Bipolar Digital-to-Analog Converter using DAC0808

INTEGRATED CIRCUITS LAB

Project Report

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The unipolar current output from a *DAC0808* is converted to a unipolar voltage using an op-amp in inverting mode. This is then processed into a bipolar voltage output after two stages of op-amps in difference amplifier mode.

TITLE: ***BIPOLAR DIGITAL-to-ANALOG CONVERTER***

OBJECTIVE:

The aim of this project is to construct a bipolar DAC using *DAC0808* and verify its operation with the anticipated values.

COMPONENTS USED:

Serial No.	Name	Type	Quantity
1.	DAC0808	8-bit monolithic	1
2.	Op-amp	IC741	3
3.	Resistor	10kΩ	11

PRINCIPLE OF OPERATION:

The *DAC0808* as such gives a current output equivalent to the digital input given to it. This current output is converted to a proportional voltage using a current-to-voltage converter (op-amp in inverting configuration). The analog output varies linearly from 0 to V_{ref} depending on the digital input and the gain setting resistors (in our case, $R_f = R_1$). For an 8-bit DAC, output V_o can be expressed as,

$$V_o = \frac{x}{2^8} \times V_{ref}$$

'*x*' being the decimal equivalent of the digital input.

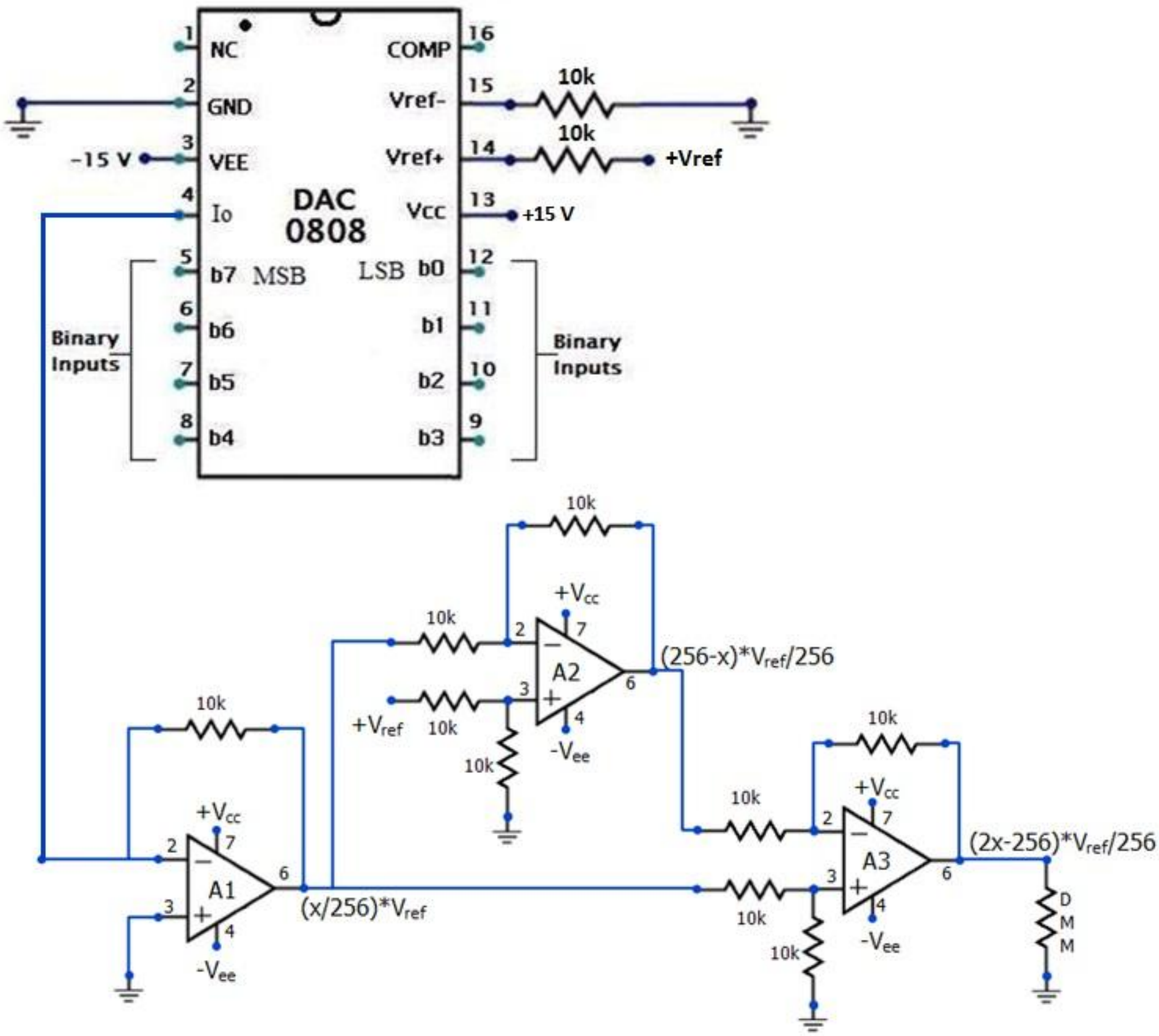
However, to get a bipolar voltage variation, the output V_o should be of the form,

$$\boxed{V_o = \frac{(2x - 2^8)}{2^8} \times V_{ref}}$$

This way, if the MSB of the input is '0', the output would be negative and if the MSB is '1', the output would be positive.

Digital Input	*x*	V_o (bipolar)
00000000	0	$-V_{ref}$
01111111	127	$-\frac{1}{128}V_{ref}$
10000000	128	0
11111111	255	$+\frac{127}{128}V_{ref}$

CIRCUIT DIAGRAM:



All the resistors are selected to be equal, to have a unity gain at each stage.

$+V_{cc}$ = +15 V

$+V_{ee}$ = -15 V

$+V_{ref}$ = +5 V

$-V_{ref}$ is grounded

x = decimal equivalent of binary (digital) input

CIRCUIT OPERATION:

Let,

i. V_{A1} be the output voltage of A_1
ii. V_{A2} be the output voltage of A_2
iii. V_{A3} be the output voltage of A_3

$$V_{A1} = \frac{x}{2^8} \times V_{ref}$$

To get the complement of this, we use a difference amplifier A_2 as shown in the circuit diagram. The resulting output voltage of A_2 is

$$V_{A2} = V_{ref} - V_{A1}$$

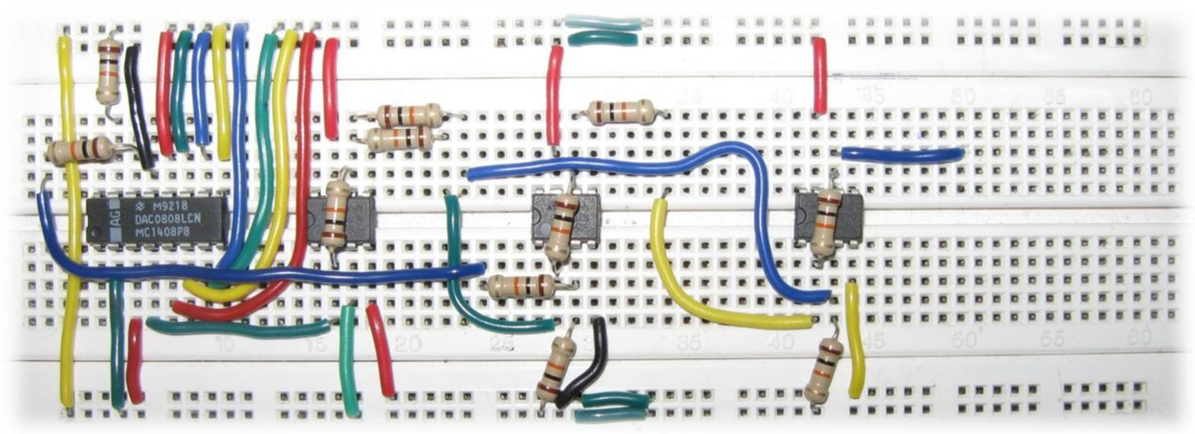
$$V_{A2} = \frac{(2^8 - x)}{2^8} \times V_{ref}$$

V_{A1} and V_{A2} are given to the next difference amplifier A_3, such that

$$V_{A3} = V_{A1} - V_{A2}$$

$$\boxed{V_{A3} = \frac{(2x - 2^8)}{2^8} \times V_{ref}}$$

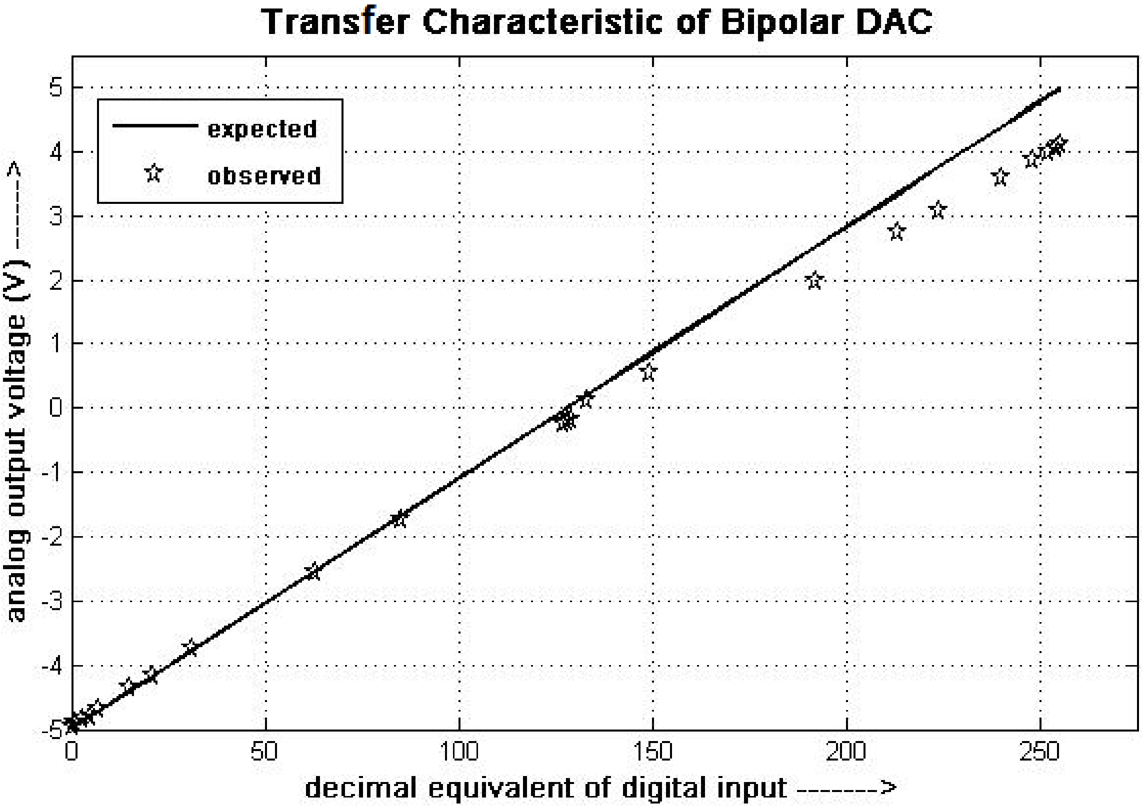
SNAPSHOT:



OBSERVATIONS:

Digital Input	Binary Value (x)	V_{A1} (V)	V_{A2} (V)	V_{A3} (V)	Expected V_{A3} (V)
00000000	0	0.7×10^{-3}	4.938	**- 4.947**	- 5.000
00000001	1	0.021	4.917	**- 4.900**	- 4.961
00000011	3	0.061	4.877	**- 4.820**	- 4.883
00000101	5	0.101	4.900	**- 4.800**	- 4.805
00000111	7	0.139	4.800	**- 4.666**	- 4.726
00001111	15	0.296	4.643	**- 4.350**	- 4.414
00010101	21	0.420	4.589	**- 4.170**	- 4.180
00011111	31	0.600	4.337	**- 3.740**	- 3.789
00111111	63	1.196	3.740	**- 2.550**	- 2.539
01010101	85	1.634	3.370	**- 1.730**	- 1.680
01111111	127	2.350	2.600	**- 0.225**	- 0.039
10000000	128	2.390	2.590	**- 0.214**	0
10000001	129	2.410	2.580	**- 0.170**	0.039
10000101	133	2.480	2.370	**0.120**	0.195
10010101	149	2.770	2.226	**0.550**	0.820
11000000	192	3.460	1.460	**2.000**	2.500
11010101	213	3.890	1.125	**2.750**	3.320
11100000	224	4.016	0.922	**3.080**	3.750
11110000	240	4.270	0.660	**3.605**	4.375
11111000	248	4.408	0.527	**3.870**	4.688
11111100	252	4.470	0.462	**4.000**	4.844
11111110	254	4.507	0.429	**4.066**	4.922
11111111	255	4.540	0.409	**4.125**	4.961

TRANSFER CHARACTERISTIC:



INFERENCES & CONCLUSIONS:

i. Using *DAC0808* as in the proposed circuit, bipolar operation is obtained and verified.

ii. From the transfer characteristic it can be seen that the deviation of the observed output from the expected output is less for smaller values of digital input.

iii. The maximum error in the analog output is for a digital input of 11111111.

iv. The various causes of error may be:

(1) Presence of output offset voltage at the op-amps

(2) Actual resistance values may differ from the specified

(3) Non-linearity and gain error of the *DAC0808*