Of Microphones and Speakers

Thursday March 6 2022

Gordon Gibby MD KX4Z

Characteristics of Speech- Power

- Reference acoustical 0dB = 10^{-12} watts
- Human ear works in range of 0dB – 130 dB (from 10^{-12} W to 10-100 W)
- Normal conversational power = approx 60-70 dB
- Alarm Clock = 80 dB
- Human conversational voice therefore approx 10^{-6} to 10^{-5} Watts (probably at 1 meter?) – microphone may pick up significantly more
- REF: https://www.engineeringtoolbox.com/sound-power-level-d_58.html#:~:text=Sound Power Level (dB)&text=The human ear is able,10-12 %3D 10 13.

Characteristics of Speech – Waveform

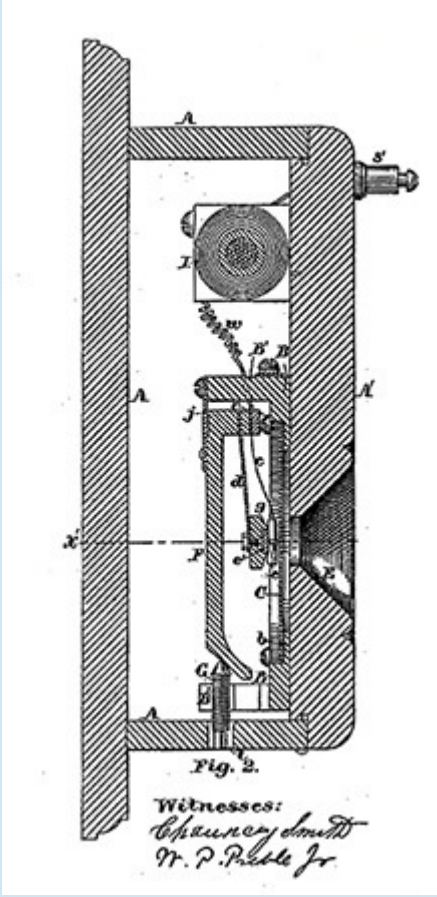
- Peak power = several dB greater than average power
- Average power easily 6dB or more below peaks
- “Crest Factor“ peak amplitude / RMS average amplitude
- This makes for problems on noisy radio circuits
- Peaks of voice may exceed transmitter limits = splatter due to non-linear amplification
- Low average voice power = difficult to discern over noise
- Typical SSB S/N required for good copy = 10dB S/N
- 1 S-Unit might be 3-6dB

Characteristics of Speech – Frequencies

- Good High Fidelity stereo = 20 Hz through 20,000 Hz (20 kHz)
- Traditional Telephone (public switched telephone network) = 300-3400 Hz (“voice band“ or “narrow band“ voice)
- Wideband Audio = 50Hz – 7kHz (e.g. higher quaity VOIP, Skype etc)
- Ham radio SSB traditionally bandwidth 2800-3000 Hz.
- Higher end important for speech recognition
- Practical lower limit for voice recognition 300-2400 Hz = 2.1 kHz
- REF: https://en.wikipedia.org/wiki/Wideband_audio#:~:text=The range of the human,50 Hz to 7 kHz.

Discovery of Microphone

- Alexander Graham Bell's first patented microphone https://www.google.com/patents/US174465
  - 1/0 (digital) switch (amature) driven by voice power on cone
- Liquid mics – steel ball against diaphragm
- Blake: platinum bead pressed against hard carbon disk (variable resistance) = higher efficiency at moduation → standard Bell Tel Mic
- Blake improved: loose carbon granules element
- Ref: https://digilab.libs.uga.edu/scl/exhibits/show/steel_vintage_mics/mic_early_history#:~:text=Alexander Graham Bell patented the,was possible from both directions.



Improved Mics

- Condenser microphone (Western Electric 7A – 1927) (diagram to right)
- Dynamic microphone (voice moves coil in magnetic field, generates alternative current) RCA – also “ribbon“ mics
- Ref: https://digilab.libs.uga.edu/scl/exhibits/show/steel_vintage_mics/advent_of_broadcasting

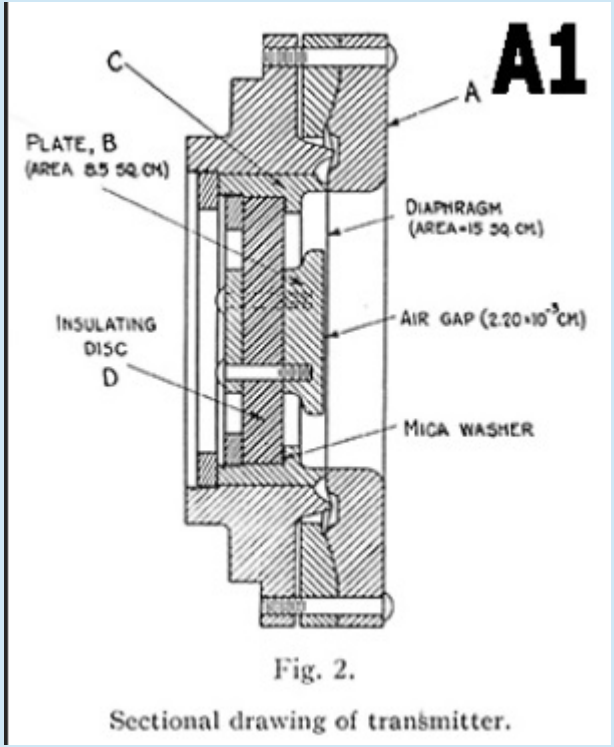


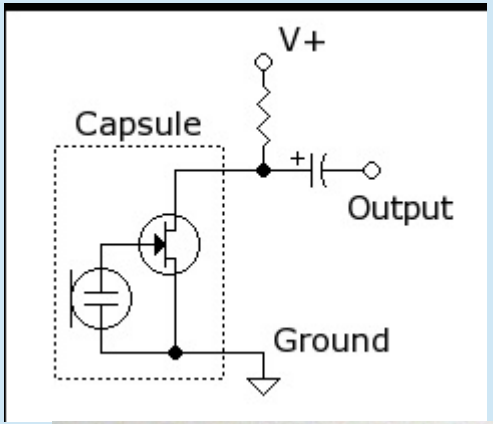
Fig. 2.
Sectional drawing of transmitter.

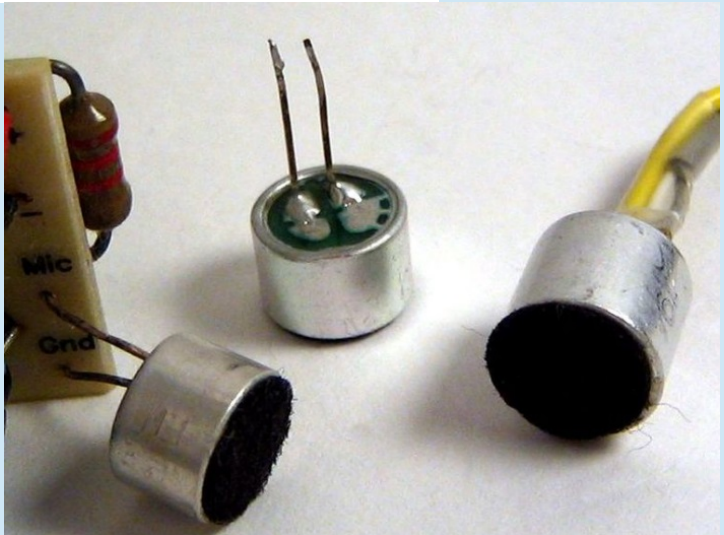
More Mic Power

- “Crystal“ microphone = piezoelectric. Acoustic stress on piezo crystal → AC voltage (very high impedance = many millivolts / very tiny current)
  - Typical for vacuum tube Heathkit microphones.
  - SHURE SM5B
- Ref: https://digilab.libs.uga.edu/scl/exhibits/show/steel_vintage_mics/developing-more-powerful-broad
-

Electret Mic

- Non-conductive resin given fixed CHARGE on opposing sides
- Acoustics vary dimensions, hence capacitance.
- Fixed charge, variable C → changing voltage of that capacitor
- Amplified by small FET built in
- Became the cheapest mic, used everywhere. 99 cents or less...
- REF: https://en.wikipedia.org/wiki/Electret_microphone





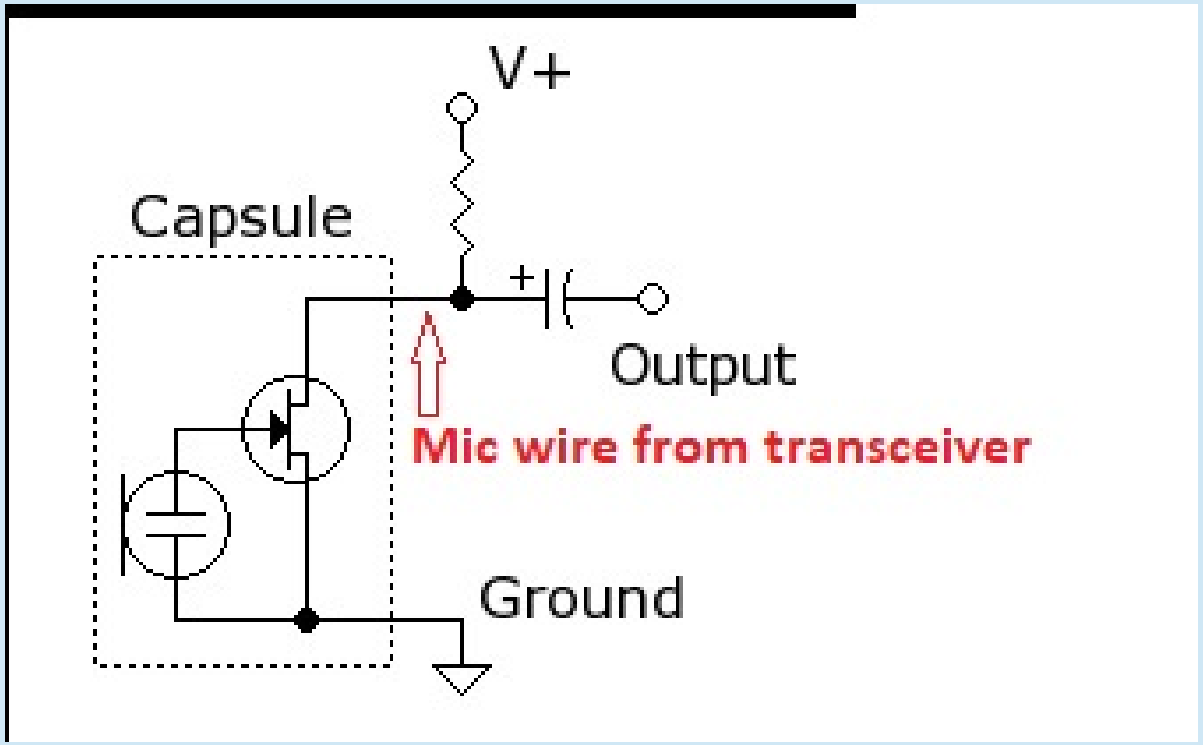
Different mic's – different outputs

- Same sound power produces different VOLTAGE outputs of different microphones
- Power = V^2/R
- "R" varies dramatically between different mic's

Mic Type	Typical Impedance Voltage Output	Special Characteristics
Carbon (resistive)	Low impedance. Voltage output depends on supplied drive voltage	Never seen it used in ham radio.
Crystal	Very high impedance (20K) 10‘s of millivolts	Used in Heathkits with limited voltage gain
Dynamic	Very low impedance (200) Fractions of a millivolt	Can be converted to high impedance with audio transformer
Electret	Typically drive 2K ohms Output low millivolts	Typically driven with 8V dc and impressed audio added to this voltage

Ham radio Mic Circuits

- Heathkits, old radios
  - AC input, high impedance, simple input to amplifier
  - Accepts AC mic signal, expects tens of millivolts
  - Can be well driven with **amplified** output of CB microphone
- MOST modern transceivers expect ELECTRET MIC
- Provide 2k source impedance with +5-8V DC impressed to drive that JFET
- DONT connect a transformer directly to this (shorts the DC and fouls the bias of the input transistor bias) – use series capacitor approx 2 uF


V+
Capsule
+
Output
Mic wire from transceiver
Ground

Very weak mic signal

- Mic signals are very tiny in most cases. Millivolts, Milliwatts
- 10-40 millivolts would be relatively normal
- EASILY interfered with by RF common mode currents.
- Solutions: parallel capacitance across wires, clip-on ferrites to reduce common mode currents.
- If high impedance, parallel capacitance must be small to avoid damaging high frequency response….try 0.001 uF or 100 pF to start

Don’t OverDrive Your Radio

- Overdrive = splatter
- EASY to avoid. “ALC“ = automatic level control. Invented in vacuum tube SSB rig days. Automatically reduces gain when you get to talking too loud. Works pretty well with speech, still intelligible.
- On DIGITAL – **becomes unintelligible** – Advantage that data signals have well-definited and repetitiave peaks. Hence: watch that ALC. If you have it kicking into action, REDUCE THE SIGNAL somewhere – anywhere – often several gains “in series“
- Set your radio for max output – then hit “tune“ on your data source – set for 50 watts output. Now you’re much safer.
- Want 10 watts digital? Just turn output back to 20.

Gain Adjustments on Modulation

- Software – may have a gain slider, or “drive level“
- Computer – if using sound devices, there may be an adjustment on “volume“ that can be employed. [if VOX-type ptt is used, may have to keep this above a minimum to keep PTT working properly]
- Hardware – Signalink has a TXGAIN adjustement
- Hardware/Software – Radio may have a sensitivity adjustment to USB or data input
- ALL THE ABOVE AFFECT **MODULATION LEVEL** – if modulation exceeds 100%...you splatter, no matter what „“power level“ you have selected.
-
-

- Software Gain---→ feeds into Computer Speaker gain --→ Signalink (or 7300 USB) Gain ---may feed into--→radio input gain
-
- Above determines MODULATION LEVEL
- Most radios: „power level“ is separate!
- Attempt to create 150% modulation will create splatter no matter whether „power level“ is 5 Watts or 500 watts!

How to connect different mics

- Electret: [Usually only 2 pins & expect a DC bias] Connect directly to the dcbias/audio pin – good chance it will work immediately
- Dynamic: Way too low an output & a DC short
  - Will often use some sort of „amplifier“ in between (e.g. CB amplified mic)
- Crystal (rare) – can connect direct or thru capacitor(better)
-
-

Speaker Output

- Much higher signal level. Often 1-2 watts
- Impedance? 8 ohms? 4 ohms?
- 0.1 watts is LOUD in a quiet room
- Power = V^2/R. 0.1 watts = $(0.9Vrms)^2$ / 8 ohms
- 900 millivolts!!
- Connections: 1/8“ plug; phono-plug; rarely screw terminals

Headphones

- Dynamic (miniature speaker) – anywhere from 8 ohms to 500 ohms
- Crystal (rare) 20,000 ohms & up
- Require MUCH LESS POWER – milliwatts
- Connections: 1/8“ – ¼“ plug. May be stereo (tip ring sleeve) or mono (tip sleeve)

Push To Talk wiring

- Almost universally, a dc signal on a wire/pin that one shorts to ground in order to cause the radio to go into „transmit“ mode.
- HOWEVER: Some motorola transceivers might be damaged – need resistance in that connection to ground.
- What dc signal??
  - Vacuum tube heathkits can give you a shock! Might be -140 VDC @ a few milliamperes (shorted current)
  - Most modern radios 2-5 POSITIVE volts at very few milliamperes
  - PAYS TO READ YOUR MANUAL

- Because the push-to-talk voltage can be either negative or positive, we chose to have a RELAY output on our homebrew „signalinks“
- Real signalinks have a relay also
- Some commercial equivalents use a TRANSISTOR or MOSFET – better be certain the polarity of your radio is a Positive ptt signal….
- Don’t connect transistorized ptt signals to OLD VACUUM TUBE RADIOS until you are sure that is safe.

Time needed to go into transmit

- After you short that line….
- Relays may mechanically switch
- Microprocessors may execute code
- Various amplifiers may be biased out of function and others biased into function
- Every radio takes a different amount of time to actually be read to TRANSMIT….typically from fast (10 milliseconds) to slow (700 mSec)