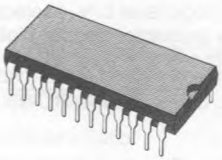
SGS-THOMSON MICROELECTRONICS

MK5376

TEN-NUMBER REPERTORY TONE/PULSE DIALER

- CONVERTS PUSH-BUTTON INPUTS TO BOTH DTMF AND PULSE SIGNALS
- STORES TEN 16-DIGIT TELEPHONE NUMBERS INCLUDING LAST NUMBER DIALED
- PACIFIER TONE AND PBX PAUSE
- LAST NUMBER DIALED (LND) PRIVACY
- MANUAL AND AUTO-DIALED DIGITS MAY BE CASCADED
- ABILITY TO STORE AND DIAL BOTH * AND # DTMF SIGNALS



DIP-24

ORDER CODE : MK5376N00

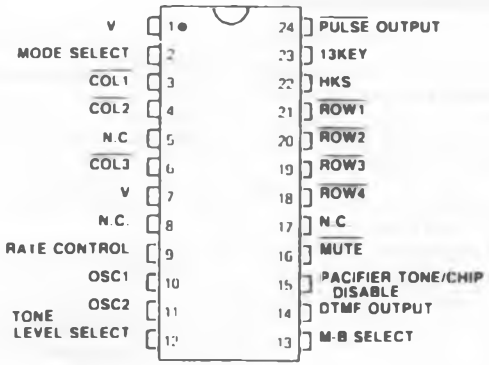
DESCRIPTION

The MK5376 is a monolithic, integrated circuit manufactured using Silicon Gate CMOS process. This circuit provides the necessary signals for either DTMF or loop disconnect dialing. Ten telephone numbers of up to 16 digits each may be stored in the on-chip RAM. Manual and auto-dialed numbers may be cascaded in any order.

Additional functions available are a Pacifier Tone output, PABX pause, external control of the signaling rate, and total functional control with either a standard 3 x 4 matrix keypad (FORM-A) or a 2-of-7 keyboard. A 13th key option allows control of the dialer's repertory features. The telephone keypad then functions for signaling purposes only, independent of the repertory functions. The 13th key mode and the M-B (Make/Break) Ratio is user selectable.

The dialer's flexibility provides for many applications, for example, off-hook programming, the use of additional chips in parallel for 10, 20, and 30 number repertory phones, permanent memory protection and the option of a supply-independent or supply-dependent tone level.

PIN CONNECTION



FUNCTIONAL DESCRIPTION

V+

Pin 1. Pin 1 is the positive supply for the circuit and must meet the voltage requirements defined in the Electrical Specifications.

MODE SELECT

Input. Pin 2. In normal operation, Pin 2 determines the Signaling Mode ; a logic level 1 (V+) selects Tone Mode, while a logic level 0 (V–) selects Pulse Mode operation. To guarantee proper dialing, this input must be tied to one of the supplies.

$\overline{COL1}$, $\overline{COL2}$, $\overline{COL3}$, $\overline{ROW4}$, $\overline{ROW3}$, $\overline{ROW2}$, $\overline{ROW1}$

Keyboard Input. Pins 3, 4, 6, 18, 19, 20, 21. The MK5376 keypad interface allows users to add either the standard 2-of-7 keyboard with negative common or the inexpensive single-contact (Form-A) keyboard (see Figure 1). A valid key entry is either a single Row connected to a single column or V- presented to both a single Row and Column. In Standby Mode, either all the Rows pull to a logic 1 (V+) and all the Columns are a logic 0 or vice versa.

The keyboard interface logic detects an input being pulled low and enables the RC (RATE CONTROL) oscillator and keypad scan. Scanning consists of Rows and Columns alternately strobing high through on-chip pullups. After both a valid Row and Column key closure have been detected, the debounce counter is enabled Breaks in contact continuity (bouncing contacts, etc.) are ignored for a debounce period (Tdb) of 32 ms. At this time, the keypad is sampled. If both Row and Column information is valid, this information is buffered into the LND.

V–

Input. Pin 7. This pin is the negative supply input to the device. This is the voltage reference for all specifications.

RATE CONTROL

Input. Pin 9. RATE CONTROL is a single-pin RC oscillator. An external resistor and capacitor determine signaling rates in both Tone and Pulse Modes. An 8 KHz oscillation provides nominal signaling rates of 10 PPS (pulses per second) in Pulse Mode and

Figure 1A : Keyboard Schematics-Calculator Type Keypad.

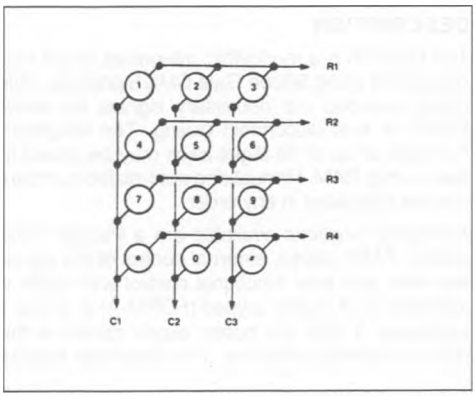
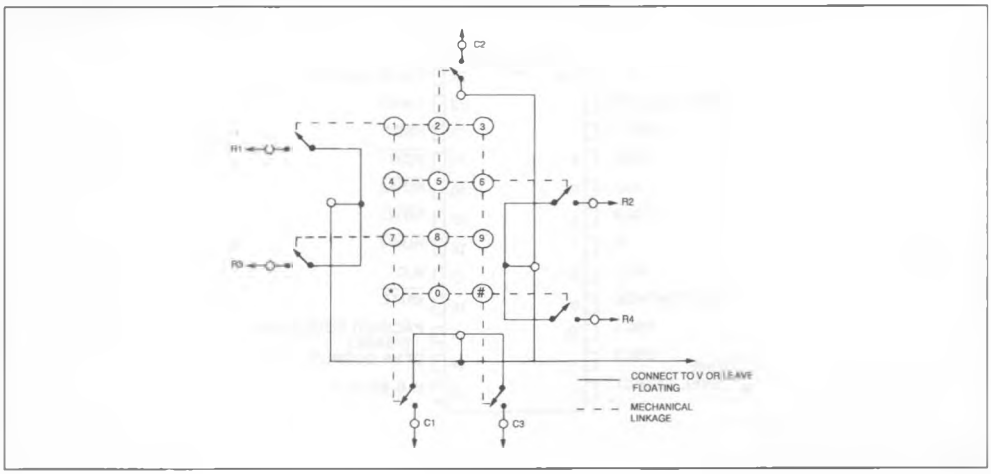


Figure 1B : Keyboard Schematics Standard Telephone Type Keypad.



5 TPS (tones per second) in Tone Mode ; the tone duty cycle is 98 ms on, 102 ms off. RC values on this input can be adjusted to a maximum oscillation frequency of 16 KHz, resulting in an effective Pulse rate of 20 PPS and Tone rate of 10 TPS.

The following equation approximates the oscillation frequency :

$$Fosc = 1/(1.49\ RC)$$

The capacitor's (C) suggested value should be a maximum of 410 pF to guarantee accuracy of the oscillator. The resistor (R) is then selected for the desired signaling rate. The nominal frequency of 8 kHz is achieved with component values of 390 pF and 220 K ohms.

OSC1, OSC2

Input/Output. Pins 10, 11. Pins 10 and 11 are the input and output, respectively, of an on-chip inverter. They have sufficient loop gain to oscillate when used with a low-cost television color-burst crystal. The nominal crystal frequency is 3.579545 MHz and any deviation is directly reflected in the Tone Output frequencies.

The repertory dialer directly controls the oscillator and is only enabled for tone signal transmission. It remains off at all other times and the input is high impedance. An external source may also drive the input.

TONE LEVEL SELECT

Input. Pin 12. The MK5376 has selectable tone levels with supply-independent or supply-dependent specifications. The tone levels available are similar to those provided on Mostek's industry standard MK5380 and MK5089 DTMF generators (see Table 1). The optimum tone scheme is application-dependent.

Table 1 : Tone Level Select.

Tone Level Select Input	Tone Reference	Compatible With
V – (method 1)	Supply	MK5089
V + (method 2)	On-chip Reference	MK5380

Method 1 operates from a regulated supply. The tone level is related to this supply by either of the following equations :

$$T_O = 20\ LOG\ [0.0776(V+)/0.775]\ dBm$$

$$T_O = 0.0776\ (V+)\ Vrms$$

Method 2 provides a constant tone output and modulates its own supply in a minimum parts count configuration. The tone level, when used in a subscriber set, is a function of the output resistor R_E and the telephone AC resistance R_L. The low-group single tone output amplitude is a function of R_E and R_L described by the equation :

$$V_O = \{1/[0.2+R_E)/R_L]\}T_O$$

where V_O is the tone amplitude at the phone line and T_O is the tone level at the DTMF OUTPUT pin. This version may also be operated on a regulated supply, but users must observe additional caution to prevent signal distortion (clipping) on longer loops.

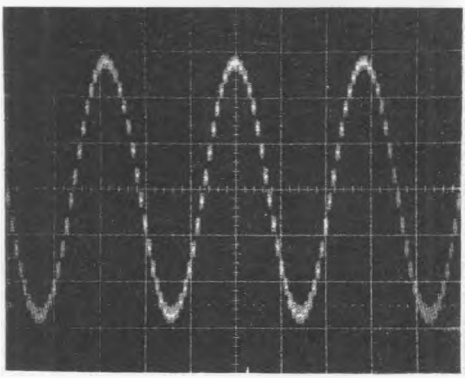
M/B SELECT

Input. Pin 13. In Pulse Mode, this pin selects the Make/Break ratio, or the percentage Break time per Pulse period (see Table 2).

Table 2 : Make/Break Ratio.

M-B Select Input	Break Time	Make Time
V +	68	32
V –	60	40

Figure 2 : Typical Sine Wave Output.



DTMF OUTPUT

Output. Pin 14. The DTMF OUTPUT pin is connected internally to an NPN transistor's emitter with a collector tied to V+. The transistor base is the output of an on-chip operational amplifier that mixes the Row and Column Tones together.

The DTMF OUTPUT level is the sum of a single Row single tone sine wave is shown in Figure 2. This waveform is synthesized using a resistor tree with sinusoidally weighted taps. DTMF output frequencies are defined by Table 3.

PACIFIER TONE OUTPUT/CHIP DISABLE

Input/Output. Pin 15. A 500 Hz square wave is output on this pin after acceptance of a valid key input

and after the 32 ms debounce time. The square wave terminates after a maximum of 30 ms or when the valid key is no longer present. The PACIFIER TONE audibly signals a valid key entry. This feature is particularly useful for on-hook storage and Pulse Mode signaling. The PACIFIER TONE is not enabled when users manually dial in Tone Mode. This eliminates any confusion between the audible DTMF feedback and the PACIFIER TONE. In both cases, the tone confirms that the key has been properly entered and accepted. Without the tone, users do not know if the keys have been properly entered.

This pin is normally high impedance until a key is entered. It also serves as a CHIP DISABLE pin. Pulling this input high through a resistor disables the keypad (high impedance) and initializes all counters and flip flops (memory remains undisturbed). Pulling the input low through the same resistor enables the circuit.

This feature is useful in several applications. It provides a convenient way to lock memory by connecting this input through a resistor to HKS. When it is on-hook, the device is then disabled and key inputs are not recognized. The circuit will function normally off-hook. Information can only be entered into the permanent memory locations by switching to Program Mode. This requires that a switch and resistor be added to connect to V–.

$\overline{\text{MUTE}}$

Output. Pin 16. This pin is the mute output for both Tone and Pulse Modes. Timing depends on which mode is used.

The output consists of an open drain N-channel device and zener input protection. During standby, the output is high impedance and generally requires an external pullup resistor to the positive supply.

In Tone Mode, $\overline{\text{MUTE}}$ removes the transmitter and receiver from the network during DTMF signaling. The output then mutes continuously while auto-dialing and during manual DTMF signaling.

In Pulse Mode, the $\overline{\text{MUTE}}$ removes the receiver or even the entire network from the line. Timing is avai-

Table 3 : Output Frequency.

Key Input	Standard Frequency	Actual Frequency	% Deviation
ROW 1	697	699.1	+ 0.31
2	770	766.2	– 0.49
3	852	847.4	– 0.54
4	941	948.0	+ 0.74
COL 1	1209	1215.9	+ 0.57
2	1336	1331.7	– 0.32
3	1477	1471.9	– 0.35

Figure 3A : MK5376 Timing Diagram - Pulse Mode Off-Hook Operation.

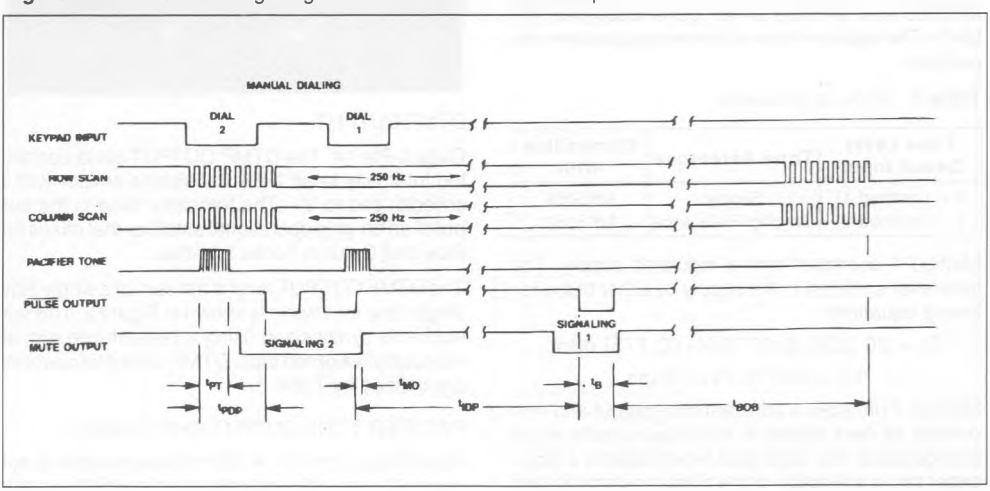
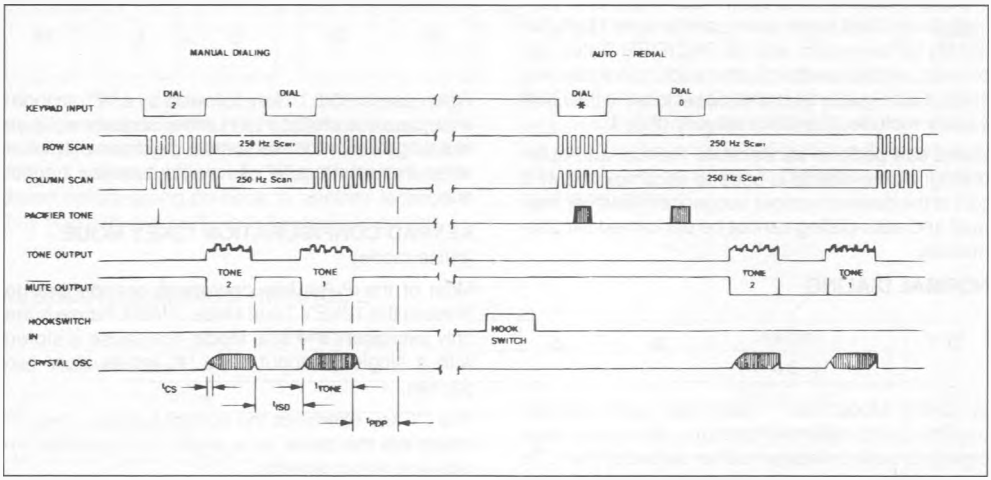


Figure 3B : MK5376 Timing Diagram - Tone Mode.



lable both as a continuous mute (provided by the MK5376) or a mute that is active only when actually pulsing the line. Figure 3 depicts these timing relationships.

HKS

Input. Pin 22. This pin is a high impedance input and must be switched high for on-hook operation or low for off-hook operation. A transition on this input initializes the on-chip logic. This stops the current operation. A logic level independent of the hookswitch position may be presented to this input, which allows on-hook operations, such as storage, to be performed off-hook.

13KEY

Input. Pin 23. This pin is a high impedance input. When it is tied permanently low, it indicates 12KEY Mode. If users desire 13KEY operation, a switch to the negative supply is attached to this pin, along with an external pullup. This forces the repertory dialer into 13KEY Mode. The dialer switches to 12KEY mode if users depress the 13th key switch while simultaneously entering information through the keypad. The differences between these modes are presented in the Device Operation Section.

$\overline{\text{PULSE}}$ OUTPUT

Output. Pin 24. An open drain N-channel device drives this pin. In Pulse Mode, the timing meets Bell Telephone and EIA specifications for loop disconnect signaling. The Make/Break ratio is user-selectable. RATE CONTROL regulates the dialing rate.

DEVICE OPERATION

The MK5376 interfaces to two keypad configurations - the 12KEY and 13KEY Modes (see Figures 4 and 5). This flexibility simplifies interfacing to existing keypads and products. The MK5376 can be used in inexpensive telephones with basic 3x4 matrix keypads to give them repertory dialer features. In 13KEY Mode, the MK5376 allows the keypad to be used for standard signaling and the special repertory functions are only activated by using the "control" (13th) key.

In both modes, keypad entries are decoded, debounced, and (if valid) stored in the LND (Last Number Dialed) buffer that acts much like a FIFO (First-In-First-Out) register. Each subsequent entry is stacked in the buffer. The dialing sequence begins 100 ms after the first digit is accepted. Each digit buffered into the RAM is dialed out with a 98 ms burst of DTMF and a 102 ms intersignal time.

Figure 4 : Keypad Configuration 12Key Mode (tone mode).

MBBMK5376-B1

Buffering data into the RAM before signaling is an important feature. This allows less expensive keypads to be used since users cannot enter digits too quickly for the system and the PACIFIER TONE can provide audible feedback after each non-toned key entry. It also guarantees that data stored in the RAM exactly matches the digits actually dialed.

Users can perform consecutive manual and auto-dialing, if auto-dialing is used to accomplish only a part of the desired number sequence. However, manual and auto-dialing cannot be performed simultaneously.

NORMAL DIALING

D	*	*	D	D

In 12KEY Mode, the "*" (Star) key is the modifier used to control repertory functions. All numeric keys signal normally unless a modifier precedes them. To signal either a "*" or "#" users must enter these keys twice in succession. The first entry is not signaled or stored.

LND PRIVACY

D	D	ON-HOOK	*	#

A "*", # input after going on-hook or prior to coming off-hook with erase information stored in the LND buffer.

AUTO-DIALING (Off-hoof))

D	D	...	D	*	N
opt	opt		opt		

The key sequence "*" followed by any digit auto-dials the number sequence stored in the designated address location. Note auto-dial can take place following manual key inputs.

STORAGE (On-hook)

D	D	...	D	*	N
opt	opt		opt		

The number sequence stored in the LND buffer can be transferred to one of the nine other "permanent" locations with the simple sequence "*" followed by the address. New digits may be written into the LND buffer while on-hook. To enter a "*" signal, users enter the "*" key twice in succession as when dialed off-hook.

PABX PAUSE (Off-hook and On-hook)

D	D	*	#	N

When users input "*" key followed by a "#", an indefinite pause is stored in a number sequence. Upon redialing the number sequence, the dialer will pause when it encounters "#". A key input makes it continue.

KEYPAD CONFIGURATION 12KEY MODE
(pulse mode)

Most of the Pulse key operations are identical to those in the 12KEY Tone Mode ; PABX Pause is the only exception. In Pulse Mode, the pause is stored with a single "#" input. Two "#" inputs store two pauses.

The "*" key exercises the control function ; two "*" inputs are the same as a single input (multiple inputs are not accepted).

Figure 5 : Keypad Sequence 13Key Cofiguration.

NORMAL DIALING AND LND PRIVACY OPTION (Off-hook)

D	D	D	....ETC	C

Normal dialing is straightforward ; all keypad entries are stored in the LND (Last Number Dialed) buffer and signaled as each is entered. All digits in the LND register are maintained unless the final key prior to going on-hook is "C". In the metal mask version, the LND buffer is cleared unless users make a Control entry before going on-hook.

AUTO-DIALING (Off-hook)

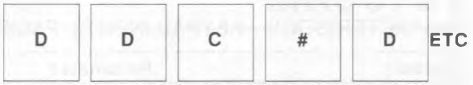
C	N	ADDRESS

To auto-dial, users enter the control key "C", followed by the address key, (shown here as "N", representing memory location N). As soon as the address key is decoded and debounced, auto-dialing begins. Address zero is used to auto-dial LND.

STORAGE (On-hook)

To store data in a given location (LOC N) users simply enter digits into the LND buffer and copy them to "N" by entering a control key "C" followed by the desired address. Users can copy the last number dialed before going on-hook to another location if they make no entries before the copy operation.

PABX PAUSE



Users may inject a pause at any point in the dialed sequences by keying in "C" followed by "#". When this number sequence is redialed, the dialer pauses indefinitely and continues to dial when another key input is received.

ABSOLUTE MAXIMUM RATINGS*

Parameter	Value	Unit
DC Supply Voltage	6.5	V
Operating Temperature	– 30 to + 60	°C
Storage Temperature	– 55 to + 85	°C
Maximum Power Dissipation (25 °C)	500	mW
Maximum Voltage on any Pin	(V+) + 0.3, (V–) – 0.3	V

* All specifications are for 2.5 V operation and full operating temperature range unless otherwise stated.

ELECTRICAL OPERATING CHARACTERISTICS

DC CHARACTERISTICS – 30 °C ≤ TA ≤ 60 °C

Symbol	Parameter	Min.	Typ.	Max.	Unit	Notes
V_+	DC Operating Voltage	2.5		6.0	V	
I_{SB}	Standby Current		0.3	1.0	µA	1
V_{MR}	Memory Retention Voltage	1.5			V	5
I_{MR}	Memory Retention Current	750	200		nA	5
I_T	Operating Current (tone)		0.5	1.0	mA	2
I_P	Operating Current (pulse)		50	150	µA	2
I_{ML}	Mute Output Sink Current	1.0	3.0		mA	3
I_{PL}	Pulse Output Sink Current	1.0	3.0		mA	3
I_{PC}	Pacifier Tone Sink/Source	250	500		µA	4
K_{RU}	Keypad Pullup Resistance		100		kΩ	
K_{RD}	Keypad Pulldown Resistance		500		kΩ	

Notes : 1. All inputs unloaded. Quiescent Mode (oscillator off).
2. All inputs unloaded. single key input.
3. V_{OUT} = 0.5 V.
4. Sink Current for V_{OUT} = 0.5 Source Current for V_{OUT} = 2.0 V.
5. Meeting these minimum supply requirements guarantees the retention of data stored in memory.

ELECTRICAL OPERATING CHARACTERISTICS (continued)

CHARACTERISTICS – KEYPAD INPUTS, PACIFIER TONE

Symbol	Parameter	Min.	Typ.	Max.	Unit	Notes
T_{KD}	Keypad Debounce Time		32		ms	1
F_{KS}	Keypad Scan Frequency		250		Hz	1
T_{RL}	Two Key Rollover Time		4		ms	1
F_{PT}	Frequency Pacifier Tone		500		Hz	1
T_{PT}	Pacifier Tone		30		ms	1
F_{RC}	Frequency RC Oscillator	– 7.0	+ 2.5	+ 7.0	%	2

Notes : 1. Times based upon 8 kHz RC input for RATE CONTROL.
2. Deviation of oscillator frequency takes into account all voltage, temperature and unit-to-unit variations, but does not include the tolerance of external components.

CHARACTERISTICS – TONE MODE

Symbol	Parameter	Min.	Typ.	Max.	Unit	Notes
T_{NK}	Tone Output no Key Down			– 80	dBm	1
T_{Od}	Tone Output (dependent)	– 13 173	– 12 194	– 11 218	dBm mV(rms)	1, 2
P_{Ed}	Pre-emphasis, High Band		2.7		dB	
V_{DCd}	Average DC Bias Tone out (V+ = 2.5 V)		1.2		V	
T_{Oi}	Tone Output (independent)		– 12 194		dBm mV(rms)	2, 3
P_{Ei}	Pre-emphasis, High Band		2.0		dB	3
V_{DCi}	Average DC Bias Tone out		1.5		V	
DIS	Output Distortion		5.0	8.0	%	3
R_E	Tone Output Load			10	kΩ	4
TR	Tone Signaling Rate		5	10	1/sec	5
PSD	Pre-signal Delay		132		ms	5
ISD	Inter-signal Delay		100		ms	5

Notes : 1. ODBm equals 1 mWatt signal power into a 600 W load or 775 mV.
2. Single tone (low group) V = 2.5 V.
3. Supply voltage = 2.5 to 6 V. R_E = 10 KΩ.
4. Maximum load which can be connected externally to pin 10 and maintain proper tone levels.
5. These values are directly related to the RC component values connected to Pin 7, the rate control frequency is nominally 8 kHz.

AC CHARACTERISTICS – PULSE MODE OPERATION

Symbol	Parameter	Min.	Typ.	Max.	Unit	Notes
P_R	Pulse Rate		10		PPS	1
PDP	Predigital Pause		172		ms	1
IDP	Interdigital Pause		940		ms	1
T_{MO}	Mute Overlap Time		2		ms	1

Note : 1. Typical times assume nominal RC input frequency of 8 kHz. An increase in frequency results in an equal decrease in time values and increase in rate values.