Computer to Rig Interfacing
–
You Don't Need to Buy an Interface!

Jim Brown
K9YC
Santa Cruz, CA
http://audiosystemsgroup.com

Interconnections Needed

- Audio from the computer
  - Playback voice messages to radio
  - Transmit RTTY, PSK31, WSJT
- Audio to the computer
  - Decode RTTY, PSK31, WSJT
- Mic to computer

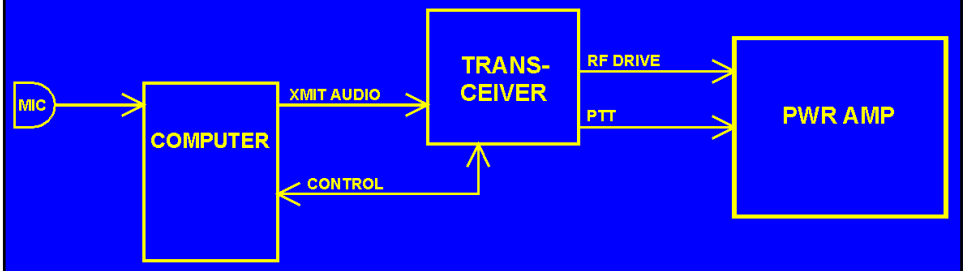
Interconnections Needed

- Sending CW
  - Computer to radio
  - Paddle and keyer to radio
- PTT from computer to radio
  - Or use VOX
- Rig control and data for logging software
  - Frequency readout, band changes

Pre-Recorded CQs are Cruical!

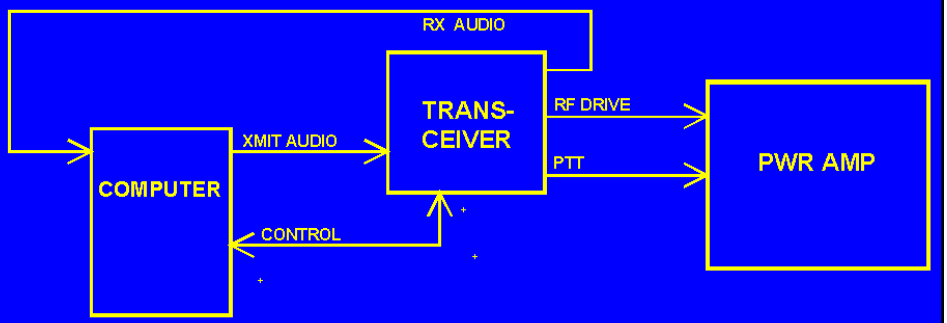
- Without them, you can't munch or drink coffee!
- Rest your voice
- Think about what you're going to do next
- Listen on another radio to find QSOs on another band

Simple SSB Setup



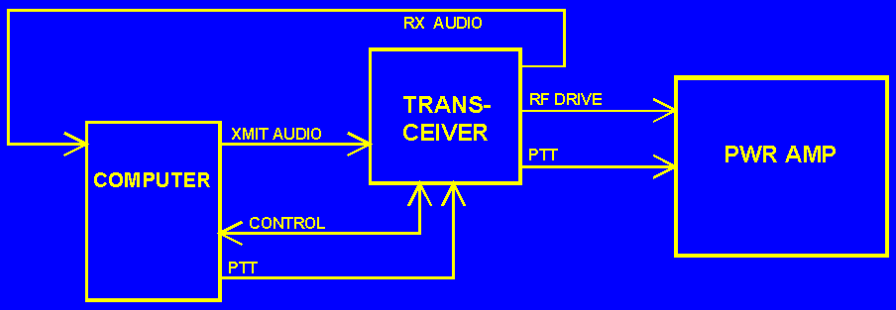
- The logging program feeds your mic to the rig
  - Allows you to record new messages during the contest
  - This setup uses VOX to key rig

Simple RTTY Setup



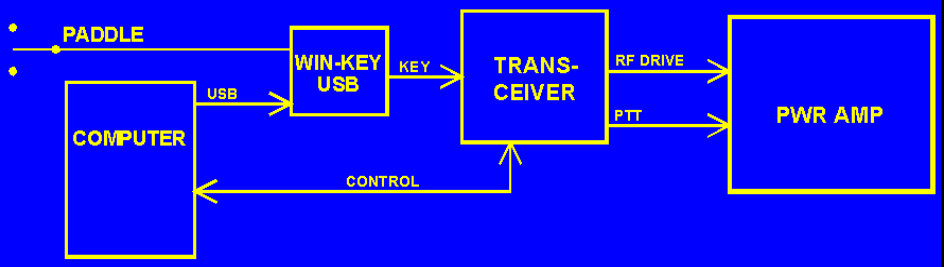
- Computer generates RTTY signal, sends to rig
- Rig sends received RTTY signal to computer, which decodes it
- This setup uses VOX to key the rig

Simple RTTY Setup with PTT



- This is the same as the first setup, but it uses PTT rather than VOX
  - PTT for RTTY requires a second serial port
  - No good reason for PTT – VOX works fine!

Simple CW Setup



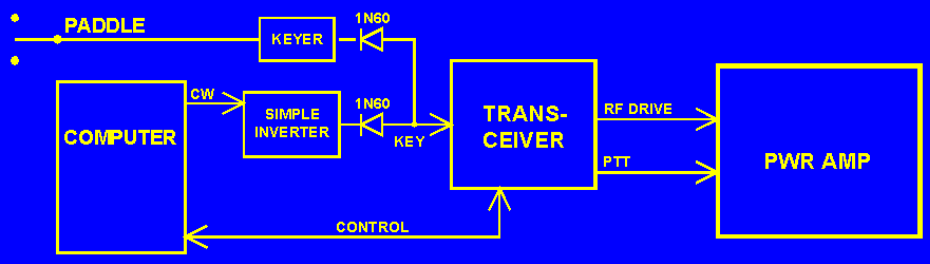
- Buy WinKey as a kit ($78)
  - Build it in two hours
  - Use your paddle with it for things that aren't programmed in your Logger
  - It's a nice stand-alone keyer too

What's a WinKey?

Why WinKey?

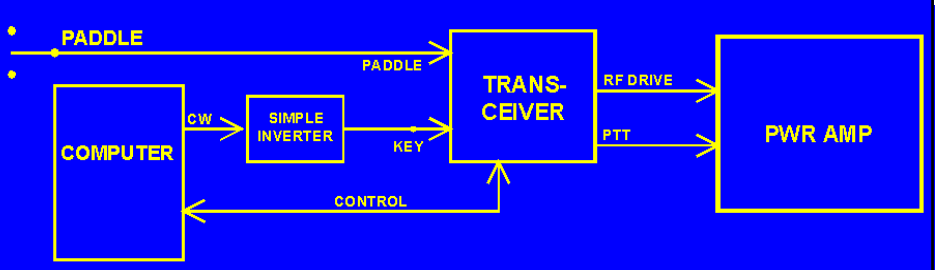
- Logging programs aren't very good at sending CW on serial port or printer port
  - It's a byproduct of Windows multi-tasking
  - Sending CW hogs the processor
  - Putting spots on a bandmap also uses a lot of processing cycles
  - CW can get choppy if the processor is too busy
- Sending CW to WinKey uses much less of the processor
- WinKey has two outputs, so it can key two radios for SO2R (Single Operator 2 Radios)

Another Simple CW Setup



- If you already own an outboard keyer
  - I've used this with an AEA MM-1 keyer on Elecraft, TenTec, Icom, and Kenwood rigs

This Works With A Few Rigs



- Most rigs with built-in keyers let you use the "key" input or the built-in keyer, but not both a the same time
- Some rigs can be modified to work
- An outboard keyer is usually easier

Audio Interconnections

The Elements of the Problem

- We must connect the right pins of the right connectors to each other
- We must match audio levels properly
  - Avoid overload of transmitter input stage
  - Optimize operation of sound card
  - Avoid distortion in sound card
- We do not need to match impedances
- All these interconnects are unbalanced
  - Noise voltage between equipment grounds
  - This is where hum and buzz comes from

Which Pins Do I Connect to What?

- Every radio is different
- Study the reference section of the manual for your rig
- Line Inputs and Line Outputs are best
  - Phone Patch connections
  - RTTY/PSK connections
  - Often on accessory DIN connectors
- Mic Inputs can work fine
  - More about that later

Audio Levels and Impedance

600 Ohm Circuits are a Myth!

- 600 ohm circuits have not been used in pro audio for nearly 50 years!
- In the olden days, telephone circuits loaded and equalized for up to 20kHz bandwidth were used as broadcast studio-to-transmitter links, and for other special uses. These were 600 ohm lines, but they have been very rare for more than 35 years!

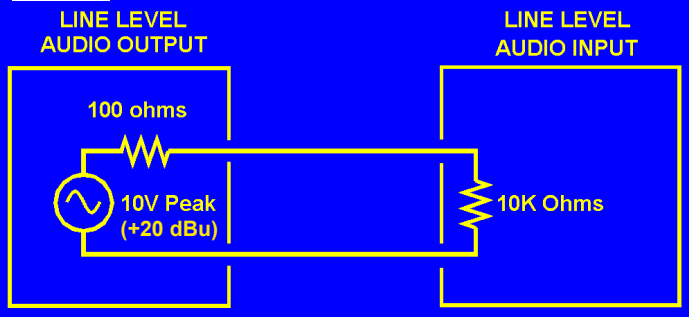
600 Ohm Circuits are a Myth!

- Those who talks about 600 ohms for audio circuits must have slept through the last 50 years!
  - Video people
  - Marketing people (product literature)
  - Hams

In the World of Audio

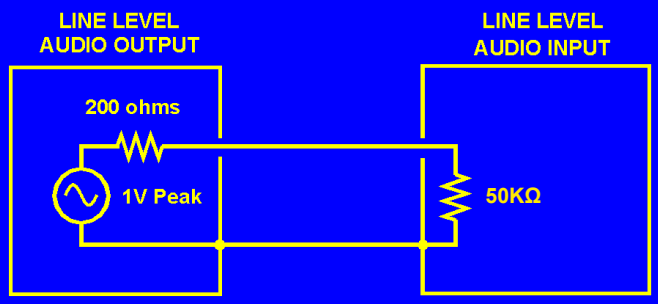
- We never match impedances
- We must match levels!

Pro Balanced Line Level



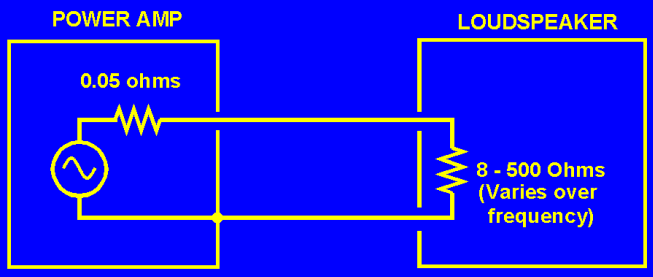
- Almost no audio current flows
- Wire size doesn't matter
- Twisting is important for hum/buzz/RFI rejection
- Shield is not necessary!
- Some pro stages are 6 dB hotter (20V peak)

Consumer Unbalanced Line Level



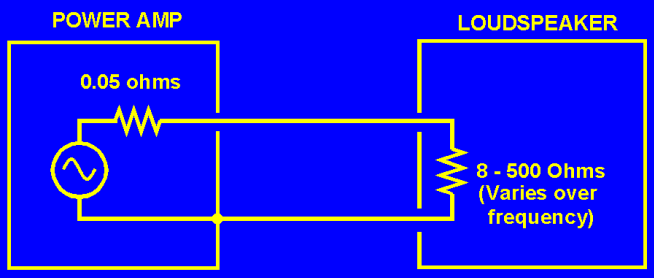
- Almost no audio current flows
- Center conductor wire size doesn't matter
- Shield resistance increases hum/buzz

Speaker Level (Medium)



- For a power amp:
  - 8 volts = 8 watts @ 8Ω, 16W @ 4Ω
  - 15 volts = 28 watts @ 8Ω, 56W @ 4Ω
- 8-15 volts is pro line level (+20 to +26 dBu)
  - It drives headphones just fine – just don't turn it up!

Speaker Levels (Low)



- For a typical computer sound card:
  - 1.4 volt = ¼ watt @ 8 ohms, ½ watt @ 4 ohms
  - 1 volt = ¼ watt to 4 ohm speaker
  - 1 – 1.4 volt is consumer line level!
  - It drives headphones just fine too!

Audio Level Matching

- Maximum Level is just before audio clips
- Clipping causes distortion
  - Harmonics, intermodulation
  - Muddy sound
  - Splatter!
- Consumer Line Ins and Outs clip at about 1 volt sine wave
- Mic Inputs may Clip at 100-200 mV
- Good output stages work best near their maximum output

Computer Output Level

- Computer sound cards usually produce less distortion about 6dB below clip
- VERY important for digital modes
  - PSK31
  - AFSK RTTY
  - Distortion produces sidebands (extra copies of your signal)
- Run the computer about 6 dB below clip

Finding Computer Level Controls

- Click the Speaker Symbol in the TaskBar
  - You should see some volume controls
  - Or Accessories, *Entertainment, Volume Control*
  - Click On *Options*
- Select *Playback* to set levels to the radio
  - Use the WAV control for Voice Playback and RTTY tones
  - If you have a mic plugged into the computer, use the Mic control to set its level when fed to the radio by your logging program
- Select *Record* to set input gain for the RTTY or PSK signal from the radio

Setting Computer Output

- Before connecting to radio, set the computer to transmit PSK31 (or AFSK RTTY) and watch audio on a scope
  - Increase output level until you see clip
  - Turn down output by 6 dB (half the voltage)
- This should optimize the computer
- The same computer settings should work for SSB message playback

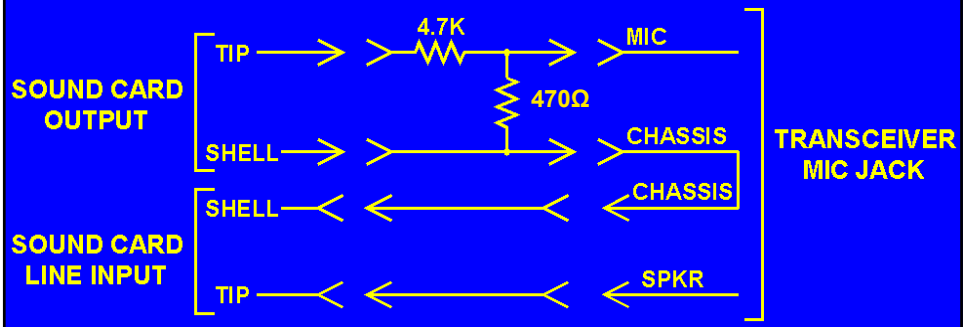
Setting Computer Output

- If you don't have a scope, listen to the computer output while it's sending PSK or RTTY tones, and increase the output level until you hear the sound change (get harsh, raspy). That's clipping.
- Now back off the level until that harshness goes away and it sounds about half as loud.
- This is the right setting for the computer, both for tones (RTTY, PSK) and SSB.

To Avoid Overloading the Radio

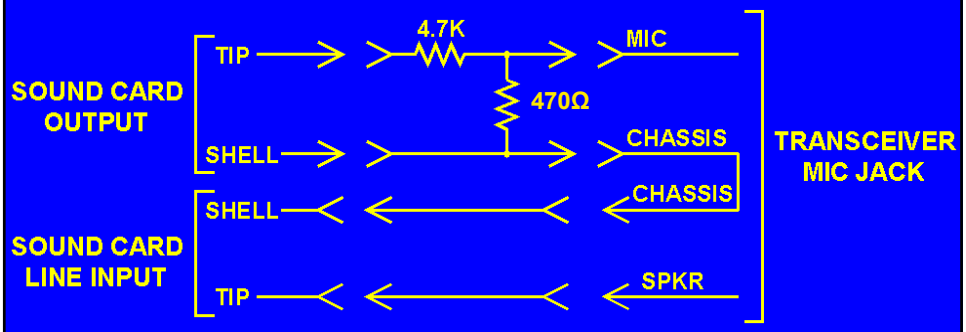
- Use a simple resistive pad (voltage divider) at the input of the radio
  - 2.2K in series, 1K across line input (10 dB)
  - 4.7K in series, 1K across line input (15 dB)
  - 4.7K in series, 470Ω across mic input (20 dB)
- The mic gain should be set about the same as it is for your mic
- Always use the 20dB pad if computer feeds the mic input
- Use the 10dB or 15dB pad on the line input if needed to put the mic gain in the right place

K6DGW Simple RTTY Interface



- Set rig for SSB, VOX operation
- No PTT required
- Follow Hum/Buzz steps 1 & 2
- MMTTY needs serial cable for rig control

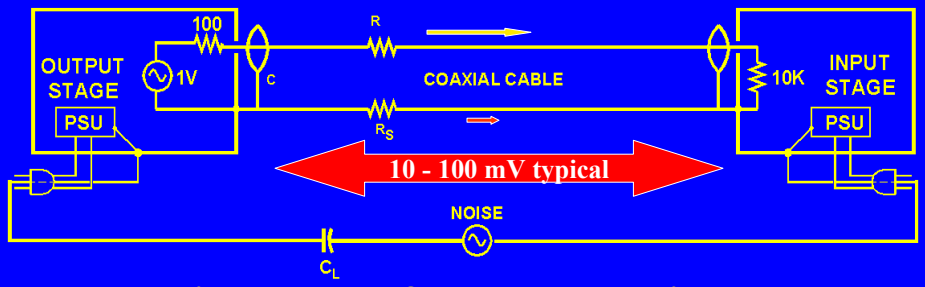
K6DGW Simple SSB Interface



- This works for SSB too!
- Plug your mic into the computer
  - Most logging programs will mute it when playing messages

The Unbalanced Interface Preventing Hum and Buzz

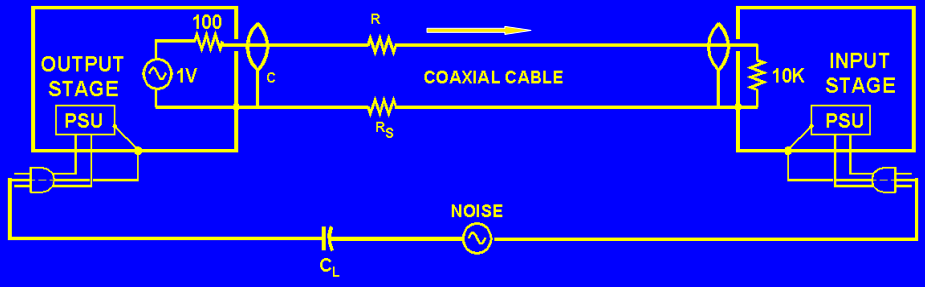
The Problem with Unbalanced Interfaces



Noise current flows on the shield, and the IR drop is added to the signal.

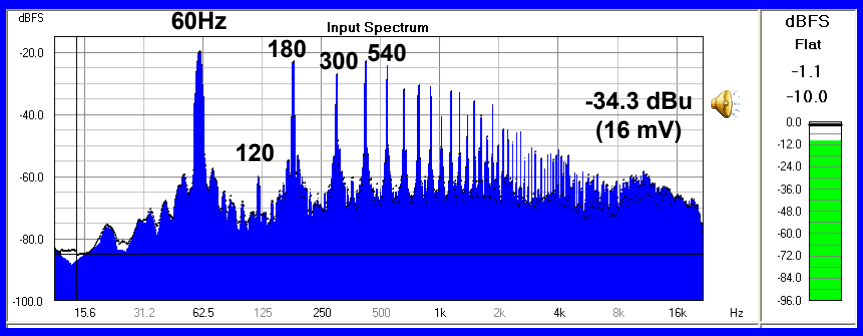
Any voltage between the two chassis is added to the signal.

The Problem with Unbalanced Interfaces



- **Input stage is high impedance, so very little signal current through R and R_S**
  - **Resistance of center conductor doesn't matter**
- **Noise current flows on the shield**
  - **Resistance of the shield is very important**
  - **Hi-fi cables have lousy shields**

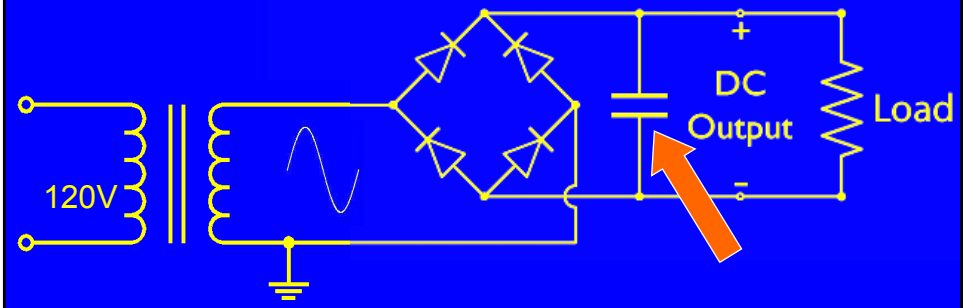
Typical Noise Spectrum on "Ground"



Measured between two outlets on opposite walls of my ham shack and office, into a high impedance

The Harmonic Problem

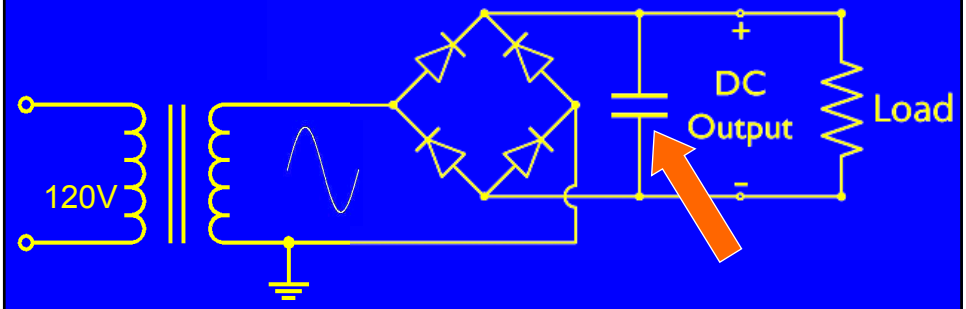
Recognize this power supply?



Something like it is in <u>every</u> piece of electronic gear – audio, video, computers, printers, copiers (even switching power supplies)

The Harmonic Problem

Recognize this power supply?



Current flows in short pulses that recharge the filter caps on each half cycle

Current is not even close to a sine wave

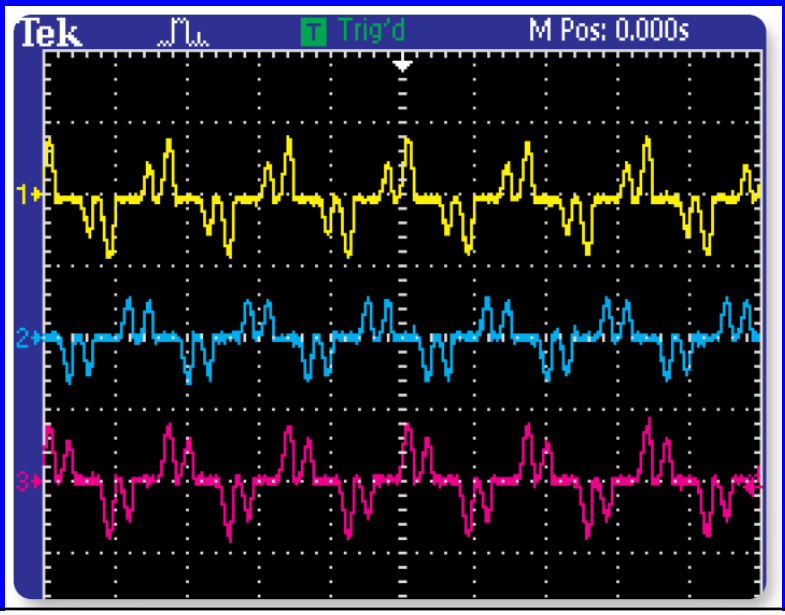
The Harmonic Problem

- **Nearly all electronic loads have power supplies with capacitor-input filters so:**
- **Load current is drawn in short pulses at peaks of the input sine wave thus:**
- **Phase, neutral, and leakage currents are highly distorted**

Problems With Pulse Currents

- Because current flows in short pulses, the IR drop at the peak of the current waveform can be much greater than for a sine wave
  - Greater I^2R losses
  - Voltage waveform is distorted
  - Lower voltage delivered to equipment
  - Increased dissipation in phase and neutral conductors
  - Increased dissipation in transformers

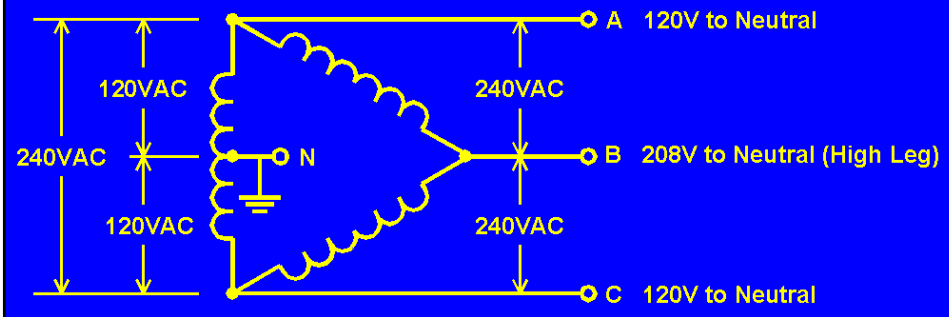
Load Currents in a 3-Phase System



But I Don't Have 3-Phase at Home!

- No, but that factory or business down the street does, so you may get your 120V-0-120V service from the "high leg" of a 240V Delta in your alley!
- Some of their neutral current may flow through your neutral to ground!

"High Leg" Delta

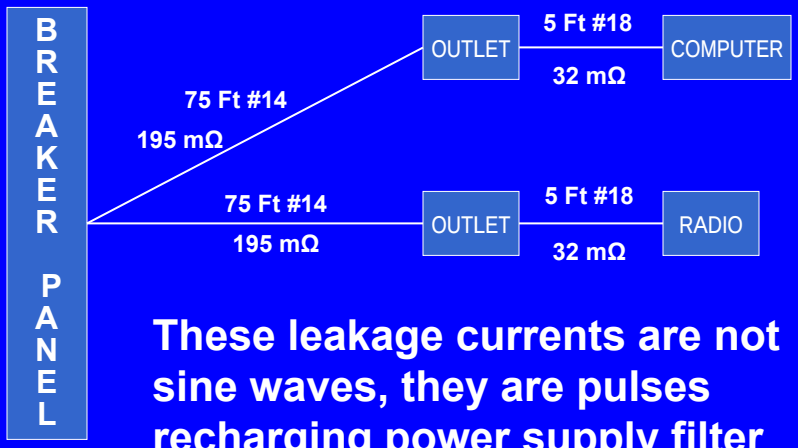


- Common in mixed industrial/residential areas where both single phase and 3-phase power are needed
  - A-N-C feeds residences (120-0-120)
  - A-B-C feeds industrial users (240-240-240)
  - Part of Neutral current from 3-phase system goes to ground through residential ground connection!

Sources of Noise on "Ground"

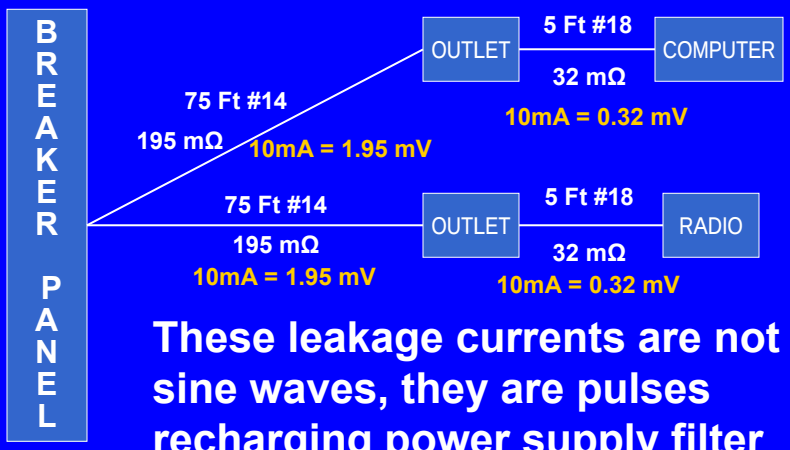
- Capacitance from AC "hot" to ground
  - Leakage capacitance in transformers
  - AC line filters
- Magnetic induction
  - Leakage fields from power transformers
  - Wiring errors in buildings and homes
    - Double bonded neutrals
  - Leakage fields from motors and controllers
    - Variable speed drives
- 3-Phase noise current from neighborhood

Power System Ground Wiring (The "Green Wire")



These leakage currents are not sine waves, they are pulses recharging power supply filter capacitors!

Power System Ground Wiring (The "Green Wire")



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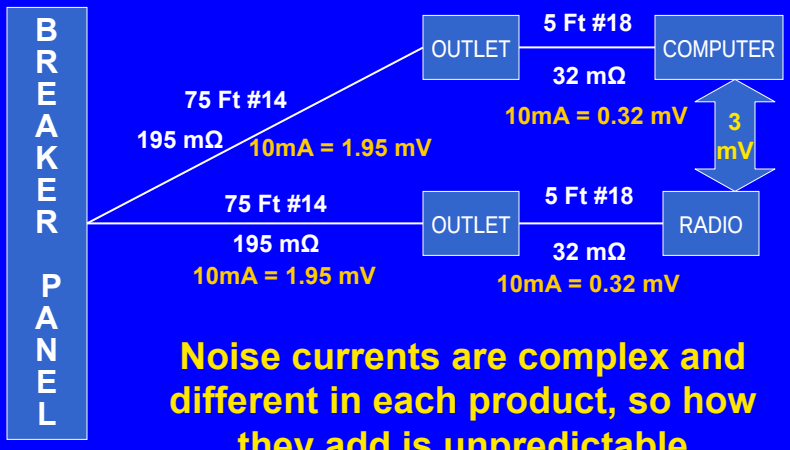
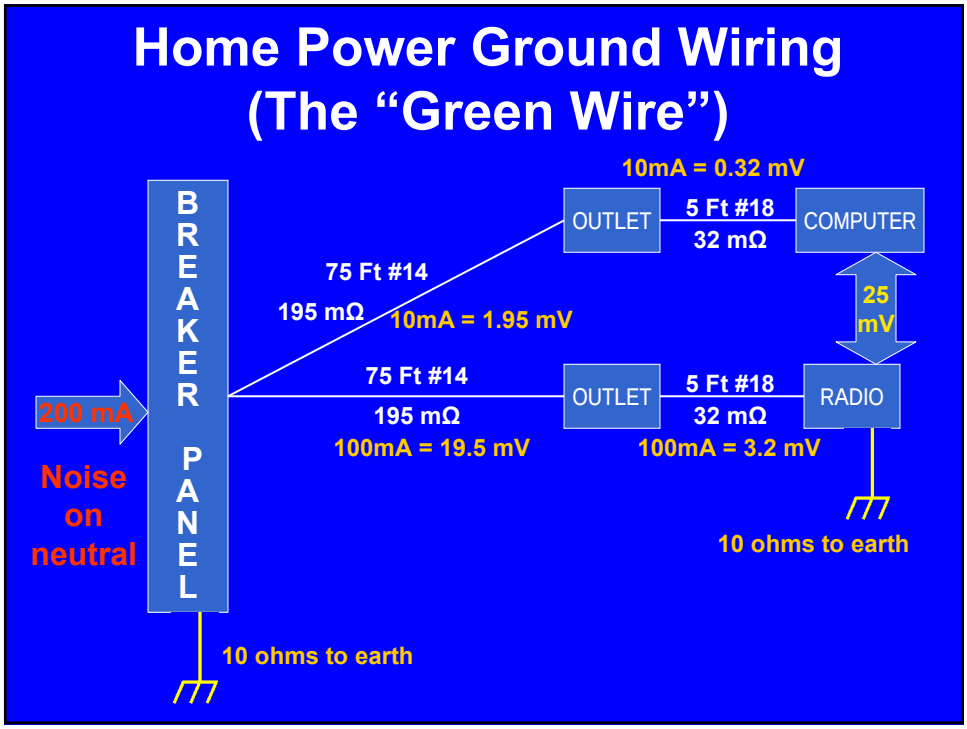


Noise currents are complex and different in each product, so how they add is unpredictable

Home Power Ground Wiring (The "Green Wire")



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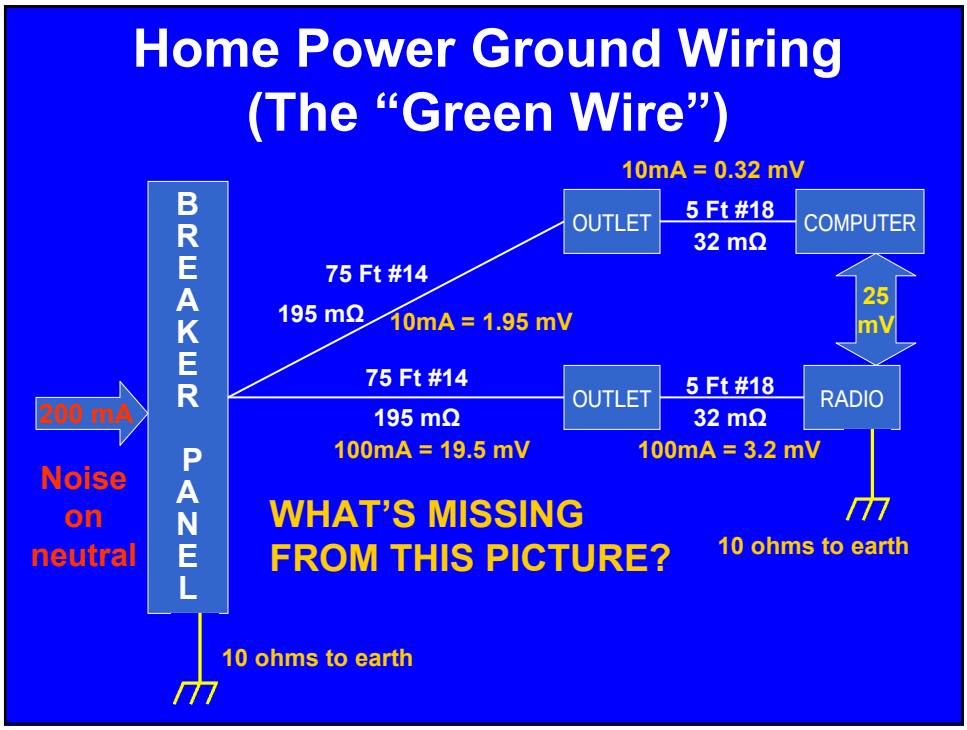

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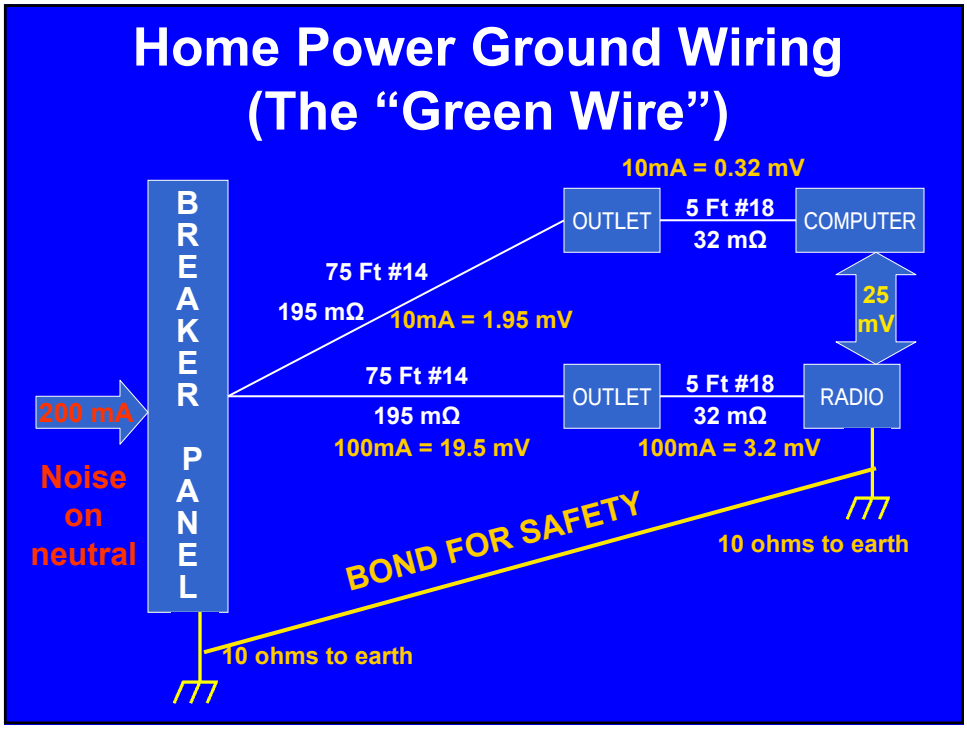

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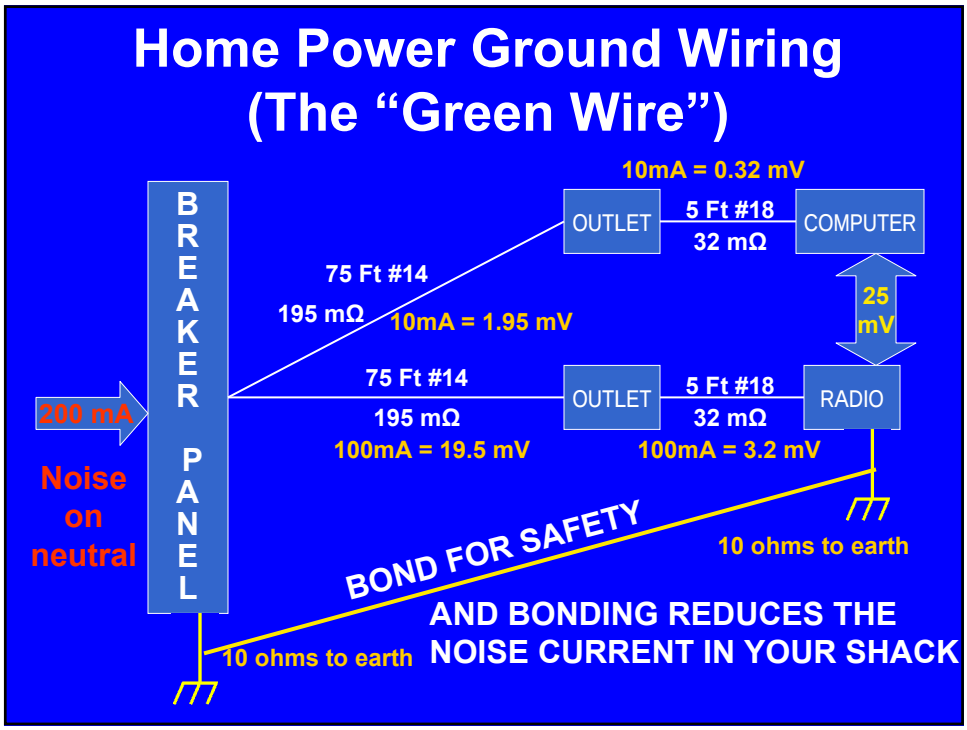
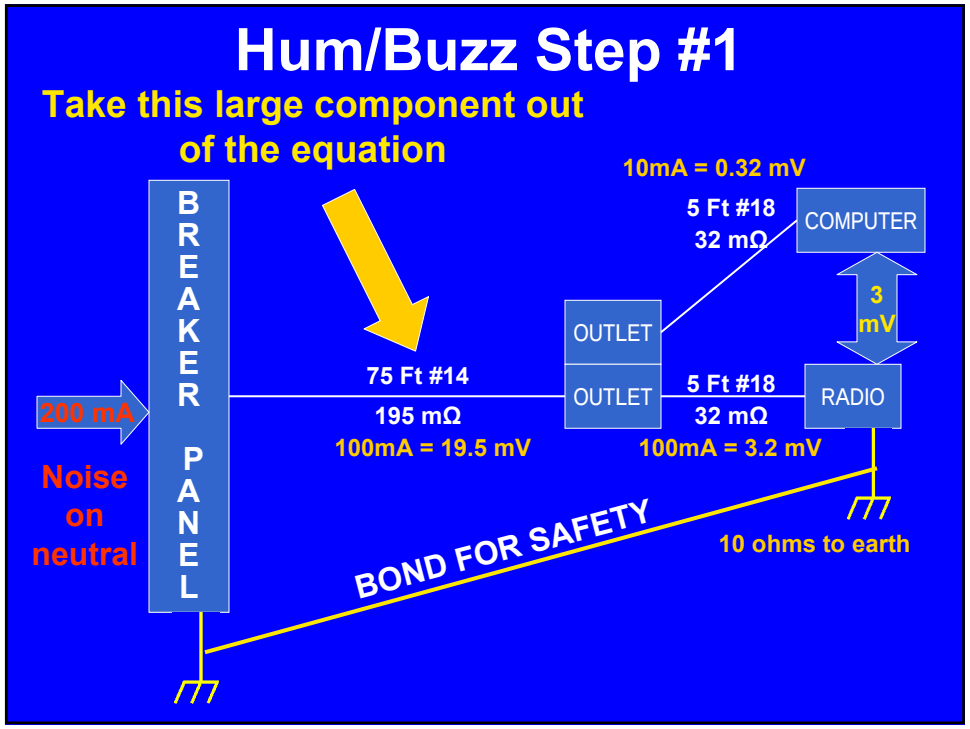


Hum/Buzz Step #1

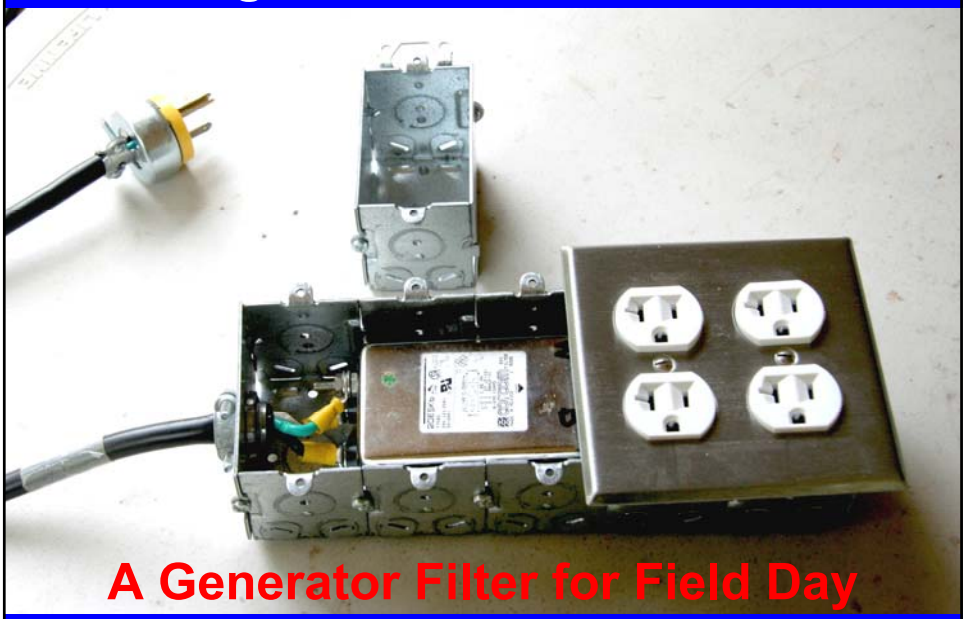


Hum/Buzz Step #1

- Get all the power for your ham station from outlets connected to the same "green wire"
  - A 15A circuit can run three 100W radios (transmitting simultaneously) and two computers
  - If you need more outlets, bolt multiple quad boxes together
  - If installing new wiring, always run #12 for 20A circuits
- Put 240V outlet in a backbox bolted to the 120V box(es)

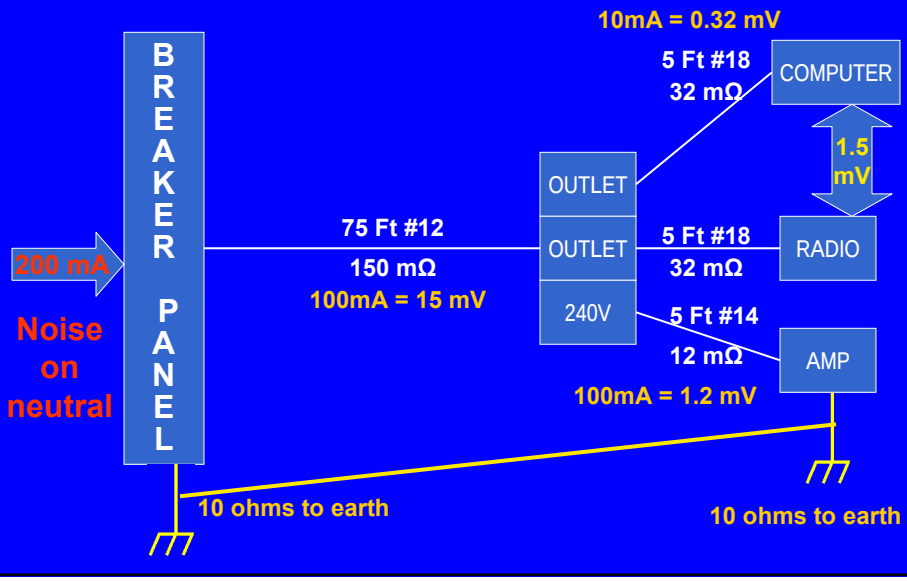
A Quad Box in My Shack

Use Gangable Boxes for More Outlets



A Generator Filter for Field Day

Home Power Ground Wiring (The "Green Wire")



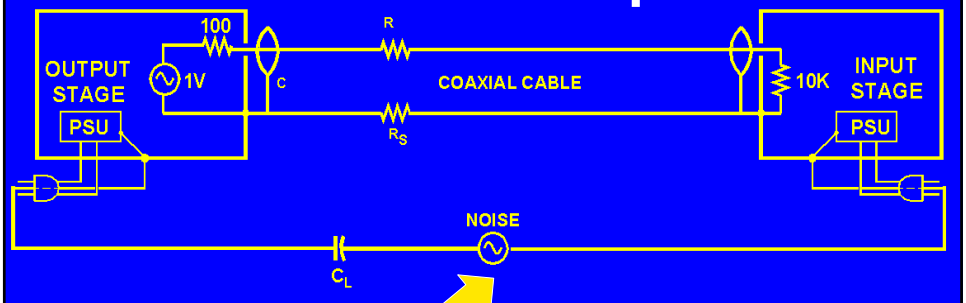
Hum/Buzz Step #1

- This reduces the voltage between outlets to a few millivolts or less
- What's left are the IR drops on line cords within your station
- Step #1 is typically good for 20 dB

Hum/Buzz Step #1 for Multi-Multi

- Get all the power for as many stations as possible from outlets connected to the same “green wire”
- Bolt more boxes together as needed
- When outlets can’t be bolted, bond them together with steel conduit or heavy braid

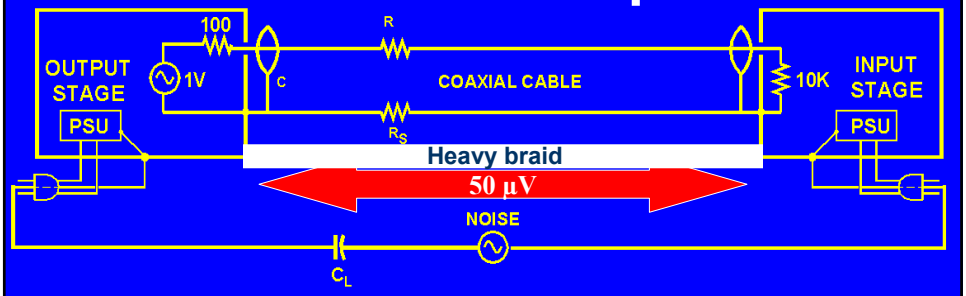
Hum/Buzz Step #1



Hum/buzz step #1 reduces this voltage, but often not enough

So we need step #2

Hum/Buzz Step #2

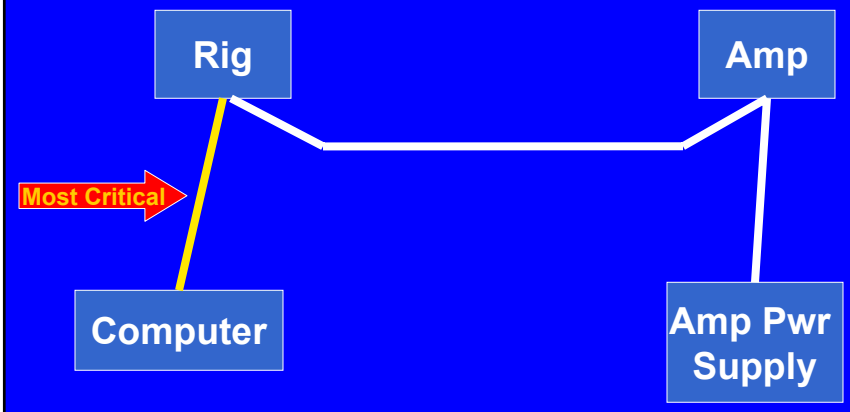


- **Short out the remaining noise (reduce the IR drop) by adding a BIG conductor between the two chassis**
- **50µV would yield 76 dB S/R ratio**

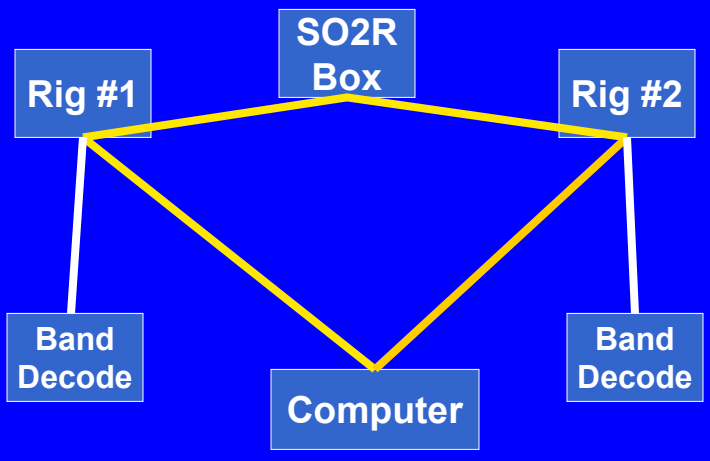
Hum/Buzz Step #2

- **Bond all interconnected equipment together with short, heavy copper braid**
  - **Radio to power supply**
  - **Radio to computer**
  - **Radio(s) to SO2R box**
  - **Radio to other band decoder, etc.**

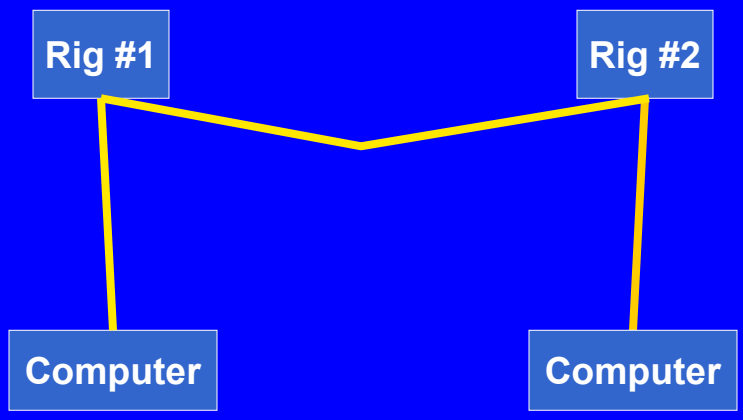
Equipment Bonding – A Basic QRO Station



Equipment Bonding – SO2R Station



Equipment Bonding – SO2R Station



Guidelines For Bonding

- Add bonding in parallel with every unbalanced audio and data path
- Bonding should be #10 copper or larger
  - Strip braid from transmitting RG8, RG11
  - Or buy braid if you see it cheap enough
  - #10 THHN stranded is fine, but stiffer
- Bond to chassis of rigs and computers
  - Retaining screw of D-connector on laptops
- Keep bonding conductors short

Guidelines For Bonding

- Noise is proportional to resistance of the bonding path
- Make conductor BIG
  - Double the size = 6dB less buzz
  - Two conductors in parallel = 6dB less buzz
  - Four conductors in parallel = 12 dB less
- Make bonding conductor SHORT
  - Half the length = 6dB less buzz

SO2R Box Bonding

- Bond transmitters together
- Bond computer(s) to transmitters
- Bond SO2R box to computer(s) or transmitters
  - This can be difficult – many SO2R boxes are built with pin 1 problems
  - Bonding all equipment connected to the SO2R box will usually kill the buzz

Multi-Transmitter Bonding

- Bond all transmitters together
- Bond all power outlet green wires together
- Use bigger copper for longer runs
  - Multiple RG8/RG11 braids in parallel

When There's No Metal to Bond To

- Power that unit from a good DC power supply and bond the chassis of the supply
- Bond to a D-connector retaining screw

Or

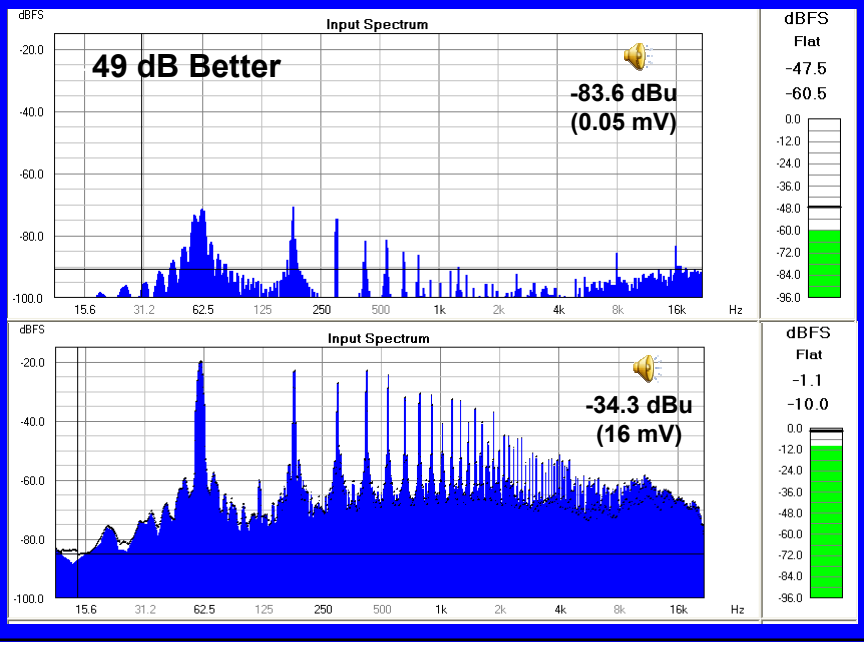
- Use a double-insulated power supply (legal 2-wire power cord) for the SO2R box and bond only the rig, amp, and computer(s)

Hum/Buzz Steps #1 & #2

- Should eliminate most hum and buzz
- No need to replace crummy cables
- AND it puts a band-aid on power-related pin 1 problems!
  - No shield current, no pin 1 problem (at audio)
- RF pin 1 problems still possible
- Still have hum/buzz?
- Suspect Magnetic Fields
- Move on to Step #3

How Well Does This Work?

Noise Reduction From Simple Bonding



And It's Right for Lightning Safety and RFI

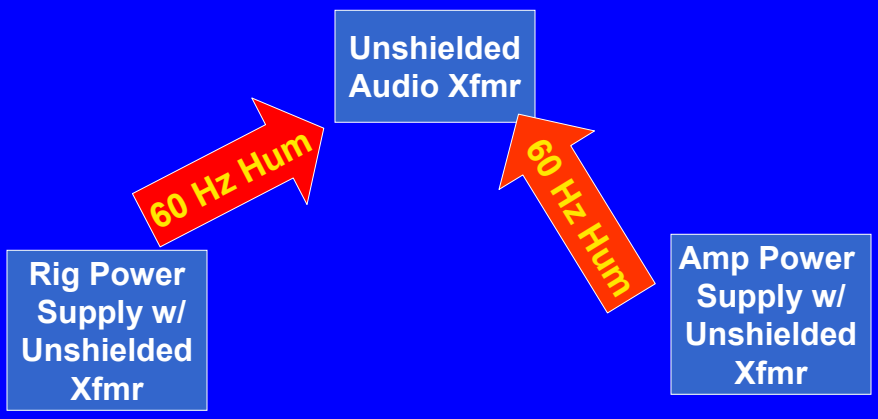
Still Have Hum/Buzz?

- Suspect Magnetic Fields
- Move on to Step #3

Hum/Buzz Step #3

- Fix magnetic field problems
  - Big transformers in power supplies can couple hum into audio transformers
  - Move power xfmr away from audio xfmr
  - Rotate the power supply to put the field at 90° to the audio transformer's field
  - Rotate the audio transformer
  - Get rid of the audio transformer (you don't need it!)
  - Shield the audio transformer

The Problem with Cheap Audio Transformers



An unshielded audio transformer can cause a hum problem!

Audio Transformers

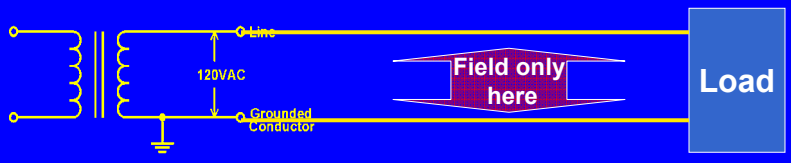
- An expensive fix for "ground loops"
- Sitting duck for magnetic fields
  - Must be well shielded!
  - Shielding is expensive (typically $50-$70)
- If you've done Hum/Buzz steps #1 and #2
  - You don't need a transformer!
  - You don't need an optoisolator!
- An *unshielded* audio transformer can cause more problems than it solves!

Audio Transformers

- You do need a transformer to bring audio in from another building
  - Remote operation, etc.
  - Need *mu-metal shield* to reject magnetic fields
  - Need *dual Faraday shields* to reject RFI
- Lundahl
  - http://lundahl.se
- Jensen
  - http://jensen-transformers.com

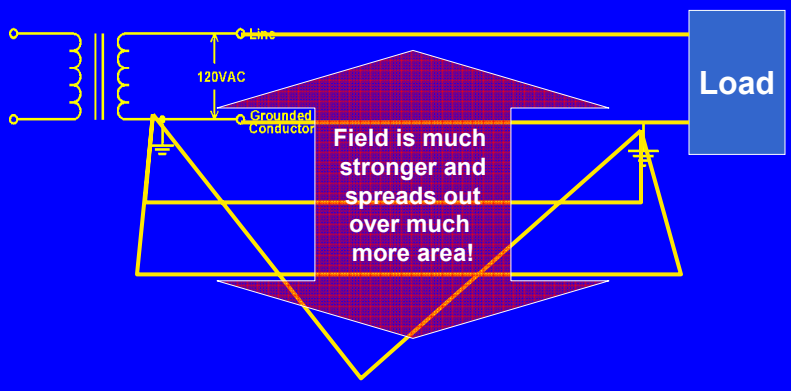
A Double-Bonded Neutral Creates An Interfering Magnetic Field

Field with Single-Bonded Neutral (Right)



- Field mostly confined to the very small area between conductors – that is, between the wires

Field With Double-Bonded Neutral (Wrong)

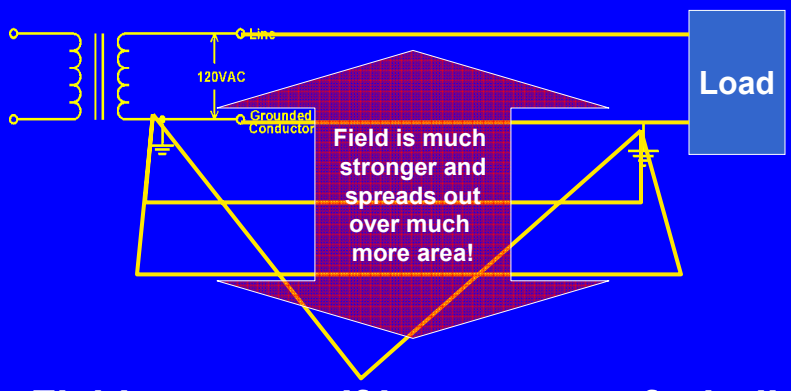


- Field may engulf large areas of a building!

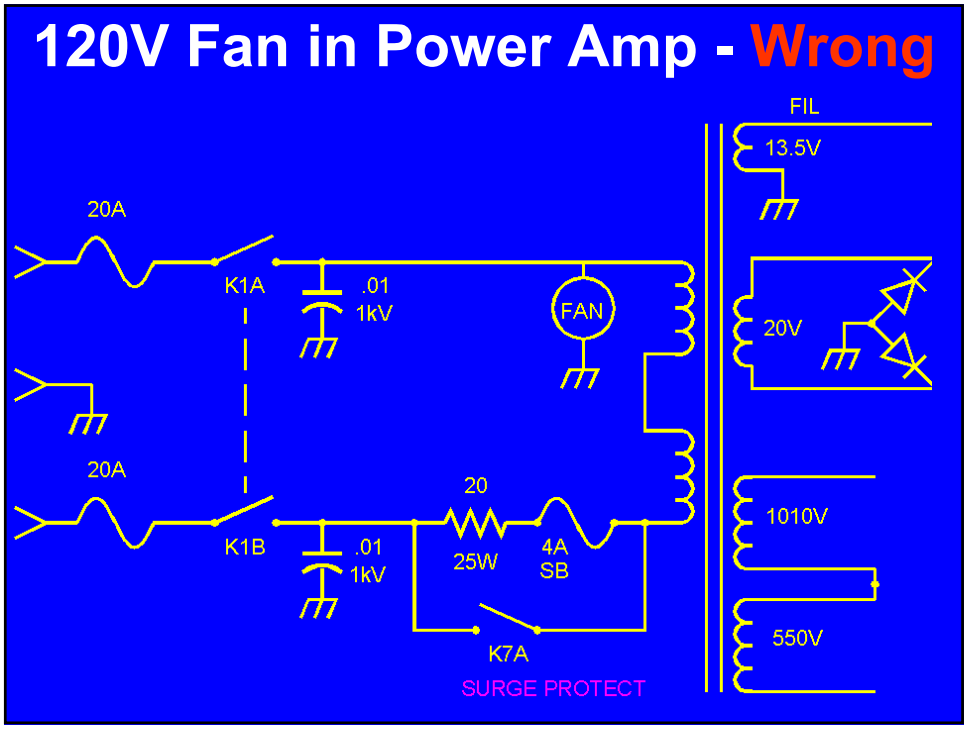
Hum/Buzz Step #3

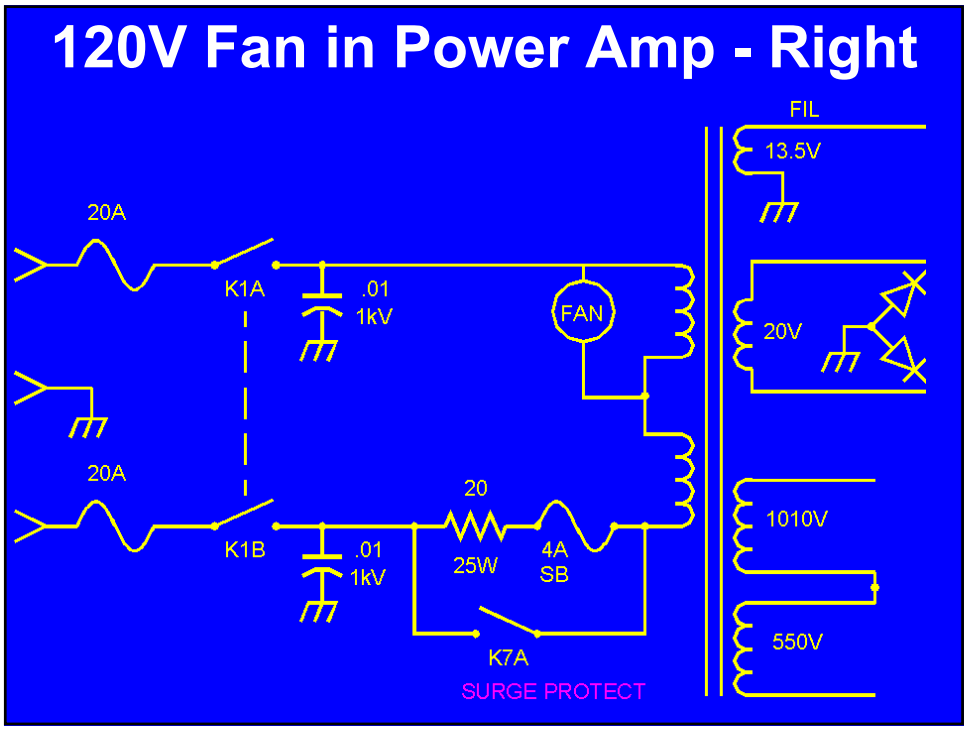
- Fix magnetic field problems
  - Double-bonded neutral
    - Neutral must be bonded to ground ONLY at the breaker panel, NEVER anywhere else
    - Use AC voltmeter to look for zero volts between neutral and ground (that's bad – it indicates an extra bond)
    - "Normal" is 20mV – 2 volts
    - This will be ***buzz***, not ***hum***

Load Connected Hot to Ground (Also Wrong)



- Field may engulf large areas of a building!
- Puts hum voltage on green wire (chassis)
- Fans in some older power amps


120V Fan in Power Amp - Wrong
FIL
13.5V
20A
K1A
.01
1kV
FAN
20V
20A
20
K1B
.01
1kV
25W
4A
SB
1010V
K7A
550V
SURGE PROTECT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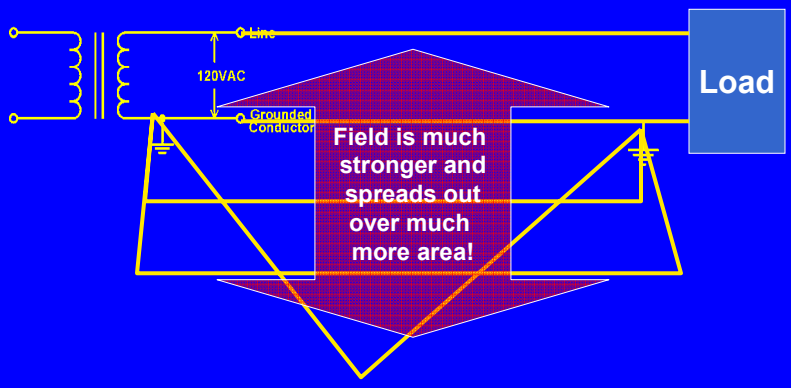
FAN
20V
20A
20
K1B
.01
1kV
25W
4A
SB
1010V
K7A
550V
SURGE PROTECT

Load Connected Hot to Ground In Alpha 77, 500 mA



- Field may engulf large areas of a building!
- Puts hum voltage on green wire (chassis)

Hum/Buzz Step #3

- Finding big ground currents
  - Use AC voltmeter to measure voltage drop on green wire between outlet and the chassis
  - Use Ohm's law and the wire resistance to find the current (measure the length – 5-6 ft is typical)
    - 5 ft of #18 = 0.032 Ω (most IEC line cords)
    - 5 ft of #16 = 0.020 Ω (a few heavier IEC line cords)
    - 5 ft of #14 = 0.0126 Ω (maybe on your power amp)
  - 6 mA is maximum leakage permitted by NEC; more is illegal, and should trip a GFCI

Hum/Buzz Step #3

- Fix magnetic field problems
  - Hot to ground loads
    - NEVER do this – causes current to flow on ground
  - Current on green wire to station ground
    - Station ground better than power system ground?
    - Power system ground not bonded to station ground?
    - Power system not properly grounded?

Now Lets Talk About Mics

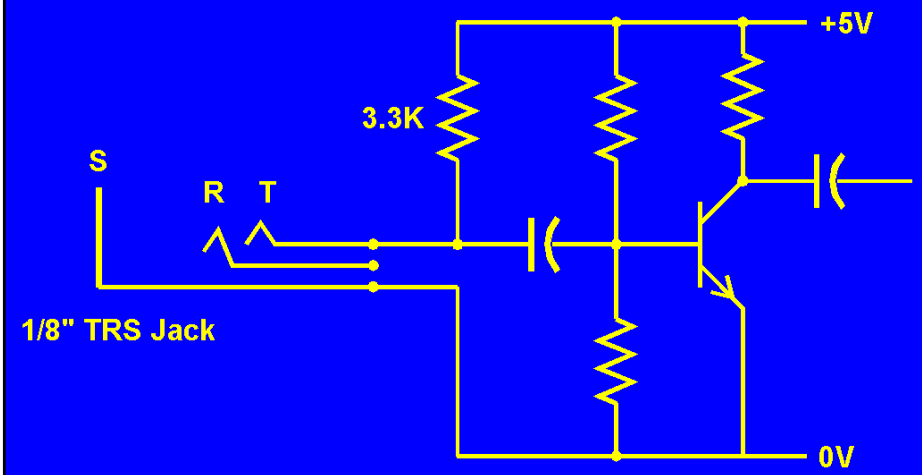
Mic Levels and Impedances

- Audio circuits operate on voltage
- Unbalanced line level is 1 volt sine wave on peaks
- Audio is quite dynamic. A low impedance mic may produce less than 1 mV with soft sounds, but 2 volts with very loud music
- Low impedance mic outputs are 150-250Ω
- Low impedance mic input stages are typically 1,000 – 4,000Ω
- Most ham mics are low impedance mics

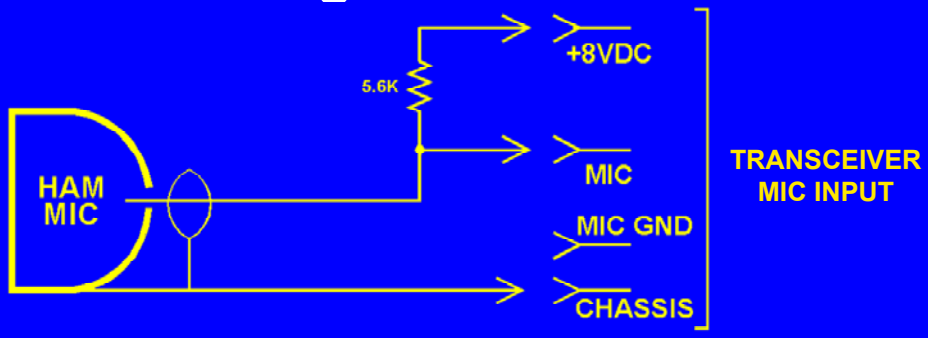
Dynamic and Electret Mics

- Mics convert sound vibrations to voltage
- *Electret* mics have a pre-polarized capacitive diaphragm connected to a FET "follower" impedance converter. The FET needs a small DC voltage (bias) to operate.
- *Dynamic* mics have a diaphragm attached to a coil that vibrates in a magnetic field.
  - These mics do not need bias, but they can tolerate bias from a high resistance source (5K)
- Many modern ham mics are electrets, but dynamic mics work fine with ham gear too

Laptop Mic Input (Type 1)

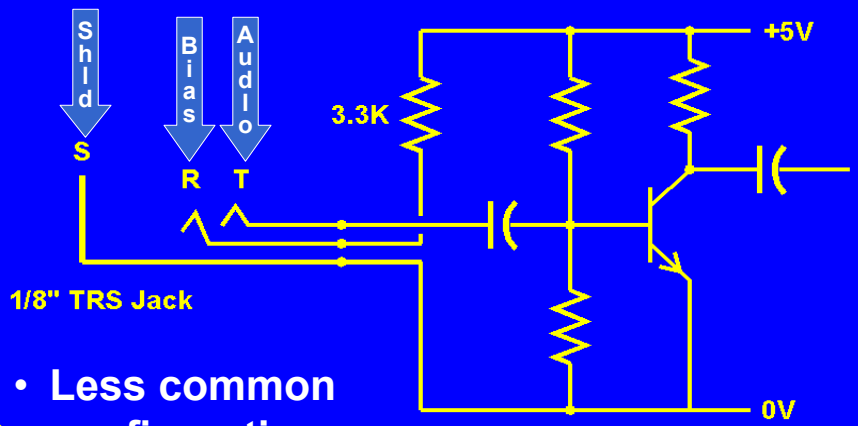


Biasing an Electret Mic



- DC voltage not critical (5-12VDC)
- Resistor value not critical (4.7K-6.8K)
  - Use lower resistor value for low voltage, higher for high voltage
  - Can fit inside ham mic connector
  - Built into K3, turn it on and off from setup menu

Laptop Mic Input (Type 2)



- Less common configuration
- Tip is audio input
- Ring provides DC to FET in electret mic

Ham Mic to Laptop

- Many ham mics are electrets
  - Need power for the FET
- If a 1/8-inch connector
  - Wire mic audio to Tip (audio input)
  - Wire mic "power" to tip thru 5.6KΩ
  - Wire mic audio ground to Shell
  - Wire mic shield to Shell
- In laptop, turn on mic pre-amp
  - Called "mic boost" in my Thinkpad
  - Not all sound cards have a mic pre-amp!
  - If no preamp, it may not be loud enough

Yamaha CM500

- About $45
- Great response for contesting
- Electret mic
- Plugs into rear panel of K3 (turn on bias)

- 1/8-in plug, so needs cable adapter for other rigs, get bias from mic connector
- Plugs straight in to most laptops
- Headphones are very comfortable, good isolation, and sound very good

CM500 Mic to Icom, Kenwood, Yaesu

- Much nicer than Heil headsets
  - Mic sounds much better
  - Headphones more comfortable
  - Much less expensive!
- Build cable adapter
  - Tip of 1/8-in connector to mic in
  - Tip of 1/8-in connector thru 5K to +8VDC
  - Shell to mic connector ground
  - No connection to ring

Make Your Own Cables

- Much better than you can buy
- Raw Audio Cable
  - Small coax with braid shield
    - RG58, RG174, etc.
  - Miniature shielded twisted pair
    - Gepco XB401 (braid shield)
    - Belden 1901A (braid shield)
- Connectors
  - Switchcraft and Neutrik are the good brands
- Avoid Radio Shack, Fry's, and hi-fi shops
  - Cheesy construction, dissimilar metals

Cable-Mount Audio Connectors

Description	Switchcraft	Neutrik
3-ckt male 1/8" plug	35HDNN	NYS231BG
2-ckt male 1/8" plug		NYS226BG
3-ckt female 1/8" jack		NYS240BG
Phono (RCA) male plug	3502	NYS352
Phono female jack	3503	

Buying Good Audio Connectors

- Stick to Switchcraft, Neutrik
- Full Compass Systems
  - Madison, WI
- Sweetwater
  - Ft Wayne, IN
- Buy in quantity – much of the cost is shipping

Now Lets Talk About Rig Control Interfaces

- Nearly all rigs use RS232
  - All rigs except Icom
  - Each radio needs its own RS232 port
- Icom has their own interface (CI-V)
  - Converts one RS232 port to two wire 1/8" plug
  - One RS232 port can control four radios
  - Icom's RS232 to CI-V is expensive
  - You can build one for about $15

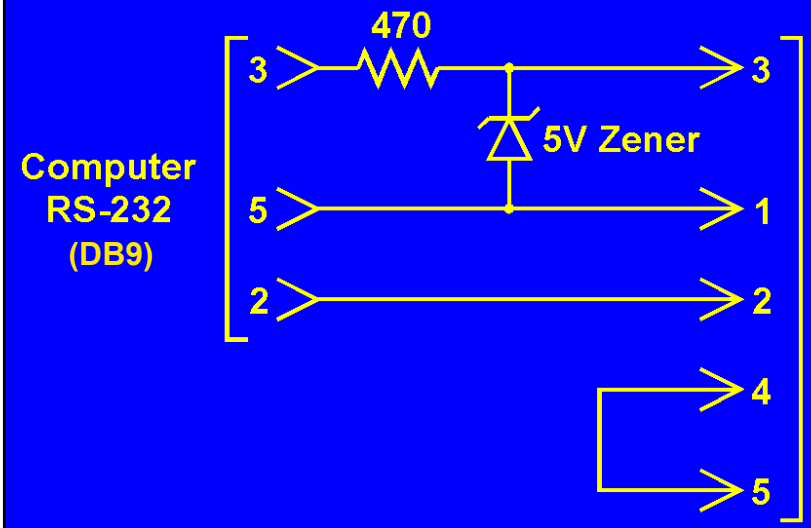
RS232 Control Functions

- Radio control
  - Read frequency, mode for logging
  - Remote control – change frequency, radio settings, filters, etc.
  - Elecraft, Kenwood, Yaesu have a serial port
  - Icom is proprietary, needs special adapter
- CW, PTT
  - Can be on same serial port used for control
  - Can be on a parallel port
  - Require a simple NPN inverter/level shifter
  - RTTY requires 2nd serial port for PTT

Control Wiring

- Interconnect is unbalanced
  - We must eliminate the noise voltage on equipment grounds (bonding helps a lot)
  - Only two circuits for radio control
  - TXD and RXD (pin 2, pin 3, return)
  - Twisted pair (CAT5) has best RFI rejection
- Send CW on COM DTR (pin 4)
  - Need simple NPN inverter/level shifter
- Send PTT on COM RTS (pin 7)
  - Same simple NPN inverter/level shifter
- Can also use parallel port for CW and PTT

Low Cost Kenwood Interface



Can fit inside a DB9 or DIN

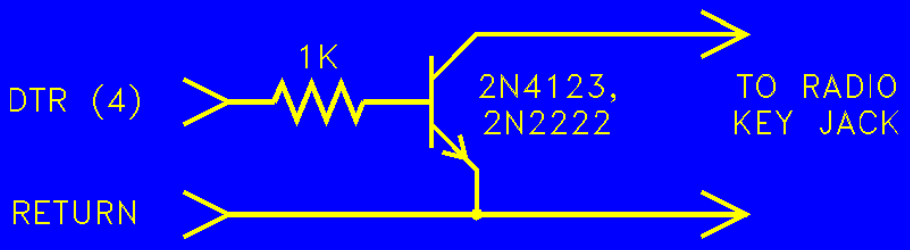
Low Cost Icom Interface

- By KG7SG, in July 1992 QST
  - Get circuit board from Far Circuits $5
- 4-transistors, 2 diodes, easy to build
- W1GEE builds them and N3FJP sells them
- Self-powered from RTS line
  - Must modify circuit if you want to use RTS for PTT
  - Get power from a 12V source instead

The K9YC Serial Cable

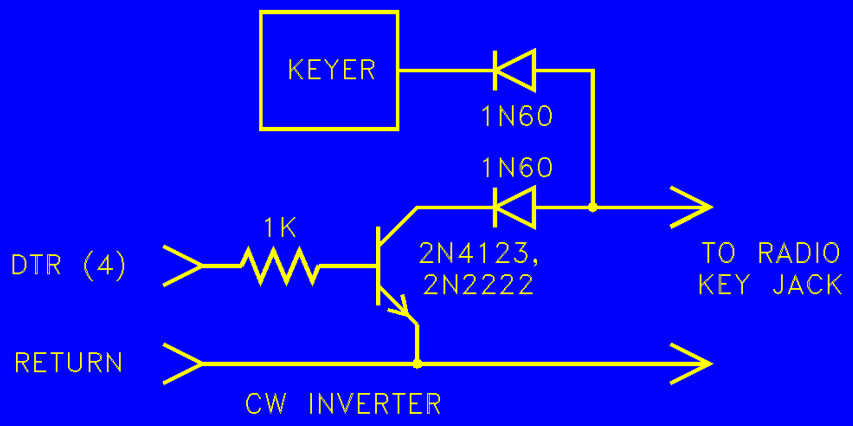
- Eliminates RFI, minimizes hum and buzz
- Use ordinary CAT5, CAT6 (4 twisted pairs)
- Use one pair for each circuit
  - Pin 2 Brown
  - Pin 3 Orange
  - Pin 4 Green (DTR, used to send CW)
  - Pin 7 Blue (RTS, used for PTT)
  - Connector shell – Brown/White, Orange/White, Green/White, Blue/White
- Don't use pin 5 – it's a pin 1 problem!
  - RFI, hum, buzz, noise interferes with RS232

The CW Inverter



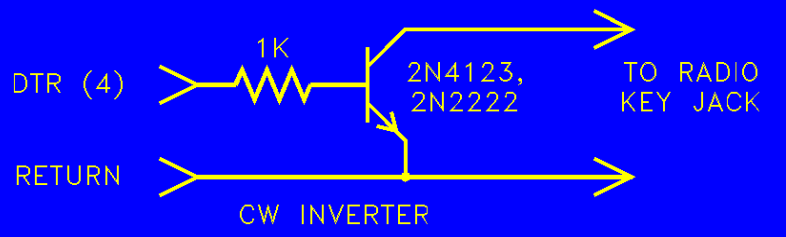
- Almost any small signal NPN works
- Can fit inside a DB9 M/F adapter
- Build a "thru" adapter to work with any radio
  - Carry control signals through it (pins 2, 3, common)
  - Break out CW and PTT (4, 7, common)

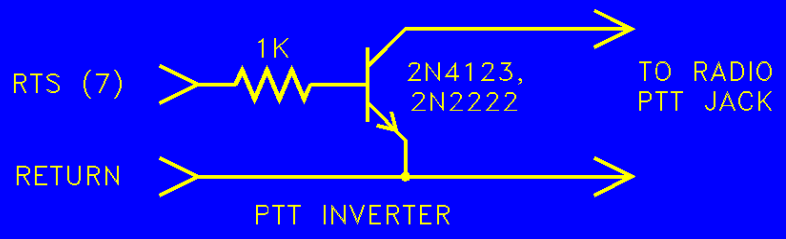
Diodes Add a Keyer to DTR Keying



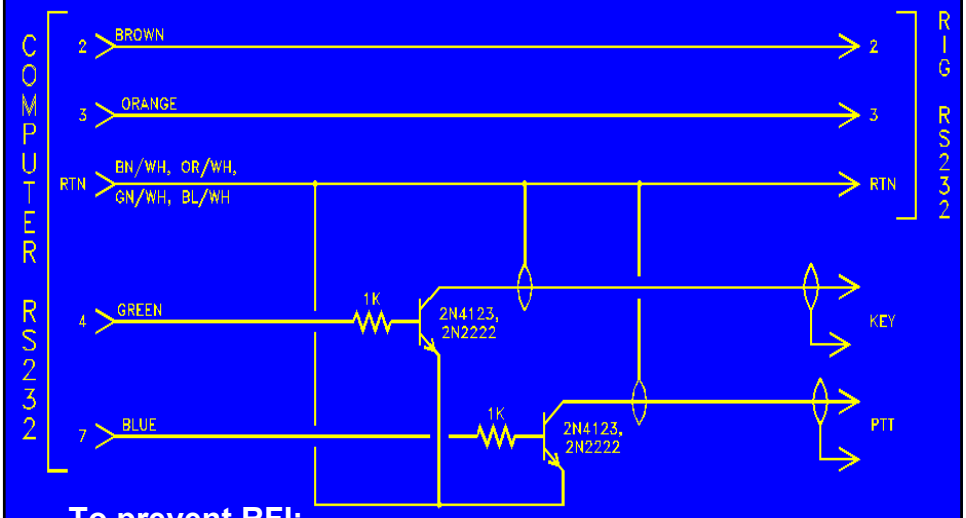
- **Works with almost any keyer**
- **Si diode works with most radios, but for a few, lower voltage of Ge diode may be needed**

PTT Inverter is the Same





Serial Port Connections

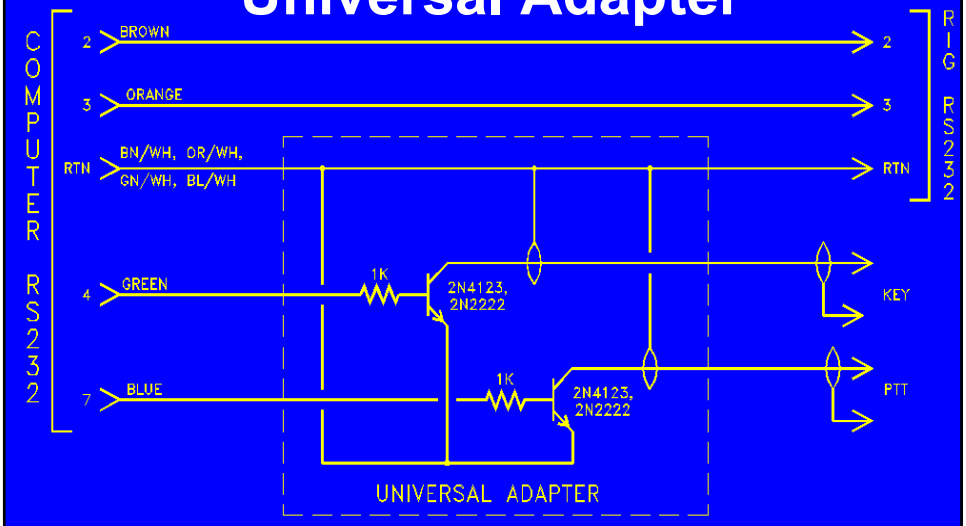


To prevent RFI:

Use CAT5 for computer to radio interface

Use chassis (DB9 shell) as return, not pin 5

Universal Adapter

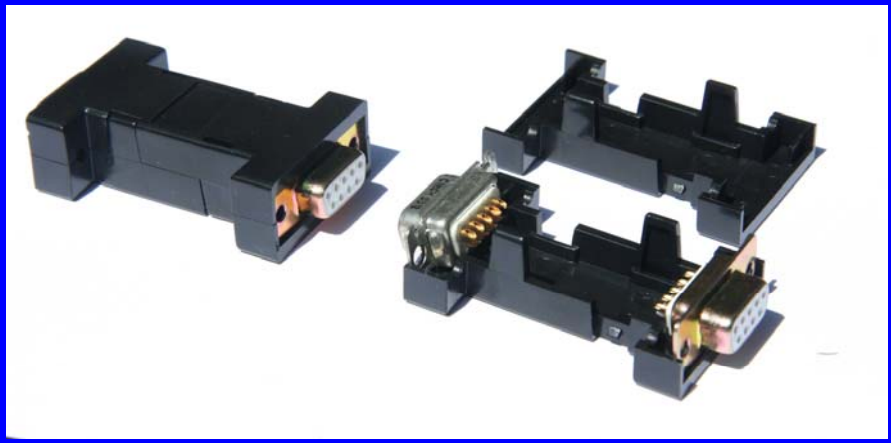


To prevent RFI:

Use CAT5 for computer to radio interface

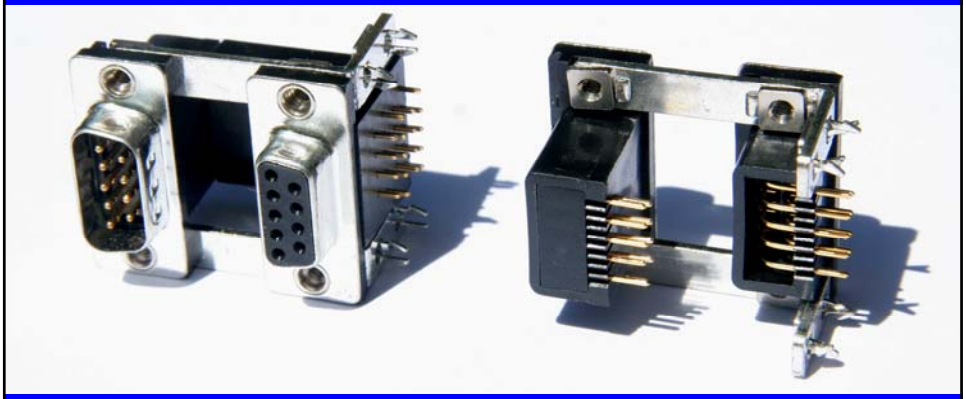
Use chassis (DB9 shell) as return, not pin 5

Building a Universal Adapter



Jumper pins 2, 3, and 5
Add transistors, resistors for Key, PTT
Drill hole(s) for Key and PTT cables to exit

Building a Universal Adapter



This costs about $1 at HSC (Halted)
Remove jumper block between connectors
Add transistors, resistors, and jumps for 2, 3, 5

Adapter – Cost of Parts

- Connector to hold adapter $1 - $2
- Transistors $0.20 at HSC
- Diodes $0.05 at HSC
- Resistors $0.01 at HSC
- DB9 Connector for Computer $1 at HSC
- DIN connector for radio $7 for a good one
- Plug for key input
  - RCA phono male $1
  - 1/4-inch stereo plug $2

Computers Without Serial Ports – What are the Options?

- Real RS232 Ports on a PCI Card
- Real RS232 Ports on a PCMCIA or PC Card
- Real RS232 Port on Port Replicator
- USB to RS232 Emulators
- A Used Computer with real RS232 ports

Computer Serial Ports

- Real Serial Ports are best
  - Look for 16550 or 16750 UART
  - PCMCIA (PC Card) Adapter for laptop
    - Quatech
    - Buy at B&B Electronics $150 2-ports
  - Buy a port replicator for your laptop
    - Ebay –$15-$50
    - Look for seller with at least 99.5% positive rating
  - PCI card for desktop or tower computer
    - B&B, Quatech $90 for one port, $115 for two, $165 for four

USB Serial Ports

- Emulate a serial port
  - Compatibility can be a problem
  - Mostly a driver and/or chip problem
  - May work with some programs and not others
  - Takes more processor overhead than a real serial port
  - Cheap
- Cheap USB to single serial port $15 - $30
- Edgeport 4-port USB to serial $270

USB Serial Ports

From a ham email list:

"Issues with USB are mostly in the drivers, but not always."

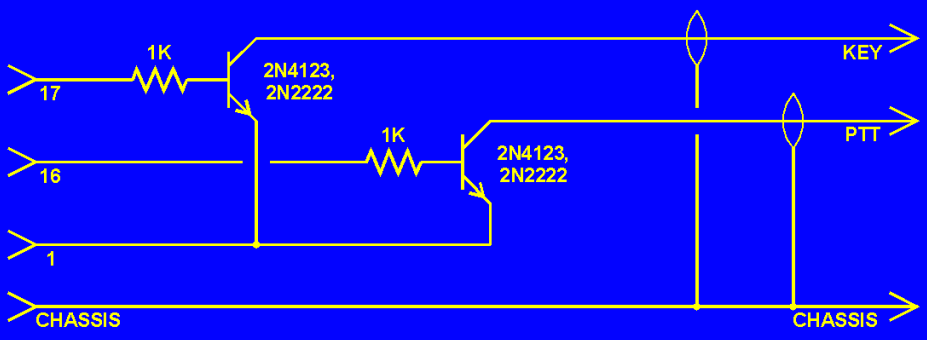
" The Elecraft USB adapter uses a Prolific chip set. It is not always trouble-free. "

"There is no universal answer to USB com port issues. Two people with identical setups, one will have problems, the other not, probably only differing in the order that applications were installed on the hard drive."

A New (Used) Computer

- Use a modern computer for Windows
  - Windows 2000 Pro, XP Pro
  - Avoid Windows 7, Vista
- Use enough RAM (512MB min, 1 GB better)
- Thinkpads work well for ham radio
  - Decent sound card, with mic preamp
  - T20-series, T30-series have a real serial port
  - T40-series and later have no serial port
- Off-lease IBM desktop $125 - $250
  - Real serial ports, XP Pro
  - Tiger Direct and other sources

LPT1: Keying and PTT



- Same inverters as for serial port keying
- Almost any small signal NPN works
- Can fit inside a DB25 shell or M/F adapter

Junk DIN Connectors

- Virtually all DIN connectors sold to hams are JUNK (but they're CHEAP – about $1)
  - Contact metal doesn't take solder
  - Body of connector melts with heat
- Some guilty parties (Hams are cheap)
  - RF Connection
  - HSC
  - Digikey
- The good ones cost $5-$7 each
  - Switchcraft, Tuchel
  - Buy from Allied, Newark, etc.

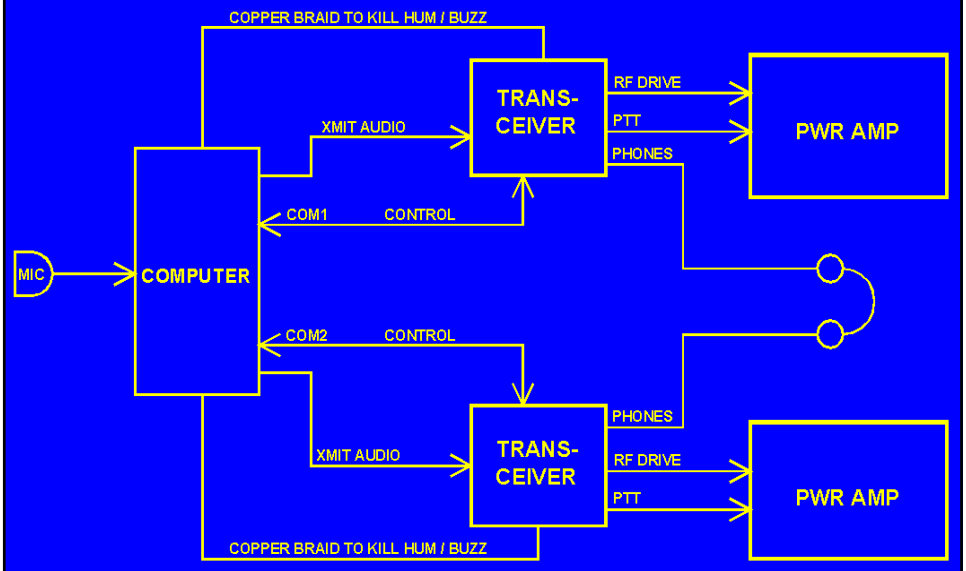
Good DIN Connectors
buy from Newark, Allied, $5 - $7 each

Configuration		Switchcraft Part Nr
4 pins at 210°	Yaesu FSK	09BL4M, 09GM4M
5 pins at 180°	Icom, Yaesu	05BL5M, 05GM5M
5 pins at 240°		12BL5M, 12GM5MX
6 pins at 240°	Icom, Kenwood, Yaesu	12BL8M, 15GM6MX
7 pins at 270°	Icom, Yaesu	15GM7MX
8 pins at 262°	Kenwood	20BL8M, 20GM8M
8 pins at 270°	Icom, Yaesu	15BL8MX, 15GM8MX

Stuttering CW??

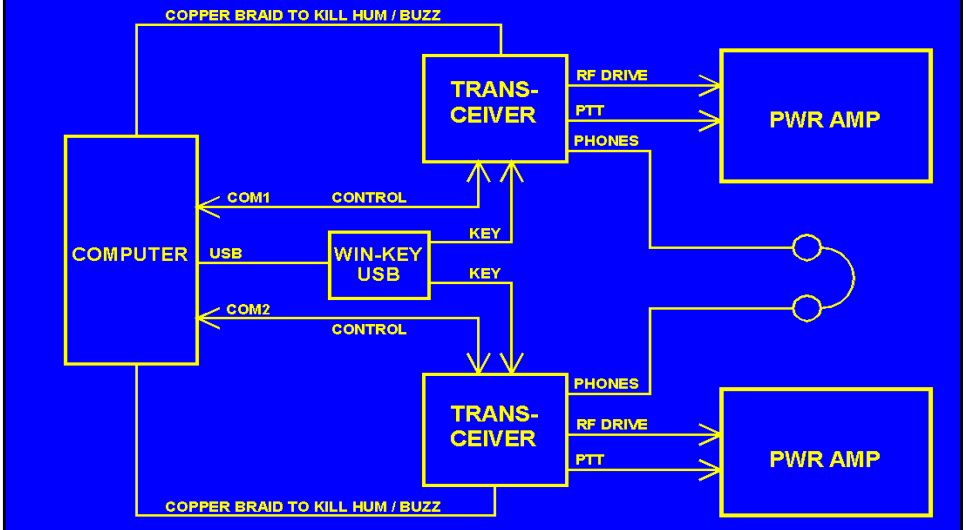
- Use a modern computer for Windows
- Use enough RAM (at least 512MB)
- My 8 year old IBM T22 with 512MB runs
  - N1MM or WriteLog
  - DXKeeper
  - DXView (map)
  - Browser with Propagation
  - VE7CC Cluster software
  - Zone Alarm
  - Quattro Pro Spreadsheet

Simple SSB SO2R with N1MM



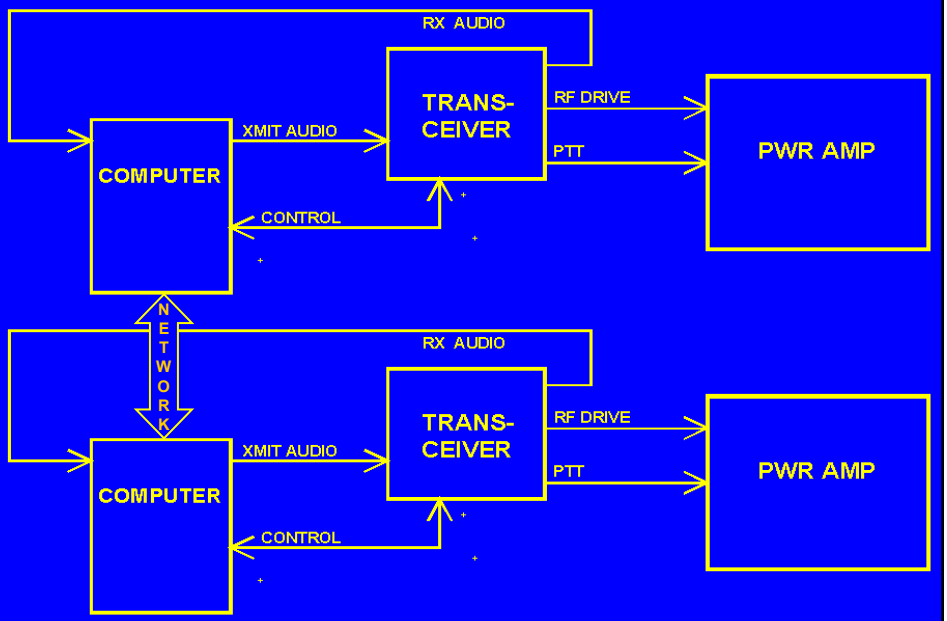
Use VOX to key radio

Simple CW SO2R with N1MM



- Buy WinKey as a kit (about $70, two hours)
  - Use your paddle with it, a good stand-alone keyer too

Simple RTTY SO2R with N1MM



See the Appendix for Slides that wouldn't fit in 45 minutes

- More about mics for ham radio
- How all that buzz ends up on the green wire and our equipment chassis
- How 3-phase buzz from a business down the street ends up on your ground wiring
- More about audio levels and wiring standards

References

- *A Ham's Guide to RFI, Ferrites, Baluns, and Audio Interfacing* by Jim Brown
  http://audiosystemsgroup.com/RFI-Ham.pdf
  - *Chapter 8 – Solving Problems in the Shack*
  - *Appendix 6 – Audio For Ham Radio*
- *Ham Interfacing* (this presentation)
  http://audiosystemsgroup.com/HamInterfacing.pdf
- *Power and Grounding for Audio and Video Systems – A White Paper for the Real World* by Jim Brown
  http://audiosystemsgroup.com/SurgeXPowerGround.pdf

Computer to Rig Interfacing – You Don't Need to Buy an Interface!

Jim Brown
K9YC
Santa Cruz, CA
http://audiosystemsgroup.com

Appendix
–
Slides and Topics That Don't Fit in 45 Minutes

Jim Brown
K9YC
Santa Cruz, CA
http://audiosystemsgroup.com

Where Does All That Buzz Come From?

Noise on "Ground" from Power

- Leakage currents to green wire
  - Power transformer stray capacitances
- Intentional currents to green wire
  - Line filter capacitors
- Power wiring faults
- Shunt mode surge suppressors
- Magnetic coupling from mains power
  - Harmonic current in neutral
  - Motors, transformers

Sources of Noise on "Ground"

- Capacitance from AC "hot" to ground
  - Leakage capacitance in transformers
  - AC line filters
- Magnetic induction
  - Leakage fields from power transformers
  - Wiring errors in buildings and homes
    - Double bonded neutrals
  - Leakage fields from motors and controllers
    - Variable speed drives
- 3-Phase noise current from neighborhood

Leakage Current to Green Wire

- Capacitance from phase ("hot") to equipment ground (green wire)
- $I = E/X_C = 120/X_C$
- $X_C = 1/(2\pi f C)$
- Maximum permitted leakage current is 5 mA with 110% of rated line voltage
- $X_C = E / I = 1.1 \times 120 / .005 = 26.4\ k\Omega$
- $C = 1/(2\pi f X_C) = 0.1\ \mu F$ is the largest capacitance that can exist from line to ground within equipment

Leakage Current to Green Wire

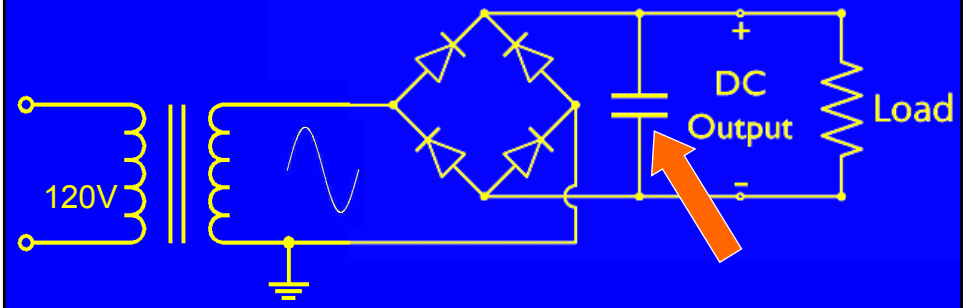
- 0.1 µF is the largest capacitance that is permitted from line to ground within equipment
  - This <u>includes</u> stray capacitance within the power transformer
- We often have many pieces of equipment connected to the same branch circuit
  - All capacitances (and leakage currents) are in parallel, so they <u>add</u>
  - <u>More noise</u>

The Harmonic Problem

- Nearly all electronic loads have power supplies with capacitor-input filters
  so:
- Load current is drawn in short pulses at peaks of the input sine wave
  thus:
- **Phase, neutral, and leakage currents are highly distorted**

The Harmonic Problem

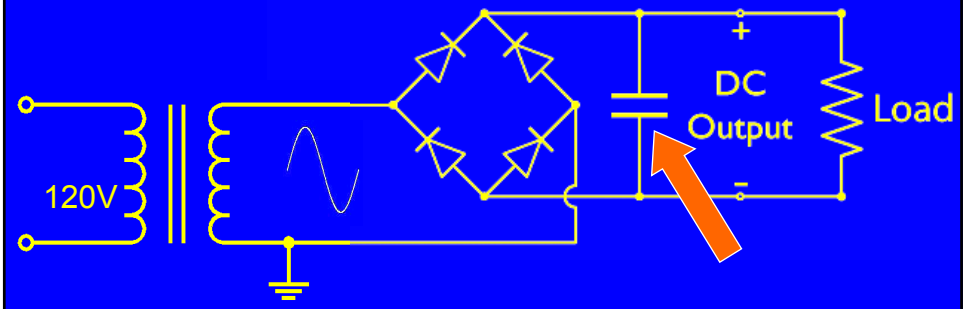
Recognize this power supply?



Something like it is in <u>every</u> piece of electronic gear – audio, video, computers, printers, copiers (even switching power supplies)

The Harmonic Problem

Recognize this power supply?



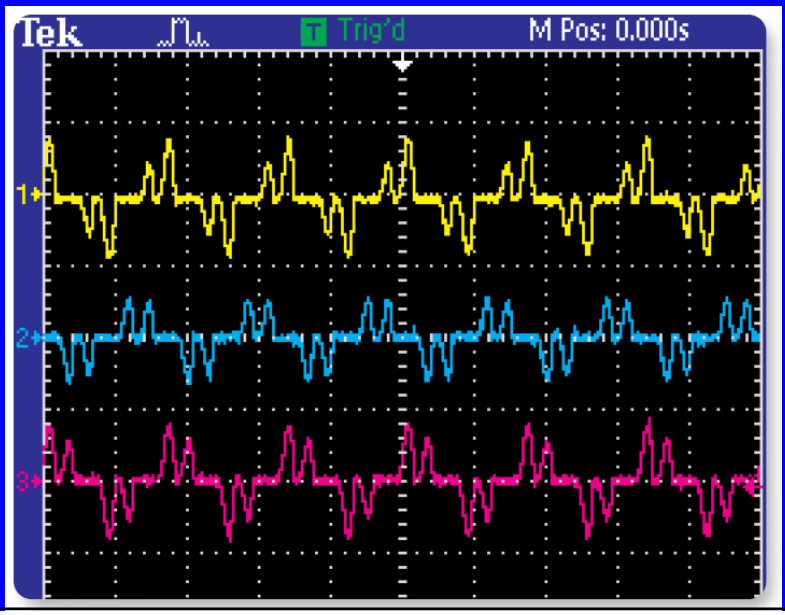
Current flows in short pulses that recharge the filter caps on each half cycle

Current is not even close to a sine wave

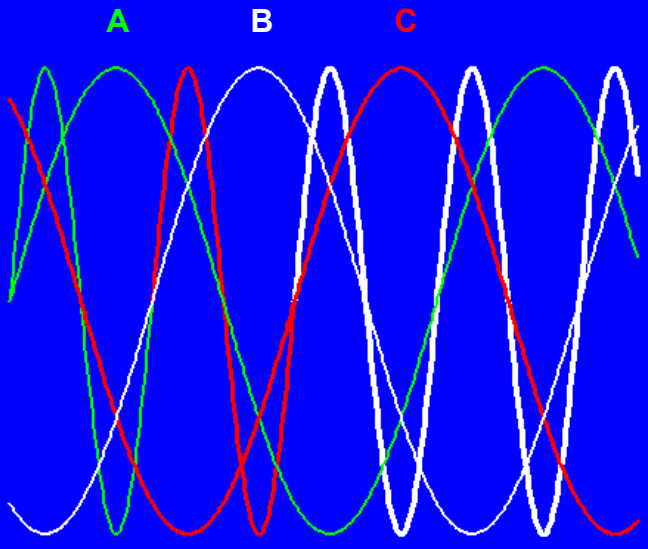
Problems With Pulse Currents

- Because current flows in short pulses, the IR drop at the peak of the current waveform can be much greater than for a sine wave
  - Greater I^2R losses
  - Voltage waveform is distorted
  - Lower voltage delivered to equipment
  - Increased dissipation in phase and neutral conductors
  - Increased dissipation in transformers

Load Currents in a 3-Phase System



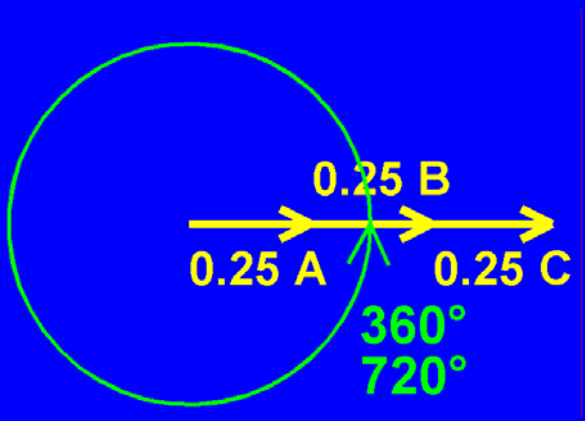
Fundamentals and Third Harmonics



What Happens in the Neutral?

- Triplen harmonics ADD!
  - Third, sixth, ninth, etc
- Neutral current can be 1.7X the phase currents, even in a perfectly balanced system!
- Potentially dangerous overheating
  - Phase conductors (and contacts)
  - Transformers
- Use bigger copper in neutrals
- Use *K-rated* transformers

25% 3rd Harmonic on the Phases becomes 75% 3rd Harmonic on Neutral



In Single Phase Systems

- 120V – 0V – 120V
- If leg currents are equal, they cancel in the neutral

In Three Phase Systems

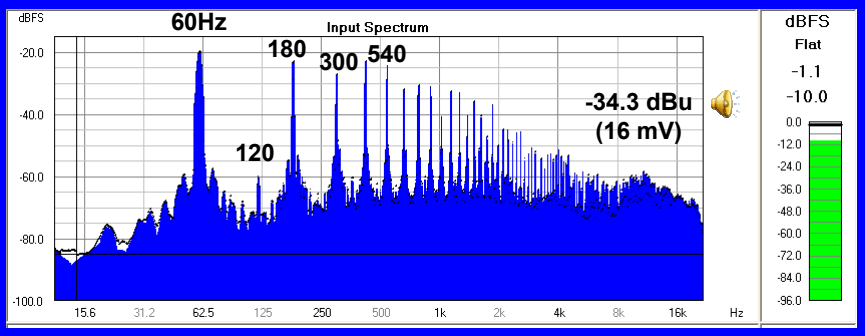
- If leg currents are equal, ***fundamental*** and most harmonics cancel in the neutral and in the ground

BUT:

- Triplen harmonics (3^{rd}, 6^{th}, 9^{th}, etc.) ADD in the neutral and in the ground
- This tends to make 180 Hz, 360 Hz, 540 Hz, etc. dominant buzz frequencies

But I Don't Have 3-Phase at Home!

3-Phase Noise in Santa Cruz Mountains!



Measured between two outlets on opposite walls of my ham shack and office

Triplen Harmonics and Leakage

- 3-phase equipment has stray capacitance to ground too
- Triplen harmonics contribute to leakage current, and ADD, just like in the neutral!
  - Third, sixth, ninth, etc
- Adds to noise current on cable shields
- Fundamental (50/60 Hz) and low harmonics (150/180 Hz, 450/540 Hz) are perceived as "hum"
- Higher harmonics are heard as "buzz"

The Hum/Buzz Problem

- Ham Interfaces are Unbalanced
  - One Conductor goes to chassis at each end
- There is noise voltage between chassis #1 and chassis #2
- "Ground" isn't a single point!
  - "Grounds" are connected by resistors (wires)
  - Capacitance from 120V to chassis causes current in those resistors (wires)
  - There are other sources of ground current
  - There's a voltage drop from that current

For Unbalanced interconnections, shield resistance can be important!

- Shield current (noise) creates IR drop that is added to the signal
- $E_{NOISE} = 20 \log (I_{SHIELD} * R_{SHIELD})$
- Coaxial cables differ widely
  - Heavy copper braid (8241F) 2.6 Ω /1000 ft
  - Double copper braid (8281) 1.1 Ω /1000 ft
  - Foil/drain shield #22 gauge 16 Ω /1000 ft
- Audio dynamic range 100 dB
  - For 1 volt signal, 10 µV noise floor

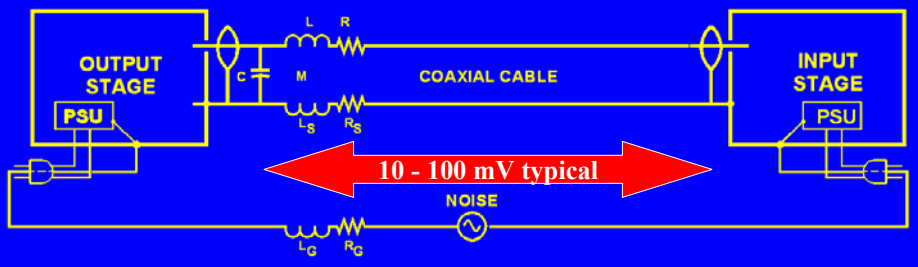
A Calculated Example

- 25-foot cable, foil shield and #26 AWG drain with resistance of 1 S
- Leakage current between two pieces of equipment is measured at 100 µA
- From Ohm's law, noise voltage =100 µV
- Consumer reference level = 316 mV
- Signal to noise ratio = 316 mV ÷ 100 µV = 3160:1 = 70 dB = not very good!
- Belden #8241F cable, shield resistance of 0.065 S, would reduce noise ≈ 24 dB!

Audio Noise Coupling Mechanisms

- IR drop on shields of unbalanced signal wiring
- Pin 1 problems – current on shields
  - Improper shield termination within equipment
- Magnetic field coupling to wiring
  - POWER TRANSFORMERS
  - Audio Transformers

The Problem with Unbalanced Interfaces

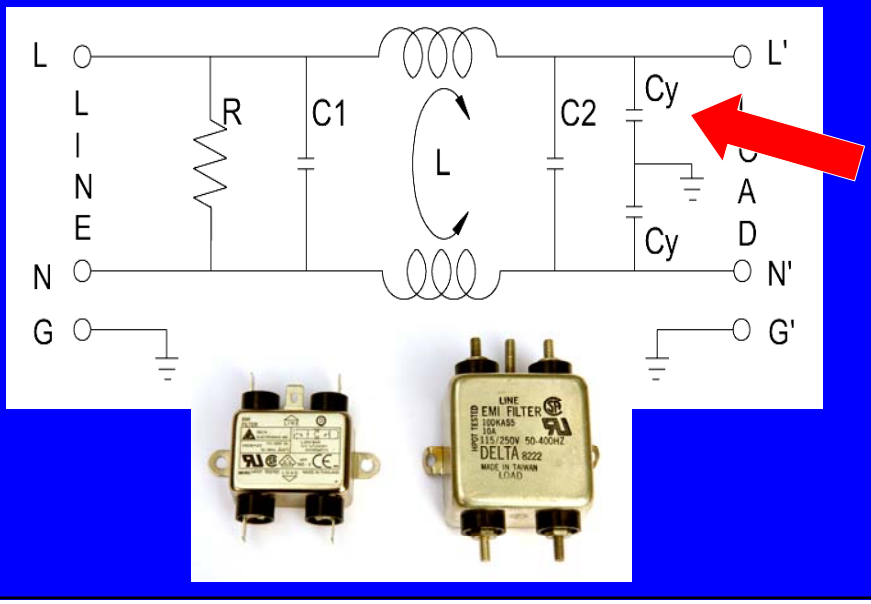


Noise current flows on the shield, and the IR drop is added to the signal.

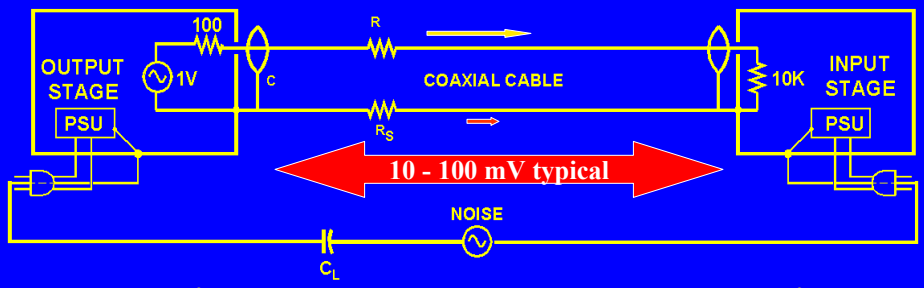
- Mutual coupling rejects RF noise, but doesn't help at audio frequencies

  Rs >> X_L

Line Filters Contribute Noise to the Green Wire



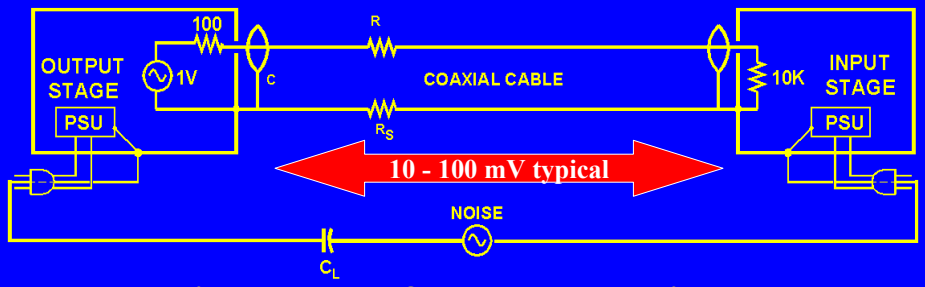
The Problem with Unbalanced Interfaces



Noise voltage between the two chassis is added to the signal.

- **So we have 1v signal (on peaks) and 10mV – 100 mV of noise**
- **Average value of speech is 10 dB below peak**
  So only 10dB - 30 dB S/N ratio!

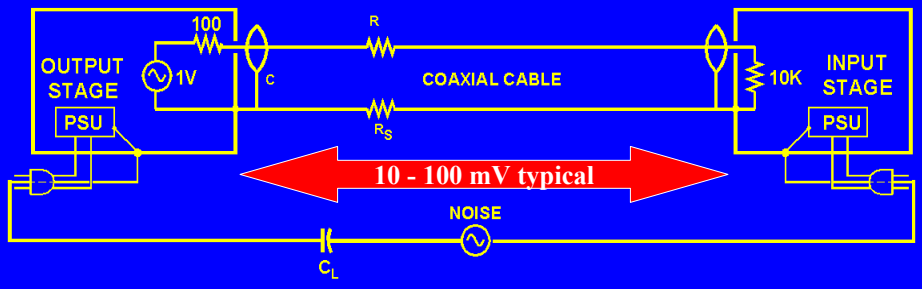
The Problem with Unbalanced Interfaces



Noise current flows on the shield, and the IR drop is added to the signal.

- Reduce the noise voltage between the ends of the cable
- Use a "beefy" cable shield
  - Minimizes the drop

The Problem with Unbalanced Interfaces



- Why we hear more buzz than hum
  - Noise is leakage through capacitance, so it's a voltage divider between C_L and R_S
  - The noise is dominated by harmonics

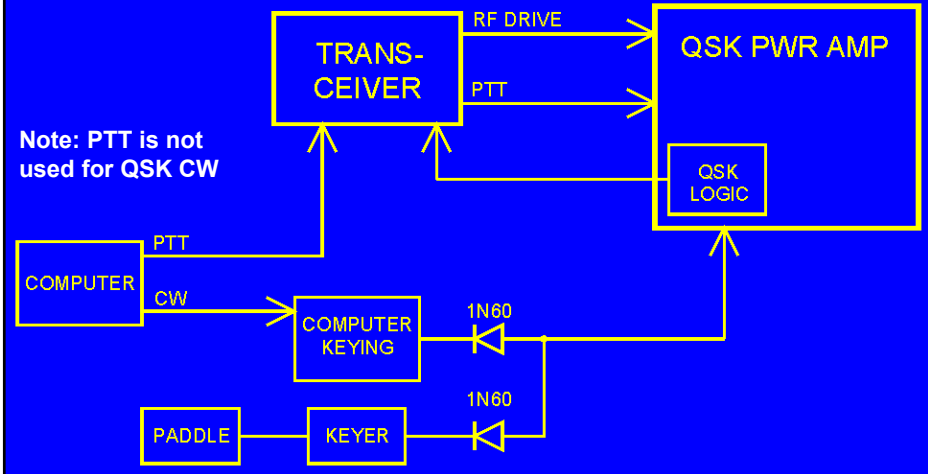
Audio Levels and Impedances

- Audio line outputs have low impedance
  - 100 ohms for pro circuits
  - 300 ohms for consumer gear
  - 0.1 ohms for loudspeaker power amps
- Audio line inputs have high impedance
  - 10K for pro circuits
  - 50K for consumer gear

Audio Level Matching

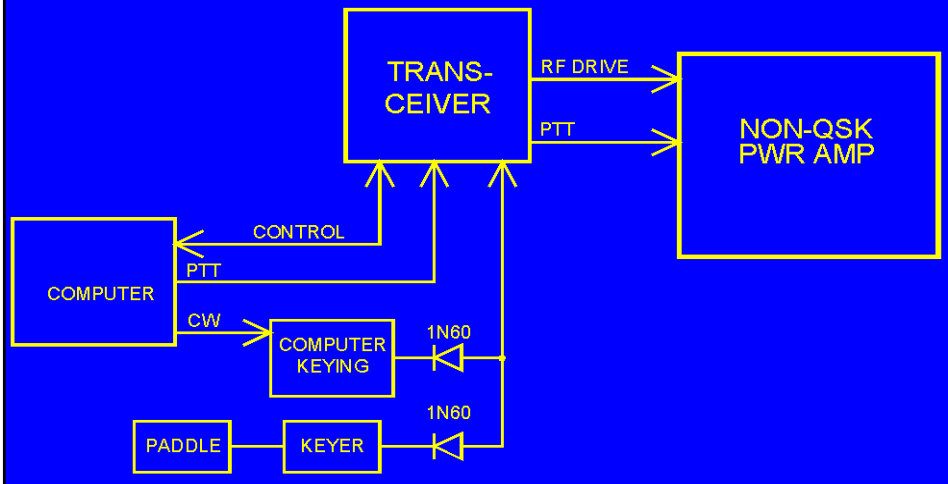
- Line level circuits are not designed to provide current
  - That is, they want to see a 10K or 50K load
  - If you load them with 600 ohms, distortion increases!
- Mic level circuits are not designed to provide current
  - Loading them with 600 ohms reduces their output and can increase distortion
- Loudspeaker and headphone outputs are designed to supply power (current)

Interface Logic – QSK CW



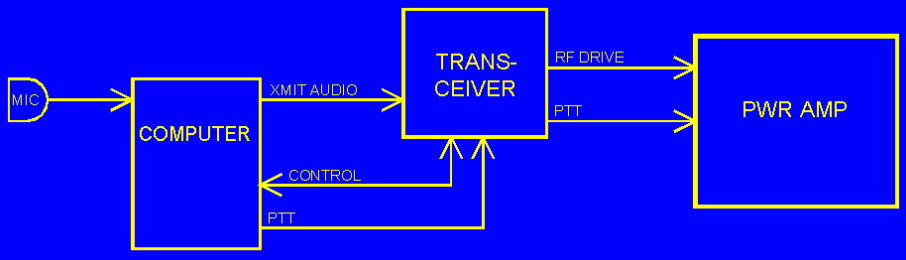
QSK logic in power amp prevents hot switching of T/R relay
Amp has fast-switching vacuum T/R relay, follows fast CW
Keying pulls in T/R relay, senses relay position, then keys transceiver

Interface Logic – Non-QSK CW



Hot-switch protection in some power amplifiers may chop the first character

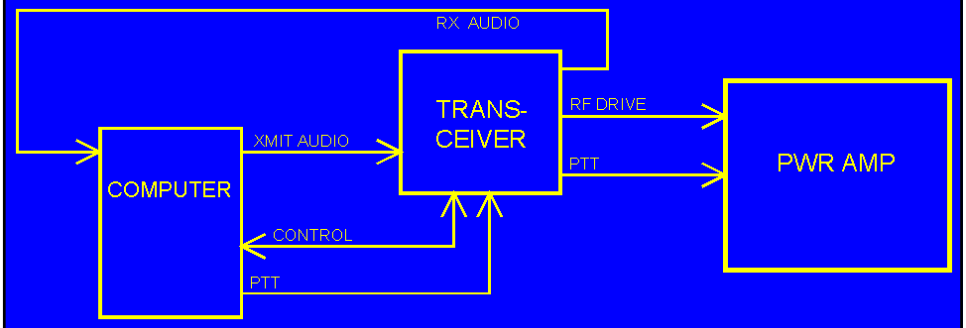
Interface Logic – SSB



Note: Assumes VOX operation

This setup allows direct recording of new voice messages "on the fly" (for example, "CQ contest, listening this frequency and 7065")

Interface Logic – RTTY, PSK



No RTTY software I know of works with "control" and PTT sharing a COM port

PTT can be on parallel port or second COM port

Pro Dynamic Mic to Laptop

- No power required
- Pro mics use XLR connector
  - Wire mic audio to Tip (audio input) (XLR pin 2)
  - Wire mic audio return to sleeve (XLR pin 3)
  - Wire shield to sleeve (XLR pin 1)
- In laptop, turn on mic pre-amp
  - Called “mic boost” in my Thinkpad
  - Not all sound cards have a mic pre-amp!
  - If no preamp, it may not be loud enough

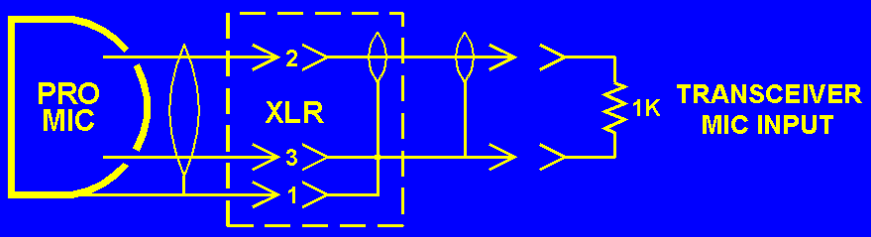
Pro Balanced Electret Mic to Laptop

- Balanced *Phantom power* is required
  - Cannot plug directly into computer
  - External phantom power supply and transformer are needed
  - Wire transformer output like a dynamic mic

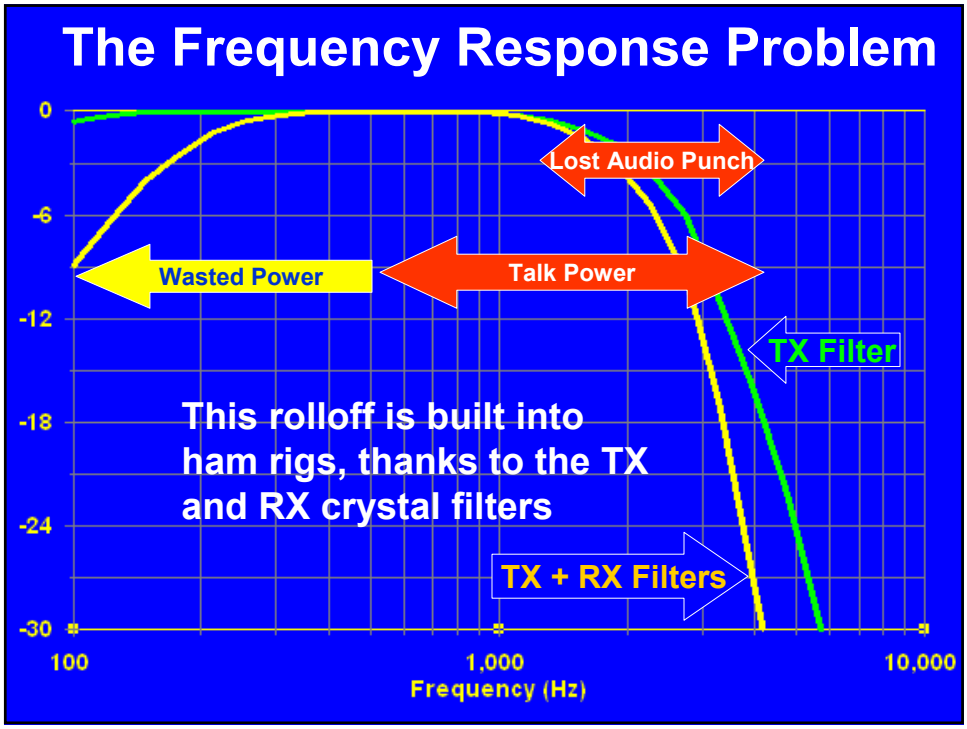
Pro Pigtail Electret Mic to Laptop

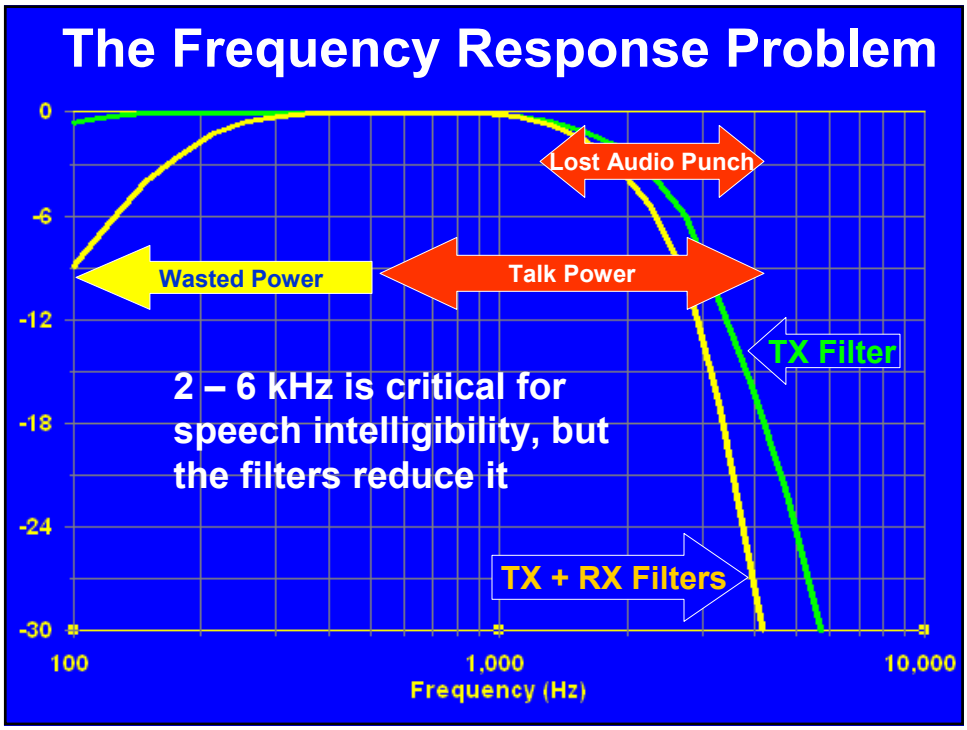
- Unbalanced electret mics with pigtail leads are built for use with wireless mics
  - Can work fine with a laptop
- On 1/8-inch TRS plug
  - Wire audio to Tip
  - Wire power to Ring (resistor may be needed)
  - Wire shield (audio return) to Shell

Pro Dynamic Mic to Ham Gear

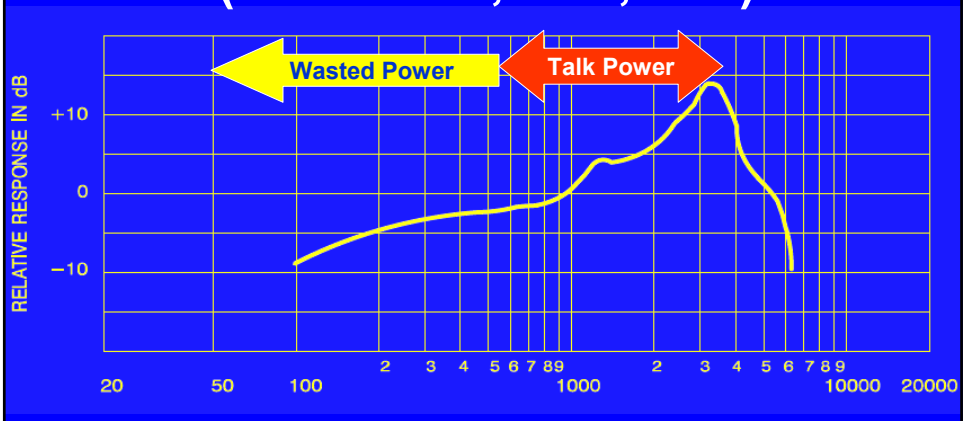


- Plenty of good clean audio
- But also a lot of low end we don't need!


The Frequency Response Problem
0
-6
-12
-18
-24
-30
Lost Audio Punch
Wasted Power
Talk Power
TX Filter
This rolloff is built into ham rigs, thanks to the TX and RX crystal filters
TX + RX Filters
100
1,000
10,000
Frequency (Hz)

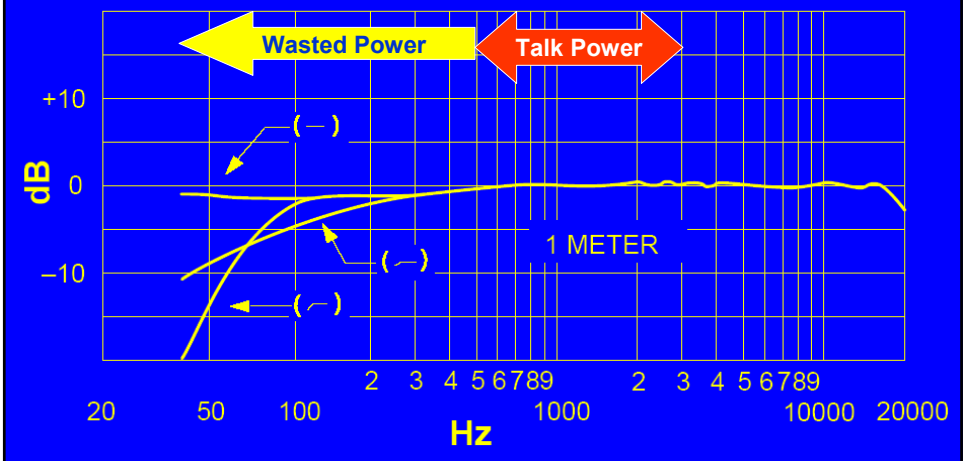

The Frequency Response Problem
0
-6
-12
-18
-24
-30
Lost Audio Punch
Wasted Power
Talk Power
TX Filter
2 – 6 kHz is critical for speech intelligibility, but the filters reduce it
TX + RX Filters
100
1,000
10,000
Frequency (Hz)

Typical Communications Mic (Shure 450, Heil, etc.)



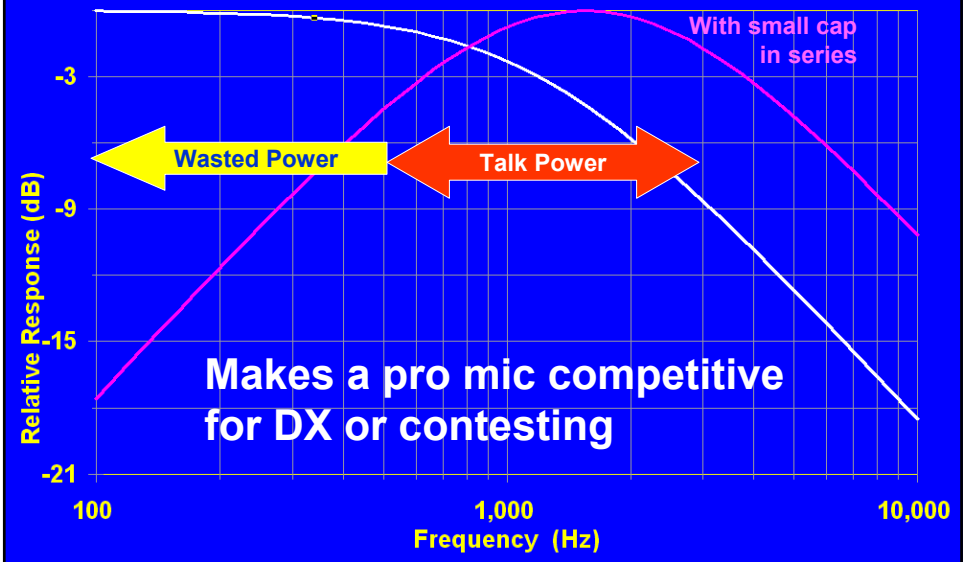
The response of the mic is tailored to correct for the TX and RX filter response

High Quality Professional Mic



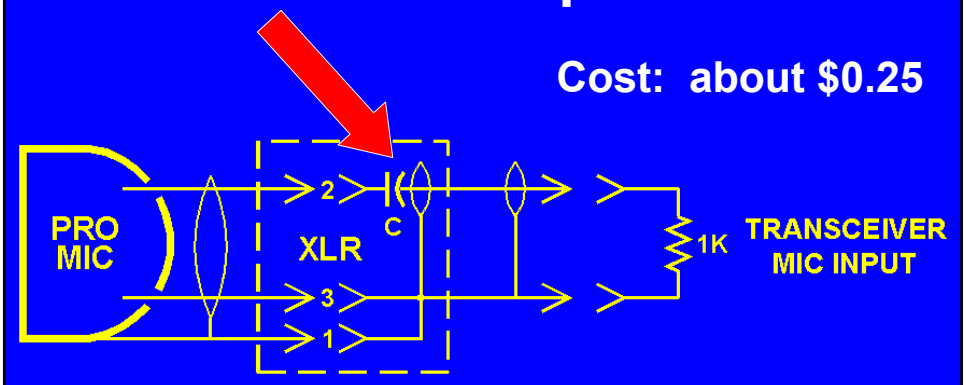
Broad, flat response to sound great on music and voices

The K9YC Mic Equalizer



The K9YC Equalizer

Cost: about $0.25

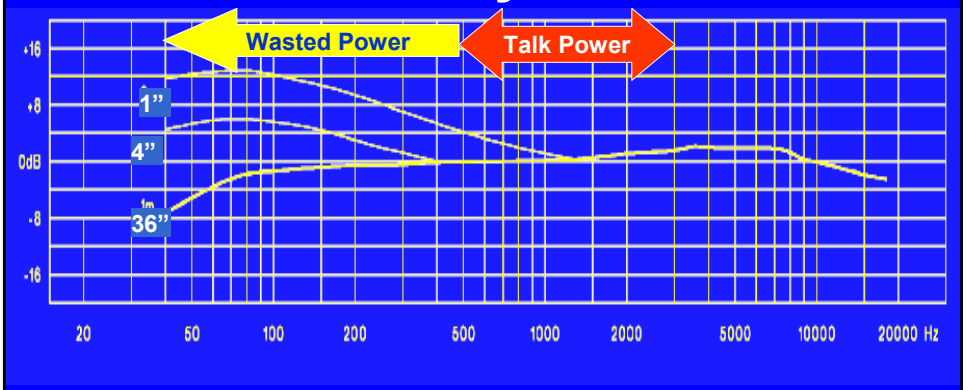


- Add capacitor in series with audio
  - C = 1 / (2πf R)
    - f is 3,000 Hz
    - R = (input Z of input stage) + (Z of mic)
    - In this example, C = 0.047µF

Directional Mics

- Most ham mics are omni-directional – they pick up sound from all directions
- Most performance mics are unidirectional
  - Pick up best from the front, reject room noise
- Most directional mics have proximity effect – bass is boosted for sounds very close to the mic
  - Breath pops
  - Very "bassy" sounding
  - Not good for communications!

Proximity Effect



- Bass boost when you talk very close to it
- Present in almost all directional mics
- K9YC equalizer will reduce it!
- Most pro mics have some low cut built-in

Directional Mics without Proximity Effect

EV RE20, RE27

EV RE11, RE16

AKG D202

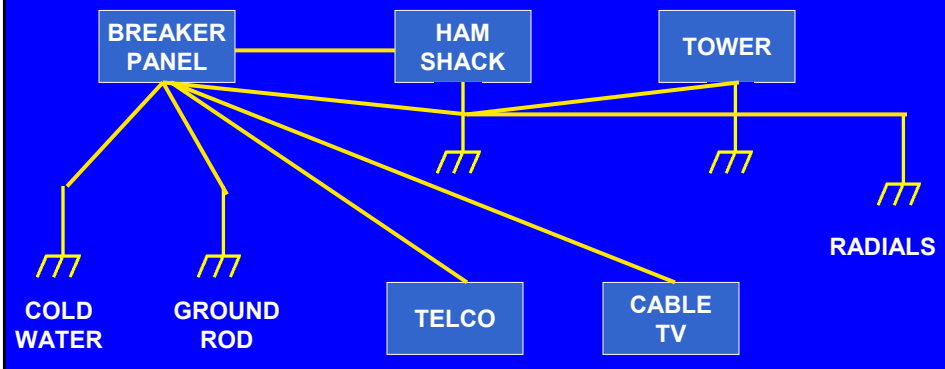
AKG D224

Good Low-Cost Headset Mics

Station Grounding

ALL GROUNDS MUST BE BONDED TOGETHER FOR SAFETY

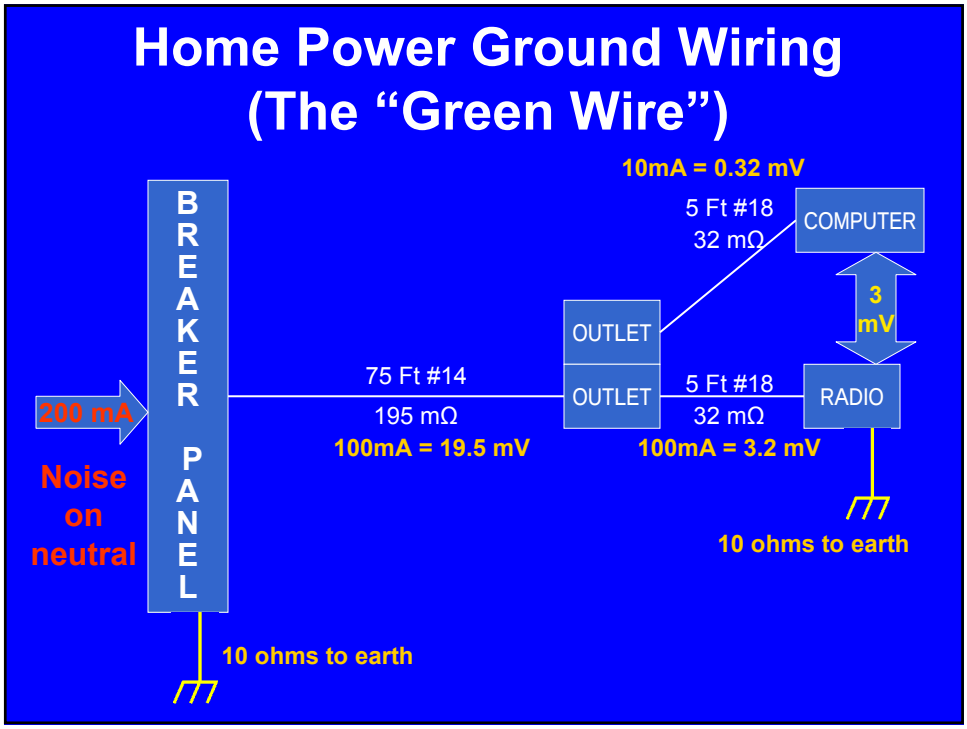
Station Grounding



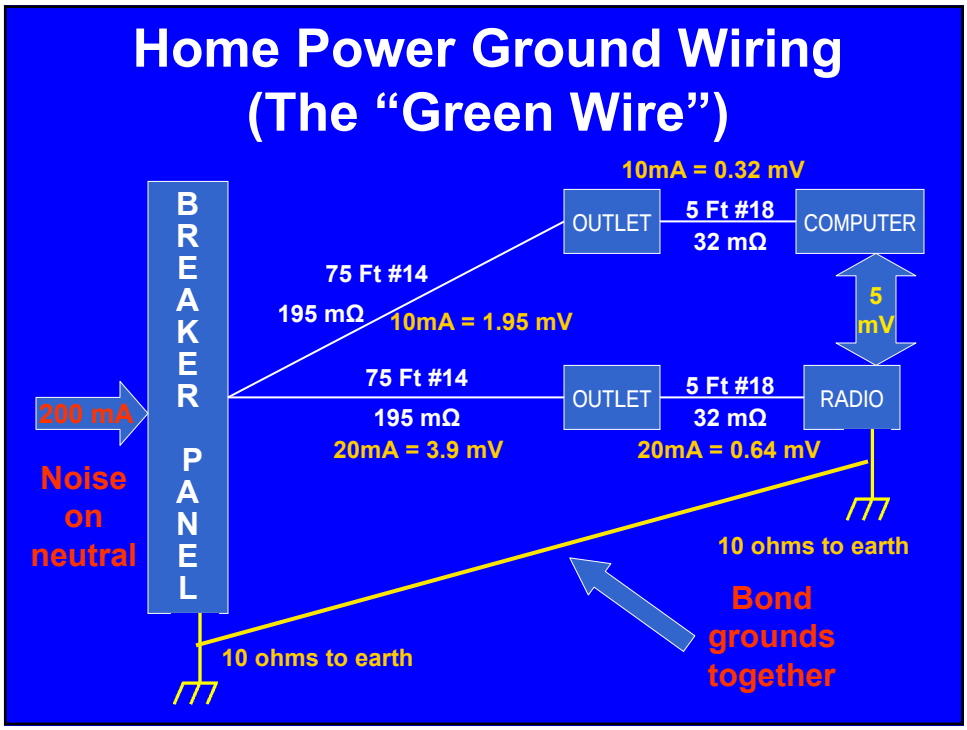
Grounding is for SAFETY
- Lightning protection
- Blow a breaker if a power system short

Connections should be big copper and short

Home Power Ground Wiring (The "Green Wire")



Home Power Ground Wiring (The "Green Wire")



Hot Switching in Amplifiers

- It takes a few msec for a T/R relay to pull in
- Keying transmitter before T/R pulls in is called “hot switching”
  - Amplifier transmits briefly without loading, can damage output stage
  - Contacts arc, causing relay failure
- Methods to prevent hot switching
  - Amp locks out input until relay has pulled in

  or:
  - Key amplifier, amp senses relay operation and keys exciter when relay has pulled in