INTERNATIONAL ATOMIC ENERGY AGENCY
UNITED NATIONS EDUCATIONAL, SCIENTIFIC AND CULTURAL ORGANIZATION
INTERNATIONAL CENTRE FOR THEORETICAL PHYSICS
I.C.T.P., P.O. BOX 586, 34100 TRIESTE, ITALY, CABLE CENTRATOM TRIESTE

H4.SMR. 403/15

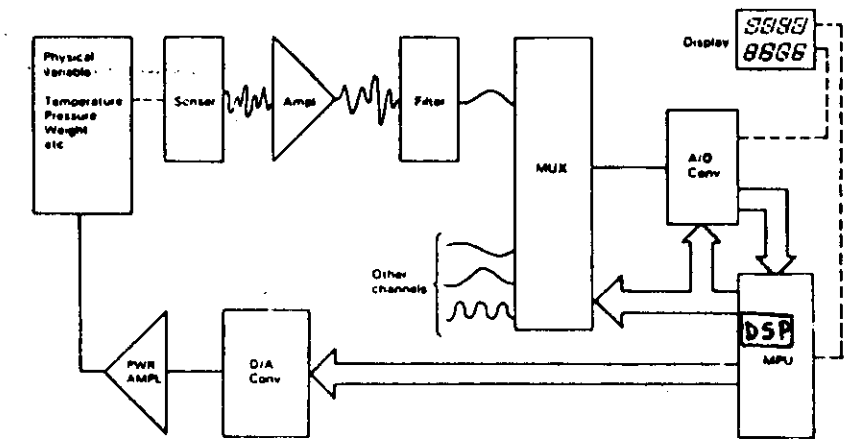
FIFTH COLLEGE ON MICROPROCESSORS: TECHNOLOGY AND APPLICATIONS IN PHYSICS

2 - 27 October 1989

Analog/Digital, Digital/Analog and Voltage to Frequency

D. CROSETTO
CERN, Geneva, Switzerland

TYPICAL ACQUISITION/CONTROL SYSTEM



How to choose a converter - check list.

Before selecting a converter, the following questions have to be answered.

- Which resolution is needed (6, 8, 10,... bit)?
- Which accuracy is needed?
- Which linearity?
- Which logic level (input, output)?
- Which type of reference voltage, fixed, variable, internal, external?
- Which speed is necessary?
- Which settling time?
- Which power supply stability?
- Which operating temperature range is needed?
- Which is the best performance/cost ratio?

CONVERTERS

- When and where to use them.
- Internal principle of operation
  - a) LIST of different types
  - b) Description of most common type
- Selection Guide.
- Applications.

Digital ... Converter (D/A

- Signals which may assume any value in a continuous range are called analog signals

- When analog signals must be processed, there is often a great advantage in converting the signal to digital form so that the processing can be done digitally.

- A most effective way of suppressing noise is to transmit the signal digitally. A communication system which operates in this way, i.e. converts the analog signal to digital form and then reconstitutes the analog signal, is called a "pulse-code modulation system"

- The D/A converters are rather simpler than the A/D converters. An A/D converter is frequently used within the structure of D/A converters. For these reasons we shall consider D/A converters first.

CONVERSION TECHNIQUES

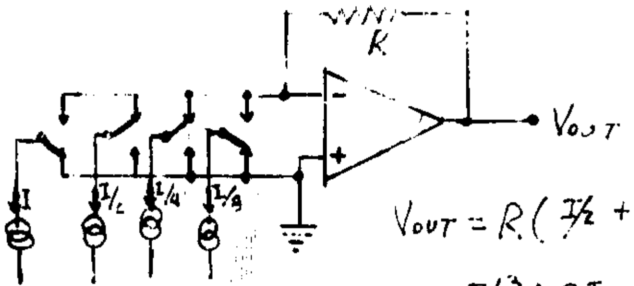
1) D/A Converter

- Weighted Resistor
- R-2R Resistive Ladder
- Current
- Voltage

2) A/D Converter

- Comparator Converter
- Successive approximation converters
- Counter converters
- Voltage to Frequency
- Voltage to Time
- The dual-slope
- Tracking type (used in comunication)
- Parallel Ripple
- Variable Threshold
- Synchronous VTF A/D system

"Current" Steering D/A



$$V_{OUT} = R\left(\frac{I}{2} + \frac{I}{4}\right) = \left(\frac{3}{4}\right) RI$$

$$V_{OUT\,MAX} = \left(\frac{15}{8}\right) RI$$

$$V_{OUT\,MAX} = RI\left(2 - \frac{1}{2^{n-1}}\right)$$

THE CIRCUIT PRODUCES AN UNIPOLAR OUTPUT 0 UP TO $V_{OUT\,MAX}$

IF A BIPOLAR OUTPUT IS DESIRED THEN INVERT THE CURRENT REPRESENTING THE M.S.B.
(DAC INPUT IN 2'S COMPLEMENT CODE)

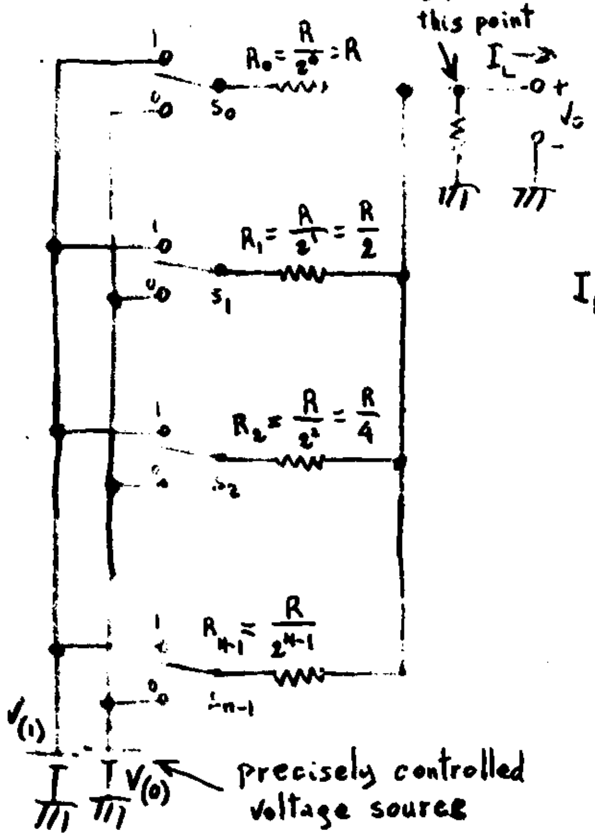
OR

ADD A BIAS CURRENT TO POLARIZE THE OP. AMP. SO THAT AN INPUT OF ALL ZEROES PRODUCES THE FULL SCALE NEGATIVE VOLTAGE OUTPUT.

(DAC INPUT IN OFFSET BINARY CODE)

Example of a circuit converting digital representation to analog form.

THE WEIGHTED-RESISTOR D/A Converter

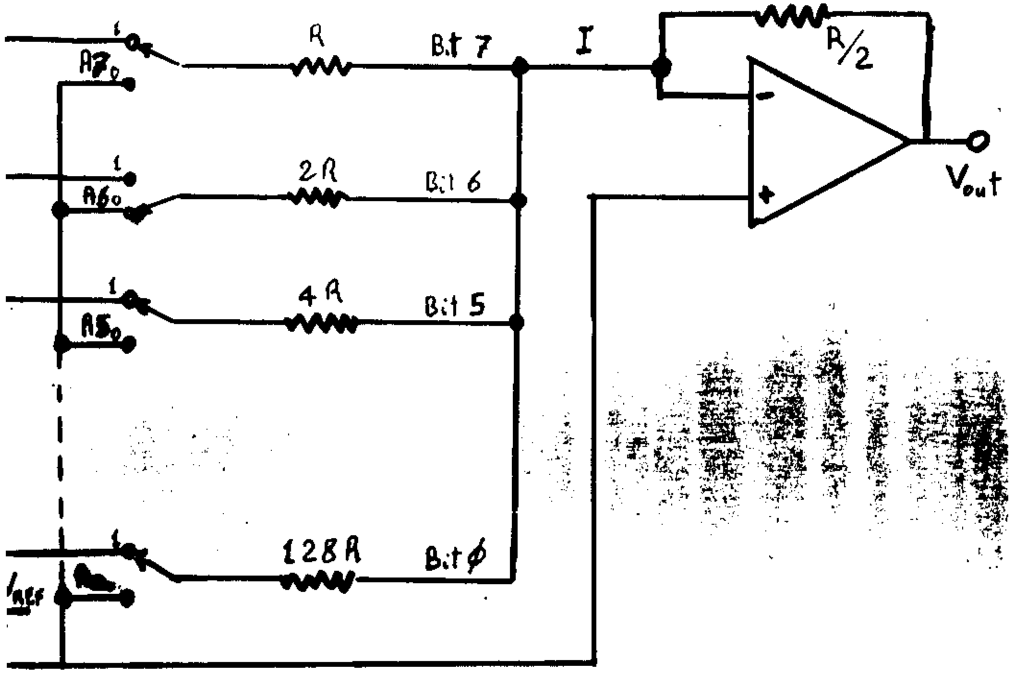


$$I_{LS} = V_R\left(\frac{S_{N-1}}{R_{N-1}} + \frac{S_{N-2}}{R_{N-2}} + \cdots \frac{S_0}{R_0}\right)$$

$$= \frac{V_R}{R}\left(S_{N-1}2^{N-1} + S_{N-2}2^{N-2} + \ldots + S_0 2^0\right)$$

-Let us assume that $V_{(1)} = V_R$, a fixed reference voltage, that $V_{(0)} = 0$, that is, all 0 switch positions are grounded, and that the load $R_L = 0$ (in which case $V = 0$). Then the output current I_L is readily calculated in terms of the switch positions.

WEIGHTED RESISTOR D/A



$$V_{out} = -V_{REF}\left(\frac{A_7}{2} + \frac{A_6}{4} + \frac{A_5}{8} \cdots + \frac{A_0}{128}\right)$$

Ex.

Bit 7 "ON" $\quad V_{out} = -V_{REF}\dfrac{\frac{R}{2}}{R} = -\dfrac{V_{REF}}{2}$

Bit 6 "ON" $\quad V_{out} = -V_{REF}\dfrac{\frac{R}{2}}{2R} = -\dfrac{V_{REF}}{4}$

ONE DRAWBACK OF THE BINARY WEIGHTED RESISTOR DAC IS THAT THE RANGE OF RESISTOR VALUES IS TOO LARGE.

EX. <u>8 bits</u>

IF $R = 10K$

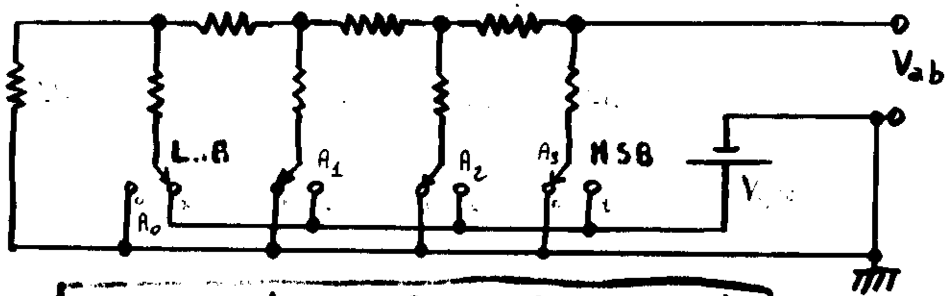
9 DIFFERENT RESISTORS

[5K .... 1.28M]

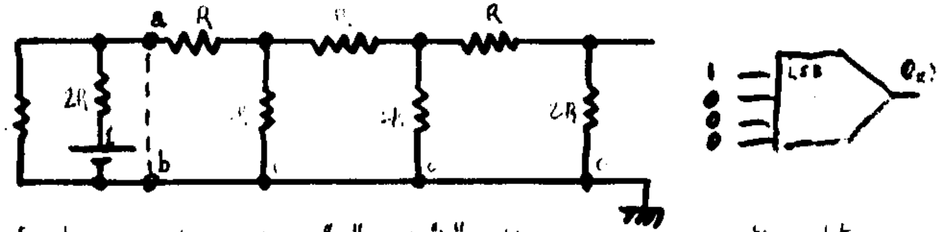
AND WITH ENOUGH PRECISION!

(DIFFICULT TO MANUFACTURE)

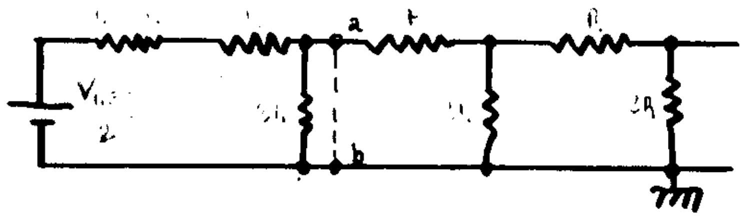
D/A R-2R CONVERTER



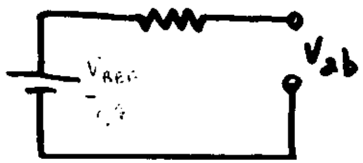
$$V_{ab} = V_{REF}\left(\frac{A_3}{2^1} + \frac{A_2}{2^2} + \frac{A_1}{2^3} + \frac{A_0}{2^4}\right)$$



Between terminals "a" and "b", the open circuit voltage is $\frac{V_{REF}}{2}$ and the resistance is R



BY THEVENIN EQUIVALENT (2nd divider stage replaced)

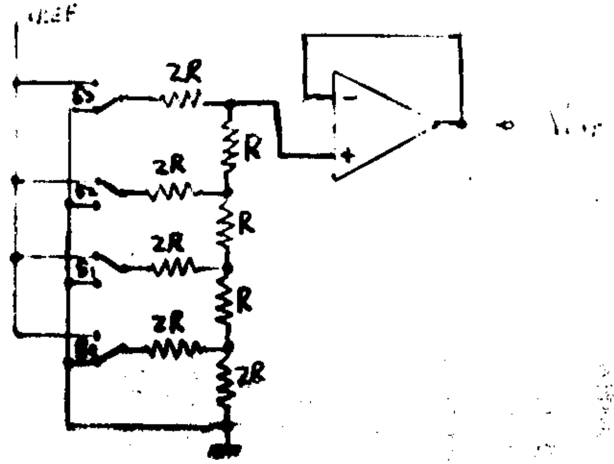


FINAL EQUIVALENT CIRCUIT FOR $A_0 = 1$, $A_1 = A_2 = A_3 = \emptyset$

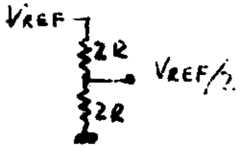
EACH SWITCH CONTRIBUTES ITS PROPER RELATIVE BINARY WEIGHT TO

$$V_{ab} = V_{REF}\left(\frac{A_3}{2^1} + \frac{A_2}{2^2} + \frac{A_1}{2^3} + \frac{A_0}{2^4}\right) = \frac{V_R}{16}$$

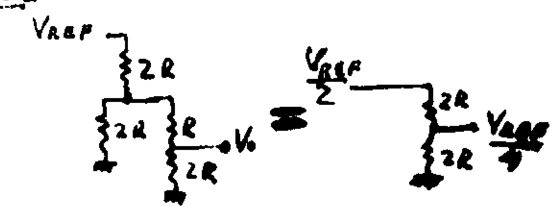
Voltage VERSION

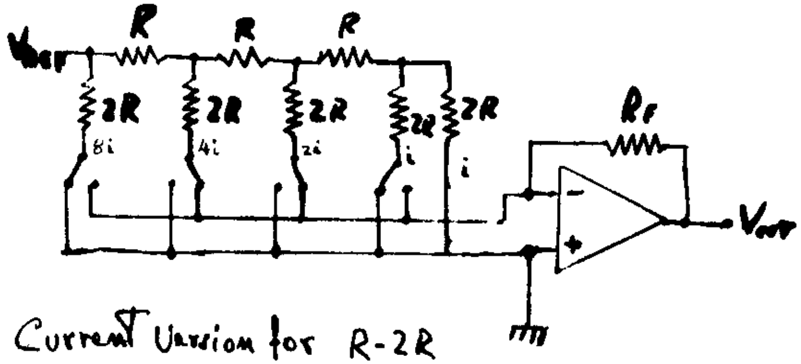


For S_0



For S_2





Current Version for R-2R Ladder network DAC

If one leg of the ladder is connected to the reference voltage by electronic switch and the remaining are all grounded, a current is produced in the "leg" which "travels" through the ladder and gets divided by a factor of two at each junction. Thus, the contribution of current from that leg at the summing junction is binarily weighted in accordance with the number of junctions through which it has passed.

Advantages:

- the impedence seen from the input of the op-amp. is constant (equal to R). Hence, bandwidth, etc, do not change with digital setting.
- All resistors are either R or 2R. Accuracy is <u>not dependent</u> upon the absolute value of R but rather only their differences. (0.1KΩ to 50KΩ)

MAIN DAC SPECIFICATIONS

<u>RESOLUTION</u>: IT SPECIFIES THE NUMBER OF BITS AND THEREFORE THE NUMBER OF OUTPUT VOLTAGES THE CONVERTER CAN SUPPLY.

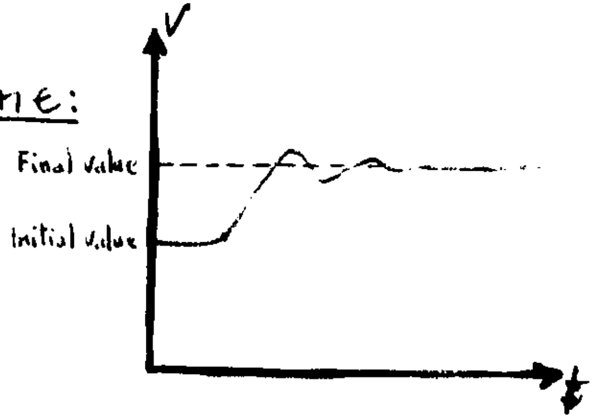
A CONVERTER WITH TEN INPUT BITS CAN DELIVER 2^{10} OR 1024 DIFFERENT VOLTAGES, AND THE SMALLEST POSSIBLE OUTPUT CHANGE IS (1/1024) OF FULL SCALE OR 0.1% RESOLUTION.

<u>LINEARITY</u>: IN AN IDEAL LINEAR DAC EQUAL INCREMENTS IN THE INPUT'S DIGITAL VALUE SHOULD PRODUCE EQUAL INCREMENTS OF THE ANALOG OUTPUT. IT IS A MEASURE OF DEVIATION OF THE ANALOG OUTPUT TO A STRAIGHT LINE BETWEEN THE MAXIMUM AND MINIMUM OUTPUT VALUES.

<u>MONOTONICITY</u>: IT IMPLIES THAT THE ANALOG OUTPUT INCREASES WHEN THE DIGITAL INPUT INCREASES. IT IS AN IMPORTANT FEATURE FOR DACs USED IN BUILDING ADCs

<u>ACCURACY</u>: A MEASURE OF THE DIFFERENCE BETWEEN THE ACTUAL OUTPUT VOLTAGE AND THE INTENDED OUTPUT VOLTAGE.

Settling Time:



When the digital input to a converter changes, switches open and close and abrupt voltage changes appear.
Not only there is a finite time required to reach the new output level, but also an oscillation may occur.

The interval that elapses from the input change to the time when the output has come close enough to its final value is called the settling time. The settling time depends, among other things, on how we define "close enough" Typically a general purpose converter might have a settling time given as "500 ns to 0.2% full scale"

Temperature sensitivity: At any fixed digital input, the analog output will vary with temperature.

Digital-To Analog Converter AD558J

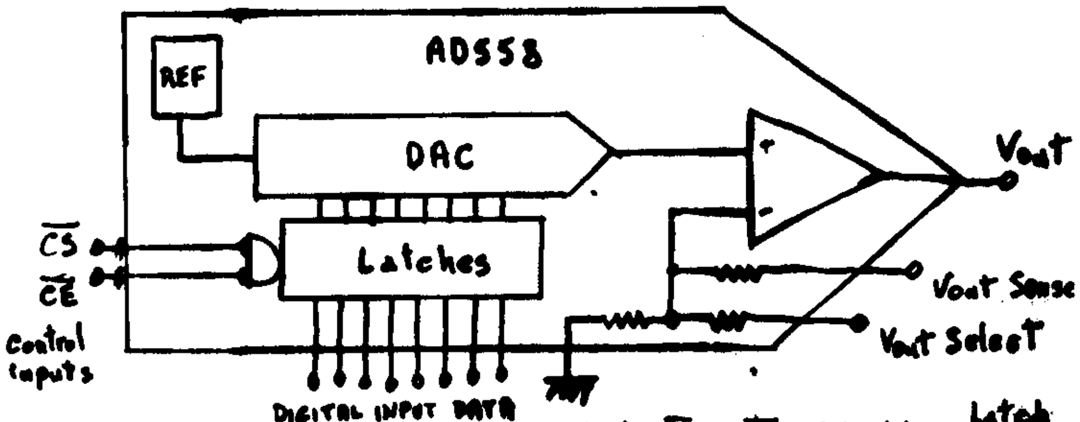
Dacport - Lowcost μP-compatible 8-Bit DAC

Product Highlights:

- 8 Bit input register microprocessor compatible. The latch may be disabled for direct DAC interfacing.

Power supply	
>+4,5 Volt →	0 Volt to 2.56 Volt or
11,4V To 16,5V →	0 volt to 10 volt output ranges by pin-strapping.

- **Settling time:** 700 nsec to 0,5% full scale
- **Accuracy** @ 25°C ±1.5LSB (±0,6% max) full



Input data	$\overline{CE}$	$\overline{CS}$	DAC data	Latch Condition
0	0	0	0	Transparent
1	0	0	1	Transparent
0	f	0	0	latching
1	f	0	1	latching
0	0	f	0	latching
1	0	f	1	latching
x	1	x	prev. data	latched
x	x	1	prev. data	latched

x = does not matter

The $\overline{CS}$ and $\overline{CE}$ inputs are interchangeable.

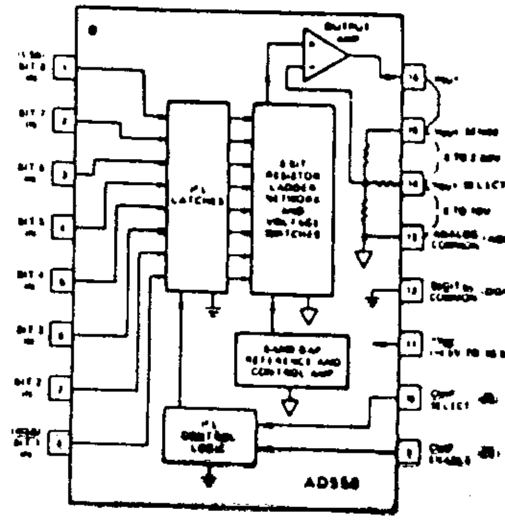
ANALOG DEVICES

DACPORT™ Low Cost Complete μP-Compatible 8-Bit DAC

AD558*

FEATURES
Complete 8-Bit DAC
Voltage Output – 2 Calibrated Ranges
Internal Precision Band-Gap Reference
Single-Supply Operation: +5V to +15V
Full Microprocessor Interface
Fast: 1μs Voltage Settling to ±1/2LSB
Low Power: 75mW
No User Trims
Guaranteed Monotonic Over Temperature
All Errors Specified T_{min} to T_{max}
Small 16-Pin DIP Package
Single Laser-Wafer-Trimmed Chip for Hybrids
Low Cost

AD558 FUNCTIONAL BLOCK DIAGRAM



TO-116

PRODUCT DESCRIPTION
The AD558 DACPORT is a complete voltage-output 8-bit digital-to-analog converter, including output amplifier, full microprocessor interface and precision voltage reference on a single monolithic chip. No external components or trims are required to interface, with full accuracy, an 8-bit data bus to an analog system.

The performance and versatility of the DACPORT is a result of several recently-developed monolithic bipolar technologies. The complete microprocessor interface and control logic is implemented with integrated injection logic (I^2L), an extremely dense and low-power logic structure that is process-compatible with linear bipolar fabrication. The internal precision voltage reference is the patented low-voltage band-gap circuit which permits full-accuracy performance on a single +5V to +15V power supply. Thin-film silicon-chromium resistors provide the stability required for guaranteed monotonic operation over the entire operating temperature range (all grades), while recent advances in laser-wafer-trimming of these thin-film resistors permit absolute calibration at the factory to within ±1LSB; thus no user-trims for gain or offset are required. A new circuit design provides voltage settling to ±1/2LSB for a full-scale step in 800ns.

The AD558 is available in four performance grades. The AD558J and K are specified for use over the 0 to +70°C temperature range, while the AD558S and T grades are specified for –55°C to +125°C operation. The hermetically-sealed ceramic package is standard. Processing to MIL-STD-883, Class B is optional on S and T grades.

PRODUCT HIGHLIGHTS
1. The 8-bit I^2L input register and fully microprocessor-compatible control logic allow the AD558 to be directly connected to 8- or 16-bit data buses and operated with standard control signals. The latch may be disabled for direct DAC interfacing.
2. The laser-trimmed on-chip SiCr thin-film resistors are calibrated for absolute accuracy and linearity at the factory. Therefore, no user trims are necessary for full rated accuracy over the operating temperature range.
3. The inclusion of a precision low-voltage band-gap reference eliminates the need to specify and apply a separate reference source.
4. The voltage-switching structure of the AD558 DAC section along with a high-speed output amplifier and laser-trimmed resistors give the user a choice of 0V to +2.56V or 0V to +10V output ranges, selectable by pin-strapping. Circuitry is internally compensated for minimum settling time on both ranges; typically settling to ±1/2LSB for a full-scale 2.55 volt step in 800ns.
5. The AD558 is designed and specified to operate from a single +4.5V to +16.5V power supply.
6. Low digital input currents, 100μA max, minimize bus loading. Input thresholds are TTL/low voltage CMOS compatible over the entire operating V_{CC} range.
7. The single-chip, low power I^2L design of the AD558 is inherently more reliable than hybrid multi-chip or conventional single-chip bipolar designs. The AD558S and T grades, which are specified over the –55°C to +125°C temperature range, are available processed to MIL-STD-883, Class B.
8. All AD558 grades are available in chip form with guaranteed specifications from +25°C to T_{max}. MIL-STD-883, Class B visual inspection is standard on Analog Devices bipolar chips. Contact the factory for additional chip information.

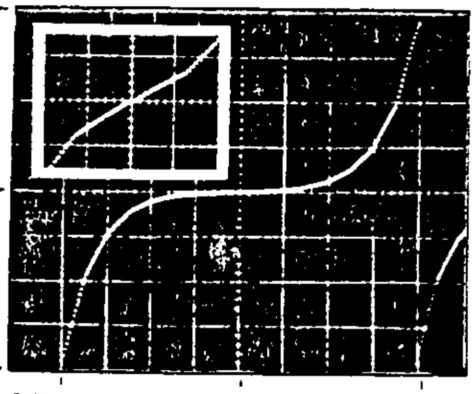
*Covered by U.S. Patent Nos. 3,887,863; 3,685,045; Patents Pending.
DACPORT is a trademark of Analog Devices, Inc.

COMDAC®

COMPANDING D/A CONVERTER (μ-255 LAW) — DAC-86

FEATURES

- Conforms With Bell System μ-255 Companding Law
- Meets D3 Compandor Tracking Specifications
- Both Encode and Decode Capability
- Tight Full-Scale Tolerance Eliminates Calibration
- Low Full-Scale Drift Over Temperature
- Extremely Low Noise Contribution
- Multiplying Reference Inputs
- Simplifies PCM System Design
- High Reliability
- Low Power Consumption and Low Cost
- Two Grades Available



COMDAC® TRANSFER CHARACTERISTIC

GENERAL DESCRIPTION

The DAC-86 monolithic COMDAC® D/A Converter provides a 15 segment linear approximation to the Bell System μ-255 companding law. The law is implemented by using three bits to select one of eight binarily-related chords (or segments) and four bits to select one of sixteen linearly-related steps within each chord. A sign bit determines signal polarity, and an encode/decode input determines the mode of operation.

Accuracy is assured by specifying chord end point values, step non-linearity, and monotonicity over the full operating temperature range. Typical applications include PCM carrier systems, digital PBX's intercom systems, and PCM recording. For CCITT "A" Law models, refer to the DAC-89 data sheet.

BELL μ-255 LAW TRANSFER CHARACTERISTIC

The DAC-86 transfer characteristic is a piecewise linear approximation to the Bell System μ-255 law expressed by:

$$Y(\chi) = \text{sgn}(\chi)\frac{\ln(1+\mu|\chi|)}{\ln(1+\mu)} \quad -1 \le \chi \le 1$$

for a normalized coding range of ±1

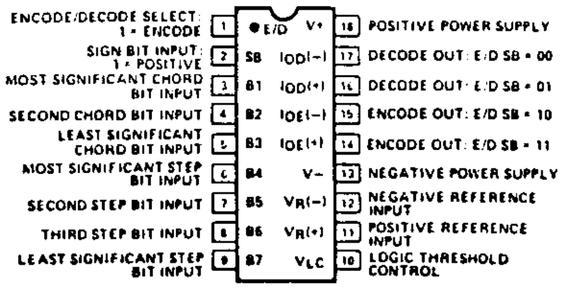
where: χ = input signal level

Y = output compressed signal level

$\mu = 255$

This law is implemented with a eight chord (or segment) piecewise linear approximation with 16 linear steps in each chord. Dynamic range of 72dB in both polarities is achieved with eight-bit coding.

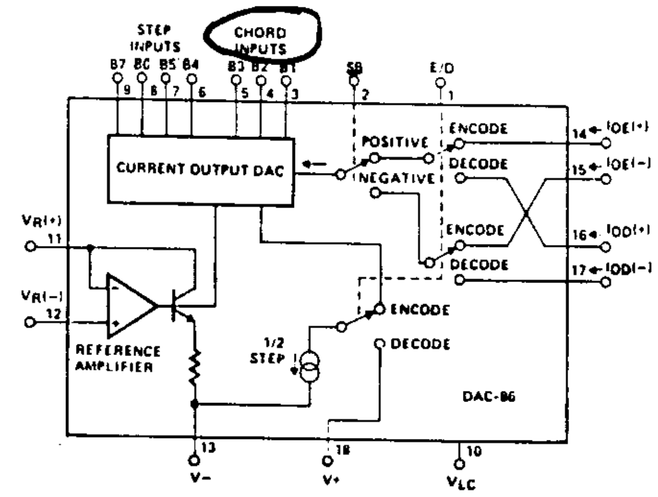
PIN CONNECTIONS & ORDERING INFORMATION



18-PIN HERMETIC DUAL-IN-LINE (X-Suffix)

GRADE	TEMP. RANGE	ACCURACY
DAC-86EX	−25°C/+85°C	±1/2 Step
DAC-86CX	−25°C/+85°C	±1 Step

EQUIVALENT CIRCUIT



NALOG TO DIGITAL CONVERTER

…E BIT CONVERSION, THE COMPARATOR

- TWO ANALOG INPUTS
- ONE DIGITAL OUTPUT SHOWS WHICH INPUT IS LARGER.

…MPORTANT PARAMETERS:

- INPUT OFFSET VOLTAGE. DETERMINES TRESHOLD LEVEL.
- RESPONSE TIME

…rallel OR FLASH CONVERTER

MADE WITH A BANK OF 2^{N-1} COMPARATORS THAT MATCH THE INPUT AGAINST VOLTAGES FROM A RESISTOR NETWORK.

THE RESPONSE TIME IS THAT ONE OF THE SLOWEST COMPARATOR IN THE BANK PLUS THE PROPAGATION TIME OF THE LOGIC CIRCUIT USED TO CONVERT THE OUTPUT OF THE COMPARATORS TO A SUITABLE DIGITAL CODE.

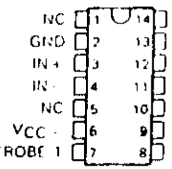
LINEAR INTEGRATED CIRCUITS

TYPES LM106, LM206, LM306 DIFFERENTIAL COMPARATORS WITH STROBES

D1106, OCTOBER 1979 - REVISED JULY 1983

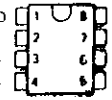
- Fast Response Times
- Improved Gain and Accuracy
- Fan-Out to 10 Series 54/74 TTL Loads
- Strobe Capability
- Short-Circuit and Surge Protection
- Designed to be Interchangeable with National Semiconductor LM106, LM206, and LM306

J OR N DUAL-IN-LINE OR W FLAT PACKAGE (TOP VIEW)



NC – No internal connection

D, JG OR P DUAL-IN-LINE PACKAGE (TOP VIEW)



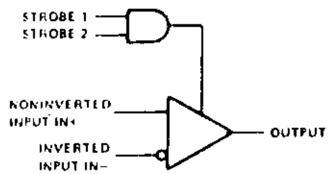
description

The LM106, LM206, and LM306 are high-speed voltage comparators with differential inputs, a low-impedance high sink-current (100 mA) output, and two strobe inputs. These devices detect low-level analog or digital signals and can drive digital logic or lamps and relays directly. Short-circuit protection and surge-current limiting is provided.

The circuit is similar to a TL810 with gated output. A low-level input at either strobe causes the output to remain high regardless of the differential input. When both strobe inputs are either open or at a high logic level, the output voltage is controlled by the differential input voltage. The circuit will operate with any negative supply voltage between −3 volts and −12 volts with little difference in performance.

The LM106 is characterized for operation over the full military temperature range of −55°C to 125°C, the LM206 is characterized for operation from −25°C to 85°C, and the LM306 from 0°C to 70°C.

functional block diagram



TYPICAL CHARACTERISTICS†

OUTPUT RESPONSE FOR VARIOUS INPUT OVERDRIVES

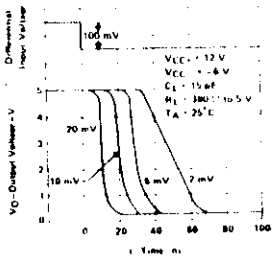


FIGURE 9

OUTPUT RESPONSE FOR VARIOUS INPUT OVERDRIVES

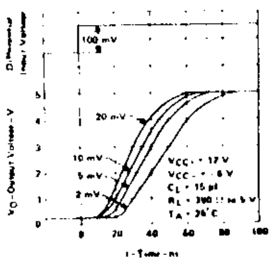


FIGURE 10

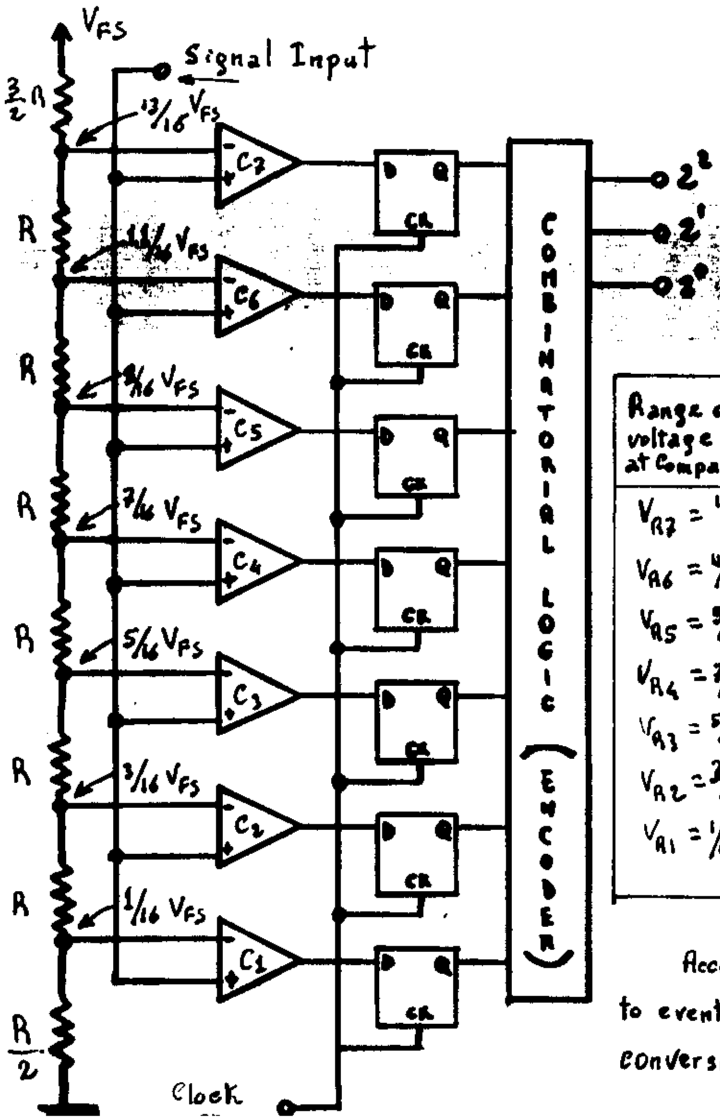
SUPPLY CURRENT FROM …

PARALLEL OR "FLASH" A/D

The unknown V_x input voltage is simultaneously compared to seven different reference voltages

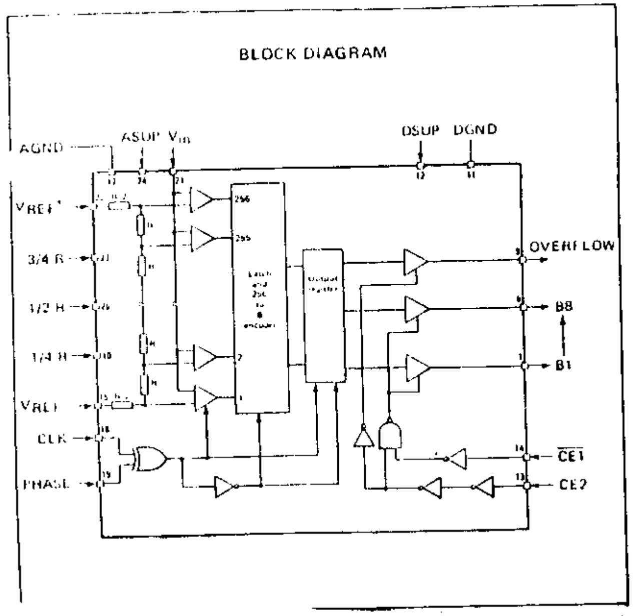
2^{n-1} COMPARATORS are needed for n-bit CONVERTER

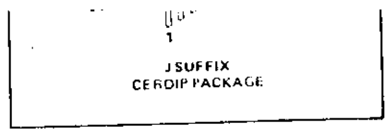
CONVERSION RATE 10÷100 MHz

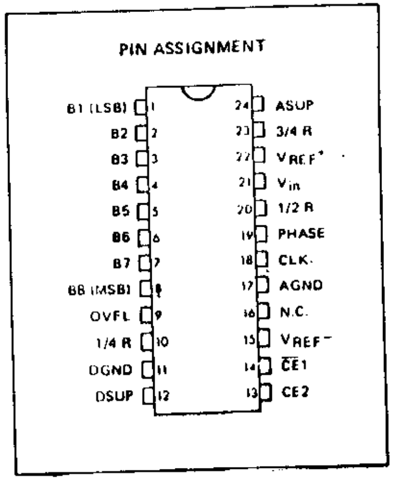


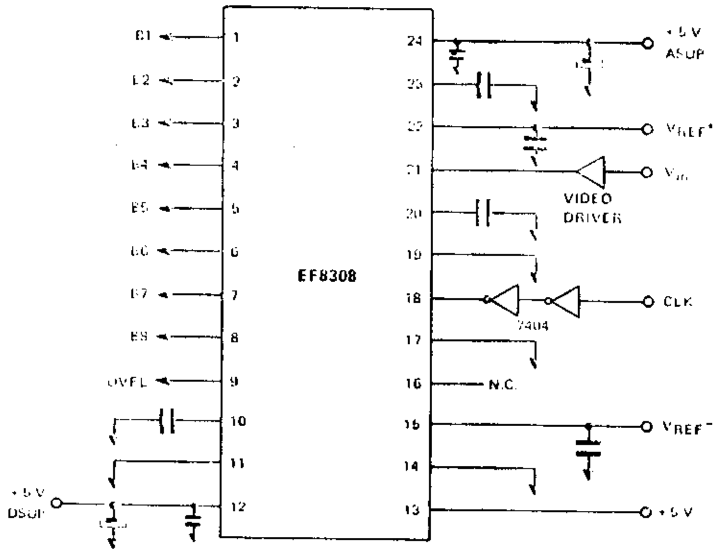
Range of analog voltage input at Comparator	Binary Digital output	Analog Voltage Output from D/A
V_{R7} = 13/16 V_{FS}	111	7/8 V_{FS}
V_{R6} = 11/16 V_{FS}	110	3/4 V_{FS}
V_{R5} = 9/16 V_{FS}	101	5/8 V_{FS}
V_{R4} = 7/16 V_{FS}	100	1/2 V_{FS}
V_{R3} = 5/16 V_{FS}	011	3/8 V_{FS}
V_{R2} = 3/16 V_{FS}	010	1/4 V_{FS}
V_{R1} = 1/16 V_{FS}	001	1/8 V_{FS}
	000	0

Access to resistor "R" ladder to eventually form a non linear conversion law (compression for example)









SUCCESIVE APPROXIMATION A/D CONVERTER

INSTEAD OF 2^n CONVERTERS DO $\log_2(n)$ COMPARISONS.

USES: ONE COMPARATOR
ONE DAC
ONE SUCCESIVE APROXIMATION REGISTER

DURING THE CONVERSION THE ANALOG SIGNAL MUST BE STEADY. USUALLY A SAMPLE AND HOLD CIRCUIT IS USED FOR THIS PURPOSE

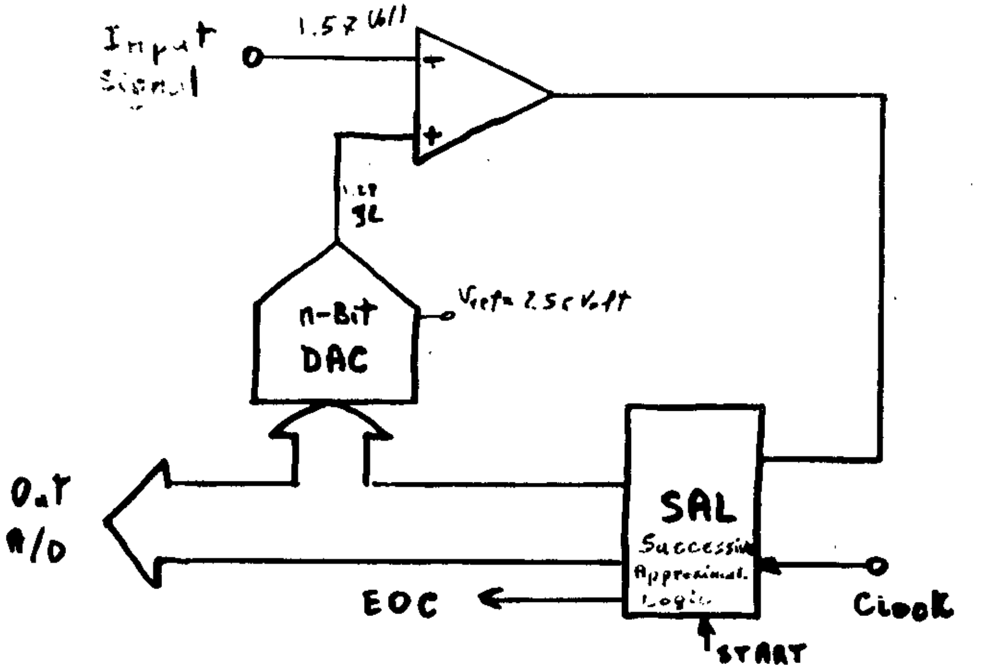
- FIXED CONVERSION TIME
- REASONABLY FAST, 5 - 150 μ Sec for 8 b.

ALGORITHM: - CLEAR REGISTER

- SET THE MSB OF REGISTER TO ONE
- WAIT FOR THE SETTLING TIME OF THE DAC PLUS RESPONSE TIME OF COMPARATOR
- SET OR RESET MSB ACCORDINGLY
- REPEAT FOR BIT NEXT TO MSB (1, 2, 3) KEEPING VALUE OF MSB.
- REPEAT DOWN TO THE LSB TO SUCCESSIVELY APROXIMATE THE DAC OUTPUT TO THE ANALOG "STEADY" INPUT.

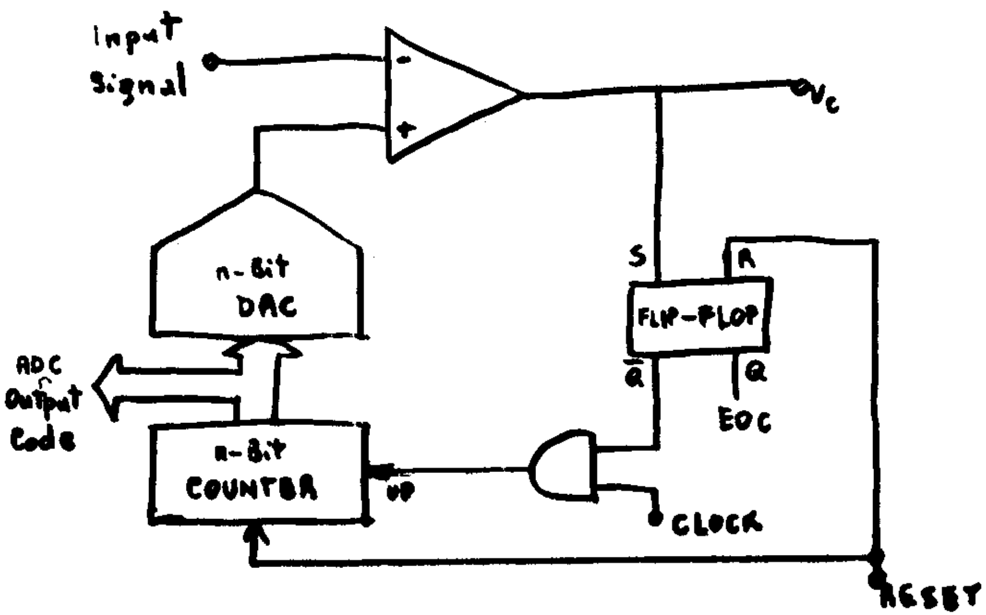
THE INTERNAL DAC (R-2R NETWORK) SHOULD BE MONOTONIC OR WE HAVE MISSING CODES.

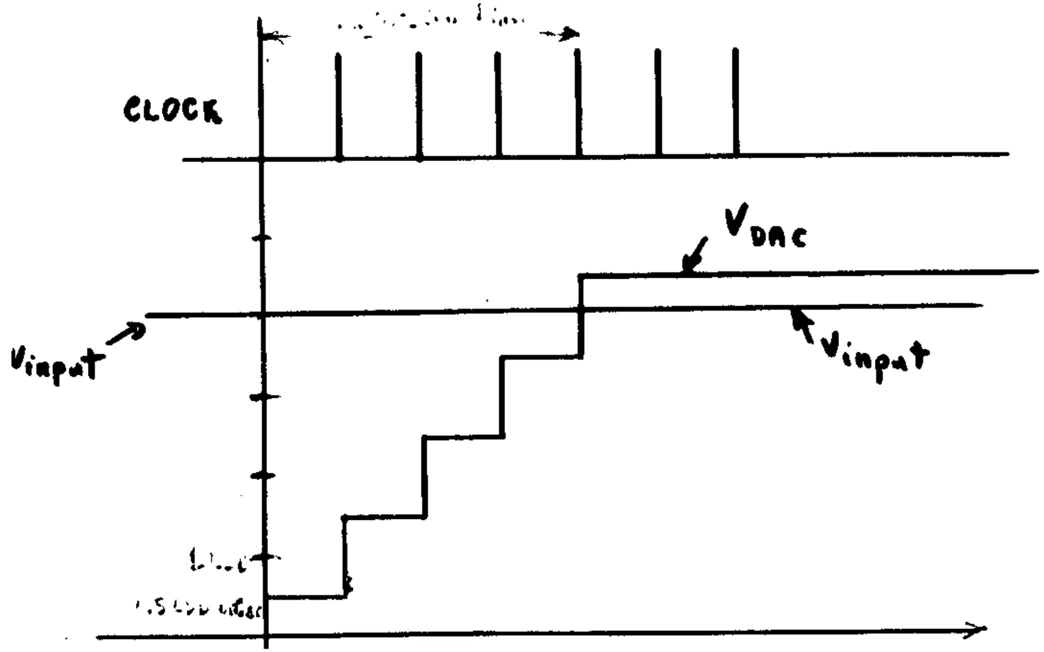
SUCCESSIVE APPROXIMATION A/D



Bit	Each Bit Weight Volt	Input Signal Volt	1	2	3	4	5	6	7	8	Value
2^7	[illegible]	1.57	1 1	1 1	1 1	1 1	1 1	1			1
2^6	[illegible]		0 0	1 0	0 0	0 0	0 0 0	0			0
2^5	[illegible]		0	0	1 0	0 0	0 0	0			0
2^4	[illegible]		0	0	0	1 1	1 1	1			1
2^3	[illegible]		0	0	0	0	1 1	1			1
2^2	[illegible]		0	0	0	0	0	1			1
2^1	[illegible]		0	0	0	0	0	0	1		0

COUNTER-RAMP A/D





Conter-ramp A/D

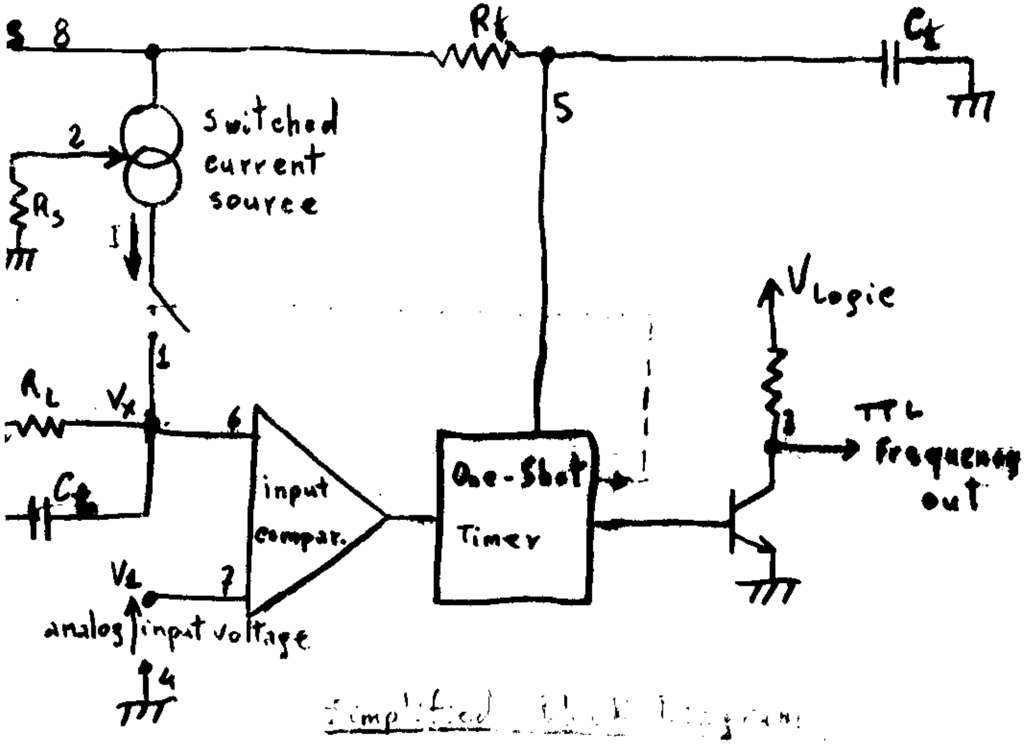
To determine the unknown input voltage V_x, each possible DAC output is sequentially compared to the input voltage.

A/D conversion begins when a pulse resets the counter output to zero. Each successive clock pulse increments the counter until the output of the DAC exceeds the unknown input. At this point the comparator change state and prevents any further clock pulse from reaching the counter

Length of the conversion cycle is proportional to the unknown input Voltage V_x $T_{max} = 2^n / f_c$

The binary value in the counter represent the smalles DAC value which is larger than the unknown input.

Principles of operation of a simplified Voltage-to-frequency converter



Simplified Block Diagram

If $V_I > V_x$, the comparator triggers the one-shot timer
-e timer turn ON both the frequency output transistor
-d the switched current source for a period ~ $R_t C_t$
Provide a fixed amount of charge $Q = i \cdot t$ into the
-pacitor C_L. This normally charges V_x up to a higher
-vel than V_I. At the end of timing period the current
-ll turn off.
Capacitor C_L will be gradually discharged by R_L

National Semiconductor

A to D, D to A

LM131A/LM131, LM231A/LM231, LM331A/LM331

LM131A/LM131, LM231A/LM231, LM331A/LM331 Precision Voltage-to-Frequency Converters

General Description

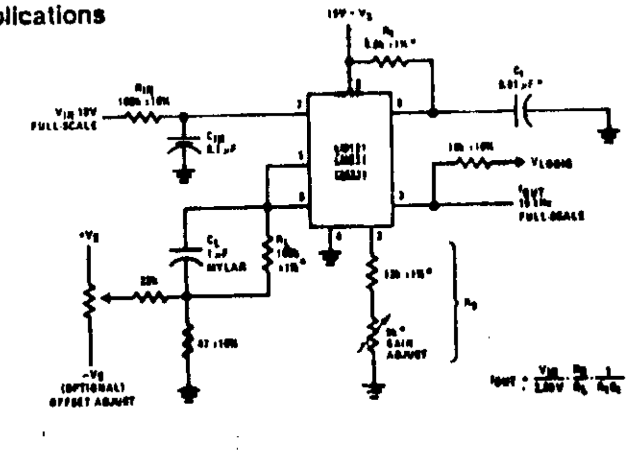
The LM131/LM231/LM331 family of voltage-to-frequency converters are ideally suited for use in simple low-cost circuits for analog-to-digital conversion, precision frequency-to-voltage conversion, long-term integration, linear frequency modulation or demodulation, and many other functions. The output when used as a voltage-to-frequency converter is a pulse train at a frequency precisely proportional to the applied input voltage. Thus, it provides all the inherent advantages of the voltage-to-frequency conversion techniques, and is easy to apply in all standard voltage-to-frequency converter applications. Further, the LM131A/LM231A/LM331A attains a new high level of accuracy versus temperature which could only be attained with expensive voltage-to-frequency modules. Additionally the LM131 is ideally suited for use in digital systems at low power supply voltages and can provide low-cost analog-to-digital conversion in microprocessor-controlled systems. And, the frequency from a battery powered voltage-to-frequency converter can be easily channeled through a simple photoisolator to provide isolation against high common mode levels.

The LM131/LM231/LM331 utilizes a new temperature-compensated band-gap reference circuit, to provide excellent accuracy over the full operating temperature range, at power supplies as low as 4.0V. The precision timer circuit has low bias currents without degrading the quick response necessary for 100 kHz voltage-to-frequency conversion. And the output is capable of driving 3 TTL loads, or a high voltage output up to 40V, yet is short-circuit-proof against V_{CC}.

Features

- Guaranteed linearity 0.01% max
- Improved performance in existing voltage-to-frequency conversion applications
- Split or single supply operation
- Operates on single 5V supply
- Pulse output compatible with all logic forms
- Excellent temperature stability, ±50 ppm/°C max
- Low power dissipation, 15 mW typical at 5V
- Wide dynamic range, 100 dB min at 10 kHz full scale frequency
- Wide range of full scale frequency, 1 Hz to 100 kHz
- Low cost

Typical Applications



*Use stable components with low temperature coefficients. See Typical Applications section.

FIGURE 1. Simple Stand-Alone Voltage-to-Frequency Converter with ±0.03% Typical Linearity (f = 10 Hz to 11 kHz)

SELECTION GUIDE

Consult Customers Data Books:

- TRW
- BURR-BROWN
- ANALOG DEVICES
- DATEL-INTERSIL
- MOTOROLA
- NATIONAL SEMICONDUCTORS
- HARRIS
- SIEMENS
- THOMSON
- RCA
- SONY

D/A Converters:

1) General Purpose Low Cost
   a) Current mode
   b) Voltage mode
   c) unipolar or bipolar output
2) High Preformance (Speed and Accuracy)
   a) High speed
   b) High resolution
   c) Very wide temperature range
3) Low Power and Multiplying
   a) 2-quadrant multiplying
   b) High speed multiplying
4) Digitally Buffered (DATA-BUS Compatible)
5) On-chip voltage reference
6) Special - Purpose
   a) PCM Audio Converter

A/D Converters:

1) General Purpose
   a) differential input
   b) internal or external reference voltage
   c) DVM Converters (Digital Voltmeter)
2) High performance (Speed and Accuracy)
   a) High speed
   b) High resolution
3) LOW POWER, CMOS
4) BUS COMPATIBLE (3 state-outputs)
5) Multichannel