

# TP5088

*TP5088 DTMF Generator for Binary Data*



Literature Number: SNOSBC2A



## Absolute Maximum Ratings

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

Supply Voltage ( $V_{DD} - V_{SS}$ )	12V
MUTE Voltage	12V
Maximum Voltage at Any Other Pin	$V_{DD} + 0.3V$ to $V_{SS} - 0.3V$

Operating Temperature, $T_A$	-30°C to +70°C
Storage Temperature	-55°C to +150°C
Maximum Power Dissipation	500 mW

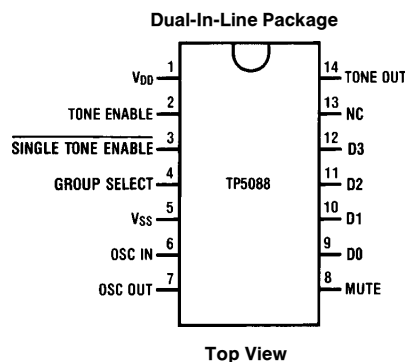
## Electrical Characteristics

Unless otherwise noted, limits printed in **BOLD** characters are guaranteed for  $V_{DD} = 3.5V$  to  $8V$ ,  $T_A = 0^\circ C$  to  $+70^\circ C$  by correlation with 100% electrical testing at  $T_A = 25^\circ C$ . All other limits are assured by correlation with other production tests and/or product design and characterization.

Parameter	Conditions	Min	Typ	Max	Units
Minimum Supply Voltage, $V_{DD}$ (min)	Generating Tones	<b>3.5</b>			V
Minimum Supply Voltage for Data Input, TONE ENABLE and MUTE Logic Functions		2			V
Operating Current Idle	$R_L = \infty$ , D0-D3 Open		55	<b>350</b>	$\mu A$
Generating Tones	$V_{DD} = 3.5V$ , Mute Open		1.5	<b>2.5</b>	mA
Input Pull-Up Resistance D0-D3			100		k $\Omega$
TONE ENABLE			50		k $\Omega$
Input Low Level TONE ENABLE, D0-D3				<b>0.2 <math>V_{DD}</math></b>	V
Input High Level TONE ENABLE, D0-D3		<b>0.8 <math>V_{DD}</math></b>			V
MUTE OUT Sink Current (TONE ENABLE LOW)	$V_{DD} = 3.5V$ $V_o = 0.5V$	<b>0.4</b>			mA
MUTE OUT Leakage Current (TONE ENABLE HIGH)	$V_{DD} = 3.5V$ $V_o = V_{DD}$		1		$\mu A$
Output Amplitudes Low Group	$R_L = 240 \Omega$ $V_{DD} = 3.5V$ $T_A = 25^\circ C$	<b>130</b>	170	<b>220</b>	mVrms
High Group		<b>180</b>	230	<b>310</b>	mVrms
Mean Output DC Offset	$V_{DD} = 3.5V$ $V_{DD} = 8V$		1.2 3.6		V V
High Group Pre-Emphasis		<b>2.2</b>	2.7	<b>3.2</b>	dB
Dual Tone/Total Harmonic Distortion Ratio	1 MHz Bandwidth, $V_{DD} = 5V$ $R_L = 240\Omega$	<b>-20</b>			dB
Start-Up Time (to 90% Amplitude), $t_{OSC}$			4		ms
Data Set-Up Time, $t_S$ (Figure 2)	$V_{DD} = 5V$	100			ns
Data Hold Time, $t_H$	$V_{DD} = 5V$	280			ns
Data Duration $t_W$	$V_{DD} = 5V$	600			ns

**Note 1:**  $R_L$  is the external load resistor connected from TONE OUT to  $V_{SS}$ .

## Connection Diagram



TL/H/5004-2

Order Number TP5088WM or TP5088N  
See NS Package M14B or N14A

## Functional Description

With the TONE ENABLE pin pulled low, the device is in a low power idle mode, with the oscillator inhibited and the output transistor turned off. Data on inputs D0–D3 is ignored until a rising transition on TONE ENABLE. Data meeting the timing specifications is latched in, the oscillator and output stage are enabled, and tone generation begins. The decoded data sets the high group and low group programmable counters to the appropriate divide ratios. These counters sequence two ratioed-capacitor D/A converters through a series of 28 equal duration steps per sine wave cycle. On-chip regulators ensure good stability of tone amplitudes with variations in supply voltage and temperature. The two tones are summed by a mixer amplifier, with pre-emphasis applied to the high group tone. The output is an NPN emitter-follower requiring the addition of an external load resistor to  $V_{SS}$ .

Table I shows the accuracies of the tone output frequencies and Table II is the Functional Truth Table.

**TABLE I. Output Frequency Accuracy**

Tone Group	Standard DTMF (Hz)	Tone Output Frequency	% Deviation from Standard
Low Group	697	694.8	-0.32
	770	770.1	+0.02
	$f_L$	852	+0.03
		941	-0.11
High Group	1209	1206.0	-0.24
	1336	1331.7	-0.32
	$f_H$	1477	+0.64
		1633	+0.37

## Pin Descriptions

**$V_{DD}$  (Pin 1):** This is the positive supply to the device, referenced to  $V_{SS}$ . The collector of the TONE OUT transistor is also connected to this pin.

**$V_{SS}$  (Pin 5):** This is the negative voltage supply. All voltages are referenced to this pin.

**OSC IN, OSC OUT (Pins 6 and 7):** All tone generation timing is derived from the on-chip oscillator circuit. A low-cost

3.579545 MHz A-cut crystal (NTSC TV color-burst) is needed between pins 6 and 7. Load capacitors and a feedback resistor are included on-chip for good start-up and stability. The oscillator is stopped when the TONE ENABLE input is pulled to logic low.

**TONE ENABLE Input (Pin 2):** This input has an internal pull-up resistor. When TONE ENABLE is pulled to logic low, the oscillator is inhibited and the tone generators and output transistor are turned off. A low to high transition on TONE ENABLE latches in data from D0–D3. The oscillator starts, and tone generation continues until TONE ENABLE is pulled low again.

**MUTE (Pin 8):** This output is an open-drain N-channel device that sinks current to  $V_{SS}$  when TONE ENABLE is low and no tones are being generated. The device turns off when TONE ENABLE is high.

**D0, D1, D2, D3 (Pins 9, 10, 11, 12):** These are the inputs for binary-coded data, which is latched in on the rising edge of TONE ENABLE. Data must meet the timing specifications of Figure 2. At all other times these inputs are ignored and may be multiplexed with other system functions.

**TONE OUT (Pin 14):** This output is the open emitter of an NPN transistor, the collector of which is connected internally to  $V_{DD}$ . When an external load resistor is connected from TONE OUT to  $V_{SS}$ , the output voltage on this pin is the sum of the high and low group tones superimposed on a DC offset. When not generating tones, this output transistor is turned off to minimize the device idle current.

**SINGLE TONE ENABLE (Pin 3):** This input has an internal pull-up resistor. When pulled to  $V_{SS}$ , the device is in single tone mode and only a single tone will be generated at pin 14 (for testing purposes). For normal operation, leave this pin open-circuit or pull to  $V_{DD}$ .

**GROUP SELECT (Pin 4):** This pin is used to select the high group or low group frequency when the device is in single tone mode. It has an internal pull-up resistor. Leaving this pin open-circuit or pulling it to  $V_{DD}$  will generate the high group, while pulling to  $V_{SS}$  will generate the low group frequency at the TONE OUT pin.

TABLE II. Functional Truth Table

Keyboard Equivalent	Data Inputs				TONE ENABLE	TONES OUT		MUTE
	D3	D2	D1	D0		f <sub>L</sub> (Hz)	f <sub>H</sub> (Hz)	
X	X	X	X	X	0	0V	0V	0V
1	0	0	0	1	↗	697	1209	O/C
2	0	0	1	0	↘	697	1336	O/C
3	0	0	1	1	↗	697	1477	O/C
4	0	1	0	0	↘	770	1209	O/C
5	0	1	0	1	↗	770	1336	O/C
6	0	1	1	0	↘	770	1477	O/C
7	0	1	1	1	↗	852	1209	O/C
8	1	0	0	0	↘	852	1336	O/C
9	1	0	0	1	↗	852	1477	O/C
0	1	0	1	0	↘	941	1336	O/C
*	1	0	1	1	↗	941	1209	O/C
#	1	1	0	0	↘	941	1477	O/C
A	1	1	0	1	↗	697	1633	O/C
B	1	1	1	0	↘	770	1633	O/C
C	1	1	1	1	↗	852	1633	O/C
D	0	0	0	0	↘	941	1633	O/C

Timing Diagram

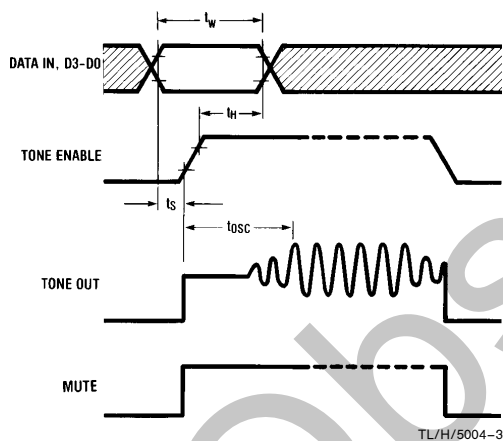
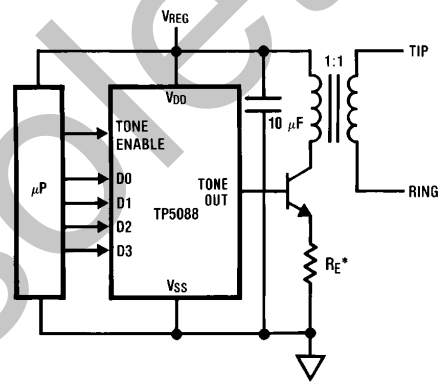


FIGURE 2

Typical Application

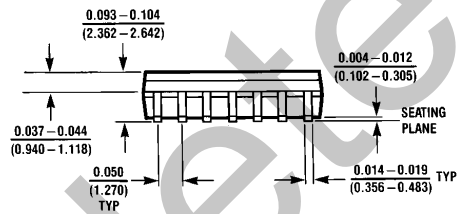
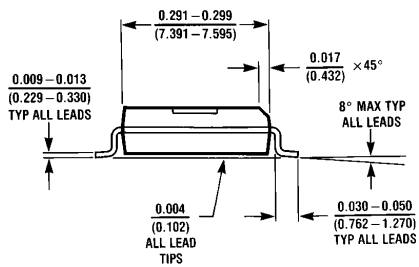
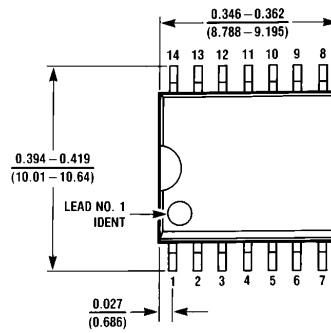


\*Adjust  $R_E$  for desired tone amplitude.

FIGURE 3

TL/H/5004-4

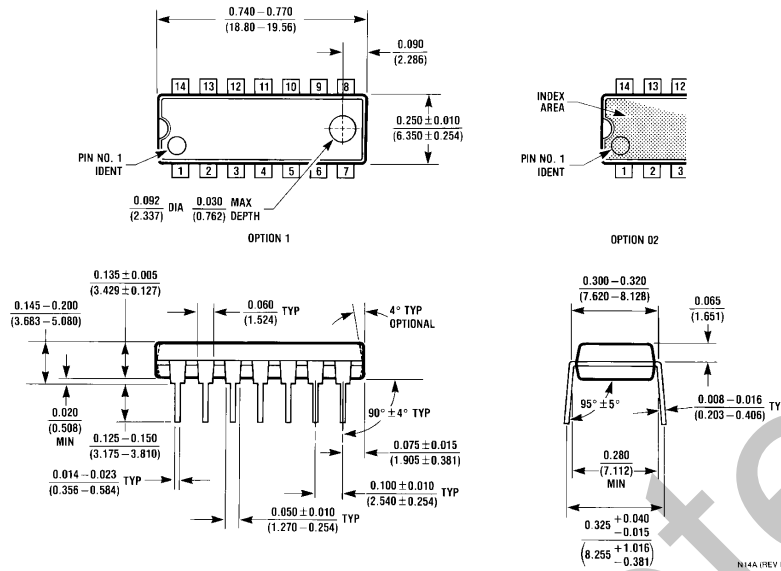
**Physical Dimensions** inches (millimeters)



M14B (REV D)

Order Number TP5088WM  
NS Package Number M14B

**Physical Dimensions** inches (millimeters) (Continued)



**Molded Dual-In-Line (N)  
Order Number TP5088N  
NS Package Number N14A**

**LIFE SUPPORT POLICY**

NATIONAL'S PRODUCTS ARE NOT AUTHORIZED FOR USE AS CRITICAL COMPONENTS IN LIFE SUPPORT DEVICES OR SYSTEMS WITHOUT THE EXPRESS WRITTEN APPROVAL OF THE PRESIDENT OF NATIONAL SEMICONDUCTOR CORPORATION. As used herein:

1. Life support devices or systems are devices or systems which, (a) are intended for surgical implant into the body, or (b) support or sustain life, and whose failure to perform, when properly used in accordance with instructions for use provided in the labeling, can be reasonably expected to result in a significant injury to the user.
2. A critical component is any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.



**National Semiconductor Corporation**  
1111 West Bardin Road  
Arlington, TX 76017  
Tel: 1(800) 272-9959  
Fax: 1(800) 737-7018

**National Semiconductor Europe**  
Fax: (+49) 0-180-530 85 86  
Email: cnjwge@tevm2.nsc.com  
Deutsch Tel: (+49) 0-180-530 85 85  
English Tel: (+49) 0-180-532 78 32  
Français Tel: (+49) 0-180-532 93 58  
Italiano Tel: (+49) 0-180-534 16 80

**National Semiconductor Hong Kong Ltd.**  
19th Floor, Straight Block,  
Ocean Centre, 5 Canton Rd.  
Tsimshatsui, Kowloon  
Hong Kong  
Tel: (852) 2737-1600  
Fax: (852) 2736-9960

**National Semiconductor Japan Ltd.**  
Tel: 81-043-299-2309  
Fax: 81-043-299-2408

National does not assume any responsibility for use of any circuitry described, no circuit patent licenses are implied and National reserves the right at any time without notice to change said circuitry and specifications.

## IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All products are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its hardware products to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by government requirements, testing of all parameters of each product is not necessarily performed.

TI assumes no liability for applications assistance or customer product design. Customers are responsible for their products and applications using TI components. To minimize the risks associated with customer products and applications, customers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any TI patent right, copyright, mask work right, or other TI intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information published by TI regarding third-party products or services does not constitute a license from TI to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. Reproduction of this information with alteration is an unfair and deceptive business practice. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI products or services with statements different from or beyond the parameters stated by TI for that product or service voids all express and any implied warranties for the associated TI product or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

TI products are not authorized for use in safety-critical applications (such as life support) where a failure of the TI product would reasonably be expected to cause severe personal injury or death, unless officers of the parties have executed an agreement specifically governing such use. Buyers represent that they have all necessary expertise in the safety and regulatory ramifications of their applications, and acknowledge and agree that they are solely responsible for all legal, regulatory and safety-related requirements concerning their products and any use of TI products in such safety-critical applications, notwithstanding any applications-related information or support that may be provided by TI. Further, Buyers must fully indemnify TI and its representatives against any damages arising out of the use of TI products in such safety-critical applications.

TI products are neither designed nor intended for use in military/aerospace applications or environments unless the TI products are specifically designated by TI as military-grade or "enhanced plastic." Only products designated by TI as military-grade meet military specifications. Buyers acknowledge and agree that any such use of TI products which TI has not designated as military-grade is solely at the Buyer's risk, and that they are solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI products are neither designed nor intended for use in automotive applications or environments unless the specific TI products are designated by TI as compliant with ISO/TS 16949 requirements. Buyers acknowledge and agree that, if they use any non-designated products in automotive applications, TI will not be responsible for any failure to meet such requirements.

Following are URLs where you can obtain information on other Texas Instruments products and application solutions:

### Products

Audio	<a href="http://www.ti.com/audio">www.ti.com/audio</a>
Amplifiers	<a href="http://amplifier.ti.com">amplifier.ti.com</a>
Data Converters	<a href="http://dataconverter.ti.com">dataconverter.ti.com</a>
DLP® Products	<a href="http://www.dlp.com">www.dlp.com</a>
DSP	<a href="http://dsp.ti.com">dsp.ti.com</a>
Clocks and Timers	<a href="http://www.ti.com/clocks">www.ti.com/clocks</a>
Interface	<a href="http://interface.ti.com">interface.ti.com</a>
Logic	<a href="http://logic.ti.com">logic.ti.com</a>
Power Mgmt	<a href="http://power.ti.com">power.ti.com</a>
Microcontrollers	<a href="http://microcontroller.ti.com">microcontroller.ti.com</a>
RFID	<a href="http://www.ti-rfid.com">www.ti-rfid.com</a>
OMAP Mobile Processors	<a href="http://www.ti.com/omap">www.ti.com/omap</a>
Wireless Connectivity	<a href="http://www.ti.com/wirelessconnectivity">www.ti.com/wirelessconnectivity</a>

### Applications

Communications and Telecom	<a href="http://www.ti.com/communications">www.ti.com/communications</a>
Computers and Peripherals	<a href="http://www.ti.com/computers">www.ti.com/computers</a>
Consumer Electronics	<a href="http://www.ti.com/consumer-apps">www.ti.com/consumer-apps</a>
Energy and Lighting	<a href="http://www.ti.com/energy">www.ti.com/energy</a>
Industrial	<a href="http://www.ti.com/industrial">www.ti.com/industrial</a>
Medical	<a href="http://www.ti.com/medical">www.ti.com/medical</a>
Security	<a href="http://www.ti.com/security">www.ti.com/security</a>
Space, Avionics and Defense	<a href="http://www.ti.com/space-avionics-defense">www.ti.com/space-avionics-defense</a>
Transportation and Automotive	<a href="http://www.ti.com/automotive">www.ti.com/automotive</a>
Video and Imaging	<a href="http://www.ti.com/video">www.ti.com/video</a>

TI E2E Community Home Page

[e2e.ti.com](http://e2e.ti.com)

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265  
Copyright © 2011, Texas Instruments Incorporated