

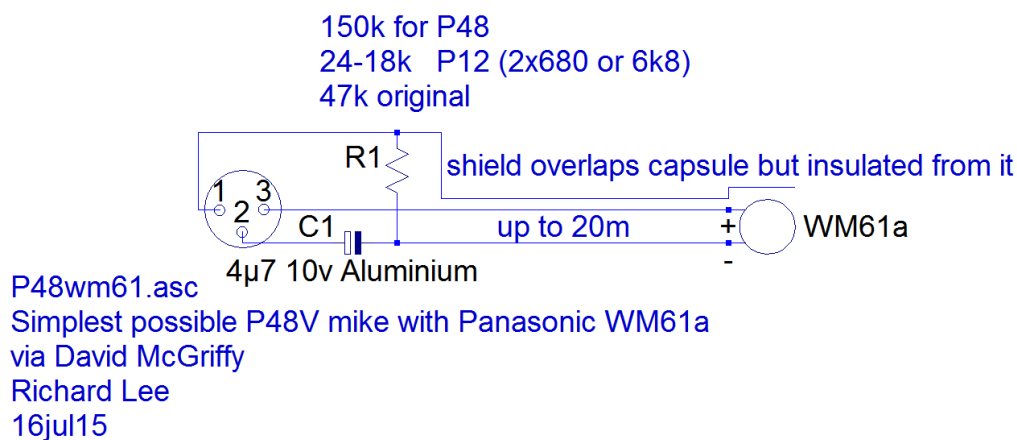
SimpleP48      **Simplest possible P48V circuit for electrets with built in FETs**

19dec18 The 2 recommended versions of SimpleP48 are

- **SimpleP48basic** with [EM172](#) or PUI 5024 Excellent noise even with less than stellar recorders/preamps. Tried & tested. Ideal for Nature Recording
- [SimpleP48RCA](#) **Rene's Charge Amp** version adds high spl performance. Excellent all round. Less sensitive so not so good as SimpleP48basic with cheaper recorders/preamps for low noise work

28aug14 I separated this from README.doc in my MicBuilders/Files directory to *explain some of the subtleties behind the simplicity.*

The original WM61a capsule is now discontinued and may be soon Unobtainium. This info is for you to optimise the circuit for other capsules like the excellent [Primo EM172](#) for very low noise [nature recording](#). (*WM61a wasn't very good for nature stuff cos it's quite noisy*)



I didn't dream this up but I wish I had. David McGriffy's circuit has excellent performance with only 2 components.

P48V version use	R1 = 150k	NOT interchangeable.
P12V with 2 x 680 or 6k8 (eg SoundDevices)	24k-18k	Mark your P12V mikes clearly

*WM61a uses a Panasonic 2sk3372 FET optimised for Electret Capsules.*

*Richard Camp measures  $I_{dss}$  at a consistent 280uA. Max  $I_{dss}$  is 470uA but rarely, if ever, found.*

**R1 (+ 6k8, the P48V resistor) is chosen to give  $V_{ds}$  across the FET about 5V**

*If you are not using WM61A (or using some other Phantom Voltage), check that R1 gives about 5-10V across your capsule*

*R1 is sorta 'constant current source' so the capsule is effectively 'floating' across p2&3 of the XLR. The balance isn't as good on the P12V version cos R1 is less than the FET  $Z_o$*

*These FETs have a medium output resistance<sup>1</sup> .. about 50k @ 390uA  $I_{dss}$  5v) and this sets the output resistance of the mike. But it is nearly 'balanced' cos its nearly 'floating'<sup>2</sup>. C1 and the  $Z_i$  of a good professional mike preamp, 1k5 - 2k, set the LF response.*

<sup>1</sup> The FET is 'floating' cos the diaphragm connects Gate to Source .. not earth. The *output resistance isn't  $1/g_m$*  as in a Source Follower. Instead it is  $1/h_{os}$  and is seen across pins 2 & 3.  $h_{os}$  in FETs is very small in their 'pentode' region. But at the small  $V_{ds}$  we use, the FET is still in the 'triode' region and  $h_{os}$  is estimated from the datasheet curves.

<sup>2</sup> The only imbalance is caused by R1 which is why the balance is worse on the P12V version. The smaller resistor for P12V puts a bigger load on one side of the balanced line ... so unbalances it more.

*4u7 & 1k5 give -3dB @ 22.6Hz There's only 5V across the capsule so 10V is enough. (My original recommendations were wonky. I was thinking of another LF effect .. not simple LF response. 47u/10V would be better for measurement and less susceptible to changing Vds on loud sounds. But condenser mikes do need LF response limited below 20Hz.)*

*Use an Aluminium Electrolytic for C1. **Do NOT use a Tantalum.***

*I show a range of resistor values for P12V cos some P12V implementations (including SoundDevices I think) use 2x6k8 resistors instead of the 2x680 spec. There's also the EXACT method used to supply phantom power.*

*Most preamps today use THAT 1510 / SSM2019 / TI INA163 and these have 2 separate 6k8 resistors so only one is involved in feeding our circuit. SoundDevices use the Sowter / Lundahl / Jensen arrangement with a transformer and effectively have 3k4 feeding our circuit cos DC through the transformer.*

*Just check that your chosen resistor gives between 5 - 10V across the capsule. **Measure voltage with everything in place & working but [wait 1min in a quiet spot first.](#)***

*This also affects P48V but to a lesser extent.*

*The maximum length of cable is determined by the HF roll-off due to cable capacitance with the impedance seen by that. This isn't the Zo of the mike but Zo in parallel with the input Zi of the preamp ... so less than 2k. Don't use more than about 20m.*



Mine is built onto the end of 20m of mike cable with 1/2" of thin Cu tube to hold the WM61a capsule and other bits.

**The Cu tube, connected to the cable screen/shield & eventually XLR p1, overlaps but is *INSULATED* from the capsule & other bits.**

Suitable for use as a reference mike for measurements.<sup>3</sup>

<sup>3</sup>eg Henry's [audioimprov.com/AudioImprov/Mics/Entries/2017/12/13\\_A\\_Simple\\_Reference\\_Mic.html](http://audioimprov.com/AudioImprov/Mics/Entries/2017/12/13_A_Simple_Reference_Mic.html) which also suggests a JLI replacement for Panasonic WM61A. Good stuff on soldering & construction.

## Caveats

- The capsule is not “Linkwitz modified” so has the same spl limitations as one operating into PiP. See Eric’s “Panasonic WM-61\_rev5.pdf” in Mic Measurements for detail .. and also the [Charge Amp](#) versions for better high spl performance.
- The case of the capsule is live. The **case must be insulated** so it cannot be touched. Touching the case of the capsule is like putting your finger on pin 2 or 3 of a microphone XLR
- It takes **current only from one leg of the P48V supply**. A problem only with very old mixers with P48V fed to a centre-tapped input transformer. (eg old Neves) Many modern mikes including some Behringer ECM8000 variants are guilty of this sin.

Newer transformer i/p preamps like the SoundDevices use the Jensen/Lundahl/Sowter arrangement with 2 x 6k8 for P48V. Good mike transformers (eg the Lundahls in the SoundDevices) are OK with less than 250uA through the primary using this circuit. Cheaper transformers may be wonky

- Johannes points out a potentially more serious fault. David McGriffy’s original used a 47k resistor. But this results in more voltage across the FET than its spec. That’s why my cryptic “47k->150k” note on the original pic which gets the voltage to its correct value.

If I was making another one, I’d use 150k but in fact, my own mike has 47k and is OK. I should get my finger out & modify the pic. *Done*

## In terms of the *best results with increasing order of complexity*, I recommend ..

- This circuit. Not RF proofed or Linkwitzed but surprisingly good. I use this.
- Next, Scott Helmke’s Alice variants. Circuit gurus will nit pick but in fact, the faults interact in a non-intuitive way to give serendipitous results. Don’t try to *improve* this.
- If you do want better, use Zapnsark’s detailed & tested Schoeps variants *in full*.

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Rick Wilkinson ([rickshawrecords](#)) did a workshop at his son's school to build 25 of these at less than \$10 each. The WM61 capsule is mounted on the XLR plug itself.

Polarity appears reversed in Rick’s excellent presentation. The polarity (p2 & p3 on the XLR) [here](#) are correct for WM61.

**RickshawrecordsDIYMicWorkshop.zip**

**Primo EM172**

The **Primo EM172** omni capsule is a larger, better WM61A. Nakamichi used it in their CM300 series mikes and it is a favourite among the Nature Recording crowd cos it is quiet.<sup>4</sup>

It uses a NEC 2sk4027 FET which is about 10dB quieter than the Panasonic one in WM61A. Zo about 33k (at 340uA Idss & 5V). The Panasonic FET appears not to mind operating above its rated voltage but the NEC doesn't like it at all.

**R1 should be sized to give about 5V across the capsule** with your preamp(s) P48V.  
Assuming 340uA

P48V version use	R1 = 120k	NOT interchangeable.
P12V with 2 x 680 or 6k8 (eg SoundDevices)	20k-14k	Mark your P12V mikes clearly

*Some prosumer units claiming 'Phantom Power' don't actually meet P48V standards. eg my MOTU Traveler is only P39V. Check your resistor gives 5-10V across the capsule with your preamp with this [caveat](#).*

Though the original was built with the 2 bits at the capsule end, this requires a SM Aluminium Electrolytic for a nice small neat arrangement at the end of the cable.

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<sup>4</sup> Pat, aka enjoybiking suggests PUI AOM-5024L-HD-R, available from Mouser, to replace EM172. Inexpensive, more sensitive but just as quiet. He says, you can take the back off and use the PCB/FET on a FET-less capsule.



**The 2 bits can be at the XLR** with the capsule on the end of 20m of mike cable as long as the **shield is maintained all the way to the capsule.**

This is Casey Connors version with EM172.

The first layer of heat shrink insulates the capsule. He uses Cu foil on top of this which is soldered to the cable shield which is connected to XLR p1. The Cu foil extends the shield so it "[overlaps the capsule but is insulated from it](#)" by the first layer of heat shrink.

A final bit of heat shrink makes everything nice and tidy at the capsule end.

Jonas Gruska found the **Zoom H6 display emits loadsa EMI** which embarrasses some VERY expensive mikes with poor RFI rejection. But our little circuit, with WM61 or EM172, shielded as described here, has no problem with this recorder.

Jonas has his 2 bits in the XLR too.

He found if C1 is a Tantalum, it has whooshy LF noise. Use an Aluminium Electrolytic for C1. **Do NOT use a Tantalum.**

*BTW, Casey's pic of the bits at the XLR has the Electrolytic reversed. The +ve lead on the Aluminium Electrolytic should be connected to p2. Tants die instantly if connected wrong .. an Aluminium might survive .. perhaps just becoming leaky/noisy.*

## Nature Recording

These **mikes with EM172** and an excellent portable recorder like the **SoundDevices** may be the most convenient way to get **portable State-of-the-Art-noise, nature recording.**

The Primo NEC FET has  $Z_o$  33k while the Panasonic in WM61 is about 50k. The impedance seen by the preamp is mostly it's own 1k5 or 2k input Z.

2k is 792nV (-122dBV) over 20kHz With the Primo's -28dBV/Pa sensitivity into 4k loads (-34dBV/Pa into 2k), this puts the electrical noise at 6dB spl unweighted. A good preamp will degrade this by about 2dB and a SoundDevices even less .. comfortably below the 14dBA spl noise spec for the capsule.

Some SoundDevices can be switched to P12V<sup>5</sup>. Making your mike to suit can double your battery life. If you are happy with omnis, less than 20m leads ... and need very low noise but not high levels (eg nature recording) it would be difficult to better this for performance & convenience even with loadsa money.

You need a very quiet preamp<sup>6</sup> though SimpleP48basic's high output level helps with lesser ones. See <http://www.avisoft.com/recordertests.htm>. If you have experience of something cheaper than a SoundDevices but just as good, please let us know.

<sup>5</sup> Alas today, December 2018, the only SoundDevices recorders with P12V are 552, 633, 664 & 688. Tascam DR100 III, DR701D, DR70D, DR60D, Zoom F8n, F4, H6, H5, H4 have P24V. Zoom H6, H5 have P12V. Please email me if you know of any others. None are of SoundDevices quality.

<sup>6</sup> SimpleP48 *IS* inherently quieter than the usual Schoeps configurations but in all good implementations, the FET / capsule noise dominates (as it should).



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For **high levels**, you need a **3-terminal capsule** like EM173 and one of **Zapnspark's Schoeps variants** ... see Eric's "Panasonic WM-61\_rev5.pdf" in Mic Measurements for performance details .. or the [Charge Amp versions of SimpleP48](#)

There's loadsa stuff on the web showing you how to 'Linkwitz' modify a WM61a (2-terminal) to 3-terminal. A **successor to Panasonic WM61a**, with its **consistent good performance**, has yet to emerge ... especially for use as a measurement mike.

There are many copies of WM61a .. but they are mostly less consistent. Also less detailed info about how to modify these from 2-terminal to 3-terminal. If you have successfully done this **surgery on a good alternative**, please post pics and your method. It's not quite micro brain surgery but nearly ...

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Dec 2015

**Jerry Lee Marcel** suggested a **mod to increase high spl handling** of this circuit. It substitutes plain WM61a with a "3-terminal capsule" with Source Resistor between Source and the 'earthy' end of the capsule .. but has the whole shebang floating like SimpleP48wm61.

**Stefano Simonelli** made some detailed measurements to prove the concept.  
<https://groups.yahoo.com/neo/groups/micbuilders/conversations/messages/25146>  
<https://groups.yahoo.com/neo/groups/micbuilders/conversations/messages/25145> et al

An important result from these is that this mod **does not degrade the noise of WM61A** so is recommended especially for those using SimpleP48wm61 for measurement mikes.

I expect doing the same with EM172, or the other Primo capsules with the same FET & sensitivity, would degrade noise by about 1dB .. ie juu.ust audible.<sup>7</sup>

A more worrying point is that R1 may need to be matched to the capsule.

The criteria is that the DC voltage across the capsule is 5-10V. There are conflicting issues.

- a resistor to give 5V gives the best EMI rejection as the resistor is less of an unbalancing force.
- 10V across the cap puts the FET more into 'pentode' range so more sensitivity, less distortion etc

It looks like 150k is too big ... certainly for Stefano's WM61A.

Would anyone who has built SimpleP48 and can do it conveniently please email [ricardo@justnet.com.au](mailto:ricardo@justnet.com.au) with what they have with subject "SimpleP48V voltages"?

I need

- Voltage on the XLR with **nothing** connected. ie the 'P48' voltage. Some prosumer preamps, eg my MOTU don't meet proper P48V spec.
- The capsule, eg WM61A, EM172 etc
- Resistor R1 and the Voltage across the capsule. If you try different R1s, post the different voltages.

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<sup>7</sup> Measurements & experiments by **Stefano & Henry Spragen**  
[audioimprov.com/AudioImprov/Mics/Mics.html](http://audioimprov.com/AudioImprov/Mics/Mics.html) suggest a method for high spl & low distortion without degrading the noise performance of very quiet capsules/FETs like the Primos.

It's done by adding a single *CGO/NPO ceramic between the Gate & Drain of the FET*. But it means disassembling the capsule and conducting brain surgery on SMD parts.

If anyone is interested in having a go, please contact me. You need some method of measuring frequency response of microphones reliably.

	Supply	R1	Vds	Id	= (Supply - Vds) / (R1 + 6k8)
<b>WM61a</b>					
Rich Camp				0.28	many
Stefano	47	150k	1.38 – 0.74	0.29	
		75k	9.23 – 9.02	0.46	R1 chosen for low THD / max Vds
Original		47k	?		
max Idss				0.47	
<b>EM184</b>					
Casey	48.3	150k	5.2 – 0.7		
<b>EM172</b>					
Adrian	P12	15k	5.4	0.3	
					<a href="https://tombenedict.wordpress.com/2016/03/05/diy-microphone-em172-capsule-and-xlr-plug/">https://tombenedict.wordpress.com/2016/03/05/diy-microphone-em172-capsule-and-xlr-plug/</a>
Akira	48.8	100k	1.7	0.44	Fostex FR2LE
		68k	4.2	0.6	
		47k	7.5	0.77	? damaged electrolytic or capsule?
Dreyfus	45.5	41k2	9	0.76	?
	23.5	25k5	9.9	0.42	DR-60D
<b>Andrzej</b>	46	43k	7.5	0.77	? E-MU1616m
		33k	8.7	0.94	?
Ellef	48	41k2	7.6	0.84	
max Idss				0.6	
<b>EM258</b>					
Ellef	48	64k9	7.2	0.57	
max Idss				0.6	
<b>PUI 5024</b>					
Stefano	48.5	47k	7.3?	0.77	? Vds max is 10V
		56k	10	0.61	
		68k	6.9	0.56	
		89k	3.8	0.47	
Rene		66k	8.8	0.54	
Ellef	45.8	69k8	7.1	0.51	
	48	69k8	8	0.52	
musicreo	46	100k	3.5-4	0.39	
		82k2	5.5-6	0.45	
				0.46	
Typical Idss				0.5	

Dec 2018 Tom Benedict's excellent blog (link above has good construction hints) and its responses bring up some important points.

- The Aluminium **Electrolytic MUST** be connected with **+ve to p2** of the **XLR**
- **Don't test without the capsule in place.** This puts the full P48V on the 4u7 which may only be rated for 10V. Use a 4u7 50V or larger if you are concerned about this. Bigger & higher voltage electrolytics good as they generally have less ESR & noise ... if they fit the space.
- If you test **without capsule in place**, the voltage across R1 should be zilch. (*ie full 48V where the capsule is supposed to be*) Any voltage across R1 (anything less than full 48V at the missing capsule) is the result of C1 leaking cos you've zapped it, probably backwards.
- If your mike still works, has 5-10V across the capsule with everything connected and acceptable noise after this misuse, don't fix it. Aluminium Electrolytics are quite robust (unlike Tantalums) and may still work with a bit more **leakage and noise**. This is likely the reason for Id > max. Idss spec from Akira, Dreyfus & Andrzej.

- But if you do swap bits, restore the Aluminium Electrolytic to its correct polarity. You can probably increase R1 as it doesn't have to carry the leakage of the 'wrong-way-round' C1. Bigger R1 gives better EMI immunity.
  - Note his caveats about quick soldering and heatsinking of the EM172s .. as does [http://audioimprov.com/AudioImprov/Mics/Entries/2017/12/13\\_A\\_Simple\\_Reference\\_Mic.html](http://audioimprov.com/AudioImprov/Mics/Entries/2017/12/13_A_Simple_Reference_Mic.html)
  - If you are taking more than the 0.6mA max. Id spec, check that the Electrolytic is the right way round. If it is correct, the capsule is likely damaged by heat.
  - *Present (2018) EM172 production may not use the NEC 2sk4027 FET . This has max Idss 340uA while EM172 and present Primo spec max Idss 600uA. Eric #293696: thinks they use the SM version of NEC 2sk660 max Idss 500uA*
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## Charge Amp mod for low THD

There's another possible mod that will give the Marcel / Simonelli improvement in distortion & maximum output without compromising the theoretical best noise performance of SimpleP48.

It involves using a KM84 type charge-amp circuit but floating the whole thing like SimpleP48. It adds a single NPO/COG ceramic capacitor to the huge parts list of SimpleP48 which goes directly between Drain & Gate of the FET. Alas, this isn't easy as you have to dismantle the capsule to get at the Gate.

The extra *voltage negative feedback* lowers gain like Jerry's mod (*which uses current feedback*) but reduces  $Z_o$  instead of increasing it. This makes it less susceptible to RFI but I wouldn't use SimpleP48 in a **high RFI / EMI environment**. For that, Zap's **full** Schoeps versions are the ones to use.

*Should point out that there are loadsa much more complicated circuits that are poorer than SimpleP48 for RFI / EMI .. including some big name Germans.*

If anyone is happy to have a go and can measure THD like Stefano (*Hint! Hint!*) I'd be pleased to hear from them & give more details.

July 2016      *I wrote the above in jun16 and put it on the back burner but recently, there's been a spate of Charge Amp stuff eg*

*Homero's **Charis Mic** in his File*

<https://groups.yahoo.com/neo/groups/micbuilders/conversations/messages/26029>

*and some of Henry Spragen's stuff*

[http://www.audioimprov.com/AudioImprov/Mics/Entries/2015/12/25\\_Measurements\\_and\\_Charge\\_Amplifiers.html](http://www.audioimprov.com/AudioImprov/Mics/Entries/2015/12/25_Measurements_and_Charge_Amplifiers.html)

[http://www.audioimprov.com/AudioImprov/Mics/Entries/2015/12/20\\_Modding\\_a\\_BM-800\\_Mic.html](http://www.audioimprov.com/AudioImprov/Mics/Entries/2015/12/20_Modding_a_BM-800_Mic.html)

*so I thought I'd better show how its possible to do it very simply (??) to advantage ...*

Stefano's "**3 versions of the simple p48.pdf**" at

<https://groups.yahoo.com/neo/groups/micbuilders/files/ss%20files>  
tests 3 versions.

The first has  $R_1 = 150k$  but that only gives  $V_{ds} 1V_4$  on Stefano's sample of WM61. I'm discounting this version as it is clearly wonky with so small  $V_{ds}$ . Remember,  **$R_1$  should be chosen to give between 5-10V for  $V_{ds}$** . But see [Stefano](#)

The second version, has  $R_1 = 75k$  chosen to give  $V_{ds}$  just below 10V. Operating at as high a voltage as possible gives the best THD and output capability

The third version introduces **Jerry's 2k2** between the FET source and the capsule case. To do this, a 2 wire capsule like WM61a must be modified to 3 wire or a 3 wire capsule like Primo EM182 used.

This does the following :

- Gain & Sensitivity reduced by 9.3dB ie 9.3dB **current** feedback
- Max. output (2.7% THD) increased by 10.6dB
- Together this increases the max. spl by 20dB for 2.7% THD to 135dB spl .. a very good spec

It also

- increases the Output Z but as this is already probably 50k, it is of no consequence
- increases the inherent electrical noise (assuming FET, capsule, preamp are noiseless) by about 3dB (*The other noise contribution in this supa circuit is the 2k Input Z of the preamp*).

WM61 is quite noisy so this is swamped. But with the Primos, total noise (including the capsule) will increase by about 1dB.

We can get the good THD and overload behaviour and still retain State of the Art noise, by adding a single COG/NPO ceramic between Gate & Drain of the FET.

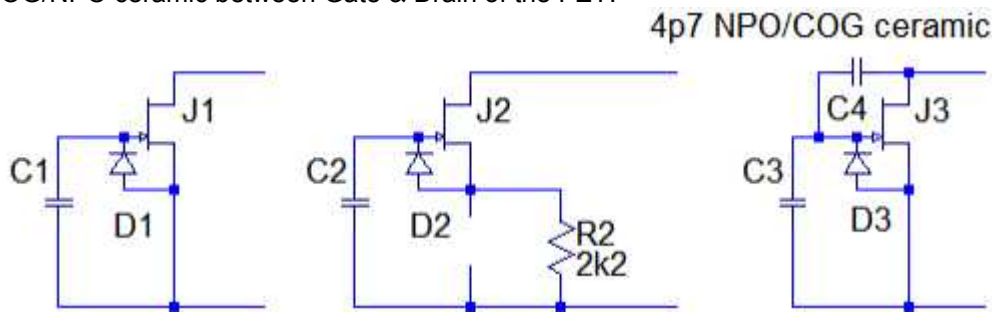


Fig 4 Original 2 wire capsule / mod to 3 wire external resistor (Marcel mod) / 2 wire C4 added inside

C1, 2, 3 are the electret elements in the capsules, about 5p for WM61a. J1+D1 etc are the FETs with built-in bias diodes; 2sk596 in the Transound capsules, 2sk4027 in the Primos.

The middle version has been converted to “3 wire” by snipping the connection between FET Source and the case. R2 2k2 bridges this gap. This “Marcel mod” is V3 in Stefano’s tests.

In the last (right hand) case, the capsule is left “2 wire” but C4, a 4p7 NPO/COG ceramic has been added between the Gate & Source of the FET converting the capsule into a Charge Amp.

- If you do this with the Transound 3 wire capsules, eg TSB120 & 140, you need to short out the internal 2k2 resistor.
- Each of the 2 later examples in Fig 4 represents an (“**improved**”) 2 wire capsule. The added bits **MUST** be AT the capsule/FET
- eg if you do the Marcel mod on a 3 wire capsule like EM173, R2 **MUST** be AT the capsule. You then **treat the assembly like a 2 wire capsule** ie insulate the capsule case from the screen but the screen **MUST** overlap it. If you put R1 & C1 at the XLR like Casey Connor, R2 the 2k2 source resistor, must still be AT the capsule.

Each case in Fig 4 is simply substituted for the 2 wire WM61a in Fig 1 and R1 adjusted to give 5 – 10V across it.

So the procedure is as follows.

- Install 2 wire (or 3 wire with resistor shorted out) cap in Fig 1 & [check R1 gives 5 – 10 V](#) across it.
- Measure response & sensitivity ( & THD at high level if possible )
- Select C4 to drop the sensitivity by 9 – 10 dB
- Measure response & sensitivity and see if high level THD & max output have improved

The sensitivity of this circuit is given by the ratio of the capsule capacitance to C4.

**If you take your Primo capsules apart, please measure & post the capacitance of the capsules.**

- retains State of the Art noise when using quiet capsules like EM172
- reduces Output Z ...
- maybe more stable Vds at high level. Stefano shows with Marcel mod, Vds drops from 10V to 4V

Pat, aka enjoybiking suggests **PUI AOM-5024L-HD-R**, available from Mouser, as good capsules in their own right ... and as an inexpensive source of the LN FETs and PCBs to mount on the back of a FETless electret (like TSB2555).

Probably the easiest way to do a traditional charge amp with an added NPO/CGO ceramic between Gate & Drain.

I’m not sure its easy to re-assemble a 5024 and get it working again once you’ve taken it apart to install the ceramic.

## WHY HAVEN'T I POSTED THIS EARLIER?

Because it's actually quite difficult to get at the Gate of the FETs in capsules.

<http://www.firstpr.com.au/rwi/mics/2009-09-a/#TSB-120A>

shows some examples and you see that only in the case of TSB 120 is it possible to do this mod without destroying the capsule.

In most cases, the Gate is hanging in mid air to make contact with the backplate.

*Go to the end of this interesting & educational page to see the FET with spring tab on Gate*

I'm really hoping Stefano or Henry Spragens will take up this investigation as they have the gear & know how.

Presently, it is moot until we figure out how to take apart eg the Primo capsules to install this cap without damage.

And it increases the BOM of SimpleP48 by 50% !!

But it might be useful for capsules without built in FETs as Henry demonstrates at [http://www.audioimprov.com/AudioImprov/Mics/Entries/2015/12/20\\_Modding\\_a\\_BM-800\\_Mic.html](http://www.audioimprov.com/AudioImprov/Mics/Entries/2015/12/20_Modding_a_BM-800_Mic.html)

It might be possible to equal Neumann KM84 performance without a transformer with a suitable FET. Gotta get my single brain cell in gear and do some calculations.

## RENE'S CHARGE AMP (SimpleP48RCA)

Dec2018 René Thomsen (renthomsen) #29422, proposed an even simpler Charge Amp mod

"Henry's page on U87 eq has a nice simplified schematic.

[http://www.audioimprov.com/AudioImprov/Mics/Entries/2014/2/7\\_Mic\\_Electronic\\_Eq\\_Pt.1.html](http://www.audioimprov.com/AudioImprov/Mics/Entries/2014/2/7_Mic_Electronic_Eq_Pt.1.html)

For our purposes we don't need the eq part, just the feedback applied through the capsule. I would try just connecting the case to drain for unity gain."

We do this by converting EM172 or 5024 from 2-wire to 3-wire and connecting the case to the Drain.

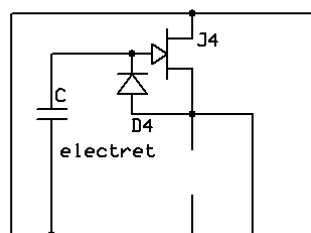


Fig 5

RCA (Rene's Charge Amp) 2-wire to 3-wire. Case to Drain

- Treat this assembly as an "improved 2-wire capsule" like the examples in [Fig 4](#) ie insulate capsule case from screen. But the screen MUST overlap it.
- Other stuff eg selection of [R1 for Vds 5-10V](#) etc holds
- Polarity reversed so Electrolytic +ve goes to XLR p3 and capsule +ve (Drain) to p2

**PROS**

Lower THD  
 Better high spl overload than the usual Schoeps variants  
 Lower Ro in use which gives:  
 Lower noise than SimpleP48basic  
 Better 'EMI / RFI / wonky P48' rejection  
 Mike line lengths up to 56m  
 Still very simple  
 2 items in huge parts list

**CONS**

Drain Follower much less sensitive than SimpleP48basic. Not so good for less than stellar recorders & preamps. About 5dB less sensitive than usual Schoeps versions with same capsule & FET  
 DC voltage across capsule is in opposition to electret charge which *may* reduce sensitivity by up to 1dB  
 Should match Resistor to supply & capsule

Feb2019

Stefano Simonelli's detailed tests on **PUI 5024 with SimpleP48basic & SimpleP48RCA** are at <https://groups.yahoo.com/neo/groups/micbuilders/files/ss%20files/SimpleP48%20PUI%205024L%20HD%20FULL.pdf>

They clarify & confirm many performance aspects of SimpleP48basic & SimpleP48RCA.

**Executive Summary**

What this shows is **Rene's Charge Amp** mod

- **reduces PUI 5024 SimpleP48basic sensitivity by about 10dB.**
- As this is achieved by Negative Feedback, **THD is also reduced by 10dB.**
- Most importantly, this reduced THD pushes the **maximum spl of PUI 5024 SimpleP48RCA to a higher level** before it gets to 3%. The improvement is more than 10dB and nearly 20dB in the versions with carefully selected R such that Vds, the voltage across the capsule, is between 5-10V when quiescent (not too much signal). This is more than 130dB spl which is very good indeed.
- It also shows **Vds drops when the FET is trying to deliver a large output** so when choosing R1 for Vds 5 – 10 V, let the capsule sit for a minute in a 'quiet' spot before measuring Vds. Don't knock or bump it when you measure Vds.

Rene (renthomsen) in post #29707 did some overload tests to see if **SimpleP48RCA blocks**

PUI 5024 R=66k Vds=8.8v idle ... 2.2v after snare hit. **Recovery time=10 minutes!!**  
**Faulty?**

Primo EM173 R=24k3 Vds=8.8v idle ..10.3v (??) after snare hit. *EM173 is '3-wire'.*  
*Why is Vds greater on overload?* Recovery time=4 seconds

Monacor MCE2000 R=102k Vds=9.3v idle 8.5v after snare hit.  
 (rebranded Panasonic WM60) Recovery time=5 seconds

Of these, PUI 5024 is the only one to 'block' significantly. Gain and headroom were noticeably reduced during the long 10min recovery period. This has implications on how PUI 5024 does the 'diode biasing'. **But Stefano's 5024 results show almost instant recovery with R=68k**

## WHY CHARGE AMP?

Eric #29396 “Why not simply modify the capsule (Linkwitz mod) to be a source follower. What is the advantage of the charge amp relative to a Source follower?”

*I gave him a wishy-washy answer so I'd better do a better one worthy of **Great Guru Baxandall** who first enlightened me circa 1978. Yus gurus, please excuse my dodgy use of [h-parameters](#) for FETs.*

This analysis assumes a single FET with very few bits around it. The electret is a few pF to a few tens of pF and the charge amp feedback caps are of similar order.

*This analysis doesn't work so well with resistive feedback cos resistors tend to load the output too much.*

The voltage gain of a simple common source amp is  $-gm \times RL$ . The output resistance, **Ro is simply RL**.

If we make RL very large, eg replacing it with a constant current source, the gain also becomes very large and is ultimately  $gm / hos$  where hos is the output admittance of the Common Source FET amp.

hos is very small (output Ro very large) in the 'pentode' range of the FET when you have sufficient Vds. Where SimpleP48V operates, 5-10V Vds, the FET is in the 'triode' range and Ro is about 33k – 50k ... which is still a large Ro and gives large gain

Here is **GG Baxandall's insight**.

*If you now apply **voltage feedback** (eg via a Charge Amp capacitor for a capacitor source) to reduce this large gain back to the **original  $-gm \times RL$** , the large **Ro is also reduced back to RL** !*

*The feedback always gives you a value for Ro which is also the value of RL you would need for the same gain without feedback.*

You can use more feedback to reduce the gain further .. perhaps until a **gain of -1 (a Drain Follower)** at which point, your 'equivalent' RL, *which is also your **Ro, is 1/gm***.

In each case, since you have used *voltage negative feedback to reduce your gain & Ro, THD is improved and also your overload level*. The physical RL is chosen to give the best operating conditions and overload for the FET. The feedback configures the gain & Ro and improves THD etc at the same time.

*Part of this advantage is cos your large RL (constant current source) has increased the Open Loop gain of the system so the signal between Gate & Source for any given output is reduced. This is especially important for FETs with built in bias diodes like 2sk660 & 2sk596 in the Primos & Transounds. They don't like large swings between Gate & Source.*

For this unity gain Drain Follower case, we don't need a separate feedback capacitor but simply connect the electret between Gate & Drain for a gain of -1. The electret's capacitance acts as its own feedback capacitor. This is Rene's Charge Amp, **SimpleP48RCA**.

Finally, we can take the large physical RL (constant current source) of our Drain Follower in SimpleP48RCA and put it in the Source making it a Source Follower with ...  $Ro = 1/gm$  ... Surprise surprise !?

This Source Follower (or the Drain Follower) with large RL is better than the usual one with 2k2 (like many Schoeps variants) as it has much larger Open Loop gain. Expect SimpleP48 RCA to have even less THD & better overload than the usual 3-wire Linkwitz mod ... especially for FETs with built in bias diodes.

> I seem to remember some guru here or elsewhere explaining that the leakage diode is actually some kind of natural leak IN the actual fet.

No. The diode must have VERY low leakage. eg 1n4148 are useless. Guru Scott Wurcer's favourite 'diode' for this is a FET used in Smoke Alarms. Another good 'diode' for this is the base/emitter of an old fashioned LN BJT like 2n5087, BC184 etc.

The advantage of the 'charge amp' variants is that cos the 'diode/1G' signal is small, you can get away without the expensive and PITA 1G, ... and just use a 'diode'

In a Schoeps or Source Follower type circuit, this signal is 'large' and a diode would introduce THD. You need the 1G.

In the recent past, an old fashioned low noise FET with 1G etc was better than the FETs with built in diodes.

It's the emergence of the Low Noise NEC FETs with built in diodes, used in the Primos etc, that enables state-of-art performance from SimpleP48

I'm certain we will have even better performance as we get to know more about how these 'charge amps' work. Presently, my only caveat with SimpleP48RCA is that it's not as loud as a Schoeps .. but still louder than KM84. Greater sensitivity is an advantage with preamps & recorders that don't have SOTA noise performance.



## History

- 5jun20 add Ellef's 'Powering Electret Capsules' Caveat about insulating case of capsule
  - 7oct19 Stefano's 5024 measurements. FINAL correct C1 calculation. HONEST!  
Rene's overload/blocking tests.  
P12V & P24V recorders Begin cable length
  - 31dec18 explain Charge Amp. More on SimpleP48RCA. Correct calculation for C1 To MicBuilders
  - 17dec NEC 2sk660 Rene's Charge Amp RCA
  - 8dec Pat(enjoybiking)'s recommendation of PUI AOM5024
  - 6dec stuff from Tom Benedict's blog. Note: Casey's photo. To MicBuilders
  - 30mar18 Henry's measurement mike
  - 14jul adjust R1 in pic. Add Charge Amp detail. Name change from SimpleP48wm61
  - 15jun clarify EMI of charge-amp Correct calculation for C1 (I wrongly assumed R1=15k)
  - 3jun16 Stefano & Jerry's stuff. R1 choice. Mention possible charge-amp mod
  - 3dec further clarify 'shield overlaps capsule', 'floating' / 'balanced', output resistance, cable length
  - 18jul15 Polarity of Rick's Powerpoint Presentation. Clarify Cu tube connection. Jonas & Casey's contributions  
Correct P12V resistors Calculate electrical noise Nature recording Alternative WM61a
  - 28aug14 from README.doc & extended. C1 was 1u 50V
- ToDo**
- buzz caps in 5024?
  - Wonky P48
  - Cable length with 2sk660 Yfs 1.2mS
  - XLR p2 & 3 swapped in first schematic
  - P48V & P12V recommendations for EM172