

FEEDBACK

MAY 2015

A Hambone and Elmer Story -- Jaimie Charlton, ADØAB

Hambone and the Op Amp

"Hey, Hambone! At last night's ham club meeting I was listening to two guys talking about op-amps. One guy said that they were so complicated that he never builds anything with them. But the other guy said that they're simple and he uses them all the time. Which guy was right?"



"First off, Dude, you should just get your ticket and join the club instead of hanging around the meetings, eavesdropping and going out for pizza afterwards. Maybe if you actually were a ham instead of a ham wanna-be you'd be smarter," replied Hambone.

"Yeah, yeah, you never give up on that license thing, do you? But do you know how an op amp works?"

"Of course, I think it's a kind of amplifier that some guys like to use while they're operating. I'd explain it to you, but I've got homework to do. I can't waste time with your dumb questions!"

Detecting weakness, Dude pressed on, "That's lame. You don't know anything about op amps, do you? Big smart Hambone!"

"What's this about op amps?" queried Uncle Elmer as he sensed the fray was about to become a major conflict.

"Hi Unck, Dude was asking about op amps, but I haven't got time to explain them -- homework, you know."

"By all means, Hambone, do your homework. Remember that old saying, 'If you don't do your homework when you is a kid, you'll always be working for someone who did.'"

Dude, what's this about op amps?"

"I heard these guys talking about them and I was just wondering what they are."

"Basically, Dude, an op amp is just a very high gain DC differential voltage amplifier with a very high input impedance." Noticing the puzzled look on Dude's face, Elmer continued.

"What I mean is the amplifier has two input terminals; a (+) or non-inverting input terminal and a (-) or inverting terminal. The op amp considers its input to be the *difference* between the voltages applied to these two terminals. The voltage gain of an op amp is very high -- fifty-thousand or more. But, although its frequency response is not typically very wide, it does go all the way down to DC."

see Hambone on page 8

APRIL MEETINGS

May 8 -- Fox Hunt -- (Note 6:30 start time)

May 22 -- Field Day team planning and nomination and election of officers

The Johnson County Radio Amateurs Club normally meets on the 2nd and 4th Fridays of each month at 7:30 PM at the Overland Park Christian Church (north entrance), 7600 West 75th Street (75th and Conser), west of the Fire Station.

Much of the membership travels to the Pizza Shoppe at 8915 Santa Fe Drive for pizza buffet and an informal continuation/criticism/clarification of the topics raised at the meeting ... or anything else.

Leave the church, turn right (west) on 75th. Turn left (south) on Antioch. Turn right (west) on Santa Fe. Pizza Shoppe is just past the Sonic on your left.

IN THIS ISSUE

1 - Hambone and the Op-Amp =
Jaime Charlton, ADØAB

2 - President's Corner

Editorial Notes

Feedback Loop

3 - Opinion - Van Van Devere,
KØHCV

4 - February Meeting Minutes

6- Repairing a GE Reed Speaker
- Tom Wheeler, NØGSG

11 - Local Meetings and Nets

-> FEEDBACK <-

*A publication of the
Johnson County Radio Amateur Club, Inc.*

Bill Gery, KA2FNK, President

Aaron Boots, AAØRN, Vice President

Ted Knapp, NØTEK, Secretary

Cal Lewandowski, KCØCL, Treasurer

* * *

Chip ACØYF and Deb KDØRYE Buckner, Editors

All email addresses are available at w0erh.org

The plan--well, all right, the *hope*--has always been to feature an "op-ed" page in the FEEDBACK. And then, without any prodding, Van Van Daveer - KØHCV (whose last name and call sign were inadvertently butchered in some editions of last month's FEEDBACK) steps up to offer his thoughts on embracing the introduction of digital voice modes to the amateur radio environment.

And, because Van wrote the piece, because there was some space on the page and because the SSTV scans were spectacular, we put some additional ISS SSTV scans on the page. The Russian transmissions from the space station were to commemorate the flight of Yuri Gagarin on April 4, 1961.

-- Chip and Deb

The FEEDBACK Loop

Congratulations on the new Fusion machine.

Just hours after you guys got the machine online [on April 28], I counted some twelve people on the machine. They all seemed excited and very pleased with the new machine. Gentleman you did a great job as always.

I heard **Jay Burgherr, NØFB; Van Van Daveer, KØHCV, Rob Underwood, KØRU; Herb Fiddick, NZØF; Bill Brinker, WAØCBW; Bob Porter, KAØGBW; Dennis Smeltzer, KCØQBU; Terry Constant, WØTLC; Bill Lawrence, N1HWC; Greg Noonan, KCØ0BBQ** and myself, KCØKW.

For a new repeater and not a lot of Fusion radios out there ... the amount of interest was amazing.

-- Jerry Dixon, KCØKW

PRESIDENT'S CORNER

Field Day, June 27-28, is just around the corner. As in years past we will be at the observation tower in Shawnee Mission Park. Set up begins Friday afternoon. That evening is a great opportunity to make some contacts and to give us a chance to be sure that all is ready.

Field Day itself starts at 1:00 p.m. CDT Saturday and continues until 1:00 p.m. CDT Sunday. We will need help with set up Friday afternoon and break down Sunday. We will have a special tent for license testing on Saturday and food later that evening. More detail will follow. Plan to come and bring your family.

The new 440 repeater went on the air April 28. The frequency of the repeater is 442.600 MHz with a +5 MHz offset. It operates exclusively in the Fusion C4FM digital mode. Thanks go to **Bill Brinker, WAØCBW**, and **"Van" Van Daveer, KØHCV**, for installing the repeater and to all the club members who donated funds to support this new capability for the Kansas City repeater community.

May is the club's first month to assist with the tours at the Ensor Museum. Ted Knapp, NØTEK has set up a web-based sign up site. The museum is open from 1:00 to 5:00 on Saturdays.

- Bill Gery - WA2FNK

Opinion: Embrace the Digital - Harold "Van" Van Daveer, KØHCV

Change. I'm not talking about the nickels and dimes in your pocket. I'm talking about the kind of change that forces us from a position of comfort and familiarity



to one of being forced to accept something new.

Change has been a constant in the history of ham radio and it will not be ending any time soon.

First there was spark, then CW, then AM, then FM, then SSB and now another change is upon us. That of digital radio.

Many public service agencies and commercial institutions have already made the switch to digital. In the future, when this now new equipment becomes surplus, the ham community may not have the choice of analog or digital. It will be all digital.

Our club is very fortunate to have a state of the art VHF repeater that is capable of not only analog but the Digital Mobile Radio (DMR)



format as well. This repeater operates in what is known as mixed mode and will probably stay that way for many years. We are also very lucky to have two other mixed mode VHF analog/DMR repeaters in Johnson County. There are also a number of UHF DMR repeaters in the area that offer communication around the world using your handy-talky. But these are digital only! DMR is here to stay.

However, when change happens there are always those who cling to the old way and don't feel it is necessary to keep up with the Jones's. Imagine if some hams were still using spark on 20 meters. Sometimes it is necessary to remove the old way as a method of encouraging people to accept the new way.



There are several other Fusion repeaters in the area with more on the way and the club now has a new Yaesu Fusion repeater on the air on 442.600. I believe that this repeater should be programmed not as a mixed mode repeater but as a Fusion only repeater.

We already have an analog repeater on 443.725 so it should offend no one to have the new repeater be Fusion only. Perhaps this would encourage everyone to reconsider their opinion of digital and be more receptive to the new way.



Granted DMR and Fusion are not compatible with each other. And, there are currently no dual band DMR radios available. And there are no radios that support both DMR and Fusion. And there are probably several other reasons that can be used for not accepting change. Not the least of which is financial.

However these types of radios will be coming in the future. Now is the time for you to research the types of digital communications offered by the club and decide which mode you would be most interested in and then use that information when you purchase your next radio. We may be the only club in the country offering its members two types of digital communications so why not take advantage of one, or both?

Johnson County Radio Amateurs Club - April 10, 2015 Meeting Minutes

Meeting Date: Friday April 10, 2015. The meeting Started at 7:30PM. However before the meeting at 6:00PM was the 1st Annual VHF Shootout.

Attendance: Self introduction with name and call sign. 30 signed the check in sheet. This was followed by the Pledge of Allegiance.

The Minutes from the March 27, 2015 meeting were read and accepted with 1 opposed vote.

The Treasurer's report, as follows, was read and accepted unanimously.

Cash on Hand	\$ 110.11
Checking Account	\$ 255.39
Savings Account	<u>\$ 7,986.26</u>
Total	\$ 8,351.76
Repeater Operating Reserve	\$ 781.87
Memorial Fund	\$ 285.00
Active Members	137

Old Business:

- Repeater Update – Both are working well! We are going to need cables when the new Yaesu Repeater arrives.
- Field Day 2015 – June 27-28, 2015. We have a Food Manager but still need a Water Manager. We will have a GOTA Station in the SATERN Communication Van. Looking for kids to help teach kids. We have a volunteer that has offered to pay of an additional tent to hold License Testing. See Jay Greenough, WJ0X if interested.
- Club Shirt Update – Shirts will be Sport Polo with a pocket and Club Logo for \$14. Deadline to order is May 22.
- We are currently looking for volunteer Ensor Tour Guides. On Line Sign-up will be available shortly. The Tour Guide Training will be in April.
- WW1USA Special Event Station May 9-10, 2015. The Club will not need to lead the May event. We do have the lead on the December event.

New Business:

- None.

Reports:

- 6 m – None.
- 10 m SSB Roundtable – NR.
- 440 Wheat Shocker net – 19 check-ins on April 8 and 17 check-ins on April 1.
- 2m Wheat Shocker net – 21 check-ins on April 9 and 23 check-ins on April 2.
- HF Activity – NR.

Announcements:

- Ararat Shrine April 18, 2015.
- Olathe Marathon April 18, 2015.
- MS Walk April 11, 2015.
- Watch Larry's List for upcoming events.

Business meeting adjourned at 8:14 PM

Program:

- The Program for this meeting was a presentation by Eddy Paul, KY0F on "Integrating SDR into your Shack".

Minutes Submitted by Aaron Boots, AA0RN, Vice President

Minutes Read by Ted Knapp, N0TEK, Secretary.

Johnson County Radio Amateurs Club - April 24, 2015 Meeting Minutes

Meeting Date: Friday April 24, 2015. The meeting Started at 7:30PM. However before the meeting at 6:00PM was the 1st Annual VHF Shootout.

Attendance: Self introduction with name and call sign. 40 signed the check in sheet. This was followed by the Pledge of Allegiance.

The Minutes from the April 10, 2015 meeting were read and accepted with 2 opposed votes.

The Treasurer's report, as follows, was read and accepted unanimously.

Cash on Hand	\$ 110.11
Checking Account	\$ 829.32
Savings Account	<u>\$ 7,986.26</u>
Total	\$ 8,925.26
Repeater Operating Reserve	\$ 794.87
Memorial Fund	\$ 285.00
Active Members	139

Old Business:

- Repeater Update – All 5 of our Repeaters are working well. The new Yaesu Fusion Repeater has arrived. It will be installed shortly. The 5 Repeater Frequencies are 145.29, 443.725, 442.600 (Fusion), 145.21, and 223.9400.
- Field Day 2015 – June 27-28, 2015. Station Captains are: Joel Meddings, K0JEM – CW, Herb Fiddick, NZ0F – Digital, and John Raydo, K0IZ – Phone.
- Club Shirt order deadline is May 22.
- We are currently looking for volunteer Ensor Tour Guides. On Line Sign-up is available through Sign-Up-Genius. The link can be found on the Club's website.
- The VHF Indoor Shootout winner was Bill McMillan, N0YUD.

New Business:

- Ted Knapp, N0TEK as an employee of Hallmark Cards, Inc. has the opportunity to participate in Hallmark's Volunteer Program. The purpose of the Volunteer Program is to recognize Hallmark employees who have volunteered a minimum of 50 hours of service to a non-profit organization in a one year period. As the club's Secretary and having met the non-profit qualification, the Hallmark Corporate Foundation has made a contribution of \$400 to the Johnson County Radio Amateurs Club.

Reports:

- 6 m – None.
- 10 m SSB Roundtable – 6 Participated on April 23.
- 440 Wheat Shocker net – 17 check-ins on April 22 and 17 check-ins on April 15.
- 2m Wheat Shocker net – 24 check-ins on April 23 and 33 check-ins on April 16.
- HF Activity – Don Reed, KØIFO just made his 600th DX contact for the year.

Announcements:

- QRP to the Field April 25.
- Tour de Bier Bike Event – May 17. See Jay KØFB.
- Hospital Hill Run – June 5&6.
- Watch Larry's List for upcoming events.

Business meeting adjourned at 8:08 PM

Program:

The Program for this meeting was a presentation by Don Reed KØIFO titled Antenna Analysis.

Submitted by Ted Knapp, N0TEK, Secretary.

Repairing a GE Reed Speaker - Tom Wheeler, NØGSG

In the *really* olden days of radio, loudspeakers were made in many forms. A popular design dating back to the 1920s is the reed speaker, as shown in Figure 1. Many early radios used this design; in these earlier times, radio was nothing short of magic.

The opposite happens during the negative half-cycle. Thus, the reed and permanent magnet make a simple linear motor that drive the speaker cone back and forth in step with the audio signal, reproducing the sound from the broadcast station.

transformer and probably saved GE corporate \$0.50 per set. It is of proprietary dimensions and because of the non-standard electrical configuration, cannot be replaced with a regular speaker. Fortunately, they are mechanically simple. Unfortunately, the speaker in this set suffered extensive damage from the battery acid, which attacked the permanent magnets, reducing them to a little pile of magnetic shavings! Figure 3 (on the following page) illustrates the damage.

Repairing this speaker was quite easy. I simply cleaned out the magnetic remnants and slipped in two neodymium cube magnets.

See SPEAKER on page 5

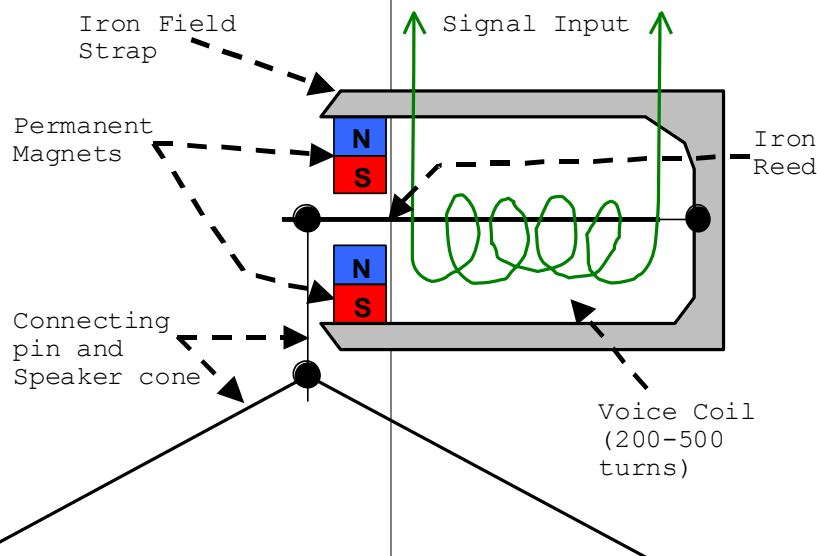


Fig. 1: Design of the Reed Speaker

It was not unusual for families to gather around the radio set in the living room after dinner, especially if Junior ate his vegetables!

In the reed speaker, an iron reed is suspended in a magnetic field provided by one or more permanent magnets. The tip of the reed is connected to the paper speaker cone by a thin metal wire or rod. The reed is surrounded by a voice coil into which the audio signal is driven.

During the positive half-cycle of the audio signal, the reed becomes magnetically attracted towards the north pole of the magnetic circuit, and it bends slightly, pushing the paper cone along with it.

I happened to pick up an early 1960s GE portable radio at a recent swap meet. It's a very pretty unit, as you can see in Figure 2. The seller said it didn't work, and it looked like a nice item to add to the office display case at work. But isn't it always better to have radios that work? My thoughts exactly. Let the disassembly begin! Once I removed the back of the set, it was obvious that the previous owner had left the battery in way too long. Acid had leaked throughout the set and damaged several components, including the speaker.

GE used reed speakers in most of its portable radios. In a GE set, the reed speaker has an 80 ohm center-tapped coil. The center-tapped coil replaces the output



Fig. 2: A nice-looking GE Portable AM Radio. The case front is chrome-plated die-cast metal.

from SPEAKER on page 6

The positioning of the magnets was not very critical, and I was easily able to adjust them while driving the speaker with a signal generator. Once the best position of the magnets was determined, I super-glued them in place. The repaired magnetic structure is shown in Figure 4.

The newly repaired speaker works great - or at least, pretty much as the original did, which is to say loud and tinny, just like most other portable transistor radios of the 60s.

A few other components in the radio were damaged by the battery acid, in particular, the plastic variable tuning capacitor; a spare unit was installed. With these repairs, some TLC, and a general alignment, mission accomplished--the little GE was again playing up a storm, just as it likely did for some youngster in the 1960s.



As your mother always told you, eat your vegetables--and do take the batteries out of your radio when you're putting it away for a while!

-- Tom Wheeler, NØGSG

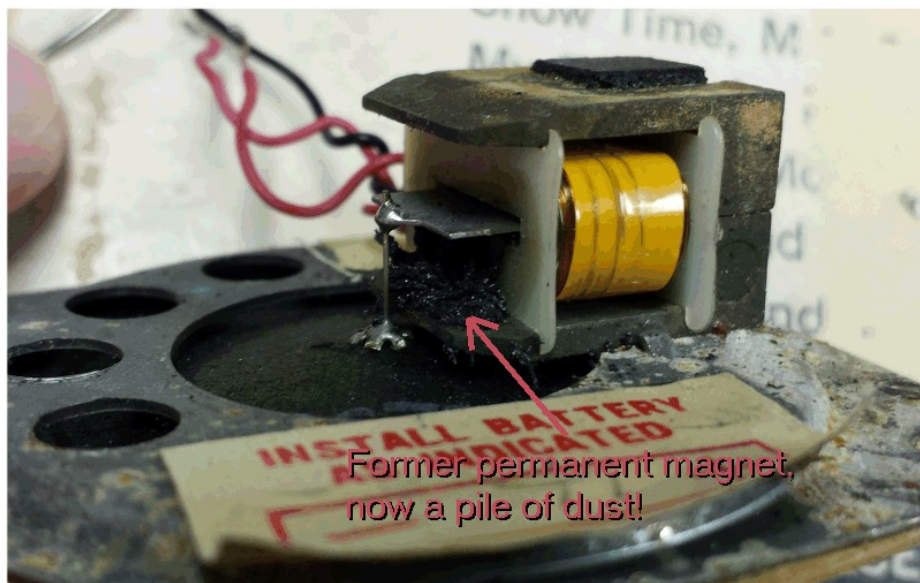


Figure 3: Speaker damaged by battery acid. The permanent magnet, formerly a nice bar, has been reduced to magnetic dust.

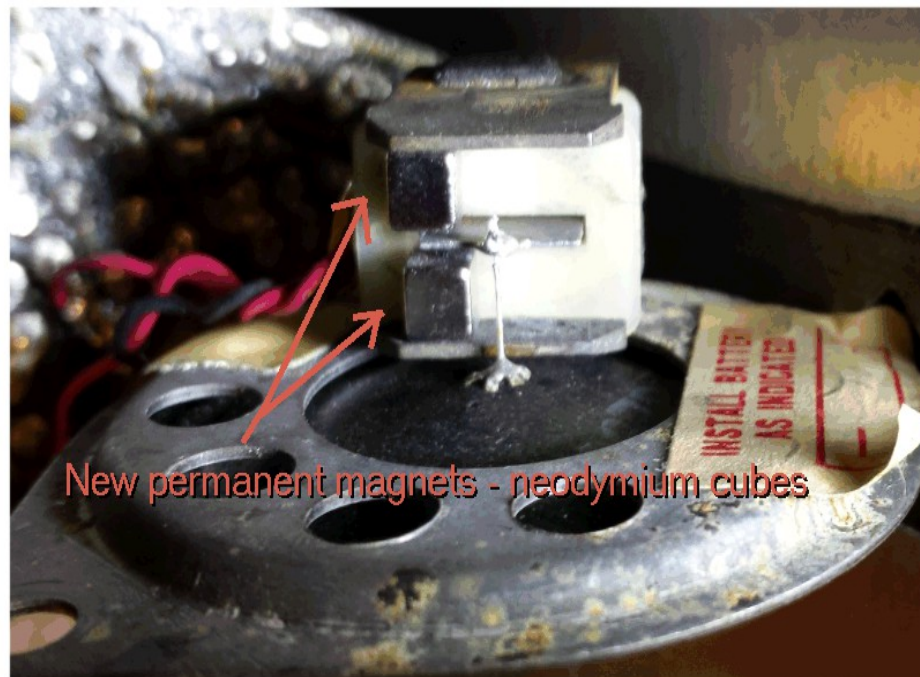
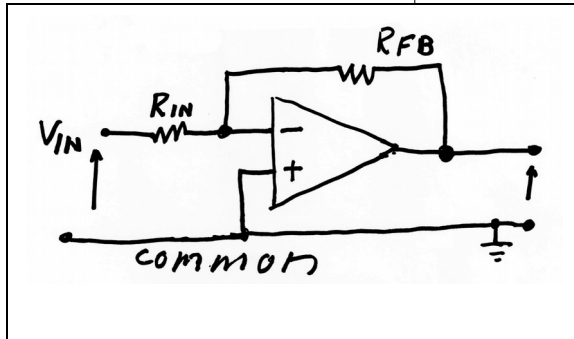


Figure 4: Cube Magnets in Place

from **HAMBONE** on page 1

Noticing that Dude still had a blank look on his face as did Hambone who was feigning studying, Elmer went on.

“To make matters easier, in many applications the non-inverting (+) input is simply grounded through a resistor and all input signals are applied to the inverting (-) input. Take a look at this sketch. I’ve left off power connections and pin numbers so you can see how simple it is to make an inverting amplifier using an op amp. Inverting means the output is the opposite polarity of the input.”



“That sure is simple.” Said Dude as Hambone, unable to contain his curiosity, came over to have a look.

“But how much gain does it have and how much output?” asked Hambone, now fully deserting his homework.

“That is the amazing thing about op amps. Because their internal gain is so high, it has almost no effect on the circuit gain. In this inverting amplifier circuit, the gain, or output voltage divided by input voltage, is simply the resistance of the feedback resistor divided by the resistance of the input resistor. The minus sign tells us that this is indeed an inverting amplifier – the output will be 180 degrees out of phase with the input. This is an approximation so it isn’t exact, but it’s pretty close.”

$$\text{Gain} = \frac{V_{OUT}}{V_{IN}} = -\frac{R_{FB}}{R_{IN}}$$

“You mean,” asked doubting Dude, “If I make the feedback resistor 100kΩ and the input resistor 1kΩ the amplifier will have a gain of 100?”

“Pretty close. The output will be inverted since you are applying the signal to the inverting input – don’t forget that minus sign - and the maximum output voltage and current will be limited to the capabilities of the op amp. A typical unit such as an LM741, when supplied with plus and minus 15 volts power supplies, will have a max output swing of about plus and minus 12 volts at a maximum current of a few milliamps,” added Elmer.

“That’s amazing!” Exclaimed Hambone. “I still don’t understand how you do that with only two resistors.”

“Think of it as a sort of balancing act. An input signal voltage is applied to the circuit’s input and causes an input current to flow through the input resistor R_{IN} . Since the operation of the amplifier depends on no current flowing into the amplifier itself (that’s one of the approximations, but it’s a good one because the op amp has a very high input impedance.), the only place for that current to go is through the

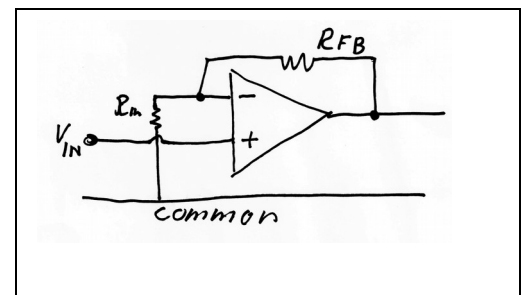
feedback resistor, R_{FB} .

In a sense, the input current flowing through the input resistor is “sucked” away through the feedback resistor by the output voltage. The higher the resistance of the feedback resistor, the more output voltage is needed to “suck away” the input current. The end result is that the gain of the circuit is very close to the feedback resistance divided by the input resistance. You may have heard the term ‘negative feedback’, well, this is it.”

“So that’s how negative feedback works.” Said Dude. “I’ve seen the name, but never knew what it meant.”

“This is sort of a duck and bunny explanation of a more complex phenomenon, but it’s good enough for now,” continued Elmer.

“ R_{IN} and R_{FB} are not limited to resistors. They can include capacitors,



inductors and nonlinear things like diodes and even other op amps. For example, add a capacitor and change the circuit a bit and you can make a high or low pass filter.

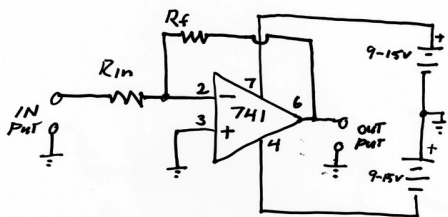
“Okay, Elmer, but what does a real circuit look like?” asked Hambone.

“Here’s an example of an inverting amplifier using a very common 741 op amp chip. These ICs (integrated circuits) come in various packages. This pinout is for the eight pin plastic DIP which costs less than a dollar.

see Hambone on page 9

from Hambone on page 8

"Here's an example of an inverting amplifier using a very common 741 op amp chip. These ICs (integrated circuits) come in various packages. This pinout is for the eight pin plastic DIP which costs less than a dollar.



I've used two 9-volt batteries in this example, but you can use other power sources to supply the plus and minus operating voltages. Notice that the signal common or ground is the power supply neutral point. The non-inverting input is grounded so the output is determined only by the input signal that is applied to the inverting input.

The gain is:

$$G = -\frac{R_f}{R_{in}}$$

If we make $R_f = 100K\Omega$ and $R_{in} = 10K\Omega$ then $G = -10$ "

"But Unck," asked Dude, "What if we don't want the output to be inverted?"

"That's easy," replied Elmer as he sketched another circuit.

"You simply apply your input signal to the non-inverting input of the amplifier. The power supplies are connected the same as before, the output comes from the same terminal, but the gain is a little different. When you use the non-inverting input the gain

is: $G = 1 + \frac{R_{FB}}{R_{IN}}$

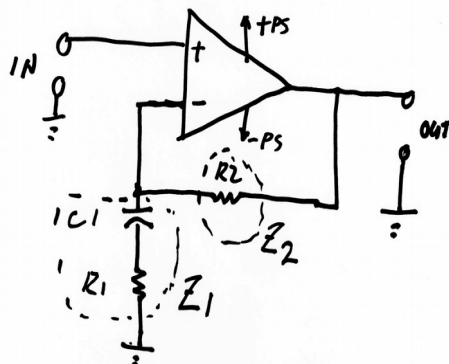
Which means that using the same $10K\Omega$ input resistor and $100K\Omega$

feedback resistor as before, the gain becomes:

$$G = 1 + \frac{100K}{10K} \quad \text{Gain} = 11$$

Notice there is no minus sign and the gain is higher by 1."

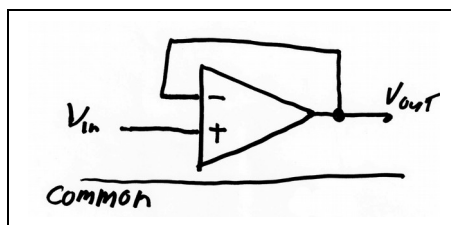
Sketching another circuit, Elmer continued. "Here is a special non-inverting circuit with gain equal to 1. It's called a buffer or isolator and is useful when you need to separate one part of a circuit from another without modifying the signals passing between them. Of course, the power supplies and pinouts are the same as for those other circuits."



"How do we know the gain is 1? asked Dude.

"That's easy," added Hambone. "The feedback resistor is a straight piece of wire or zero ohms. Make R_{FB} in that formula equal to zero and all that's left is the number 1 making the gain equal to 1."

"But wait, there's more," continued Elmer. "There are actually hundreds of applications for op amps including voltage



comparators, integrators, differentiators, oscillators, precision rectifiers, analog adders and subtractors to name a few. But I think the most common is filters.

By adding capacitors to the input or feedback circuits you can create a high pass filter like this. I've labeled the input and feedback resistors R_1 and R_2 to make the circuit more generic.

First, notice that this is a non-inverting filter because we are applying our input signal to the (+) terminal.

Second, notice that this is the same non-inverting circuit as above except I have put a capacitor in series with R_{IN} , now labeled R_1 . Remember, that the reactance of a capacitor is:

$$X_C = 1 / 2\pi fC \text{ Ohms}$$

where f =frequency in hertz and C is capacitance in farads.

Remember, too, that at low frequencies the capacitor looks something like a high resistance and at high frequencies it looks like a low resistance, more or less. The reactance formula helps to figure out how many ohms the capacitor actually presents at some specific frequency.

The idea is that at very low frequencies, the high reactance of that capacitor in series with R_1 makes the combination look something like a very high resistance.

Here's that same gain formula rewritten using Z s instead of R s. I did this because Z stands for impedance which is a more general term that includes the characteristics of both resistors and capacitors.

see HAMBONE on page 10

from HAMBONE on page 9

$$G = 1 + (Z_2 / Z_1)$$

We see that at very low frequencies where the apparent resistance of the combination of R_1 and X_C is large compared to Z_2 , the gain will be about 1.

But, as the frequency increases, X_C becomes smaller and smaller until we really only have R_1 left in the circuit. When that happens, the gain approaches our original formula:

$$G = 1 + (R_{FB} / R_{IN})$$

So, you see, just by adding one capacitor we have made an amplifier into a high-pass filter. That's pretty close to magic."

"But we can't just add that capacitor's reactance to the resistance of R_1 even though they are in series, can we?" asked Hambone.

"No we can't," replied Elmer.

"For this discussion I'm ignoring phase angles which means we will work only with the magnitude of impedance Z_1 . That means that we have to calculate the magnitude using the formula:

$$|Z_1| = \sqrt{(X_C^2 + R_1^2)}$$

I put those lines around the Z to be technically correct, but most people leave them out and just write Z_1 .

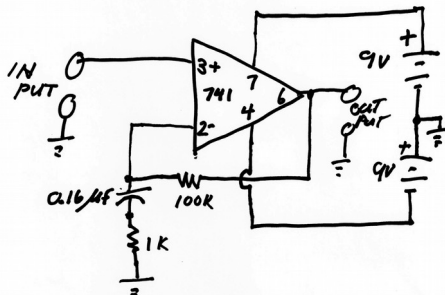
So, putting Z_1 in the denominator of our gain formula, we get our final high-pass filter formula:

$$G = 1 + [R_2 / \sqrt{(X_C^2 + R_1^2)}]$$

Simple, isn't it?"

Noticing that both boys' eyes had glazed over from all the technobabble, Elmer continued.

"To see how this all works, let's build this high-pass filter.



We'll use two 9-volt batteries for power and this 741 op amp IC. Let's calculate the gain at two frequencies, say, 100 Hz and 10,000 Hz using the gain formula.

We'll use a 100KΩ feedback resistor, a 1KΩ input resistor and this 0.16 microfarad capacitor.

$$G = 1 + [R_2 / \sqrt{(X_C^2 + R_1^2)}]$$

First, we must find the reactance of the capacitor at 100 Hz. We do that by filling in the formula for capacitive reactance:

$$X_C = 1 / 2\pi fC$$

$$X_C = 1 / [6.28(100)(.16 \times 10^{-6})]$$

$$X_C = 1 / 0.0001$$

or 9952Ω, which is pretty close to 10,000 ohms

Notice a couple of things. I used 6.28 for 2π , that's close enough for our work here. Also, I used engineering notation for 0.16 microfarads rather than write 0.00000016. That saves writing a lot of zeros. It doesn't change the value.

Putting all that into our formula for Gain at 100 Hz we get:

$$G = 1 + [R_2 / \sqrt{(X_C^2 + R_1^2)}]$$

$$G_{100} = 1 + [100K / \sqrt{(10K^2 + 1K^2)}] = 1 + 9.95$$

which means our filter has a gain of about 11 at 100 Hz.

Now let's do the same thing at 10,000 Hz.

We could re-calculate X_C using 10,000 Hz, but we don't have to. Since we know that the reactance of a capacitor is inversely proportional to frequency, we know that making the frequency 100 times higher will cause X_C to be 100 times lower, or, 99.5 ohms. Let's call it 100 ohms.

Putting that new value in the gain formula we get:

$$G_{10K} = 1 + [100K / \sqrt{(100^2 + 1K^2)}] = 1 + 99.5$$

or about 100.

This has got to be the world's simplest high pass filter, but not its best. I'll leave it up to you boys to build it and check the results. You'll find the actual gains are a bit lower than the formula indicates because the 741 amplifier's open-loop gain is only about 50,000 which is way less than infinity.

You can Google op amp circuits to see what else you can build and how to make better filters. I'm going to take my nap."

- FEEDBACK -

LOCAL MEETINGS AND FM NETS

	SUN	MON	TUE	WED	THU	FRI	SAT
AM	0:00 Paul Revere 146.94- (88.5)				11:00 Quarter Century Wireless Assn - RC's Restaurant, 135th & Wornall		07:00 - Santa Fe Trail ARC @ Perkins, Santa Fe E. of I-35, Olathe 09:00 - Ray/Clay ARC - Bargain Town (Hwy 10&13), Richmond, MO
18:00	18:45 Miami County D4 ARES/Paola 147.360- (151.4)	18:30 4th: KCDX Club @ Better Homes & Gardens Realty, 8101 College Blvd, #100 OPKS	JoCo ARES Simplex 146.450				
19:00	Wheat State Net/Paola 147.360- (151.4)	145.47- (151.4) JoCo ECS 1st: Clay Co ARC @ Liberty Hospital (Dialysis Ctr - Lower Level)	JoCo ARES 145.29+ (151.4) 2nd: Indep. FM ARC, St. Matt's UMC, 2415 R D Mize Rd., Indep, MO 3rd: Heart of Amer RC - Red Cross HQ, 211 W Armor, KCMO 3rd: Testing @ Community Christ, 63rd & Manning, Raytown	2nd: Douglas Co ARC @ Douglas Co Fairgrounds Bldg#1 2nd: Wheat State Wireless Assn @ Paola Fire Station	Jayhawk ARS 147.150+ (151.4) 1st: Pilot Knob ARC @ Leavenworth Co Courthouse - Emer. Op. Ctr.	3rd: Santa Fe Trail ARC Meeting and Fun Night @ Faith Technologies, 11086 Strang Line Rd, Lenexa	
19:30	Swap and Shop 145.17- (151.4) Pilot Knob ARC 147.00- (151.4)		JoCo SATERN 145.13- ()	Clay Co ARC 146.79- (107.2) Pilot Knob ARC 147.00- (151.4)	4th: Raytown ARC @ basement of Comm of Christ, 63rd & Manning, Raytown	2nd/4th: JCRAC "Regular Meeting" @ OP Christian Church, 7600 W 75th St. OPKS	
20:00	Douglas Co ARES 146.76- (88.5) Raytown ARC 145.17- (151.4) Clay Co ARC 147.33+ ()	145.13- () KC Assoc of the Blind ARC 147.375+ (156.7) Ray/Clay ARC	Southside ARC 147.12+ () Santa Fe Trail ARC 147.24+ ()	Johnson Co RAC 443.725+ (151.4)	Johnson Co RAC 145.29+ (151.4)	VA Casual/Ham Roundtable 443.500+ (151.4)	
20:30				Jackson Co ARES Digital Training 146.97- ()	Independence RACES 145.31- ()		
21:00	Right Wing Wacko Net 146.97- ()			Swap and Shop 147.09+ ()		2nd/4th: JCRAC "Annex Meeting" @ Pizza Shoppe, 8915 Santa Fe Dr., OPKS	

Local nets, meetings and testing sessions are posted as the FEEDBACK editor becomes aware of them.

A net is "local" if it can be heard on an attic VHF/UHF J-pole near I-435 and US69. Boldfaced type indicates that FEEDBACK heard the net. Plain type indicates that someone reported it to the FEEDBACK or referred to it on Larry's List, but the FEEDBACK has not confirmed its presence.

A meeting is local if the person who prepares the calendar thinks that it is local.