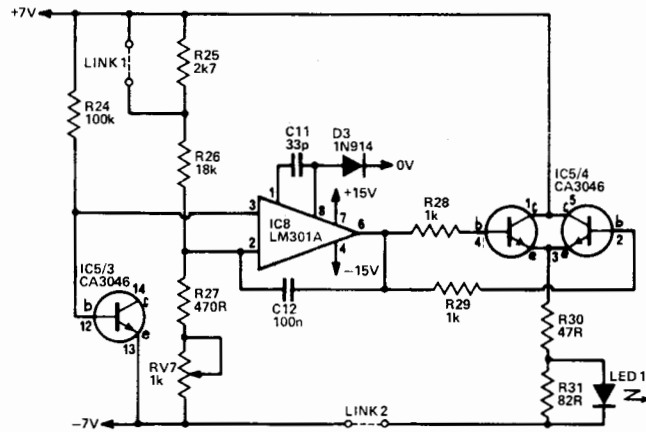# TEMP STABILISED LOG CONVERTER

This design 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.

Trouble

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.

As the unit will normally be used with some other equipment, we have not described any mechanical housing.

Below: the circuit diagram of the converter section. One channel only is shown here, the second — identical — uses the even components numbers. Above: the oven circuitry.

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 D–C	A–D B–C
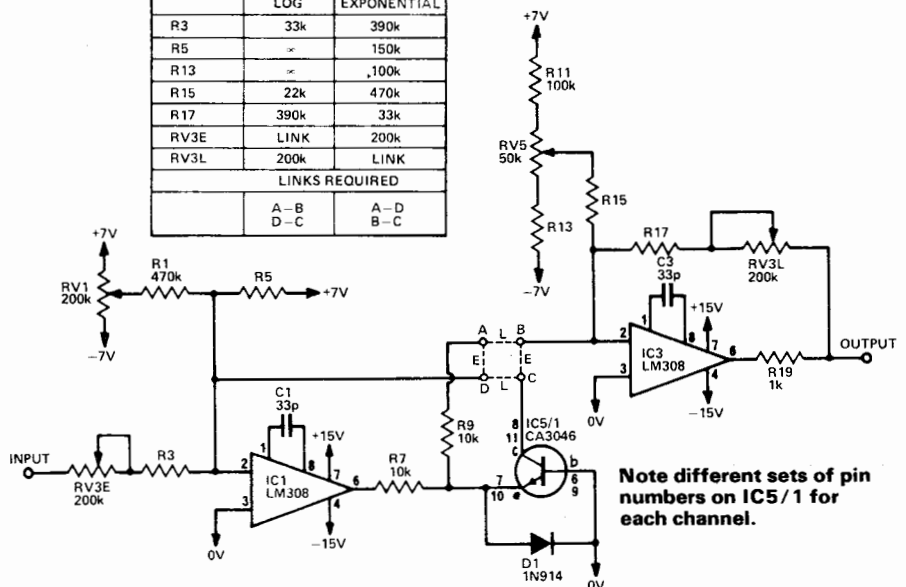
Note different sets of pin numbers on IC5/1 for each channel.
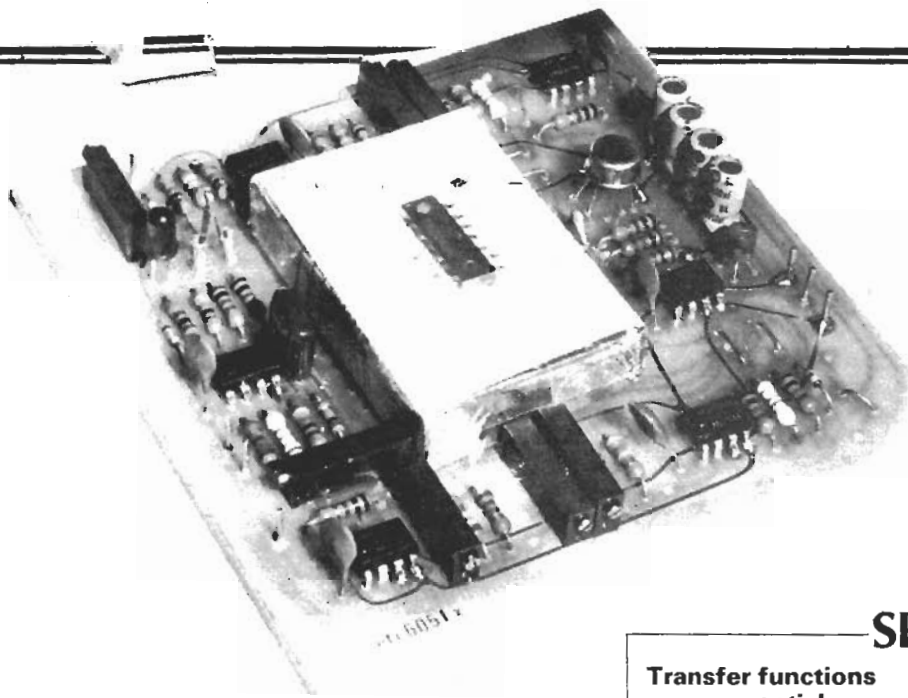
The photo on the left shows the complete unit with the oven top removed to show IC5. Link 1 is made from a couple of valve socket pins in this prototype.

SPECIFICATION

Transfer functions	
exponential	**V out = 0.15625 x 2Vin**
log.	**V out = Ln (Vin / 0.15625) / Ln2**
Useful dynamic range	**50dB or 8 octaves**
Oven temperature	**approx. 55° C**
Warm up time	**about 2 minutes**
Power supply	**± 10 to ± 15 volts**

HOW IT WORKS

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 viltage. 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.
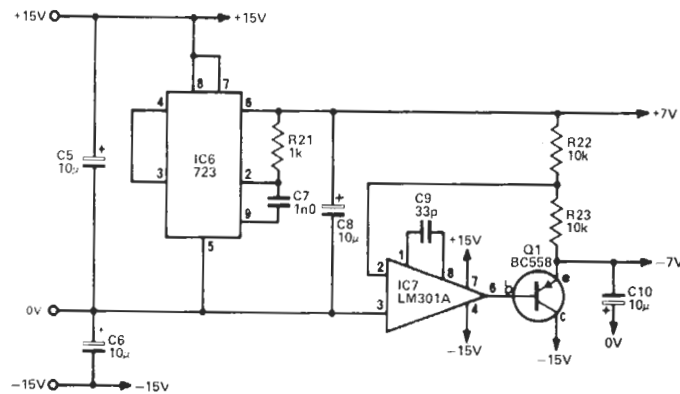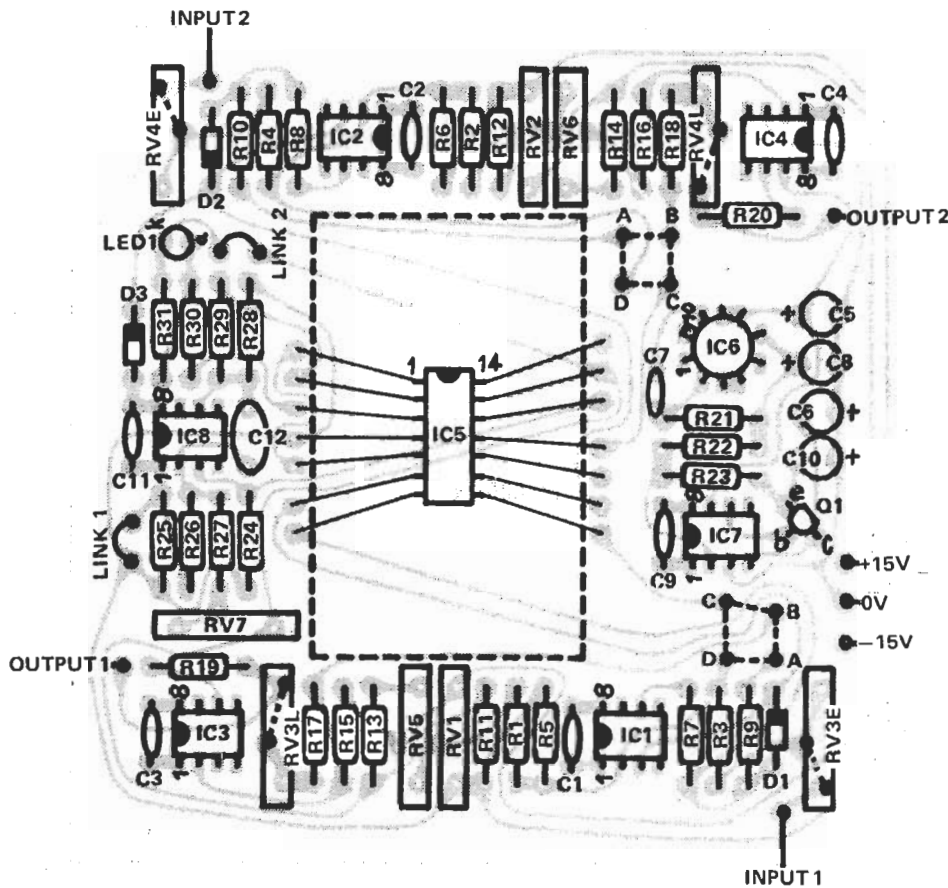

Fig. 1b. The power supply section which supplies the stable ± 7 V needed for the bias and adjustment controls.

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 12mm. The outside of the oven should 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.

Half Baked

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 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

►

INPUT 2

OUTPUT 2

+15V
0V
-15V

OUTPUT 1

INPUT 1

Component overlay for the complete log converter project.

BUYLINES

The project depends upon the CA 3046 device — near equivalents will probably **not** function. The CA 3046 itself is readily available — we found it in both the Marshalls and Stevenson catalogues when we looked for it! Initial reaction here had been that it would be difficult to obtain.

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 valuves 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.

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 mutli-turn potentiometer.

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

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

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 in 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 0V.
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 output. If low, repeat steps 1-5 except adjust RV5 to give about 10mV output. **ETI**

Both sides of the PCB shown full size. On the top is the underside and the pattern beneath that is for the topside of the board.

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