

B.T.S. ELECTRONIQUE

SESSION 2003

ETUDE D'UN SYSTEME TECHNIQUE

SYSTEME DE DISTRIBUTION DE CARTES D'ENTREE DE PISCINE

EXTRAITS DE DOCUMENTS TECHNIQUES

Escap 28LT12
Encoder E9
LM231/LM331
TL494
2953 – 2954

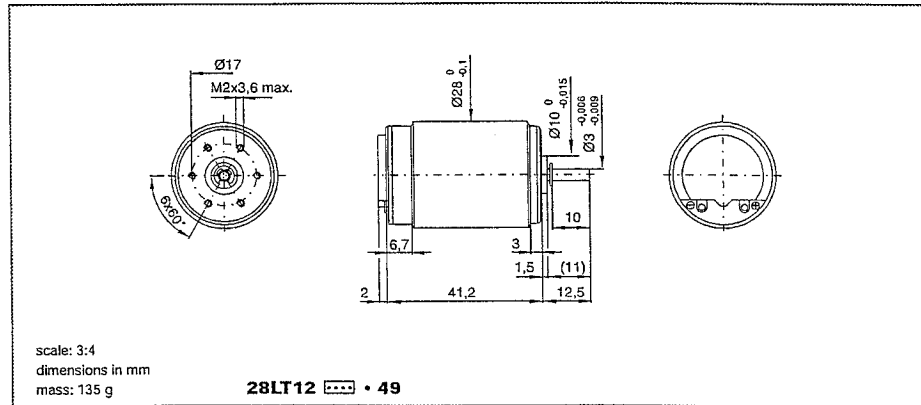
page DT2
page DT3
pages DT4 à DT16
pages DT17 à DT24
pages DT25 à DT29

Ce dossier comporte 29 pages

escap 28LT12

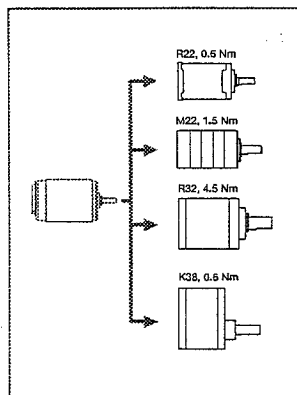
Graphite/copper commutation system - 9 segments

D.C. Motor
21 Watt

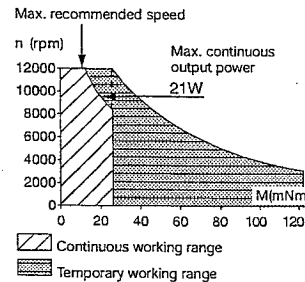


Winding types		-219P	-219	-416E
Measured values				
1 Measuring voltage	V	9.0	18.0	32.0
2 No-load speed	rpm	7900	7900	7400
3 Stall torque	mNm (oz-in)	57 (8.1)	63 (8.86)	65 (9.26)
4 Average no-load current	mA	125.0	65.0	35.0
5 Typical starting voltage	V	--	--	--
Max. recommended values				
6 Max. continuous current	A	2.15	1.13	0.63
7 Max. continuous torque	mNm (oz-in)	21.6 (3.06)	22.8 (3.23)	24.2 (3.42)
8 Max. angular acceleration	10 ³ rad/s ²	51	53	34
Intrinsic parameters				
9 Back-EMF constant	V/1000 rpm	1.12	2.24	4.26
10 Torque constant	mNm/A (oz-in/A)	10.7 (1.51)	21.4 (3.03)	40.7 (5.76)
11 Terminal resistance	ohm	1.70	6.15	19.9
12 Motor regulation R/k ²	10 ³ /Nms	15	13	12
13 Rotor inductance	mH	0.10	0.50	2.40
14 Rotor inertia	kgm ² · 10 ⁻⁷	10.70	10.70	17.80
15 Mechanical time constant	ms	16	14	21

Availability: see enclosed document at the end of the catalogue



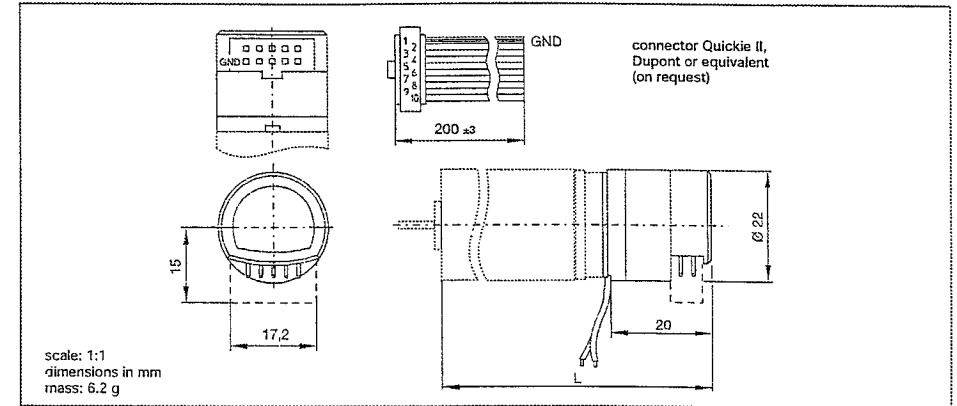
- Thermal resistance:
rotor-body 5°C/W
body-ambient 12°C/W
- Thermal time constant - rotor / stator:
17 s / 760 s
- Max. rated coil temperature: 155°C
- Recom. ambient temperature range:
-10°C to +80°C (14°F to 176°F)
- Max. axial static force for press-fit: 250 N
- End play: ≤ 150 μm
Radial play: ≤ 18 μm
Shaft runout: ≤ 10 μm
- Max. side load at 5 mm from mounting face:
- sleeve bearings 6 N
- ball bearings 8 N
- Motor fitted with sleeve bearings (ball bearings optional)



E9

3 channel optical encoder

Encoder



Characteristics at 22°C

1 Number of lines available		100, 144, 200, 256, 360 ¹⁾ , 500 ¹⁾
2 Supply current	typical	mA 10
	max.	mA 20
	stand-by	μA 50
3 Output signal		CMOS compatible
4 Electrical phase shift between A and B		degree 90 ± 20
5 Duty cycle		% 50 ± 10
6 Max. count frequency		kHz 200
7 Operating temperature range	at 90% humidity	°C -40 to + 85
8 Code wheel moment of inertia		10 ⁻⁷ x kgm ² 0.12
9 Supply voltage	Vcc	V 5 ± 10%

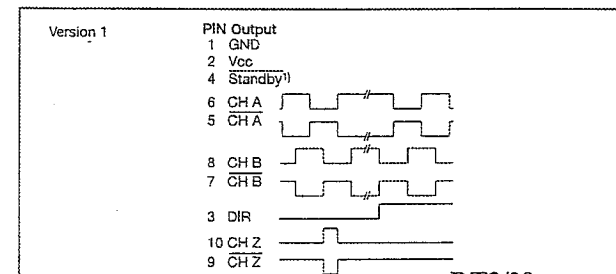
Pin out	1	2	3	4	5	6	7	8	9	10
10 Version 1	GND	Vcc	dir.	stand-by	A	A	B	B	Z	Z

Available on motor types **22V48 23LT12 23DT12 26N48 28DT12 35NT P530/2.84 P632.04 P850/2.11**

11 L = length (mm)	56.2	57.6	71	62.1	85.1	84	57.6	62.3	75.7
12 see page	17	18	19	20	22	23	31	32	33

¹⁾ ask for a 2R motor type for use with the E9 in 360 and 500 line versions.

Typical encoder output signal



Features

- 2 channel quadrature output and index pulse
- small size
- integrated direction of rotation detection
- stand-by function with latched state of channels (to deactivate the stand-by mode, connect the pin 4 to the +5 V)
- complementary outputs
- up/down pulse signals (on request)
- CMOS compatible.
¹⁾ The input Standby has to be connected to 0 V_{cc} or +5 V_{cc}.
- single 5 V_{cc} supply

LM231A/LM231/LM331A/LM331

Precision Voltage-to-Frequency Converters

General Description

The 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 LM231A/LM331A attain a new high level of accuracy versus temperature which could only be attained with expensive voltage-to-frequency modules. Additionally the LM231/331 are 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.

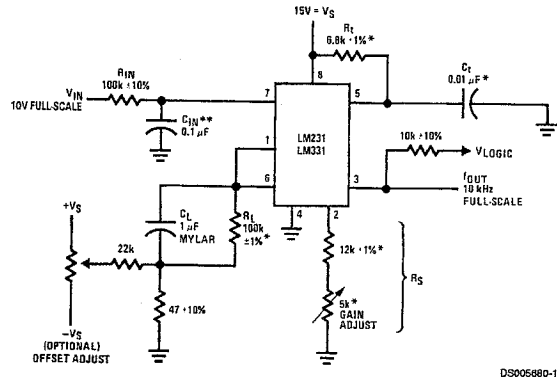
The LM231/LM331 utilize a new temperature-compensated band-gap reference circuit, to provide excellent accuracy

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 are 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/ $^{\circ}$ 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



$$f_{OUT} = \frac{V_{IN}}{2.09V} \cdot \frac{R_S}{R_L} \cdot \frac{1}{R_1 C_T}$$

*Use stable components with low temperature coefficients. See Typical Applications section.
 **0.1µF or 1µF, See "Principles of Operation."

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

LM231A/LM231/LM331A/LM331 Precision Voltage-to-Frequency Converters

Absolute Maximum Ratings (Note 1)

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/Distributors for availability and specifications.

	LM231A/LM231	LM331A/LM331
Supply Voltage	40V	40V
Output Short Circuit to Ground	Continuous	Continuous
Output Short Circuit to V_{CC}	Continuous	Continuous
Input Voltage	-0.2V to $+V_S$	-0.2V to $+V_S$
T_{MIN} T_{MAX}	-25 $^{\circ}$ C to +85 $^{\circ}$ C	0 $^{\circ}$ C to +70 $^{\circ}$ C
Operating Ambient Temperature Range		
Power Dissipation (P_D at 25 $^{\circ}$ C) and Thermal Resistance (θ_{JA}) (N Package) P_D	1.25W	1.25W
θ_{JA}	100 $^{\circ}$ C/W	100 $^{\circ}$ C/W
Lead Temperature (Soldering, 10 sec.)		
Dual-In-Line Package (Plastic)	260 $^{\circ}$ C	260 $^{\circ}$ C
ESD Susceptibility (Note 4)		
N Package	500V	500V

Electrical Characteristics

$T_A = 25^{\circ}$ C unless otherwise specified (Note 2)

Parameter	Conditions	Min	Typ	Max	Units
VFC Non-Linearity (Note 3)	$4.5V \leq V_S \leq 20V$		± 0.003	± 0.01	% Full-Scale
	$T_{MIN} \leq T_A \leq T_{MAX}$		± 0.006	± 0.02	% Full-Scale
VFC Non-Linearity In Circuit of Figure 1	$V_S = 15V, f = 10$ Hz to 11 kHz		± 0.024	± 0.14	% Full-Scale
Conversion Accuracy Scale Factor (Gain) LM231, LM231A LM331, LM331A	$V_{IN} = -10V, R_S = 14$ k Ω	0.95	1.00	1.05	kHz/V
		0.90	1.00	1.10	kHz/V
Temperature Stability of Gain LM231/LM331 LM231A/LM331A	$T_{MIN} \leq T_A \leq T_{MAX}, 4.5V \leq V_S \leq 20V$		± 30	± 150	ppm/ $^{\circ}$ C
			± 20	± 50	ppm/ $^{\circ}$ C
Change of Gain with V_S	$4.5V \leq V_S \leq 10V$ $10V \leq V_S \leq 40V$		0.01	0.1	%/V
			0.006	0.06	%/V
Rated Full-Scale Frequency	$V_{IN} = -10V$	10.0			kHz
Gain Stability vs Time (1000 Hrs)	$T_{MIN} \leq T_A \leq T_{MAX}$		± 0.02		% Full-Scale
Overrange (Beyond Full-Scale) Frequency	$V_{IN} = -11V$	10			%
INPUT COMPARATOR					
Offset Voltage LM231/LM331 LM231A/LM331A	$T_{MIN} \leq T_A \leq T_{MAX}$ $T_{MIN} \leq T_A \leq T_{MAX}$		± 3 ± 4 ± 3	± 10 ± 14 ± 10	mV
Bias Current			-80	-300	nA
Offset Current			± 8	± 100	nA
Common-Mode Range	$T_{MIN} \leq T_A \leq T_{MAX}$	-0.2		$V_{CC} - 2.0$	V
TIMER					
Timer Threshold Voltage, Pin 5		0.63	0.667	0.70	x V_S
Input Bias Current, Pin 5	$V_S = 15V$				
All Devices	$0V \leq V_{PIN5} \leq 9.9V$		± 10	± 100	nA
LM231/LM331	$V_{PIN5} = 10V$		200	1000	nA
LM231A/LM331A	$V_{PIN5} = 10V$		200	500	nA

Electrical Characteristics (Continued)

$T_A=25^\circ\text{C}$ unless otherwise specified (Note 2)

Parameter	Conditions	Min	Typ	Max	Units
TIMER					
V_{SAT} PIN 5 (Reset)	$I = 5\text{ mA}$		0.22	0.5	V
CURRENT SOURCE (Pin 1)					
Output Current	$R_S=14\text{ k}\Omega$, $V_{PIN\ 1}=0$				
LM231, LM231A		126	135	144	μA
LM331, LM331A		116	136	156	μA
Change with Voltage	$0\text{V} \leq V_{PIN\ 1} \leq 10\text{V}$		0.2	1.0	μA
Current Source OFF Leakage					
LM231, LM231A, LM331, LM331A			0.02	10.0	nA
All Devices	$T_A=T_{MAX}$		2.0	50.0	nA
Operating Range of Current (Typical)			(10 to 500)		μA
REFERENCE VOLTAGE (Pin 2)					
LM231, LM231A		1.76	1.89	2.02	V_{DC}
LM331, LM331A		1.70	1.89	2.08	V_{DC}
Stability vs Temperature			± 60		ppm/ $^\circ\text{C}$
Stability vs Time, 1000 Hours			± 0.1		%
LOGIC OUTPUT (Pin 3)					
V_{SAT}	$I=5\text{ mA}$		0.15	0.50	V
OFF Leakage	$I=3.2\text{ mA}$ (2 TTL Loads), $T_{MIN} \leq T_A \leq T_{MAX}$		0.10	0.40	V
			± 0.05	1.0	μA
SUPPLY CURRENT					
LM231, LM231A	$V_S=5\text{V}$	2.0	3.0	4.0	mA
LM331, LM331A	$V_S=40\text{V}$	2.5	4.0	6.0	mA
	$V_S=5\text{V}$	1.5	3.0	6.0	mA
	$V_S=40\text{V}$	2.0	4.0	8.0	mA

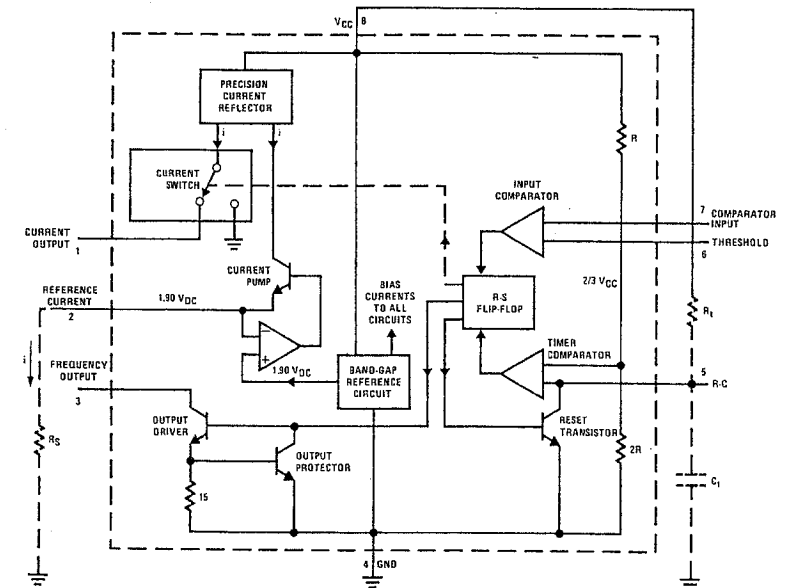
Note 1: Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. DC and AC electrical specifications do not apply when operating the device beyond its specified operating conditions.

Note 2: All specifications apply in the circuit of Figure 4, with $4.0\text{V} \leq V_S \leq 40\text{V}$, unless otherwise noted.

Note 3: Nonlinearity is defined as the deviation of f_{OUT} from $V_{IN} \times (10\text{ kHz}/-10\text{ V}_{DC})$ when the circuit has been trimmed for zero error at 10 Hz and at 10 kHz, over the frequency range 1 Hz to 11 kHz. For the timing capacitor, C_T , use NPO ceramic, Teflon®, or polystyrene.

Note 4: Human body model, 100 pF discharged through a 1.5 k Ω resistor.

Functional Block Diagram



Pin numbers apply to 8-pin packages only.

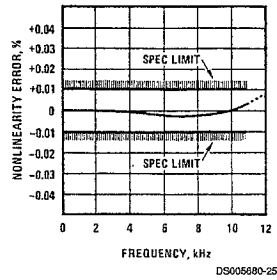
FIGURE 2.

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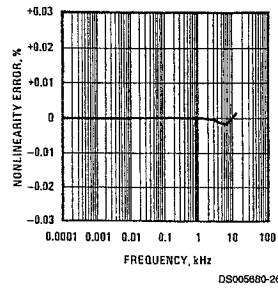
Typical Performance Characteristics

(All electrical characteristics apply for the circuit of Figure 4, unless otherwise noted.)

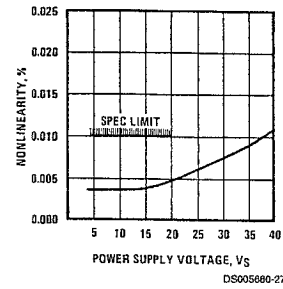
Nonlinearity Error as Precision V-to-F Converter (Figure 4)



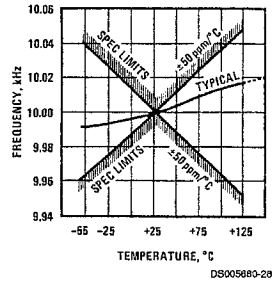
Nonlinearity Error



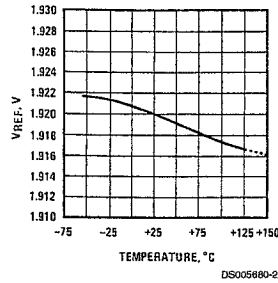
Nonlinearity Error vs Power Supply Voltage



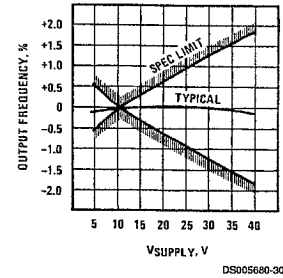
Frequency vs Temperature



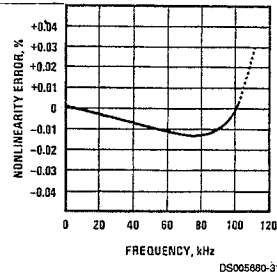
V_{REF} vs Temperature



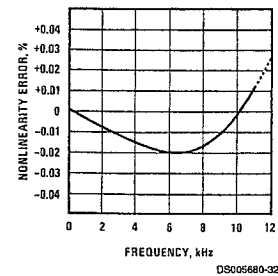
Output Frequency vs V_{SUPPLY}



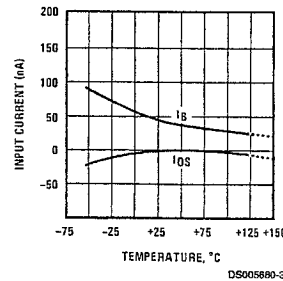
100 kHz Nonlinearity Error (Figure 5)



Nonlinearity Error (Figure 1)

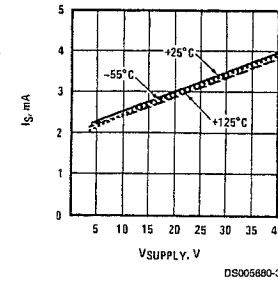


Input Current (Pins 6,7) vs Temperature

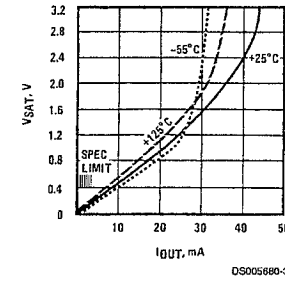


Typical Performance Characteristics (Continued)

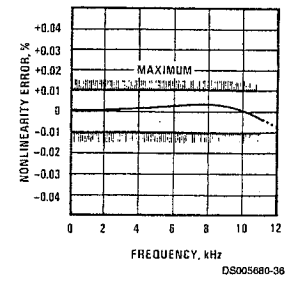
Power Drain vs V_{SUPPLY}



Output Saturation Voltage vs I_{OUT} (Pin 3)



Nonlinearity Error, Precision F-to-V Converter (Figure 7)



Typical Applications

PRINCIPLES OF OPERATION OF A SIMPLIFIED VOLTAGE-TO-FREQUENCY CONVERTER

The LM231/331 are monolithic circuits designed for accuracy and versatile operation when applied as voltage-to-frequency (V-to-F) converters or as frequency-to-voltage (F-to-V) converters. A simplified block diagram of the LM231/331 is shown in Figure 3 and consists of a switched current source, input comparator, and 1-shot timer.

The operation of these blocks is best understood by going through the operating cycle of the basic V-to-F converter, Figure 3, which consists of the simplified block diagram of the LM231/331 and the various resistors and capacitors connected to it.

The voltage comparator compares a positive input voltage, V₁, at pin 7 to the voltage, V_x, at pin 6. If V₁ is greater, the comparator will trigger the 1-shot timer. The output of the timer will turn ON both the frequency output transistor and the switched current source for a period $t = 1.1 R_t C_t$. During this period, the current *i* will flow out of the switched current source and provide a fixed amount of charge, $Q = i \times t$, into the capacitor, C_t. This will normally charge V_x up to a higher level than V₁. At the end of the timing period, the current *i* will turn OFF, and the timer will reset itself.

Now there is no current flowing from pin 1, and the capacitor C_t will be gradually discharged by R_L until V_x falls to the level of V₁. Then the comparator will trigger the timer and start another cycle.

The current flowing into C_t is exactly $i_{AVE} = i \times (1.1 \times R_t C_t) \times f$, and the current flowing out of C_t is exactly $V_x / R_L \equiv V_{IN} / R_L$. If V_{IN} is doubled, the frequency will double to maintain this balance. Even a simple V-to-F converter can provide a frequency precisely proportional to its input voltage over a wide range of frequencies.

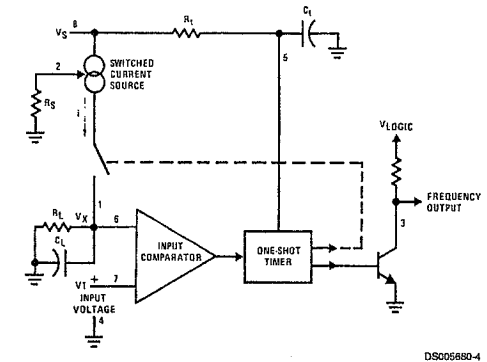


FIGURE 3. Simplified Block Diagram of Stand-Alone Voltage-to-Frequency Converter and External Components

DETAIL OF OPERATION, FUNCTIONAL BLOCK DIAGRAM (Figure 2)

The block diagram shows a band gap reference which provides a stable 1.9 V_{DC} output. This 1.9 V_{DC} is well regulated over a V_S range of 3.9V to 40V. It also has a flat, low temperature coefficient, and typically changes less than 1/2% over a 100°C temperature change.

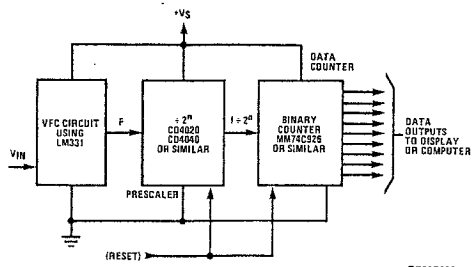
The current pump circuit forces the voltage at pin 2 to be at 1.9V, and causes a current $i = 1.90V / R_S$ to flow. For R_S = 14k, $i = 135 \mu A$. The precision current reflector provides a current equal to *i* to the current switch. The current switch switches the current to pin 1 or to ground depending on the state of the R_S flip-flop.

The timing function consists of an R_S flip-flop, and a timer comparator connected to the external R_tC_t network. When the input comparator detects a voltage at pin 7 higher than pin 6, it sets the R_S flip-flop which turns ON the current switch and the output driver transistor. When the voltage at pin 5 rises to 2/3 V_{CC}, the timer comparator causes the R_S flip-flop to reset. The reset transistor is then turned ON and the current switch is turned OFF.

However, if the input comparator still detects pin 7 higher than pin 6 when pin 5 crosses 2/3 V_{CC}, the flip-flop will not be reset, and the current at pin 1 will continue to flow, in its attempt to make the voltage at pin 6 higher than pin 7. This

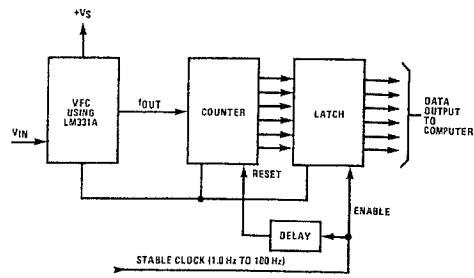
Typical Applications (Continued)

Long-Term Digital Integrator Using VFC



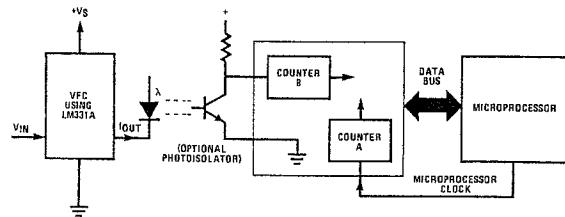
DS005880-11

Basic Analog-to-Digital Converter Using Voltage-to-Frequency Converter



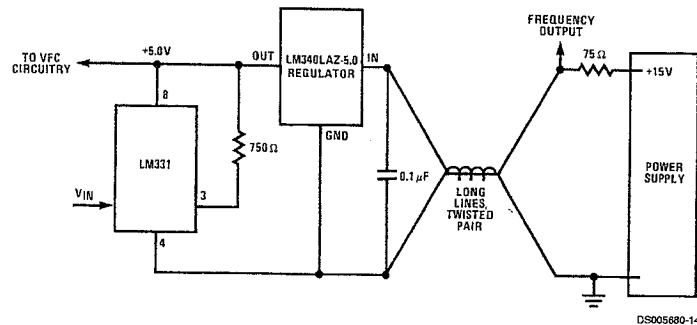
DS005880-12

Analog-to-Digital Converter with Microprocessor



DS005880-13

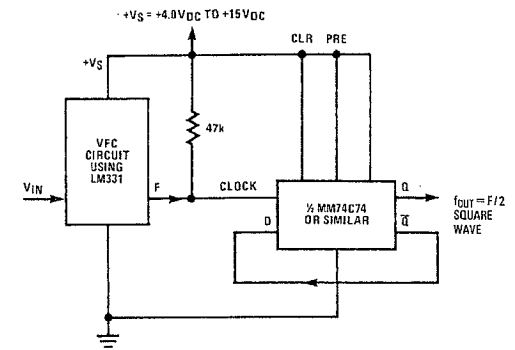
Remote Voltage-to-Frequency Converter with 2-Wire Transmitter and Receiver



DS005880-14

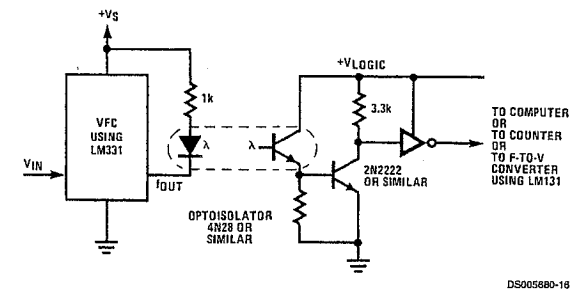
Typical Applications (Continued)

Voltage-to-Frequency Converter with Square-Wave Output Using ÷ 2 Flip-Flop



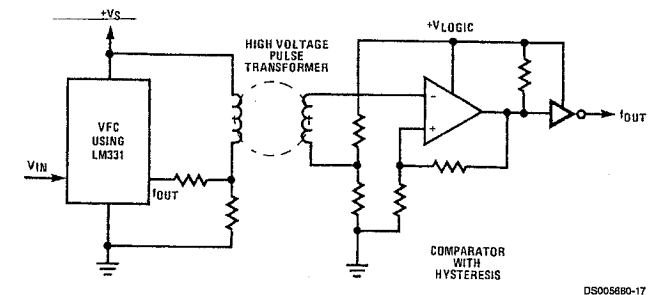
DS005880-15

Voltage-to-Frequency Converter with Isolators



DS005880-16

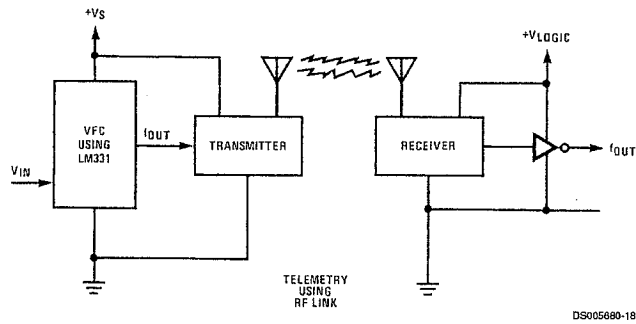
Voltage-to-Frequency Converter with Isolators



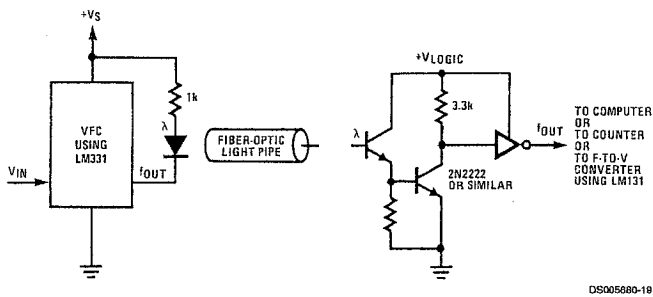
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Typical Applications (Continued)

Voltage-to-Frequency Converter with Isolators

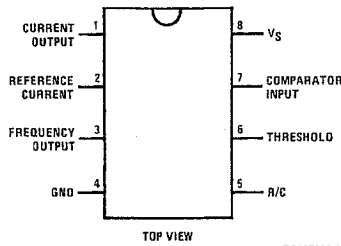


Voltage-to-Frequency Converter with Isolators



Connection Diagram

Dual-In-Line Package

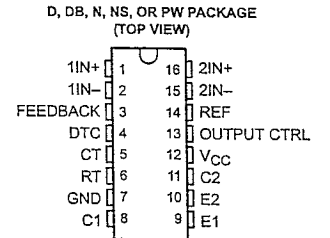


Order Number LM231AN, LM231N, LM331AN,
or LM331N
See NS Package Number N08E

TL494 PULSE-WIDTH-MODULATION CONTROL CIRCUITS

SLVS074D - JANUARY 1983 - REVISED MAY 2002

- Complete PWM Power-Control Circuitry
- Uncommitted Outputs for 200-mA Sink or Source Current
- Output Control Selects Single-Ended or Push-Pull Operation
- Internal Circuitry Prohibits Double Pulse at Either Output
- Variable Dead Time Provides Control Over Total Range
- Internal Regulator Provides a Stable 5-V Reference Supply With 5% Tolerance
- Circuit Architecture Allows Easy Synchronization



description

The TL494 incorporates all the functions required in the construction of a pulse-width-modulation (PWM) control circuit on a single chip. Designed primarily for power-supply control, this device offers the flexibility to tailor the power-supply control circuitry to a specific application.

The TL494 contains two error amplifiers, an on-chip adjustable oscillator, a dead-time control (DTC) comparator, a pulse-steering control flip-flop, a 5-V, 5%-precision regulator, and output-control circuits.

The error amplifiers exhibit a common-mode voltage range from -0.3 V to $V_{CC} - 2\text{ V}$. The dead-time control comparator has a fixed offset that provides approximately 5% dead time. The on-chip oscillator can be bypassed by terminating RT to the reference output and providing a sawtooth input to CT, or it can drive the common circuits in synchronous multiple-rail power supplies.

The uncommitted output transistors provide either common-emitter or emitter-follower output capability. The TL494 provides for push-pull or single-ended output operation, which can be selected through the output-control function. The architecture of this device prohibits the possibility of either output being pulsed twice during push-pull operation.

The TL494C is characterized for operation from 0°C to 70°C . The TL494I is characterized for operation from -40°C to 85°C .

AVAILABLE OPTIONS

TA	PACKAGED DEVICES				
	SMALL OUTLINE (D)	PLASTIC DIP (N)	SMALL OUTLINE (NS)	SHRINK SMALL OUTLINE (DB)	THIN SHRINK SMALL OUTLINE (PW)
0°C to 70°C	TL494CD	TL494CN	TL494CNS	TL494CDB	TL494CPW
-40°C to 85°C	TL494ID	TL494IN	—	—	—

The D, DB, NS, and PW packages are available taped and reeled. Add the suffix R to device type (e.g., TL494CDR).



Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.

PRODUCTION DATA information is current as of publication date. Products conform to specifications per the terms of Texas Instruments standard warranty. Production processing does not necessarily include testing of all parameters.

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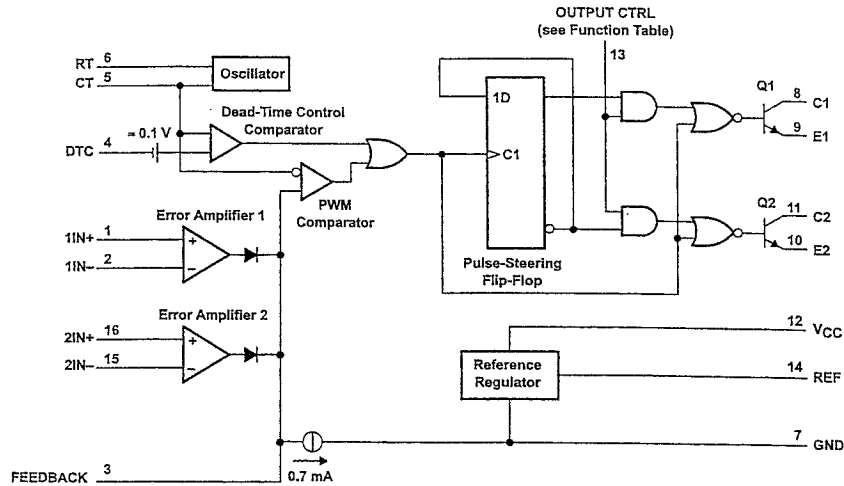
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TL494
PULSE-WIDTH-MODULATION CONTROL CIRCUITS

SLVS074D – JANUARY 1983 – REVISED MAY 2002

INPUT TO OUTPUT CTRL	OUTPUT FUNCTION
$V_I = \text{GND}$	Single-ended or parallel output
$V_I = V_{\text{ref}}$	Normal push-pull operation

functional block diagram



TL494
PULSE-WIDTH-MODULATION CONTROL CIRCUITS

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absolute maximum ratings over operating free-air temperature range (unless otherwise noted)†

Supply voltage, V_{CC} (see Note 1)	41 V
Amplifier input voltage, V_I	$V_{CC} + 0.3$ V
Collector output voltage, V_O	41 V
Collector output current, I_O	250 mA
Package thermal impedance, θ_{JA} (see Note 2 and 3):	
D package	73°C/W
DB package	82°C/W
N package	67°C/W
NS package	64°C/W
PW package	108°C/W
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds	260°C
Storage temperature range, T_{stg}	-65°C to 150°C

† Stresses beyond those listed under "absolute maximum ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under "recommended operating conditions" is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

- NOTES:
- All voltage values are with respect to the network ground terminal.
 - Maximum power dissipation is a function of $T_J(\text{max})$, θ_{JA} , and T_A . The maximum allowable power dissipation at any allowable ambient temperature is $P_D = (T_J(\text{max}) - T_A)/\theta_{JA}$. Operating at the absolute maximum T_J of 150°C can affect reliability.
 - The package thermal impedance is calculated in accordance with JESD 51-7.

recommended operating conditions

		MIN	MAX	UNIT
V_{CC}	Supply voltage	7	40	V
V_I	Amplifier input voltage	-0.3	$V_{CC}-2$	V
V_O	Collector output voltage		40	V
	Collector output current (each transistor)		200	mA
	Current into feedback terminal		0.3	mA
f_{osc}	Oscillator frequency	1	300	kHz
C_T	Timing capacitor	0.47	10000	nF
R_T	Timing resistor	1.8	500	k Ω
T_A	Operating free-air temperature			
		TL494C	0	70
		TL494I	-40	85

TL494
PULSE-WIDTH-MODULATION CONTROL CIRCUITS

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electrical characteristics over recommended operating free-air temperature range, $V_{CC} = 15\text{ V}$, $f = 10\text{ kHz}$ (unless otherwise noted)

reference section

PARAMETER	TEST CONDITIONS†	TL494C, TL494I			UNIT
		MIN	TYP‡	MAX	
Output voltage (REF)	$I_O = 1\text{ mA}$	4.75	5	5.25	V
Input regulation	$V_{CC} = 7\text{ V to }40\text{ V}$	2	25		mV
Output regulation	$I_O = 1\text{ mA to }10\text{ mA}$	1	15		mV
Output voltage change with temperature	$\Delta T_A = \text{MIN to MAX}$	2	10		mV/V
Short-circuit output current§	REF = 0 V	25			mA

† For conditions shown as MIN or MAX, use the appropriate value specified under recommended operating conditions.

‡ All typical values, except for parameter changes with temperature, are at $T_A = 25^\circ\text{C}$.

§ Duration of the short circuit should not exceed one second.

oscillator section, $C_T = 0.01\ \mu\text{F}$, $R_T = 12\ \text{k}\Omega$ (see Figure 1)

PARAMETER	TEST CONDITIONS†	TL494, TL494I			UNIT
		MIN	TYP‡	MAX	
Frequency			10		kHz
Standard deviation of frequency¶	All values of V_{CC} , C_T , R_T , and T_A constant		100		Hz/kHz
Frequency change with voltage	$V_{CC} = 7\text{ V to }40\text{ V}$, $T_A = 25^\circ\text{C}$		1		Hz/kHz
Frequency change with temperature#	$\Delta T_A = \text{MIN to MAX}$			10	Hz/kHz

† For conditions shown as MIN or MAX, use the appropriate value specified under recommended operating conditions.

‡ All typical values, except for parameter changes with temperature, are at $T_A = 25^\circ\text{C}$.

¶ Standard deviation is a measure of the statistical distribution about the mean as derived from the formula:

$$\sigma = \sqrt{\frac{\sum_{n=1}^N (x_n - \bar{x})^2}{N - 1}}$$

Temperature coefficient of timing capacitor and timing resistor are not taken into account.

error-amplifier section (see Figure 2)

PARAMETER	TEST CONDITIONS	TL494, TL494I			UNIT
		MIN	TYP‡	MAX	
Input offset voltage	$V_O(\text{FEEDBACK}) = 2.5\text{ V}$		2	10	mV
Input offset current	$V_O(\text{FEEDBACK}) = 2.5\text{ V}$		25	250	nA
Input bias current	$V_O(\text{FEEDBACK}) = 2.5\text{ V}$		0.2	1	μA
Common-mode input voltage range	$V_{CC} = 7\text{ V to }40\text{ V}$	-0.3 to $V_{CC}-2$			V
Open-loop voltage amplification	$\Delta V_O = 3\text{ V}$, $R_L = 2\ \text{k}\Omega$, $V_O = 0.5\text{ V to }3.5\text{ V}$	70	95		dB
Unity-gain bandwidth	$V_O = 0.5\text{ V to }3.5\text{ V}$, $R_L = 2\ \text{k}\Omega$		800		kHz
Common-mode rejection ratio	$\Delta V_O = 40\text{ V}$, $T_A = 25^\circ\text{C}$	65	80		dB
Output sink current (FEEDBACK)	$V_{ID} = -15\text{ mV to }-5\text{ V}$, $V(\text{FEEDBACK}) = 0.7\text{ V}$	0.3	0.7		mA
Output source current (FEEDBACK)	$V_{ID} = 15\text{ mV to }5\text{ V}$, $V(\text{FEEDBACK}) = 3.5\text{ V}$	-2			mA

‡ All typical values, except for parameter changes with temperature, are at $T_A = 25^\circ\text{C}$.

TL494
PULSE-WIDTH-MODULATION CONTROL CIRCUITS

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electrical characteristics over recommended operating free-air temperature range, $V_{CC} = 15\text{ V}$, $f = 10\text{ kHz}$ (unless otherwise noted)

output section

PARAMETER	TEST CONDITIONS	MIN	TYP†	MAX	UNIT
Emitter off-state current	$V_{CC} = V_C = 40\text{ V}$, $V_E = 0$			-100	μA
Collector-emitter saturation voltage	Common emitter	$V_E = 0$, $I_C = 200\text{ mA}$	1.1	1.3	V
	Emitter follower	$V_O(C1\text{ or }C2) = 15\text{ V}$, $I_E = -200\text{ mA}$	1.5	2.5	
Output control input current	$V_I = V_{ref}$			3.5	mA

† All typical values except for temperature coefficient are at $T_A = 25^\circ\text{C}$.

dead-time control section (see Figure 1)

PARAMETER	TEST CONDITIONS	MIN	TYP†	MAX	UNIT
Input bias current (DEAD-TIME CTRL)	$V_I = 0\text{ to }5.25\text{ V}$		-2	-10	μA
Maximum duty cycle, each output	$V_I(\text{DEAD-TIME CTRL}) = 0$, $C_T = 0.01\ \mu\text{F}$, $R_T = 12\ \text{k}\Omega$		45%		
Input threshold voltage (DEAD-TIME CTRL)	Zero duty cycle		3	3.3	V
	Maximum duty cycle		0		

† All typical values except for temperature coefficient are at $T_A = 25^\circ\text{C}$.

PWM comparator section (see Figure 1)

PARAMETER	TEST CONDITIONS	MIN	TYP†	MAX	UNIT
Input threshold voltage (FEEDBACK)	Zero duty cycle		4	4.5	V
Input sink current (FEEDBACK)	$V(\text{FEEDBACK}) = 0.7\text{ V}$	0.3	0.7		mA

† All typical values except for temperature coefficient are at $T_A = 25^\circ\text{C}$.

total device

PARAMETER	TEST CONDITIONS	MIN	TYP†	MAX	UNIT
Standby supply current	$R_T = V_{ref}$, All other inputs and outputs open	$V_{CC} = 15\text{ V}$	6	10	mA
		$V_{CC} = 40\text{ V}$	9	15	
Average supply current	$V_I(\text{DEAD-TIME CTRL}) = 2\text{ V}$, See Figure 1		7.5		mA

† All typical values except for temperature coefficient are at $T_A = 25^\circ\text{C}$.

switching characteristics, $T_A = 25^\circ\text{C}$

PARAMETER	TEST CONDITIONS	MIN	TYP†	MAX	UNIT
Rise time	Common-emitter configuration, See Figure 3		100	200	ns
Fall time		25	100		
Rise time	Emitter-follower configuration, See Figure 4		100	200	ns
Fall time		40	100		

† All typical values except for temperature coefficient are at $T_A = 25^\circ\text{C}$.

PARAMETER MEASUREMENT INFORMATION

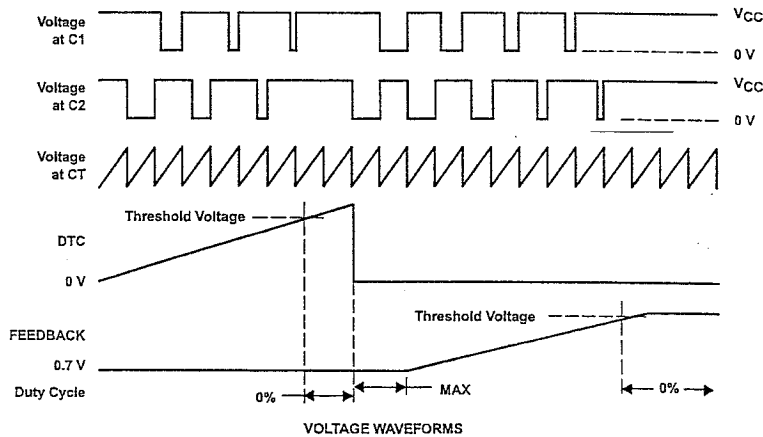
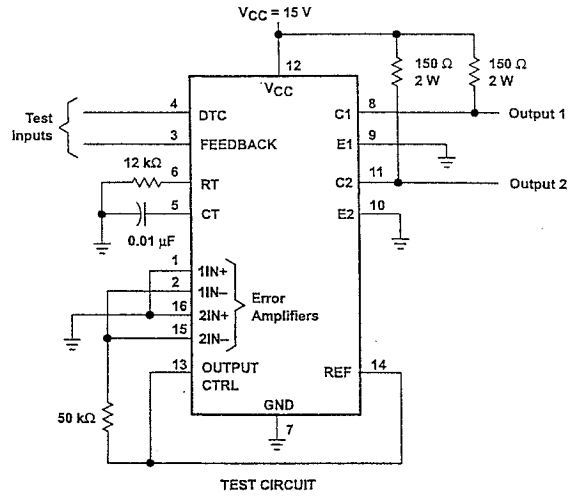


Figure 1. Operational Test Circuit and Waveforms

PARAMETER MEASUREMENT INFORMATION

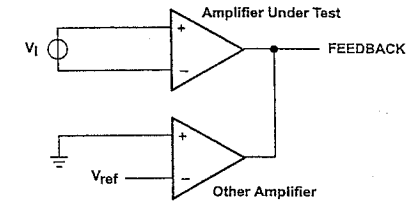
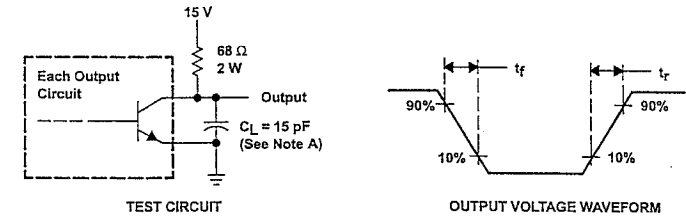
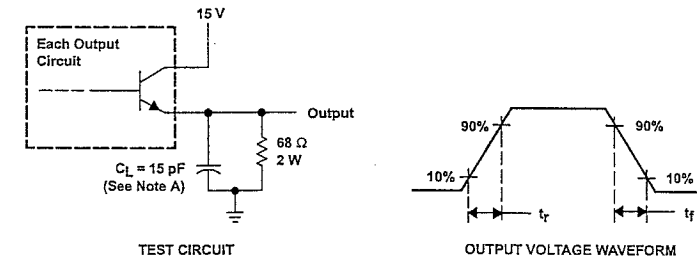


Figure 2. Amplifier Characteristics



NOTE A: C_L includes probe and jig capacitance.

Figure 3. Common-Emitter Configuration



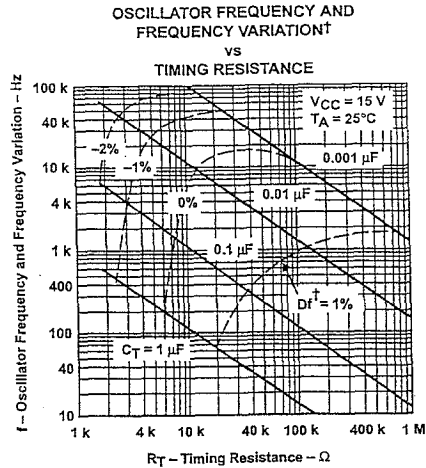
NOTE A: C_L includes probe and jig capacitance.

Figure 4. Emitter-Follower Configuration

TL494
PULSE-WIDTH-MODULATION CONTROL CIRCUITS

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TYPICAL CHARACTERISTICS



† Frequency variation (Δf) is the change in oscillator frequency that occurs over the full temperature range.

Figure 5

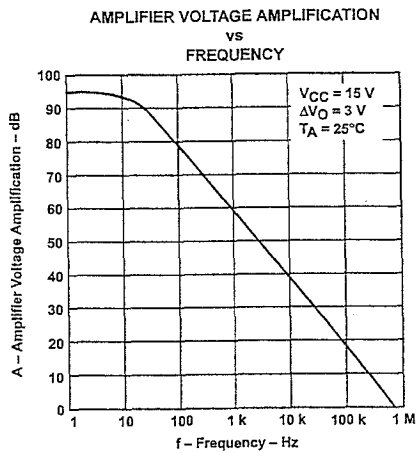


Figure 6

2953 AND
2954

Data Sheet
2953/9,2/8

FULL-BRIDGE
PWM MOTOR DRIVERS

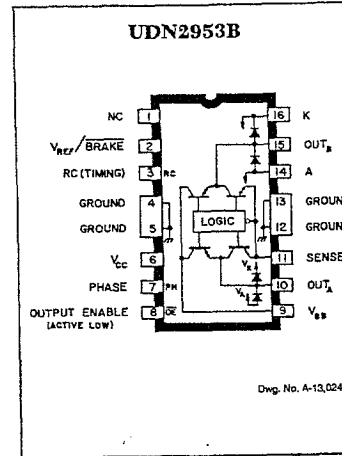
The UDN2953B and UDN2954W are designed for bidirectional control of dc or stepper motors with continuous output currents to 2 A and peak start-up currents as high as 3.5 A. For pulse-width modulated (chopped-mode) operation, the output current is determined by the user's selection of a reference voltage and sensing resistor while the OFF pulse duration is set by an external RC timing network. PWM operation is characterized by maximum efficiency and low power-dissipation levels. Extensive internal circuit protection includes thermal shutdown with hysteresis, transient-suppression diodes, and crossover current protection.

When the $V_{REF}/BRAKE$ pin is low (<0.8 V), the braking function is enabled. This turns both sink drivers OFF and the source drivers are turned ON. When $V_{REF}/BRAKE$ is set above 2.4 V, that voltage (and the current sensing resistor) determines the load current trip point. An RC TIMING pin is available to use for an internal one-shot to control load current decay time.

The UDN2953B driver is supplied in a 16-pin dual-in-line plastic package with copper heat-sink contact tabs. The lead configuration enables easy attachment of a heat sink while fitting a standard integrated circuit socket or printed wiring board layout. The UDN2954W, for higher package power dissipation requirements, is supplied in a 12-pin single in-line power tab package. In both package styles, the heat sink is at ground potential and needs no insulation.

FEATURES

- 50 V Output Voltage Rating
- 2 A Continuous Output Rating
- Internal Flyback Diodes
- Thermal Shutdown
- Crossover Current Protection
- BRAKE, ENABLE, and Current-Limit Functions



Dwg. No. A-13,024

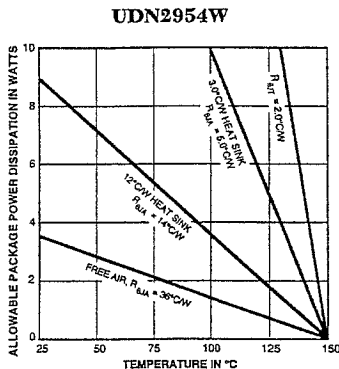
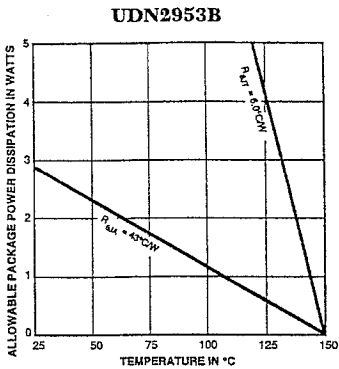
ABSOLUTE MAXIMUM RATINGS
at $T_J \leq +150^\circ\text{C}$

Motor Supply Voltage, V_{BB}	50 V
Output Current, I_{OUT}	
(Peak)	± 3.5 A
(Continuous)	± 2.0 A
Flyback Diode Voltage, V_K	V_{BB}
Minimum Clamp Diode Voltage, V_A	Ground
Logic Supply Voltage, V_{CC}	7.0 V
Logic Input Voltage, V_{PHASE} , V_{ENABLE}	V_{BB}
Sense Voltage, V_{SENSE}	1.5 V
Reference Voltage, $V_{REF}/BRAKE$	15 V
Package Power Dissipation, P_D	See Graphs
Operating Temperature Range, T_A	-20°C to $+85^\circ\text{C}$
Storage Temperature Range, T_S	-55°C to $+150^\circ\text{C}$

Always order by complete part number:

Part Number	Package
UDN2953B	16-Pin DIP
UDN2954W	12-Pin Power-Tab SIP

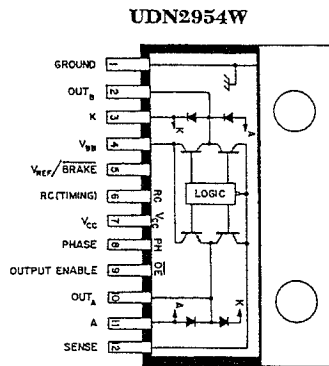
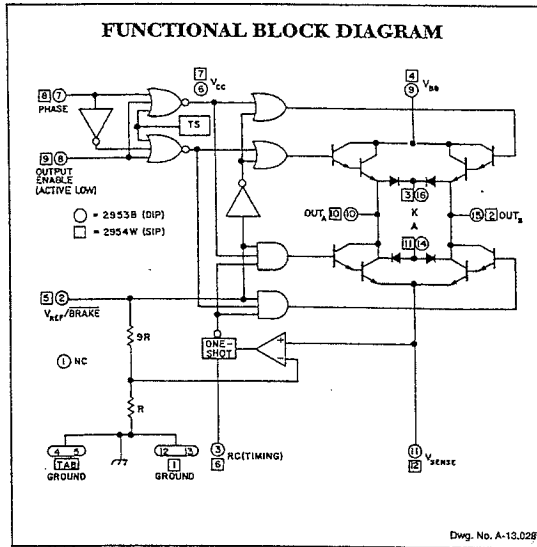
2953 AND 2954 FULL-BRIDGE PWM MOTOR DRIVERS



TRUTH TABLE

Output Enable	Phase	V _{REF} /BRAKE	Out _A	Out _B
Low	High	> 2.4 V	High	Low
Low	Low	> 2.4 V	Low	High
High	X	> 2.4 V	Open	Open
X	X	< 0.8 V	High	High

X = Irrelevant



2953 AND 2954 FULL-BRIDGE PWM MOTOR DRIVERS

ELECTRICAL CHARACTERISTICS at T_A = +25°C, T_J ≤ +150°C, V_{BB} = 50 V, V_{CC} = 5 V, V_{SENSE} = 0 V, RC = 20 kΩ/470 pF to Ground.

Characteristic	Symbol	Test Conditions	Limits			
			Min.	Typ.	Max.	Units
Output Drivers (OUT_A or OUT_B)						
Output Supply Range	V _{BB}		6.5	—	50	V
Output Leakage Current	I _{CEX}	V _{ENABLE} = 5 V, V _{OUT} = V _{BB} , (note)	—	—	50	μA
		V _{ENABLE} = 5 V, V _{OUT} = 0 V, (note)	—	—	-50	μA
Output Sustaining Voltage	V _{CE(SUS)}	I _{OUT} = ±2 A, L = 2 mH	50	—	—	V
Output Saturation Voltage	V _{CE(SAT)}	V _{ENABLE} = 0 V, I _{OUT} = ±0.5 A	—	1.0	1.2	V
		V _{ENABLE} = 0 V, I _{OUT} = ±1.0 A	—	1.2	1.4	V
		V _{ENABLE} = 0 V, I _{OUT} = ±2.0 A	—	1.5	1.8	V
Clamp Diode Leakage Current	I _R	V _R = 50 V	—	—	50	μA
Clamp Diode Forward Voltage	V _F	I _F = 2 A	—	1.8	2.2	V
Motor Supply Current	I _{BB(CN)} I _{BB(OFF)}	V _{ENABLE} = 0.8 V, V _{REF} = 2.4 V, No Load	—	20	30	mA
		V _{ENABLE} = V _{REF} = 2.4 V, No Load	—	2.5	3.5	mA
		V _{ENABLE} = 5 V, V _{REF} = 0.8 V, No Load	—	40	60	mA

Control Logic

Logic Supply Range	V _{CC}		4.5	5.0	5.5	V
Logic Input Current	I _{IN(1)} I _{IN(0)}	All inputs = 2.4 V	—	<-1.0	-10	μA
		All inputs = 0.8 V	—	-50	-200	μA
Logic Input Voltage	V _{IN(1)} V _{IN(0)}	All inputs	2.4	—	—	V
		All inputs	—	—	0.8	V
V _{REF} Open-Circuit Voltage	V _{REF(OOPEN)}	I _{REF} = 0	—	V _{CC} /2	—	V
Current Limit Threshold	V _{REF} /V _{SENSE} at Trip Point		9.5	10	10.5	—
Turn-On Delay	t _{on}	All Drivers	—	1.0	—	μs
Turn-Off Delay	t _{off}	All Drivers	—	1.0	—	μs
Thermal Shutdown Temp.	T _J		—	165	—	°C
Logic Supply Current	I _{CC}	V _{ENABLE} = V _{REF} = 2.4 V	—	15	20	mA
		V _{ENABLE} = 0.8 V, V _{REF} = 2.4 V	—	22	30	mA

NOTE: Tests performed at OUT_B with V_{PHASE} = 0.8 V and at OUT_A with V_{PHASE} = 2.4 V



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2953 AND 2954 FULL-BRIDGE PWM MOTOR DRIVERS

APPLICATIONS INFORMATION

The UDN2953B and UDN2954W full-bridge motion control ICs are designed for pulse-width-modulated (PWM) bidirectional interface to many types of dc (brush) servo, brushless dc, and 2-phase stepper motors. These power ICs permit various techniques of direct motor interface and offer internally and externally programmed current control. Pulse-width-modulated output current can be regulated by an (external) PWM control signal or use of an external sensing resistor (R_{SENSE}) in combination with an RC network and/or voltage reference.

The output current trip point or sense resistor formulas are:

$$I_{TRIP} = \frac{V_{REF}}{10 R_{SENSE}}$$

$$R_{SENSE} = \frac{V_{REF}}{10 I_{TRIP}}$$

The allowable reference voltage range is from 2.4 V to 15 V. If unconnected, the reference input (V_{REF}) defaults to $V_{CC}/2$ (refer to Figure 1) and $I_{TRIP} = 0.5$ A (per typical application where $R_S = 0.5 \Omega$).

When the motor current attains the specified design value, the internal comparator triggers the monostable ('one-shot') multivibrator, which disables (switches OFF) the sink (lower) output. The actual load current may vary slightly, and the difference is (chiefly) related to the circuit propagation delays between comparator (trip point) command and power output switching. Applications involving very-low inductance windings may necessitate specific consideration; typical circuit delays (t_d) are about 2 μ s.

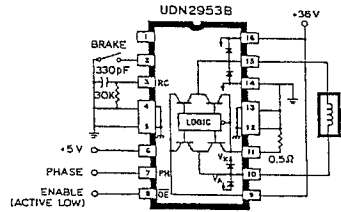
After the sink ('low-side') output is switched OFF, motor current starts to decay, and the circulation path is through the ON source (upper) drive output and the flyback diode protecting the sink (lower) output. The output OFF interval is set by an external RC timing network connected to the monostable. The magnitude of the current decay is directly related to the OFF period and the duration should allow the current level to drop below the trip point before reactivating the sink output. This ON-OFF PWM cycle repeats, sustaining the desired average current to the motor winding, and continues free-running until a new input command switches the output state. The RC network values range from 20 k Ω to 100 k Ω for resistors, and capacitor values from 200 pF to 500 pF. The parallel RC network establishes the t_{OFF} interval and directly affects the decaying motor current.

Internal timing circuitry is an alternative to the external RC timing network. However, with internal timing the logic supply current rises approximately 6 mA. Connecting the RC input to the logic supply activates internal circuitry; $t_{OFF} = 12 \mu$ s with $V_{CC} = +5$ V and $T_A = +25$ C, and increases with temperature.

The sink (lower) output is repeatedly re-enabled until the motor is reversed, braked, or stopped. Current control via pulse modulating the lower outputs is based on the dynamic characteristics of the much faster NPN Darlington outputs.

Another method of controlling motor current involves external circuitry to pulse modulate the OUTPUT ENABLE pin. Switching

TYPICAL APPLICATION



Dwg. No. A-12,649B

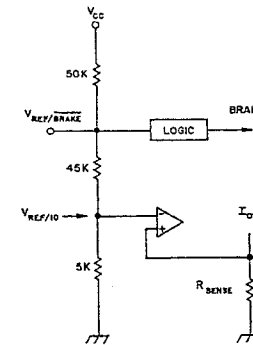
NOTE: Pin 3 must be connected to an RC network as shown, or to V_{CC} . It must NOT be left unconnected.

(toggling) the OUTPUT ENABLE affects both the sink (low-side) and upper (high-side) outputs. Both lower and upper transient-protection diodes conduct during the OFF interval. This method of operation produces very rapid current decay. The sink driver parallel diodes (common anode pin) are connected to ground; the source output flyback diodes (common cathode pin) are connected to the motor supply (V_{BB}). The RC input pin is to be terminated to ground through 20 k Ω (minimum).

The motor is braked by simultaneously activating both source driver outputs and disabling both sink outputs. Basically, this shorts both terminals of the motor winding to the supply. The back EMF (electromotive force) of the motor develops current which functions as a dynamic brake. Typically, the braking current approaches the values related to a locked rotor (or stall) condition. Fundamentally, locked rotor (or stall) current is dependent upon the motor winding impedance and driver output ON characteristics. Internal current control circuitry is not operational during braking. Therefore, designers should exercise caution to ensure that the current produced by the back EMF does not exceed the absolute maximum ratings of the power outputs.

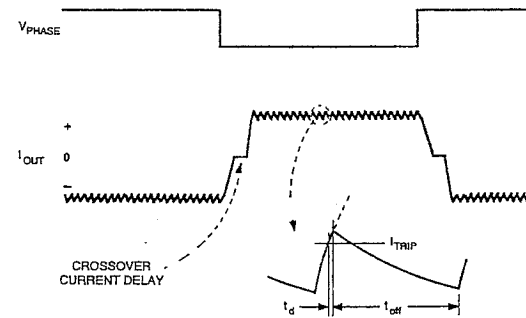
2953 AND 2954 FULL-BRIDGE PWM MOTOR DRIVERS

Figure 1



Dwg. No. A-13,025

Figure 2



Dwg. WM-003-1

In bidirectional drive applications, especially dc (brush) servos, the PHASE input is utilized for direction control. The current generated by back EMF at reversal is comparable to that of dynamic braking, and should be limited to the absolute maximum output current rating.

An internally generated deadtime (approximately 3 μ s) precludes the high crossover (or 'shoot-through') currents associated with momentary, overlapping conduction of both upper and lower outputs. This very abrupt, coincident-ON mode occurs with change of direction (PHASE reversal) and/or dynamic braking.

Integrated thermal shutdown protection circuitry switches OFF all power outputs should the junction temperature exceed +165°C (typical). The thermal protection is designed to avoid power IC failures stemming from extreme, excessive junction heating. Thermal shutdown self protection does not afford a proper safeguard from shorted load and/or shorted output conditions, and should not be operated as such. The thermal self-protection circuitry has a (typical) hysteresis of 8°C.

The printed wiring board should utilize a large, heavy ground plane. To optimize power IC performance, the package should be soldered directly into the circuit board. The ground side of R_S should have an individual path to the ground terminal(s) of the device. Also, the load supply (V_{BB}) should be closely decoupled with an electrolytic capacitor of between 10 μ F and 100 μ F (typically $\geq 47 \mu$ F) depending on printed wiring board layout.

CURRENT CONTROL OPTIONS

Control Option	Circuit Terminal			
	$V_{REF}/BRAKE$	RC (TIMING)	V_{SENSE}	OUTPUT ENABLE
No PWM	V_{CC} or High	≥ 20 k Ω to Ground	Ground	Low
PWM with Internal Timing	V_{CC} or High	V_{CC}	R_{SENSE}	Low
PWM with External Timing	2.4 V or 15 V* or V_{CC}	20-100 k Ω /200-500 pF	R_{SENSE}	Low
External PWM	V_{CC} or High	≥ 20 k Ω to Ground	R_{SENSE}^\dagger	Toggle †

* Programmed reference, i.e., A/D converter.

† Primarily, closed-loop speed and/or current control applications. I_{TRIP} can be peak (or default) limit for protecting motor and/or driver IC.



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