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"Volume Unit" meters, analog and digital design thoughts.

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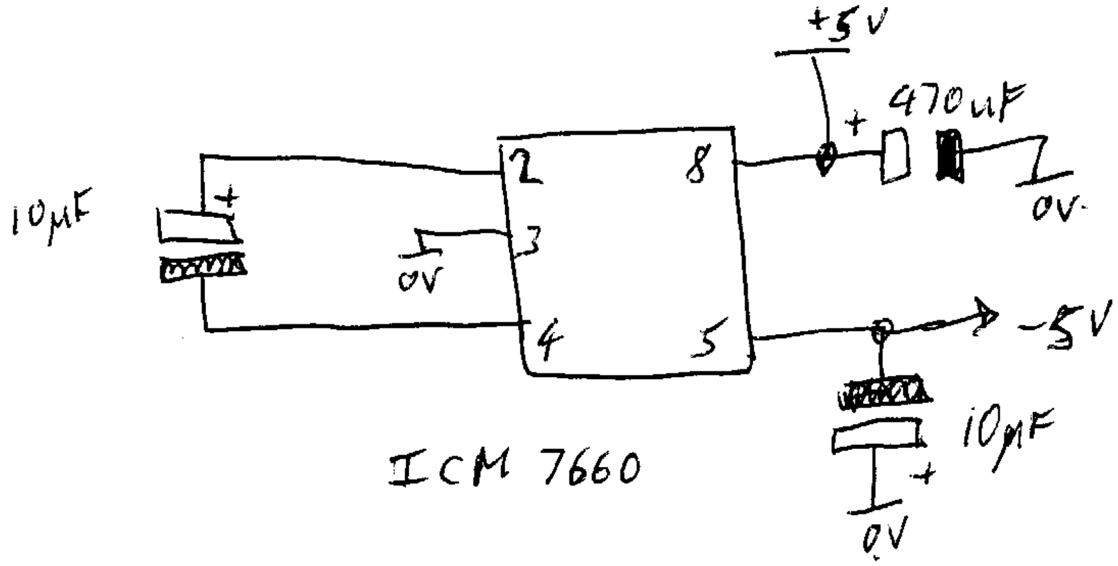
Introduction

From the RGSB book “Test Equipment”, I found an interesting circuit that I wish to use as a control agc voltage for a voice compressor circuit using the LM570.

Negative voltage generator circuit.

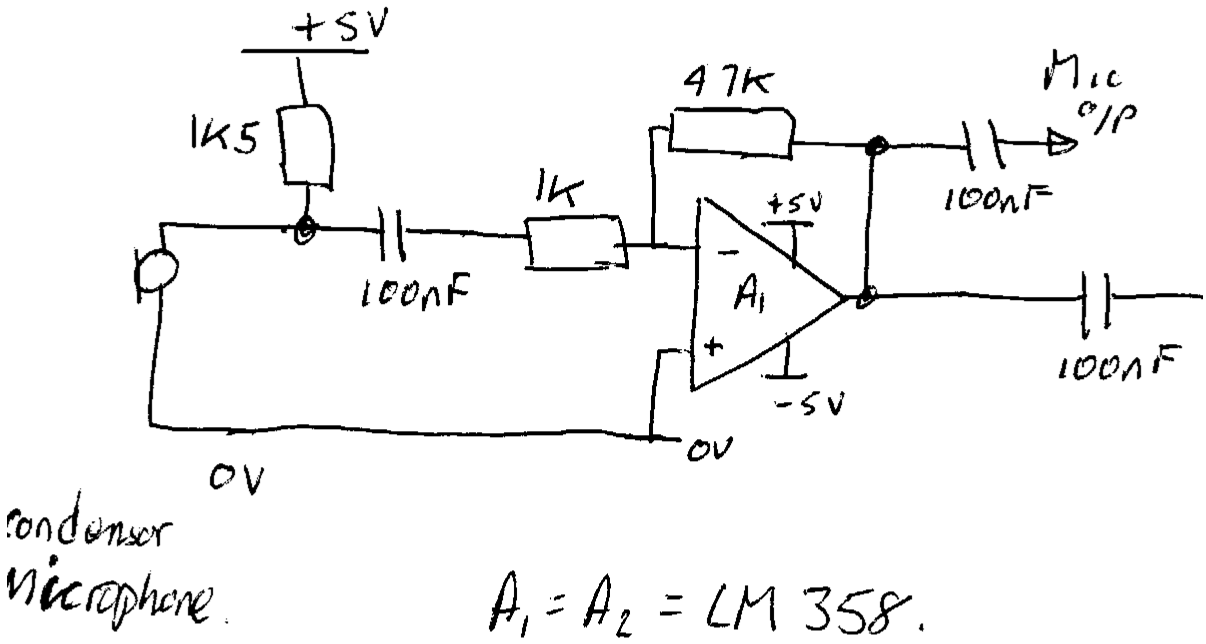
However, while I thought this one over, I decided to see if could be added to the microphone voltage supply found on the microphone leads. Usually this is 5volts, so to gain a greater supply voltage for the op-amp to function with, I decided to use a split voltage supply, generating the -5volts supply from an ICM6770 chip, a negative voltage generator circuit.



On first-hand the 5volt supply was sourced from a series of “AA” sized batteries, but I eventually dug out the variable voltage “psu” and used the 5volt supply output. However, I found that switching signals are present, so by adding a 470uF capacitor to the 5volt line, the disturbance was removed.

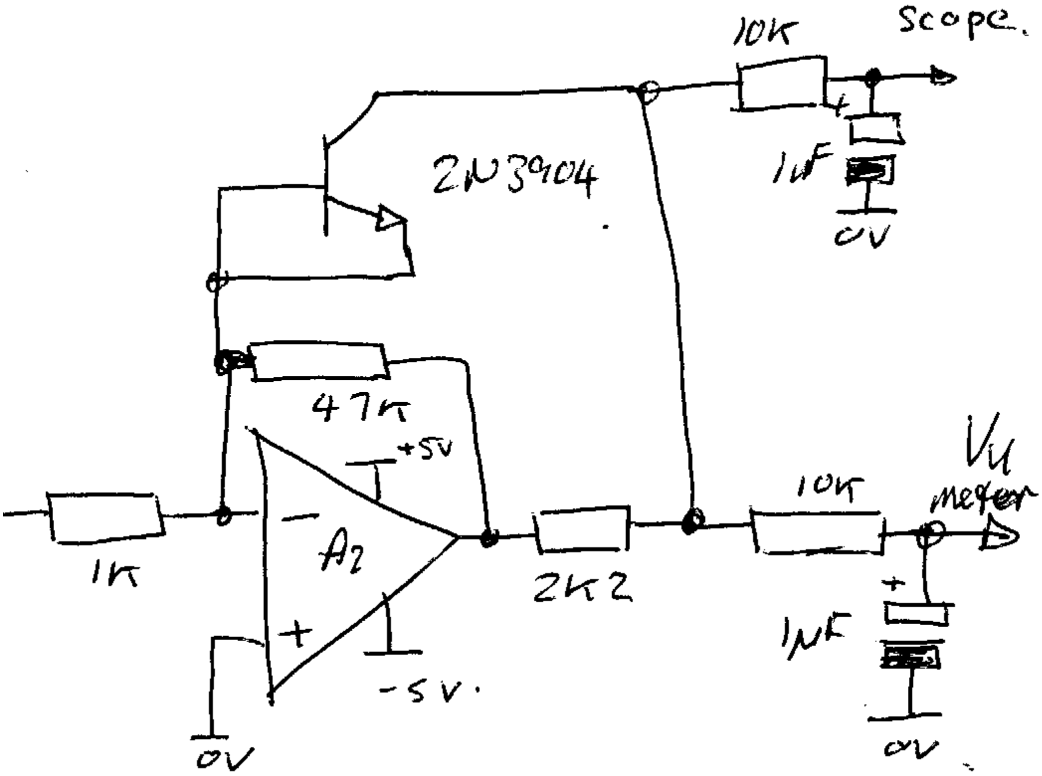
Microphone amplifier.

The microphone used was a condensor mic, and I found that the best load resistor is a 1k5 ohm resistance, as this gave a balanced signal output. The microphone amplifier for this project is shown below.

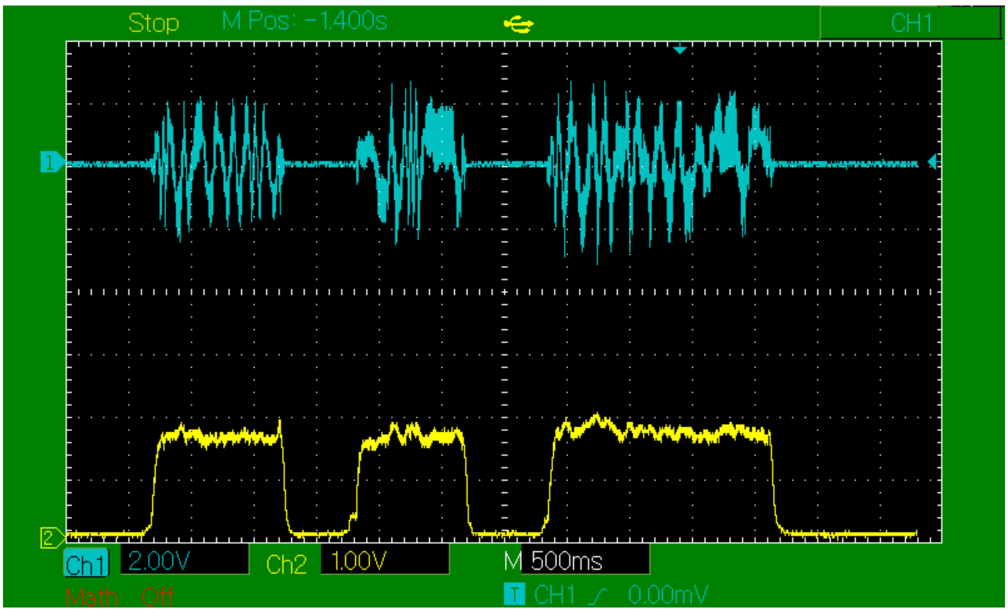


Logarithmic amplifier circuit.

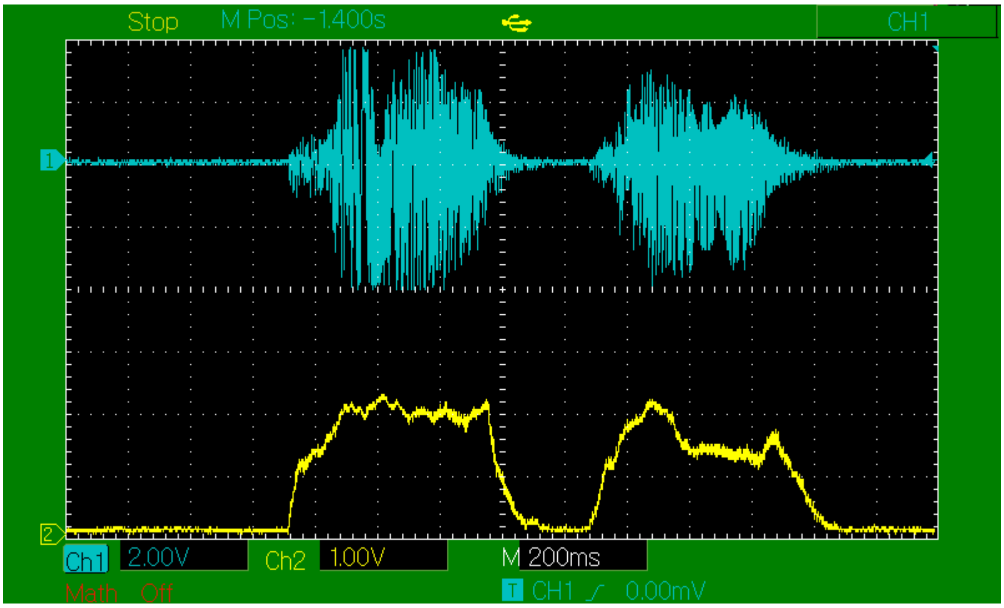
The log amplifier processor circuit shown below, is basically the same as the RSGB book. However I found that circuit within the book worked if an integral voltage was required, but if a 47K ohm feed back resistor was added to the circuit, as shown within the below circuit, then the control output signal voltage then represented the log voltage of the input voice signal.



The voice signal shown below, is the wording “four”, as if a transmitter is being test aligned. The blue trace is the microphone amplifier output, while the yellow trace represents the logarithmic signal voltage, used for the “Vu” meter, or the agc voltage for the LM570 device.



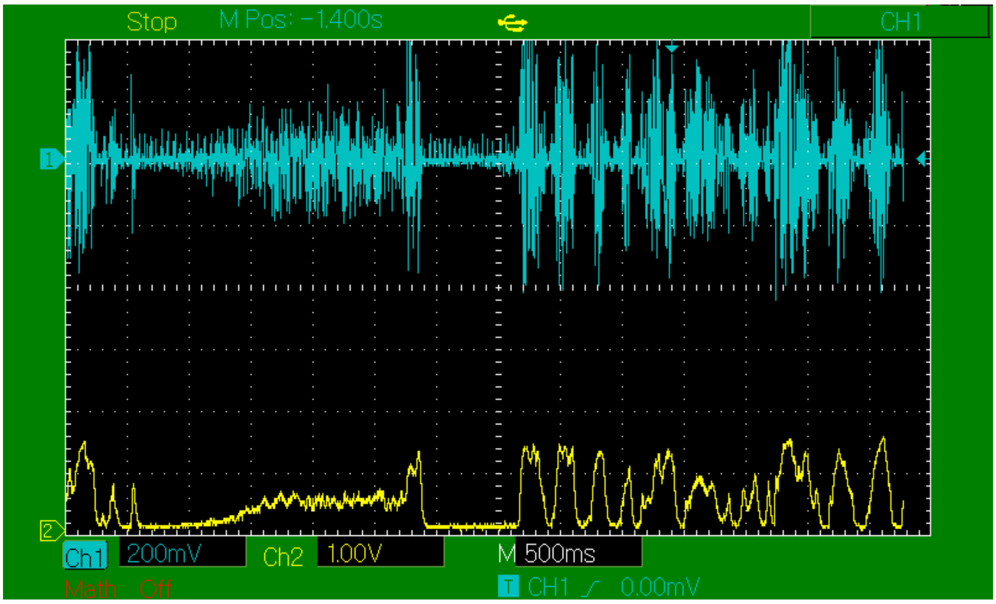
The next oscilloscope plot tracing are test wordings on the microphone, using the wording "hello" twice around.



The principle test circuit can be used as a monitor sound test, by simple placing the microphone in front of the radio's speaker.

I had often wondered if the radio's agc circuit implementation was un-usual, many radio's these days are D.S.P. based, as I have found that the base floor noise background "hiss", bounces up and down.

If the radio has picked up a signal, then it can be seen clearly, shown below, that the yellow trace of the logarithmic voltage, clearly defines the voice signal log voltage, hence the "Vu" meter reading.



However, notice the gradual ramping of the yellow line to the left, as this is the radio's agc response rebalancing the radio agc circuit voltage. The conclusion here, is that the modern radio's use a reduce and then boost of the voice signal, in that there are using a constant volume amplifier circuit implementation. This then accounts for bouncing noise floor of the radio in noisy band conditions.

The output labelled “Vu” meter, when connected to an analogue “Vu” meter, purchased from Ebay, the maximum reading is 0dB. For a full-scale reading, reduce the 10k ohm resistor. The output labelled “scope”, this connects to the voltage-controlled amplifier, such as the LM570 agc input.

Calculator Times.

The "Vu" I have here ranges from -20dBV to +7dBV, a total range of 27dB. However, as the meter has a zero "0dBV" indication point, the actual range is "30dBV".

For the meter circuit to function over this range, then the op-amp circuit signal amplification needs to match the meter range, in this case over 30dBV.

Essentially, the logarithmic measurement circuit control the circuit amplification gain in a logarithmic characteristic profile manner.

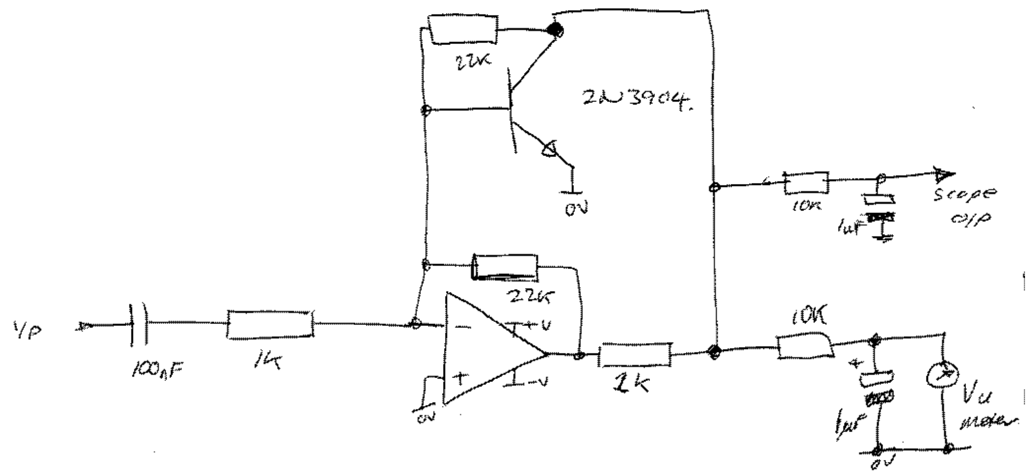
Op-amp circuit loop gain = $10^{(30/20)}$ = 31 times

The logarithmic circuit shown has a "Ri" of 1K ohm, thus the loop feedback resistance "Rf" would equates to as 31K ohms, or just a 32k ohm resistor.

Taking things just a little bit further, with an op-amp input circuit resistance of 600ohms, the op-amp feedback resistance equates to as : = 600 * 31 = 18k ohms.
As the logarithmic circuits stands as illustrated in the above diagram, there is an 3dBV range error, due to the 47k ohm loop feedback resistance.

However, I have noticed that the meter response was quite fast, in that the meter reading was perhaps too responsive, near to that of erratic.

It also dawned that the transistor was effectively operating in an open loop gain manner. Should a different transistor be used with a different open loop gain value, then the meter response would be different from one circuit to another, with a different open loop gain transistor.



-20dB
0dB
+6dB
27dB

27dB = 20X $\log_{10}$ (ratio) = $10^{(27/20)}$
= ratio
= 22K.

The transistor feedback to provide the logarithmic function, now has a closed loop gain equal to that of the op-amp circuit. I found that the volume unit meter now longer possesses an erratic type of response. It maybe perhaps suggested that a non-inverting op-amp circuit may be used to drive the Volume unit meter itself, to act as a buffer op-amp circuit.

Re-examining the meter used, I have set both the op-amp and the transistor to a 27dBV gain.

Op-amp and transistor closed loop gain = $10^{(27/20)}$ = 22 times

The logarithmic circuit shown has a "Ri" of 1K ohm, thus the loop feedback resistance "Rf", which is also in parallel with the feedback transistor logarithmic curve, "Rf" equates to as 22k ohms resistor for a 27dBV gain or dynamic range of the Volume Unit meter.

A viewpoint here regarding the volume meter response curve maybe expressed as thus:

Vu meter division step = $\log_{10}$(transistor) / $\log_{10}$(op-amp)

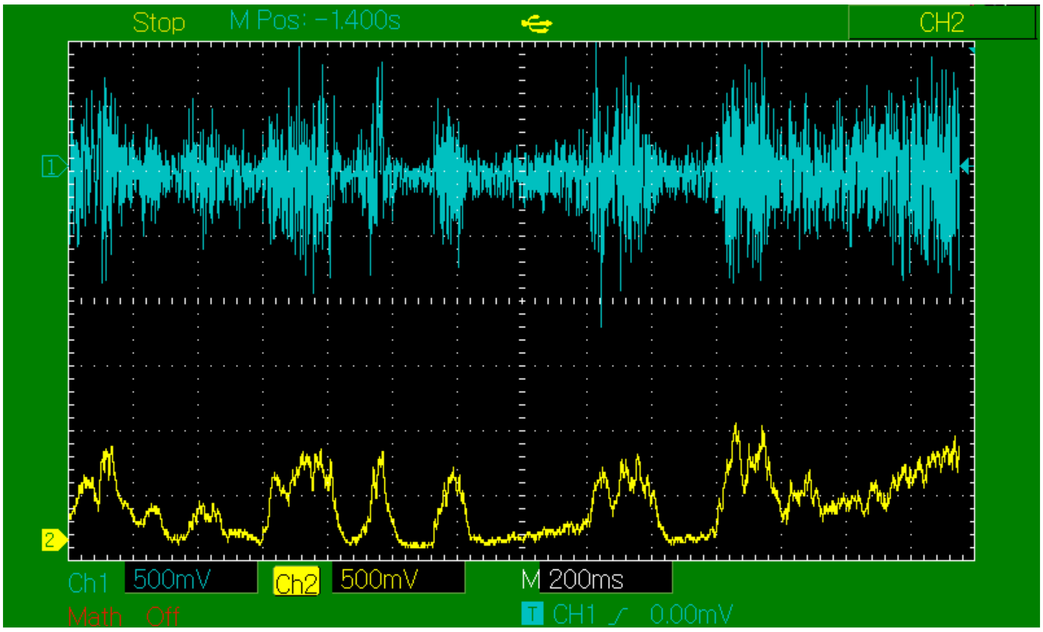
Vu meter division step increment = $\log_{10}$(27) / $\log_{10}$(27)

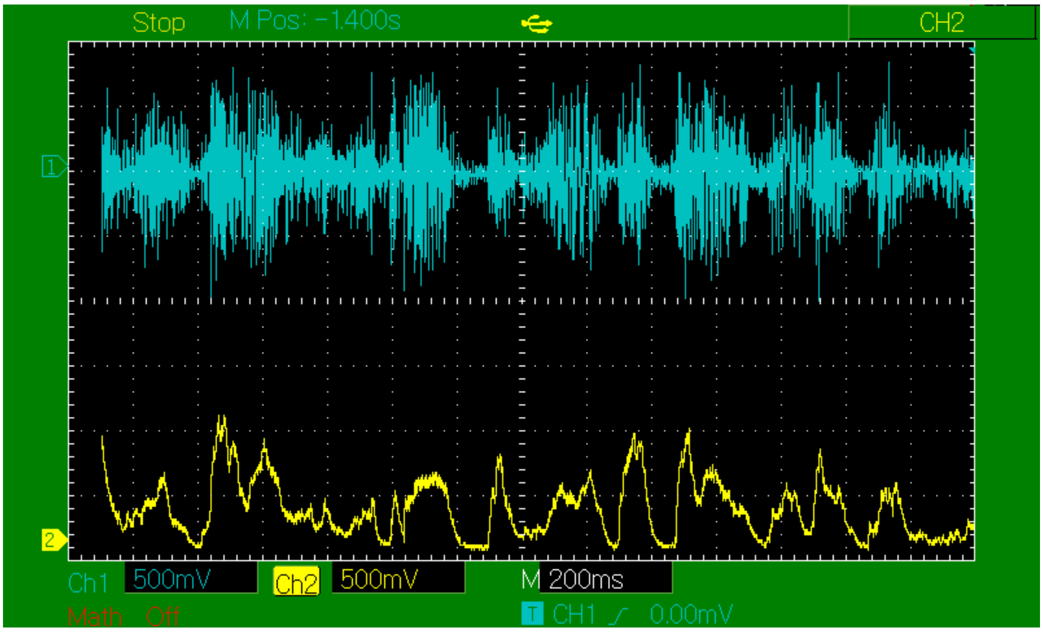
Vu meter division step increment = 1dBV

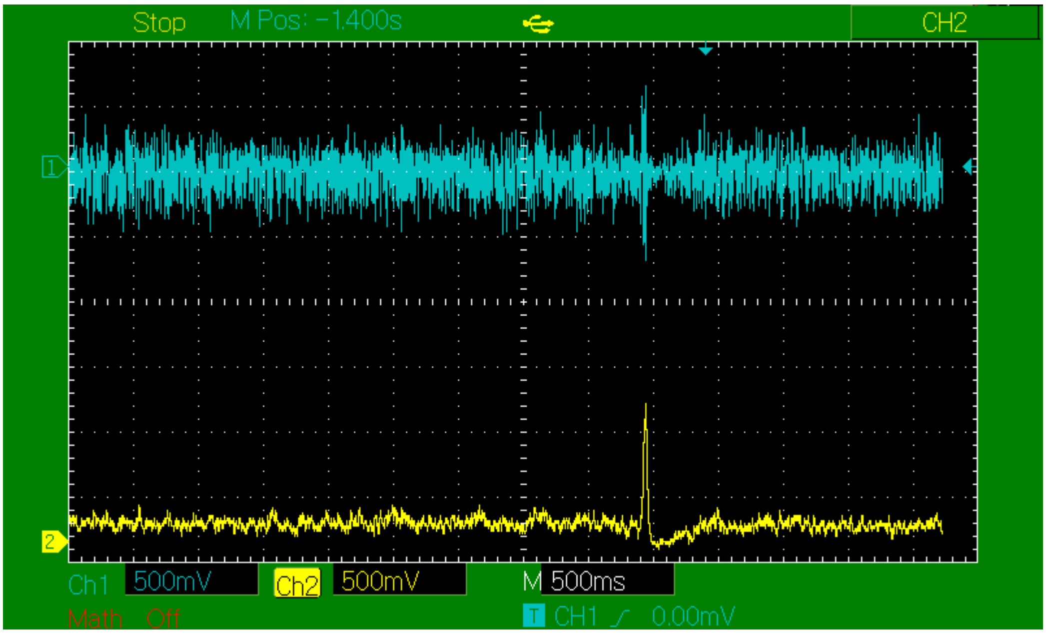
Input signal response curve = $10^{(1/20)}$ = 1·12 times magnitude

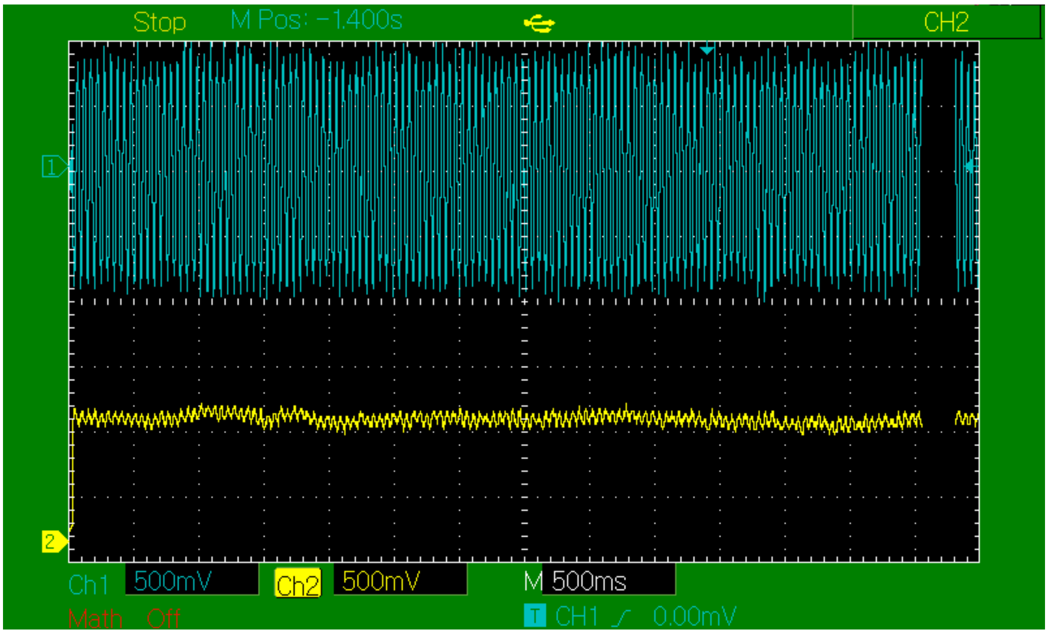
The "Volume meter " response of an 1dBV step increment to the input signal, equates to 1.12 times difference of voltage of the input signal, to 1dBV division rise in the meter response.

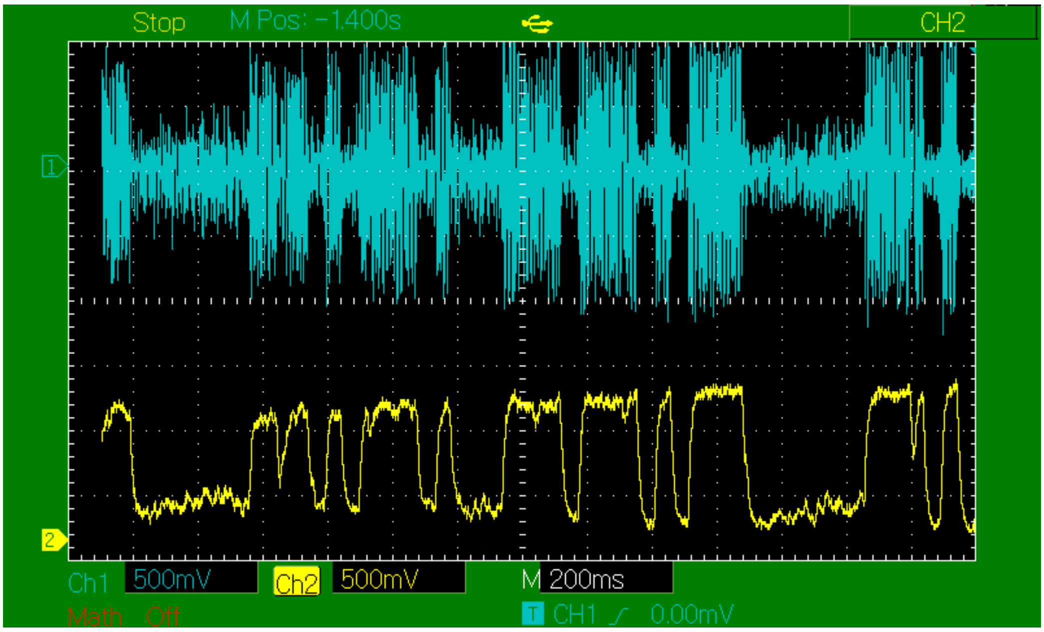
Below are a series of digital oscilloscope plots from a USB memory stick download, related to the updated circuit.

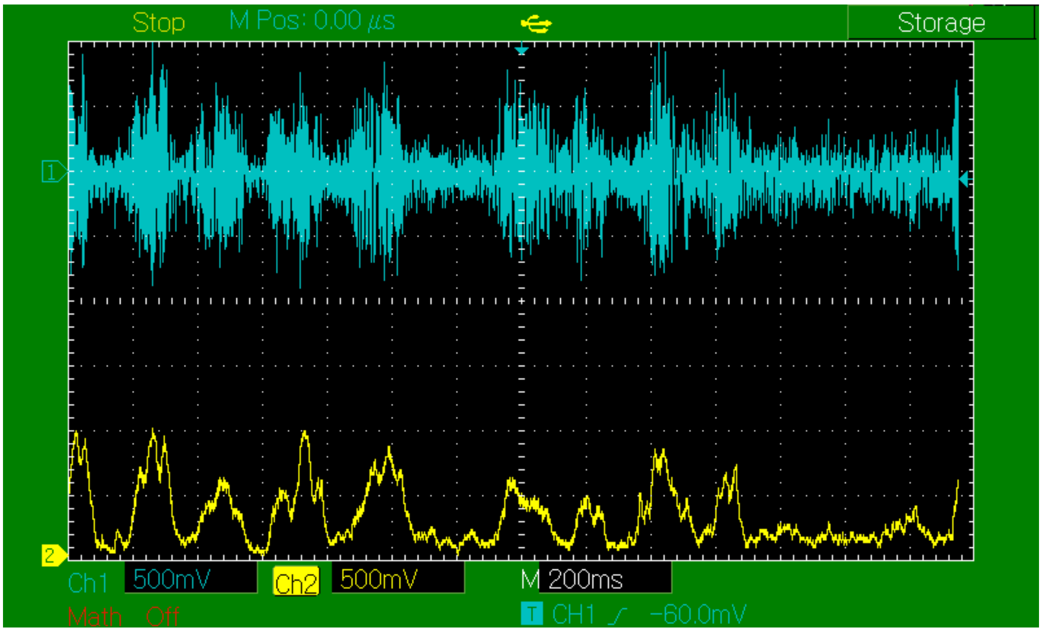



Stop
M Pos: -1.400s
CH2
Ch1 500mV
Ch2 500mV
M 200ms
Math Off
T CH1 0.00mV


Stop
M Pos: -1.400s
CH2
Ch1 500mV
Ch2 500mV
M 500ms
Math Off
T CH1 0.00mV


Stop
M Pos: -1.400s
CH2
Ch1 500mV
Ch2 500mV
M 500ms
Math Off
T CH1 0.00mV





It may well be worth mentioning, as the feedback transistor creating the logarithmic function for the Volume Unit meter, the transistor collector is attached to the 1K ohm output resistance from the op-amp.

The transistor collector connection would experience the input signal, which in effect brings down the waveform envelope down to a zero I.F. frequency, in other words a base band pass bandwidth.

The synchronous demodulation of the audio signal envelope waveform output, feed to the “Vu” meter and the scope monitoring output connection, is the lower yellow scope trace.

The upper blue scope trace is the audio signal on the input of the logarithmic curve op-amp circuit.

By altering the feedback transistor closed loop gain, the logarithmic curve characteristic could be varied. At present the feedback transistor closed loop gain, is set equal to the op-amp circuit, such that for every 1·12 magnitude of difference of the input audio, the volume unit meter rises by 1dBV.

CAD programming

I had wondered if the 27dBV feedback and the op-amp itself functioned to a base scale power function of $\log_{10}(27)$.

There is a principle in mathematics to recalibrate a Logarithmic table to a different base value. This is achieved by using the below equation function:

$$\text{Answer} = \log_{10}(\text{ value }) / \log_{10}(\text{ base })$$

Should the value be our microphone audio signal voltage, the base scale to 27dBV, the op-amp feedback transistor, then the below scale can be calculated. The discovered results are quite interesting to say the least.

volume unit meter scaling.bbc

```
feedback gain = 27 dBV, equates = 22 times
op-amp gain = 27 dBV, equates = 22 times
circuit i/p att = 3.5 mag
```

signal	circuit	dBV
1 mV	0.2 mV	-21
3 mV	0.8 mV	-17.7
5 mV	1.4 mV	-16.1
7 mV	2 mV	-15.1
9 mV	2.6 mV	-14.3
11 mV	3.1 mV	-13.7
13 mV	3.7 mV	-13.2
15 mV	4 mV	-12.8
24 mV	7 mV	-11.2
34 mV	9 mV	-10.2
44 mV	12 mV	-9.5
50 mV	14 mV	-9.1
60 mV	17 mV	-8.6
70 mV	20 mV	-8.1
80 mV	22 mV	-7.7
89 mV	25 mV	-7.4
100 mV	28 mV	-7
200 mV	57 mV	-4.9
300 mV	85 mV	-3.7
400 mV	114 mV	-2.8
500 mV	142 mV	-2.2
600 mV	171 mV	-1.6
700 mV	200 mV	-1.1
800 mV	228 mV	-0.7
900 mV	257 mV	-0.4
1 V	285 mV	0
1.5 V	428 mV	1.2
2 V	571 mV	2.1
2.5 V	714 mV	2.7
3 V	857 mV	3.3
3.5 V	1000 mV	3.8
4 V	1142 mV	4.2
4.5 V	1285 mV	4.5
5 V	1428 mV	4.8
5.5 V	1571 mV	5.1
6 V	1714 mV	5.4
6.5 V	1857 mV	5.6
7 V	2000 mV	5.9
7.5 V	2142 mV	6.1

```
>_
```

The above function could be used for Arduino Uno or Nano coding to construct a “Vu” digital meter. The 10bit ADC would reach down to 4·8mV (-17dB) and up to 5Volts ADC (+4·8dB). With just a 3 times pre-amp on the Uno ADC input, the min sense would -20dB, and max limit nearly 1·5dB on the Volume Unit meter. The 0dB “Vu” meter reading could then be used as the 100% modulation limit of the radio transmitter, hence the 1·5dB reading an overload condition.

The middle section of numbers is the attenuated input audio sounds, so the op-amp circuit does not top end its output signal voltage. This is assuming that the op-amp circuit used is designed with a unity op-amp circuit gain, although the transistor feedback logarithmic scalar, is still set to 27dBV.
At present, the op-amp gai is set to a 27dBV reference circuit design.

The below “BBC Basic” coded program, is the program used to calculate the “Volume Unit” scaling to input audio signal voltage.

```
curve = 27
att = 3.5
amp = 10^(curve/20)
PRINT TAB(7);"feedback gain = ";curve;" dBV, equates = ";INT(amp);" times"
PRINT TAB(7);"op-amp gain = ";curve;" dBV, equates = ";INT(amp);" times"
PRINT TAB(7);"circuit i/p att = ";att;" mag"
PRINT
PRINT TAB(7);"signal";TAB(19);"circuit";TAB(33);"dBV"
PRINT

FOR value = 1E-3 TO 5E-3 STEP 2E-3
  ans = LOG(value)/(LOG(curve))
  PRINT INT(value*1E3);" mV";TAB(19);INT((value/att)*1E4)/10;" mV";TAB(33);INT(ans*10 *10)/10
NEXT value

FOR value = 5.1E-3 TO 14E-3 STEP 2E-3
  ans = LOG(value)/(LOG(curve))
  PRINT INT(value*1E3);" mV";TAB(19);INT((value/att)*1E4)/10;" mV";TAB(33);INT(ans*10 *10)/10
NEXT value


FOR value = 15E-3 TO 49E-3 STEP 0.01
  ans = LOG(value)/(LOG(curve))
  PRINT INT(value*1E3);" mV";TAB(19);INT((value/att)*1E3);" mV";TAB(33);INT(ans*10 *10)/10
NEXT value


FOR value = 50E-3 TO 90E-3 STEP 0.01
  ans = LOG(value)/(LOG(curve))
  PRINT INT(value*1E3);" mV";TAB(19);INT((value/att)*1E3);" mV";TAB(33);INT(ans*10 *10)/10
NEXT value

FOR value = 100E-3 TO 500E-3 STEP 0.1
  ans = LOG(value)/(LOG(curve))
  PRINT INT(value*1E3);" mV";TAB(19);INT((value/att)*1E3);" mV";TAB(33);INT(ans*10 *10)/10
NEXT value

FOR value = 600E-3 TO 1000E-3 STEP 0.1
  ans = LOG(value)/(LOG(curve))
  PRINT INT(value*1E3);" mV";TAB(19);INT((value/att)*1E3);" mV";TAB(33);INT(ans*10 *10)/10
NEXT value

FOR value = 1 TO 7.5 STEP 0.5
  ans = LOG(value)/(LOG(curve))
  PRINT INT(value*10)/10;" V";TAB(19);INT((value/att)*1E3);" mV";TAB(33);INT(ans*10 *10)/10
NEXT value
```