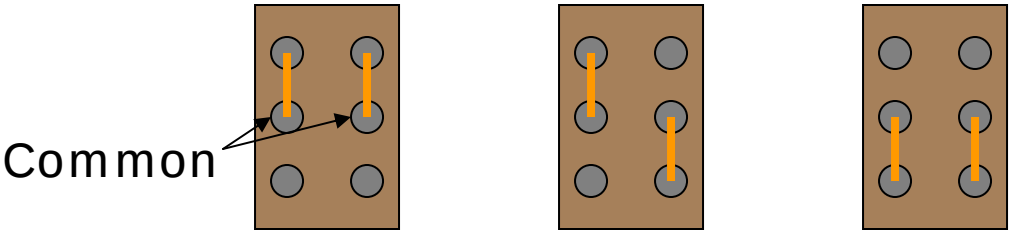
2P3T w or w/o B



4P5T

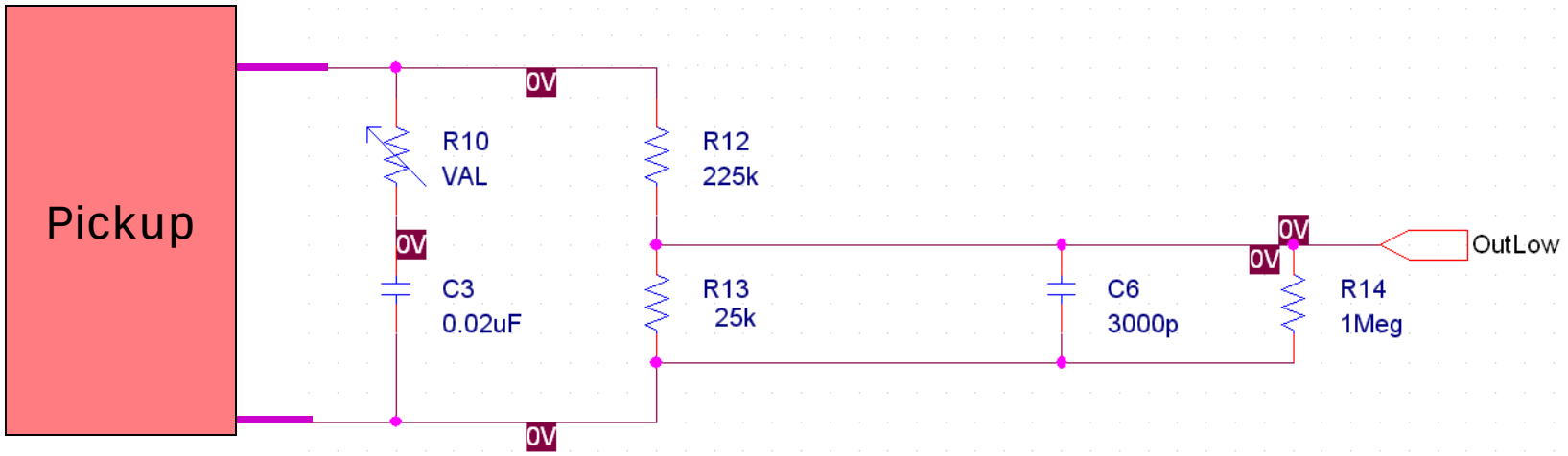


DPDT on-on-on (connections shown)



- Guitar Switches are a little different in that they often use bridging positions
  - 1pole 2 through with bridging – Les Paul
  - 2 pole 3 throw – telecaster
  - 2 pole 3 throw with bridging – Stratocaster
  - 4 pole 5 throw – super switch
  - DPDT on on on

Basic Circuit



Signal Source

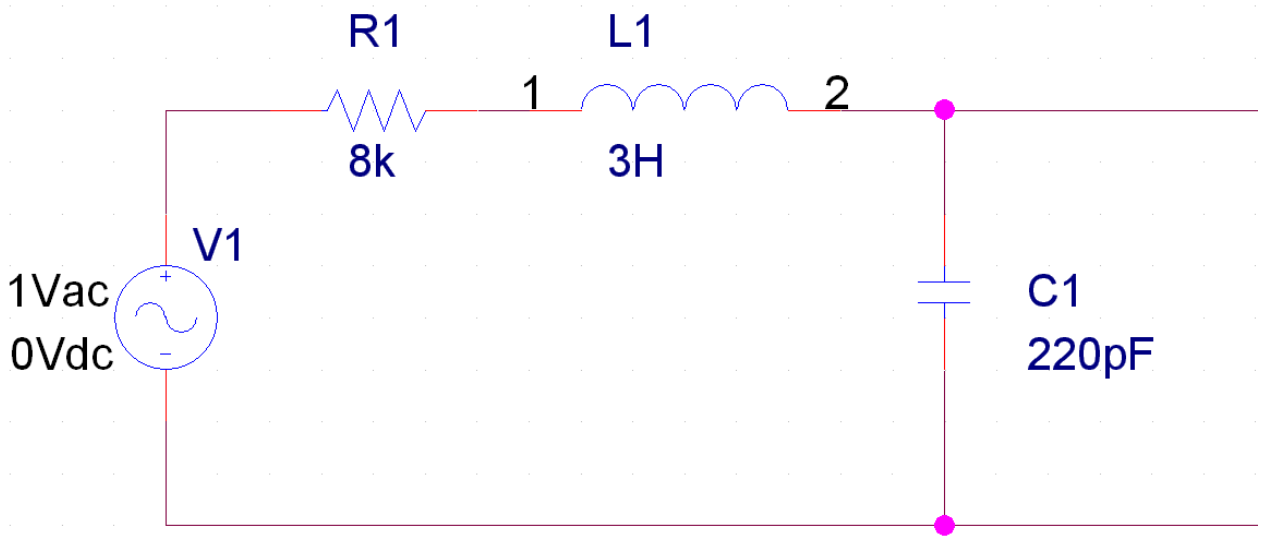
Tone Control

Volume Control

Patch Cable

Amp Input Impedance

Pickup Simulated Circuit



- Based on the Lemur handout from class
- Still under investigation
- Parameters
  - What the physical parts that are modeled by the lumped elements (L,R,C)
  - How do we measure the parameters?

Styles of Electric Guitars

- Original designs were often focused on two types of guitars
  - Hawaiian – Similar to the style of guitar now referred to as lap steel
    - Played with a slide bar
    - Used in open tuning
  - Spanish – What more people now think of as an Electric guitar
    - The ES in Gibon's ES-335 or other ES model line actually stands for Electric Spanish.
    - The frets are used for fretting the strings (as apposed to as indicators for the slide bar)
- The 1950s saw the creation of the "big three" in terms of classic guitar designs that are still sold to this day
  - The Telecaster by Fender
  - The Les Paul by Gibson
  - The Stratocaster by Fender
- Also created in the 1950s was the electric bass guitar. Leo Fender invented the EBG as a more convenient alternative to an upright acoustic bass.

Fender Telecaster® style

Neither of the above guitars are genuine Fender Telecasters, but do represent the general design of one (Telecaster is a registered trademark of the Fender Corporation)

- **Original Model:** Fender Telecaster
- **Headstock:** inline 6 tuners on one side, flat w/ retainers
- **Nut:** plastic
- **Scale Length:** 25.5”
- **Pickups:** 2
  - **Neck:** Single coil with metal cover
  - **Bridge:** Single coil with exposed pole pieces
- **Switching:** 2 pole 3 position (neck, neck & bridge, bridge)
- **Bridge:** Fixed 3 or 6 saddle
- **Controls:** 1 volume 1 tone
- **Associated Style / Songs:** most typically associated with country, but played in just about all music.

Fender Stratocaster ® style

Both of the above guitars are Stratocasters from Fender companies (MII Squier on the left and MIM Fender on right) - (Stratocaster is a registered trademark of the Fender Corporation)

- **Original Model:** Fender Stratocaster
- **Headstock:** inline 6 tuners on one side, flat w/ retainers
- **Nut:** plastic
- **Scale Length:** 25.5”
- **Pickups:** 3
  - **Neck:** Single coil with exposed pole pieces
  - **Middle:** Single coil with exposed pole pieces (sometimes Reverse Wound, Reverse polarity)
  - **Bridge:** Single coil with exposed pole pieces
- **Switching:** 2 pole 3 position with bridging (neck, neck & middle, middle, middle & bridge, bridge)
- **Bridge:** 6 saddle vibrato system
- **Controls:** 1 volume 2 tones (1 for neck pickup, 1 for middle pickup)
- **Associated Style / Songs:** rock and roll, from Buddy Holly to Iron Maiden.

Super Strats - Strat® variants

(Strat is a registered trademark of the Fender Corporation)

- **Original Model:** Various (Jackson, BC Rich, etc)
- **Headstock:** inline 6 tuners on one side – pulled back
- **Nut:** locking or plastic with behind the nut lock
- **Scale Length:** 25.5”
- **Pickups:** 2 or 3
  - **Neck:** Humbucker or Single coil
  - **Middle:** Single coil or not present
  - **Bridge:** Humbucker
- **Switching:** 2 pole 3 position with bridging (neck, neck & middle, middle, middle & bridge, bridge); 4 pole 5 position or individual toggles
- **Bridge:** 6 saddle locking vibrato system
  - Floyd Rose double locking
  - Kahler cam based
- **Controls:** 1 volume varying tones
- **Associated Style / Songs:** hard rock and heavy metal usually.

Gibson Les Paul® style

Neither of the above guitars are genuine Gibson Les Pauls, but do represent the general design of one. (Les Paul is a registered trademark of the Gibson corporation)

- **Original Model:** Gibson Les Paul
- **Headstock:** classic 3 on each side with angled pulled back headstock
- **Nut:** plastic or bone
- **Scale Length:** 24.75”
- **Pickups: 2**
  - **Neck:** Humbucker (or P90 on some models)
  - **Bridge:** Humbucker (or P90 on some models)
- **Switching:** 1 pole 3 position with bridging (neck, neck & bridge, bridge)
- **Bridge:** 6 saddle Tune-o-matic bridge. Strings anchor in separate stop tail
- **Controls:** 2 volume 2 tones (1 of each for each pickup)
- **Associated Style / Songs:** Everything from Jazz to rock and Metal.

Other Variations

- **Original Model:**
- **Tuners:**
- **Nut:**
- **Scale Length:**
- **Pickups:**
  - **Neck:**
  - **Bridge:**
- **Switching:**
- **Bridge:**
- **Controls:**
- **Associated Style / Songs:**

Fender Precision bass

The above bass guitar is a MIM Fender Precision bass

- **Original Model:** Fender Precision
- **Headstock:** inline 4 tuners on one side, flat w/ retainers
- **Nut:** plastic
- **Scale Length:** 34”
- **Pickups:** 1
  - **Middle:** Split humbucker with each portion covering 2 strings
- **Switching:** none
- **Controls:** 1 volume 1 tone
- **Associated Style / Songs:** rock and roll, from Sting to Iron Maiden.

Fender Jazz bass

The above bass guitar on the left is a MIM Fender Jazz bass. The instrument on the right is a MIC copy.

- **Original Model:** Fender Jazz
- **Headstock:** inline 4 tuners on one side, flat w/ retainers
- **Nut:** plastic
- **Scale Length:** 34”
- **Pickups:** 2
  - **Middle:** single coil with 2 pole pieces per string
  - **Bridge:** single coil with 2 pole pieces per string (reverse wound from neck for hum canceling)
- **Switching:** none
- **Controls:** 2 volumes 1 tone
- **Associated Style / Songs:** Jazz, Fusion, Rock, etc

Beatle bass

- **Original Model:** Hofner Violin bass
- **Headstock:** 2 tuners on each side with a pull back
- **Nut:** plastic
- **Scale Length:** 30.3”
- **Pickups:** 2
  - **Neck:** single coil with metal cover
  - **Bridge:** single coil with metal cover
- **Switching:** on/off switches for each pickup and tone switch
- **Controls:** 2 volumes
- **Associated Style / Songs:** rock

The above bass guitar is a MIK variant on the original Hofner design

Steinberger bass

- **Original Model:** Steinberger XL-4
- **Headstock:** none – tuning is part of bridge
- **Nut:** plastic
- **Scale Length:** 34”
- **Pickups:** 2
  - **Neck:** humbucker with plastic cover
  - **Bridge:** humbucker with plastic cover
- **Switching:** none
- **Controls:** 2 volumes 1 tone
- **Associated Style / Songs:** rock, 80s

The above bass guitar is a MIK variant on the original Steinberger design, made with wood instead of the original composite design.

5 String bass

- **Original Model:**
- **Tuners:**
- **Nut:**
- **Scale Length:**
- **Pickups:**
  - **Neck:**
  - **Bridge:**
- **Switching:**
- **Bridge:**
- **Controls:**
- **Associated Style / Songs: - extra string is a B, a 4th below the low E**

Multi-string basses
(8 & 12 strings)

- **Original Model:** Hamer custom shop
- **Headstock:** 4 or 6 tuners per side, usually with a pull-back.
- **Nut:** brass
- **Scale Length:** 30” – 34”
- **Pickups:** 2
  - **Neck:** humbucker with plastic cover
  - **Bridge:** humbucker with plastic cover
- **Switching:** push-pull volume pot for active bypass
- **Controls:** 1 volume, 1 blend 3 active tone controls
- **Associated Style / Songs:** Cheap Trick, King’s X, Pearl Jam

References

- http://www.geofex.com/article_folders/potsecrets/potscret.htm
  - The Secret Life of Pots – great intro to how potentiometers are constructed and how they work.
- http://www.elby-designs.com/documents/tailoringpotentionometers.pdf
  - Similar to the secret life of pots, but with a bit more
- http://tangentsoft.net/audio/atten.html
  - More fun with pots
- http://www.maxim-ic.com/appnotes.cfm/appnote_number/838
  - Article on sythesizing log pots using a digitally programmable resistor