

TEMPERATURE STABILIZED LOG - EXPONENTIAL CONVERTER

This converter can be set up for either logarithmic or exponential operation and incorporates a neat heater circuit for temperature stability.

IN THE CONVENTIONAL musical scale, consecutive notes are not separated by the same frequency, but by the same ratio — the twelfth root of two. This is quite acceptable for most musical instrument manufacturers, except that in electronic music equipment it is easier to make oscillators which have an accurately linear frequency/control voltage characteristic. The keyboards of most music synthesizers give an output voltage of 1 V for each octave on the keyboard. This can easily be generated by a set of equal resistors between the contacts on each key and a voltage applied to each end (normally 5 V). However this means the oscillator is required to have an exponential frequency/control voltage response.

This is where the trouble usually starts. An exponential converter is normally used which relies for its operation on the relationship between current and voltage in a silicon diode or transistor. However unless temperature stabilisation is used the oscillator will not stay in tune for very long. With this unit the transistor used is heated to around 55°C and stabilised at this temperature, eliminating the problem of thermal drift.

In the instrumentation field a lot of functions are displayed in dBs which are a logarithmic measurement. As this unit can be connected in either exp or log modes it is useful for this purpose also.

Construction

As the unit will normally be used with some other equipment, we have not described any mechanical housing. The only difference between the assembly of this board and any other is the oven and the connections to the transistor array package. The oven is made out of two pieces of polystyrene about 55 x 35 x 12 mm. The outside of the oven should

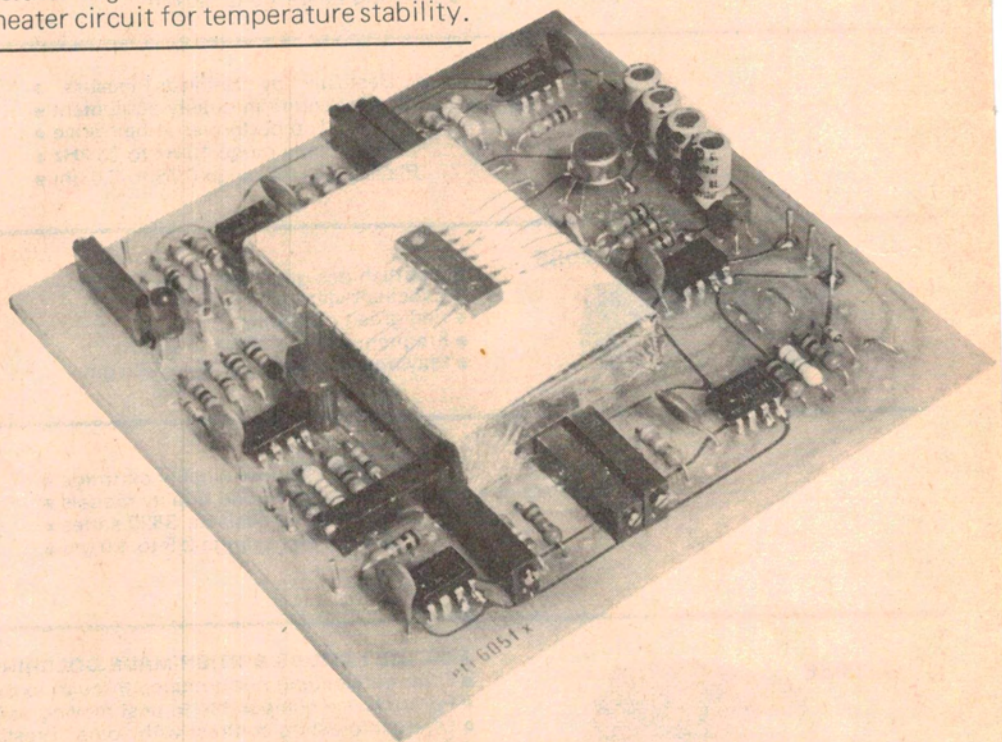


Photo showing the complete unit with the top of the oven removed to show IC5. Note that link 1 is made out of a couple of pins from an old valve socket.

be covered with aluminium foil to help reduce heat loss. The aluminium itself should be covered with a layer of adhesive tape where the leads can touch. A piece of thick paper should be used between the oven and the pcb to insulate the tracks.

The centre of the oven should be hollowed slightly to hold the IC (bend the leads out straight as shown in the photo); a hot soldering iron is the easiest method. Do not remove more than necessary. Now solder a 40 mm length of thin copper wire (a single strand of a multistrand cable is best) to each pin, then with the base of the oven in position, sit the IC in the oven and connect the leads to the appropriate

holes. If a small amount of epoxy cement is placed under the oven it will stay in position. Now fit the top of the oven and secure with a piece of adhesive tape until it has been checked out. It finally can be cemented with epoxy adhesive.

The potentiometer values chosen are a compromise between ease of adjustment and the ability to compensate different transistors. If the potentiometer does not have enough range then the series resistor will have to be varied. We have specified 2% resistors throughout to obtain a better temperature coefficient than is possible with conventional 5% resistors. It will not help to select out of normal 5% types.

SPECIFICATION – ETI 605

Transfer functions
exponential
log.

$$V_{out} = 0.15625 \times 2^{V_{in}}$$

$$V_{out} = \text{Ln}(V_{in}/0.15625) / \text{Ln} 2$$

Useful dynamic range

50dB or 8octaves

Oven temperature

approx. 55°C

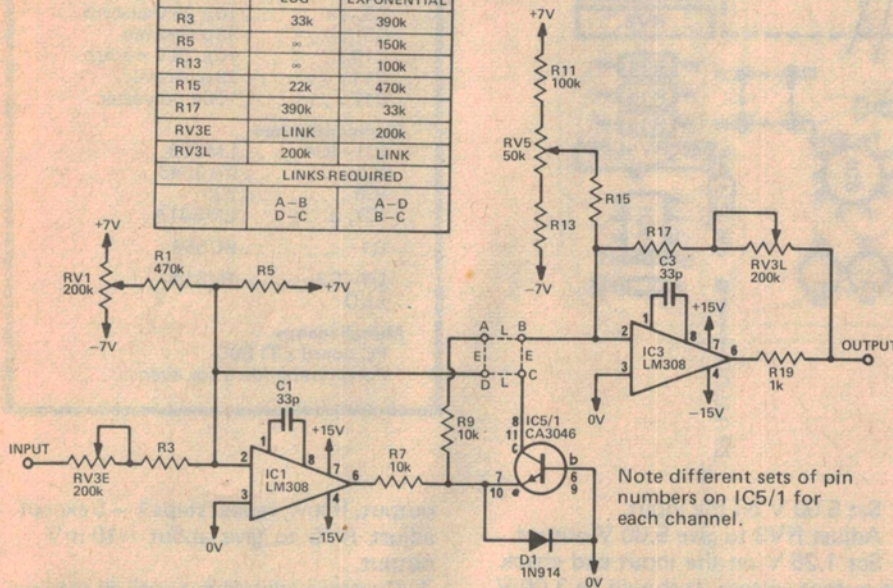
Warm up time

about 2 minutes

Power supply

±10 to ±15 volts

VALUES OF UNMARKED COMPONENTS		
	LOG	EXPONENTIAL
R3	33k	390k
R5	∞	150k
R13	∞	100k
R15	22k	470k
R17	390k	33k
RV3E	LINK	200k
RV3L	200k	LINK
LINKS REQUIRED		
	A-B	A-D
	D-C	B-C



Note different sets of pin numbers on IC5/1 for each channel.

Fig. 1a. The circuit diagram of the converter section. Note that although only one channel is shown here that there are two identical units on the pcb. The component numbers used on the second channel are the missing even numbers, ie R12 is the same as R11

HOW IT WORKS – ETI 605

This unit relies on the fact that the collector current of a transistor is exponentially related to the base voltage.

In the log mode the collector of the transistor is linked back to the input of IC1. In this way the collector current is proportional to the input voltage and therefore the voltage on its emitter is logarithmically related to the input voltage. This voltage is then amplified and level shifted by IC3 to give the desired output.

In the exponential mode the 10k resistor R9 is linked back to the input of IC1 and the voltage on the emitter of the transistor is proportional to the input voltage; the collector current is exponentially related to the input voltage. This current is converted to a voltage by IC3.

All this works well provided the transistor is at a constant temperature. Compensation can be made by using other junctions and thermistors, however even the self-heating effect of the transistors can affect linearity. The transistors we have used are part of a transistor array IC which has three individual NPN transistors and a differential pair. We heat the chip up by dissipating heat in the differential pair while measuring the base-emitter voltage of one of the individual transistors. IC8 is used to compare this voltage to one set by the divider R25, 26, 27 and RV7. The base-emitter voltage is normally about 0.67 V at 20°C and drops about 2.2 mV per degree above this temperature. IC8 then stabilises the chip temperature to about 35°C above the temperature at which it was initially calibrated. As it warms up the current in the transistors will fall and when hot the voltage drop across R31 will be low enough that the LED will extinguish. The transistor array is housed in a polystyrene housing to conserve heat.

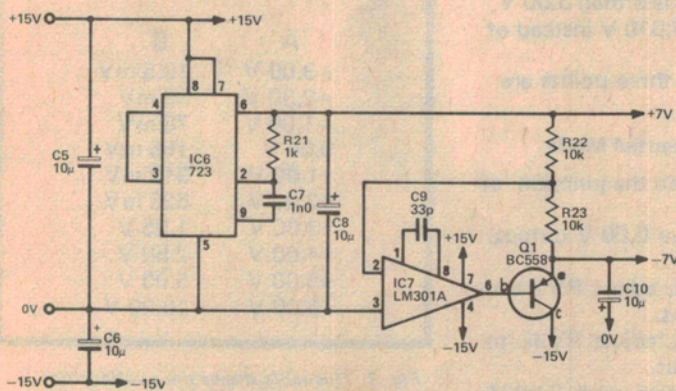


Fig. 1b. The power supply section which supplies the stable ±7 volts needed for the bias and adjustment controls.

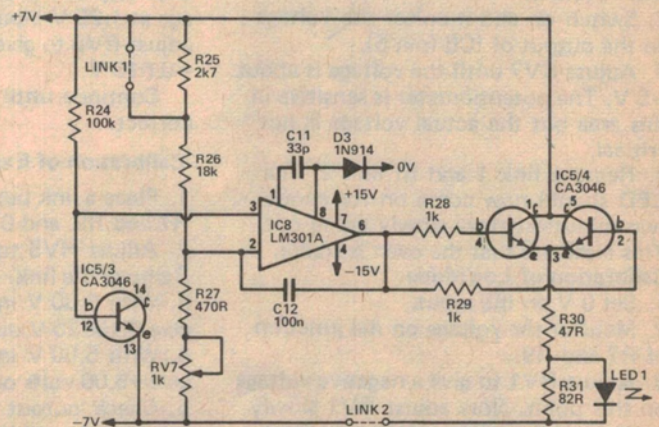


Fig. 1c. The oven circuitry.

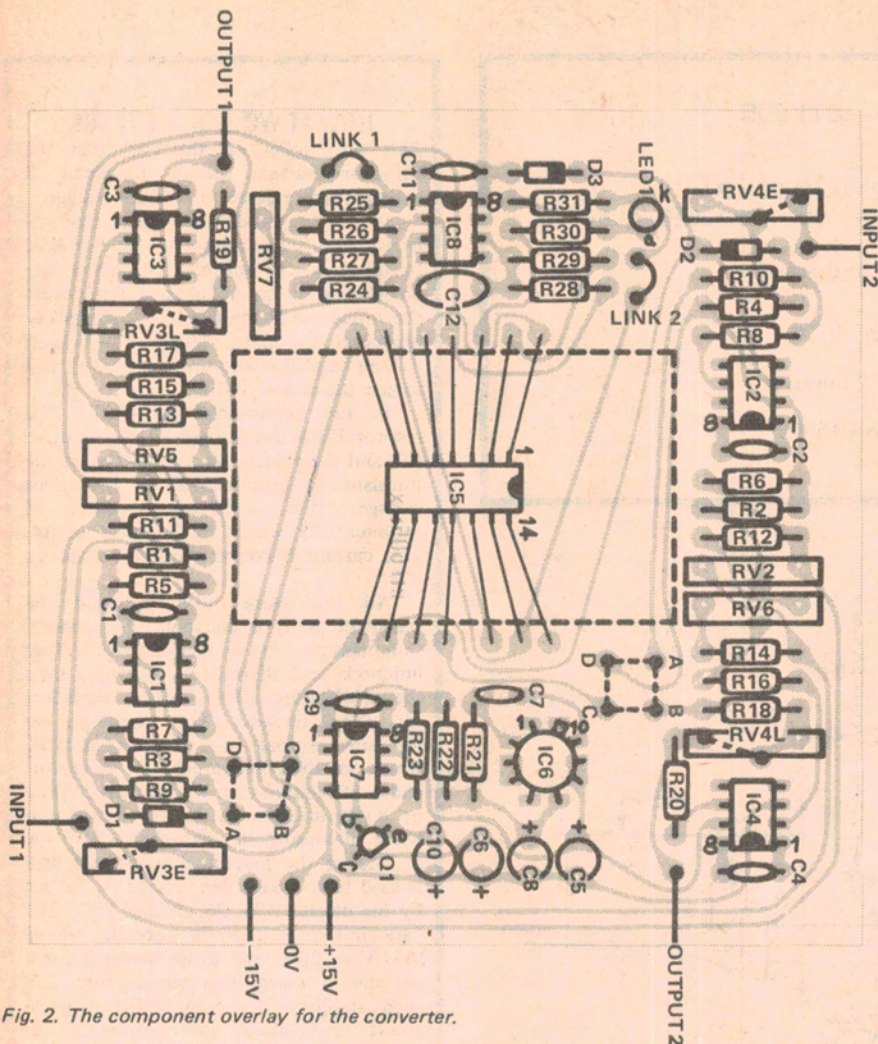


Fig. 2. The component overlay for the converter.

Calibration

The equipment needed comprises an accurate digital voltmeter and a variable power supply with a fine voltage control. The +7 V rail can be used for this with a multi-turn potentiometer.

Oven Control

1. Before switching on, remove link 2 and fit link 1.
2. Switch on and monitor the voltage on the output of IC8 (pin 6).
3. Adjust RV7 until the voltage is about -5 V. The potentiometer is sensitive in this area but the actual voltage is not critical.

4. Remove link 1 and fit link 2. The LED should now come on for about two minutes before slowly going out. This indicates that the oven is stable.

Calibration of Log Mode

1. Set 0 V on the input.
2. Monitor the voltage on the junction of R7 and R9.
3. Adjust RV1 to give a negative voltage on this point. Now adjust RV1 slowly until the voltage just switches positive.
4. Set 0.15625 V on the input.
5. Adjust RV5 to give 0 V output.

6. Set 5.00 V on the input.
7. Adjust RV3 to give 5.00 V output.
8. Set 1.25 V on the input and check the output voltage. It should be 3.00 V. If it is higher go back to step 4 except adjust RV5 to give -0.010 V and use RV1 to bring it back to zero. Continue with step 6, 7 and 8. If the output voltage at 1.25 V input is less than 3.00 V adjust RV5 to give +0.010 V instead of -0.010 V.

Continue until all three points are correct.

Calibration of Exponential Mode

1. Place a link between the junction of R7 and R9, and 0 V.
2. Adjust RV5 to give 0.00 V output. Remove the link.
3. With 0.00 V input, adjust RV1 to give 0.15625 V output.
4. With 5.00 V input, adjust RV3E to give +5.00 volts output.
5. Check output voltage with 3.00 V input. It should be 1.25 V.
6. If high repeat steps 1 - 5 except adjust RV5 to give about +10 mV

- output. If low, repeat steps 1 - 5 except adjust RV5 to give about -10 mV output.
7. Continue adjustment until all readings are correct.

CALIBRATION TABLE

A	B
-3.00 V	19.5 mV
-2.00 V	39 mV
-1.00 V	78 mV
0.00 V	156 mV
+1.00 V	312 mV
+2.00 V	625 mV
+3.00 V	1.25 V
+4.00 V	2.50 V
+5.00 V	5.00 V
+6.00 V	10.00 V

Fig. 3. This table shows the relationship between the input and output. In the exponential mode A is the input with B the output while in the log mode B is the input and A the output.

PARTS LIST - ETI 605

Resistors

- all 2%, 5W
 R1, 2 470k
 R3-R6 see table 1
 R7-R10 10k
 R11, 12 100k
 R13-R18 see text
 R19-R21 1k
 R22, 23 10k
 R24 100k
 R25 2k7
 R26 18k
 R27 470R
 R28, 29 1k
 R30 47R
 R31 82R

Potentiometers

- RV1-RV4 200k multturn trim
 RV5, 6 50k multturn trim
 RV7 1k multturn trim

Capacitors

- C1-C4 33p ceramic
 C5, 6 10μ 25V electro
 C7 1n0 polyester
 C8 10μ 25V electro
 C9 33p ceramic
 C10 10μ 25V electro
 C11 33p ceramic
 C12 100n polyester

Semiconductors

- IC1-IC4 LM308
 IC5 CA3046
 IC6 723
 IC7, 8 LM301A
 Q1 BC558
 D1-D3 1N914
 LED

Miscellaneous

- PC board ETI 605
 Polystyrene foam for oven