J4 Microphones (New Mexico and Popo)

November 1, 2003

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Overview
The J4 Microphone was designed and constructed by Jeff Johnson for deployments in both New Mexico and Mexico (Popocatepetl and Colima Volcanoes) in 2003. Its name is derived from the fact that it uses four (4) co-located electret condenser buttons (Panasonic WM-034BY). Its design is based upon the McChesney 4 microphone summing amplifier box. The four redundant buttons help to achieve heightened signal-to-noise and provide robustness in case one of the elements should fail. The strengths of this unit are its modularity -- microphone elements can be easily exchanged and single-ended power can be administered either externally or internally (inside the environmental Pelican Case enclosure). Future versions will incorporate lower noise, lower power consumption voltage inverters.

The primary difference between the ***J4 New Mexico*** and ***J4 Popo*** is the choice of power supply inverter for the instrumentation amplifiers. In the ***J4 New Mexico***, a negative voltage supply is achieved through a 7662 charge pump inverter. However high frequency voltage ripple (10 k Hz) can cause noise to bleed through to the analog signal output, so it is necessary to low-pass filter the output signal before digitization. ***The J4 Popo*** uses an LM386 audio amplifier to produce positive and negative supplies relative to a ground which is halfway between the power ground and supply voltage (i.e. a 12 V supply will give +/- 6 V relative to +6 V). Though this power supply is low noise and uses relatively low power consumption (3 mA), it is only suitable for telemetry/digitizers, which accepts differential input. In both instruments, power consumptions is approximately 6 mA.

Other notable differences between the two different J4 microphones are that the ***J4 Popo*** has two switchable low-pass filters at 10 and 58 Hz and the ***J4 New Mexico*** circuit boards have two fixed low-pass filters at 58 Hz and two different gain settings (2.1 and 8.4).

Basics

a) external connections
  i) ***J4 New Mexico***
  ii) ***J4 Popo***
b) condenser element box (same for both ***J4 New Mexico*** and ***J4 Popo***)
c) circuit board notes

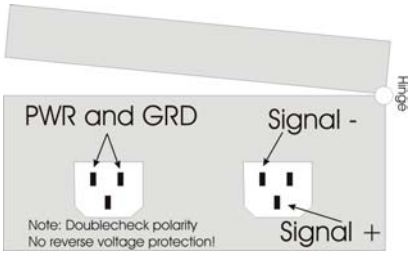
a) external connections

i) If you open the gray Pelican Case for the ***J4 New Mexico***, you will see a barrier strip with four clearly-labeled connections as follows.

PWR is +power and accepts +9 to +15 V. Be careful to maintain correct polarity!
GRD is power ground
GRD is also signal ground, identical to power ground
SIG is +signal. Signal is measured between SIG and GRD.

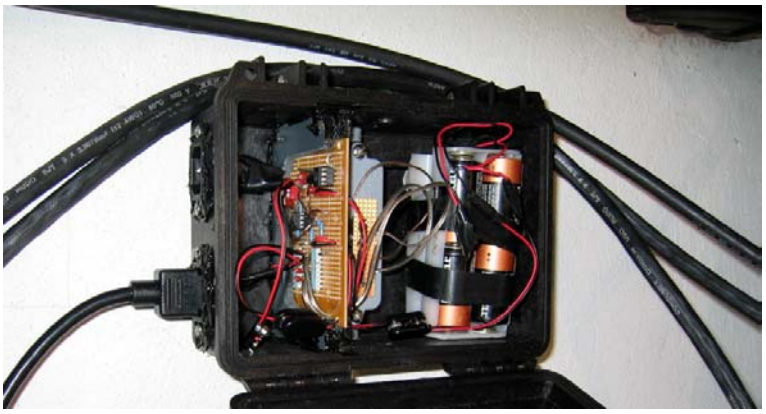
In the field, power will probably be supplied externally (from solar charged battery) and signal will be output to the digitizer. This can be accomplished either with a single 3/4-pin plug (Milspec?) or two individual two-conducter plugs attached directly to the Pelican (not installed). For testing purposes in the lab, test leads may be connected to signal output directly on the barrier strip inside the Pelican Case. For bench tests, the snap-together 9V connector (power supply) can be pulled apart and a 9 Volt alkaline battery can be temporarily attached to power up the microphone for a quick test (note: a 9V alkaline battery will only survive for about 48 hours before being drained).

ii) If you open up the black Pelican Case for the ***J4 Popo***, you will not see a barrier strip. Instead, two 9 Volt snap-together battery connectors emerge from the circuit board. The one that emanating from the upper left-hand corner of the circuit board is the power supply. The other is signal output. For the power supply connector positive voltage must be supplied to the female (large) 9 Volt terminal. This is wired correctly so that an alkaline 9V battery can be used for test purposes. For external supply, the 9 Volt connector mates with another 9 Volt terminal leading to the left connector plug (as viewed from outside the Pelican Case - see cartoon below). This left plug connector is an AC power supply socket that utilizes only the two upper conductors. Always double-check to make sure that polarity from the external power supply is correct (i.e. that the 9 Volt connector coming out of this plug has positive voltage associated with the small male terminal -as is the case for an alkaline 9 Volt battery). The other baffled AC power supply-type socket is associated with the differential signal output. Signal (+) is the bottom conductor and signal (-) is the top left conductor (as viewed externally from the Pelican Case - see diagram above). Note that unlike the ***J4 New Mexico***, Signal (-) is NOT tied to power ground.



b) condenser element box

Inside both the ***J4 New Mexico*** and ***J4 Popo*** is a small (10 cm x 3 cm x 5 cm) gray electrical box, which houses the microphone elements that are directly vented into the atmosphere. This condenser element box can be opened by removing two screws so that individual buttons may be replaced. The inside of the condenser element box is sealed from the interior of the Pelican case to protect the circuit board electronics, but it is connected directly to the atmosphere via a short PVC pipe (and optional perforated hose wind screen). The best aspect of the condenser element box is its modularity. Replacing microphone elements is as easy as pulling the buttons and putting in new ones (taking care to maintain the correct labeled polarity). The buttons that are included with the units have been calibrated with a reasonably good degree of accuracy (see section on instrument response). If you suspect that the microphone elements have been damaged by corrosion, simply exchange for inexpensive ($1.50) replacements. Note that the circuit board is optimally configured for Panasonic WM-034BY elements. These microphones were discovered by Chris Hayward (Southern Methodist University) to have very good low-end frequency response.



View of ***J4 Popo*** microphone deployed inside hut at Popocatepetl using a temporary C-cell internal battery supply (right side). Note the grey electret condenser element box (middle behind the circuit board) and the two cables extending from the AC plugs (left).

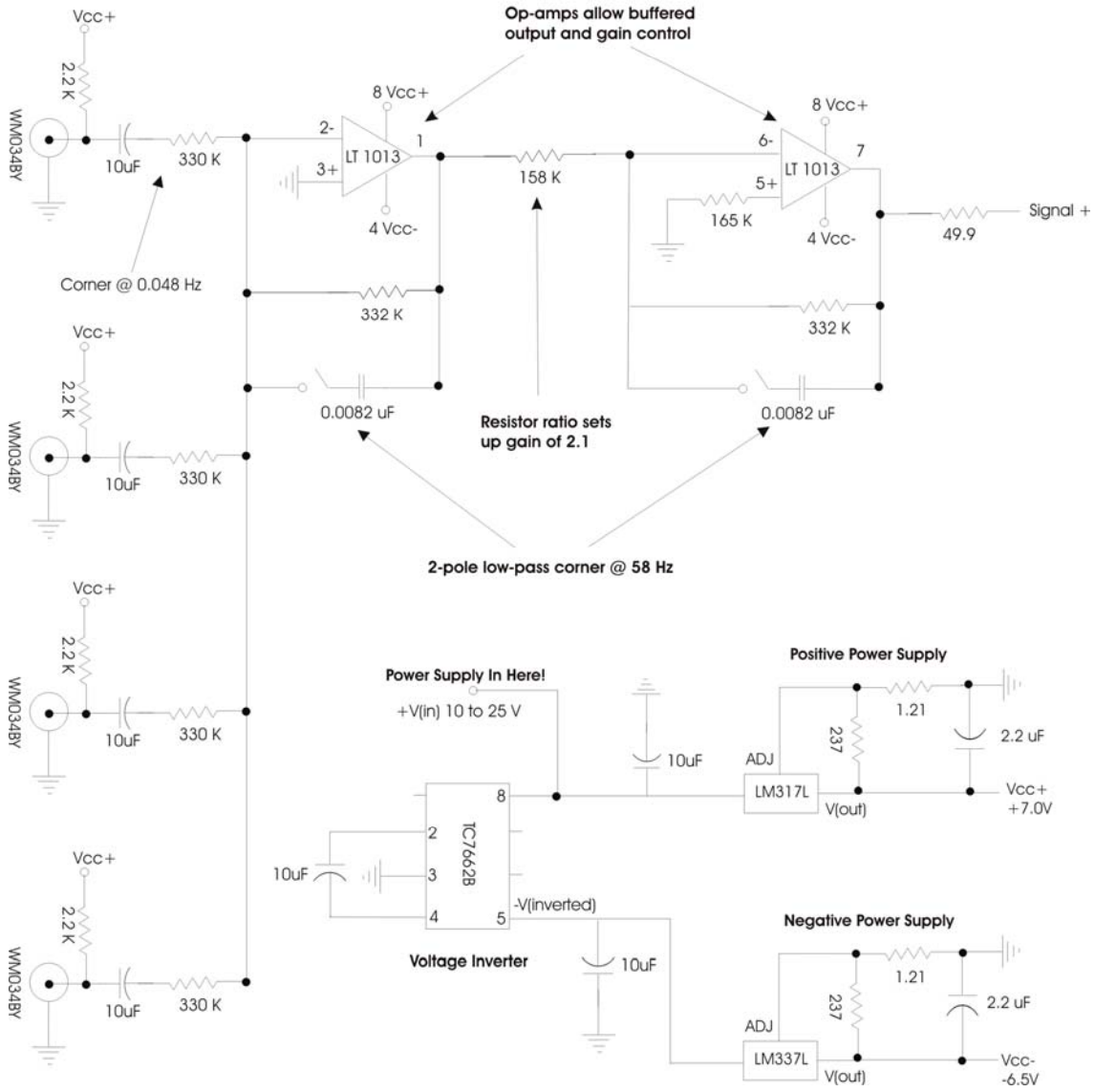
c) The circuit board is hand soldered, but is sturdy and robust as long as the elements are kept out of the Pelican case. The circuit board includes a voltage inverter (TC7662) or audio amp (LM386), which creates negative and positive power supplies for the instrument amplifiers. Variable instrument gains can be used, but at unity gain, ~50 mV/Pa to ~60 mV/Pa will be typical output for the in-band frequency response (assuming an average button sensitivity of 6 to 8mV/Pa/button x 4 installed buttons). Since the amplifier output voltage can swing to +/-8 V (***J4 New Mexico***) or +/-6V (***J4 Popo***), this gives at least +/-100 Pa dynamic range at unity gain. Since the buttons themselves have a dynamic range of only about 50 Pa, instrument gains have been set either to 2.1/2 or to 8.4 for the high-gain ***J4 New Mexico*** (see circuit diagrams to follow).

Circuit Diagrams

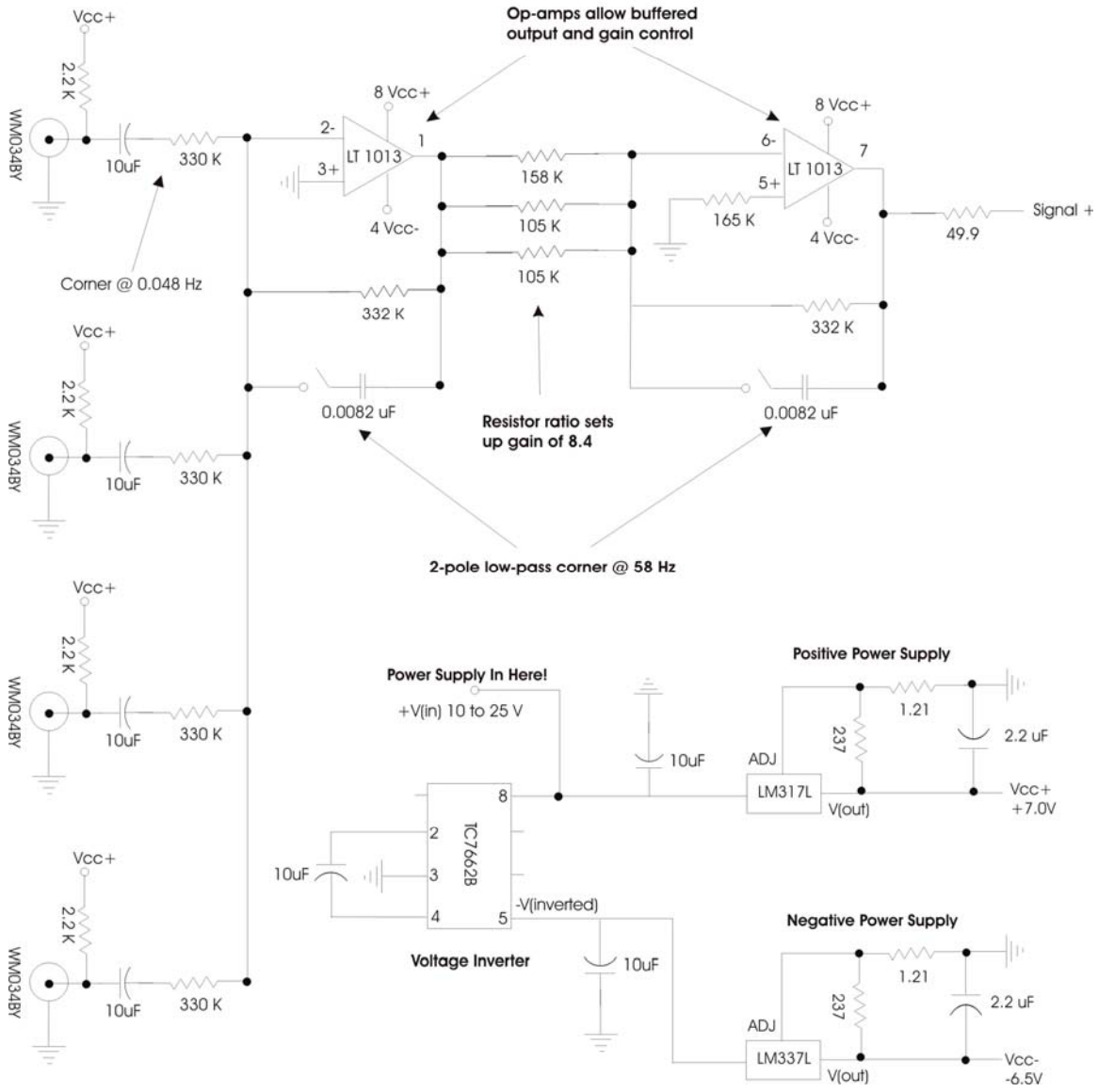
On the following pages circuit diagrams are given for:

- ***J4 New Mexico*** Unit #1 - gain 2.1
- ***J4 New Mexico*** Unit #2 - gain 8.4
- ***J4 Colima*** (same as J4 New Mexico Unit #1) - gain 2.1
- ***J4 Popo*** - gain 2

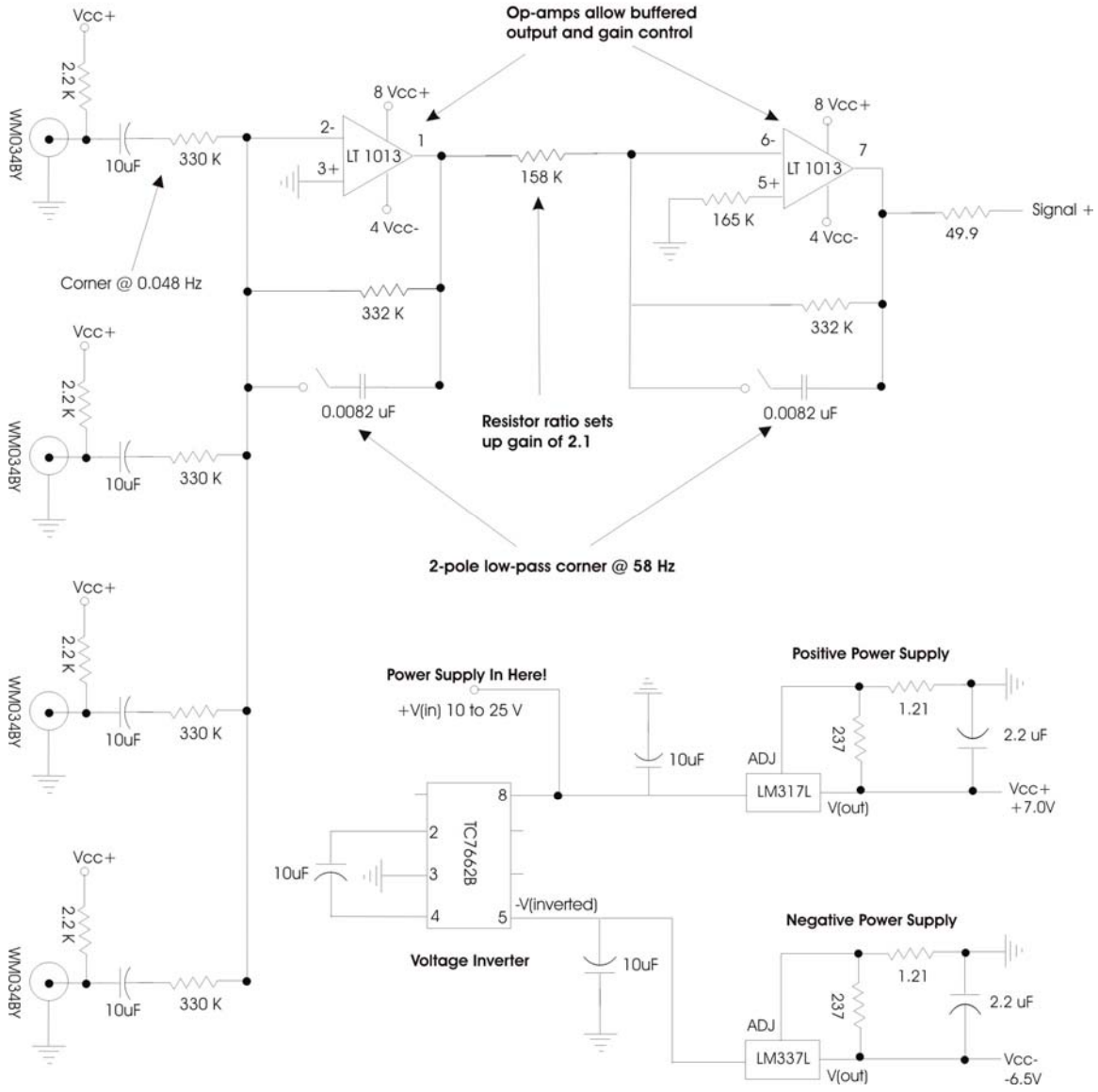
New Mexico J4 Unit #1 Microphone Circuitr Diagram (3/31/2003)



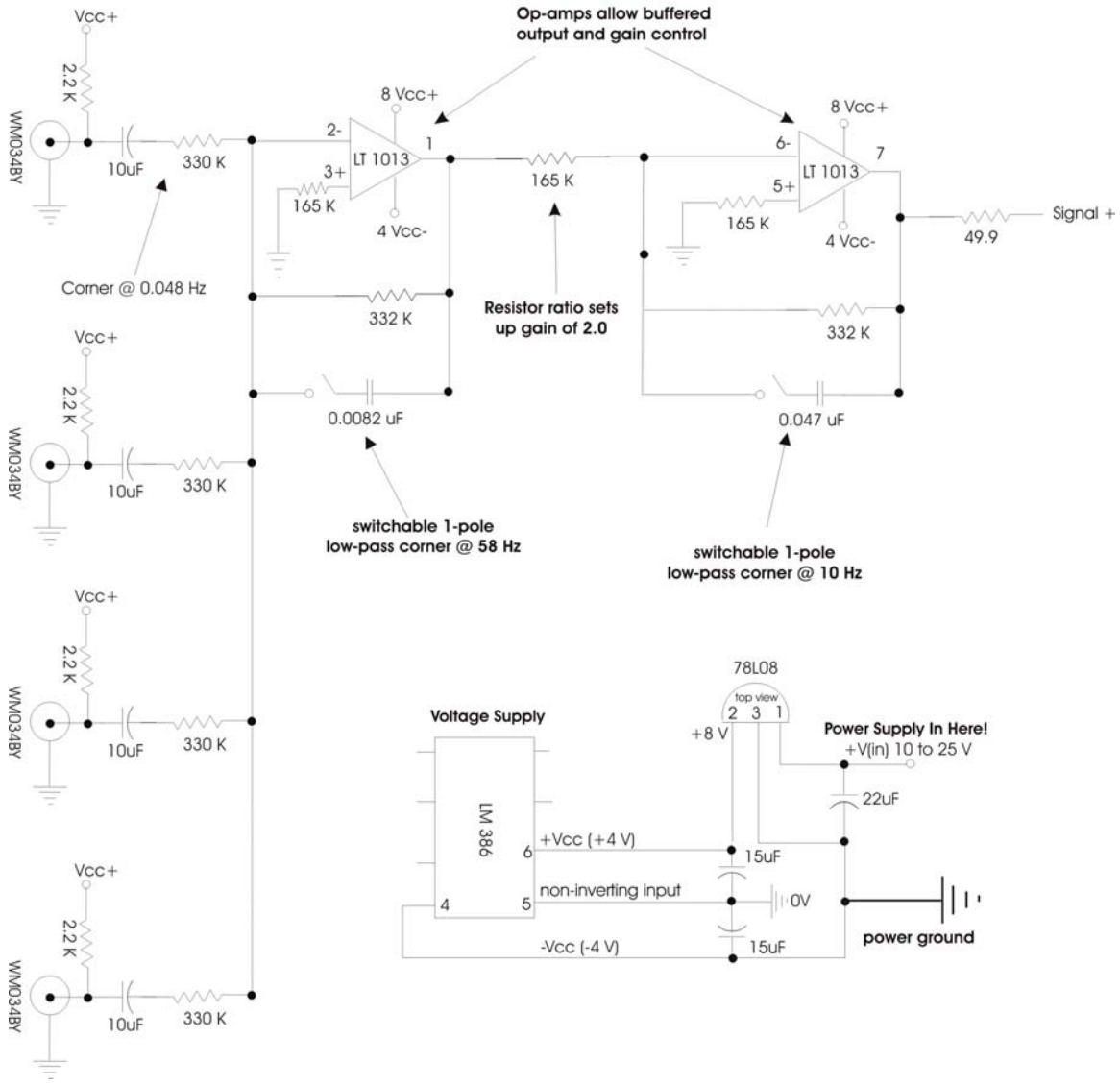
New Mexico J4 Unit #2 Microphone Circuitr Diagram (3/31/2003)



Colima J4 (identical to New Mexico J4 unit #1)
Microphone Circuitr Diagram
(10/03/2003)

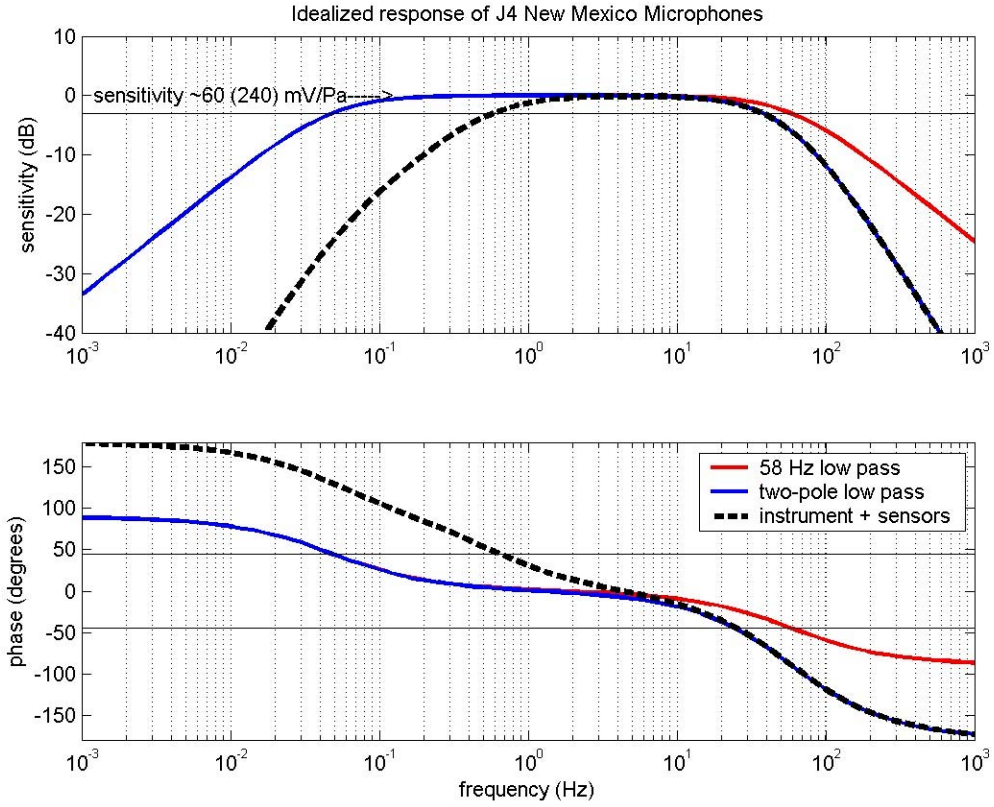


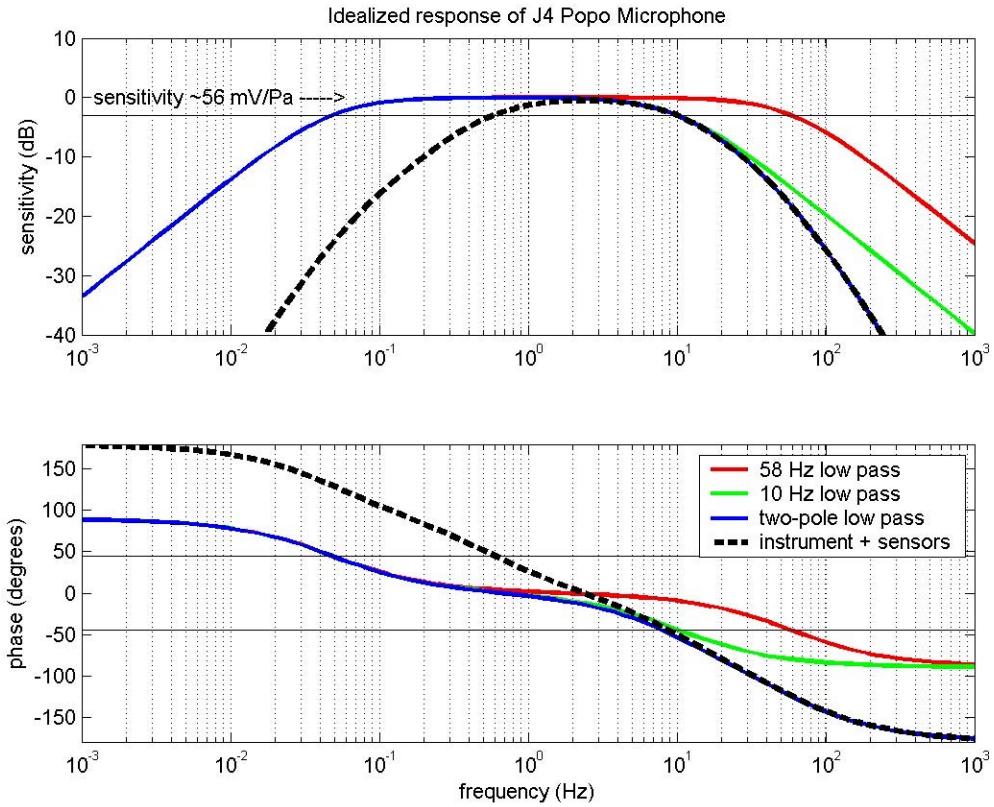
Popo J4 Microphone Circuitry Diagram (September 2003)



Instrument Responses

The ***J4 New Mexico*** has fixed gains of either 2.1 or 8.4 depending upon the circuit board. For the four electret condenser elements each with fixed sensitivities of 6 mV/Pa to 8 mv/Pa, the total in-band sensitivity will then be ~60 mV/Pa or 240 mV/Pa. Because the electret condenser elements have output which becomes saturated at about ~45 Pa, output dynamic range will be ~2.5 V to ~11 V. The ***J4 Popo*** has similar gain to the low-***gain J4 New Mexico***. Plots on the following pages show approximate instrument responses for ***J4 New Mexico*** Unit #1 (low gain unit - same as ***J4 Colima***) and ***J4 Popo***. Note that the low-pass filters for the ***J4 New Mexico*** are fixed, whereas the low-pass filters for the ***J4 Popo*** are switchable.




Idealized response of J4 Popo Microphone
sensitivity ~56 mV/Pa ----->
sensitivity (dB)
phase (degrees)
frequency (Hz)
58 Hz low pass
10 Hz low pass
two-pole low pass
instrument + sensors