CML Semiconductor Products

PRODUCT INFORMATION

FX613 Universal Call Progress Decoder

Publication D/613/3 December 1995

Features

- **Covers Worldwide Call Progress Frequencies (300Hz to 2,150Hz)**
- **3 Volt <1mA Requirement**
- **Decodes Single or Modulated Tones**
- **Analogue In/Serial Data Out**
- **Speech Discrimination Ability**
- **µProcessor Compatible Outputs**
- **Telephone/Telecoms, Radio and Fax/Modem Applications**
- **Mixed Analogue/Digital Technology**

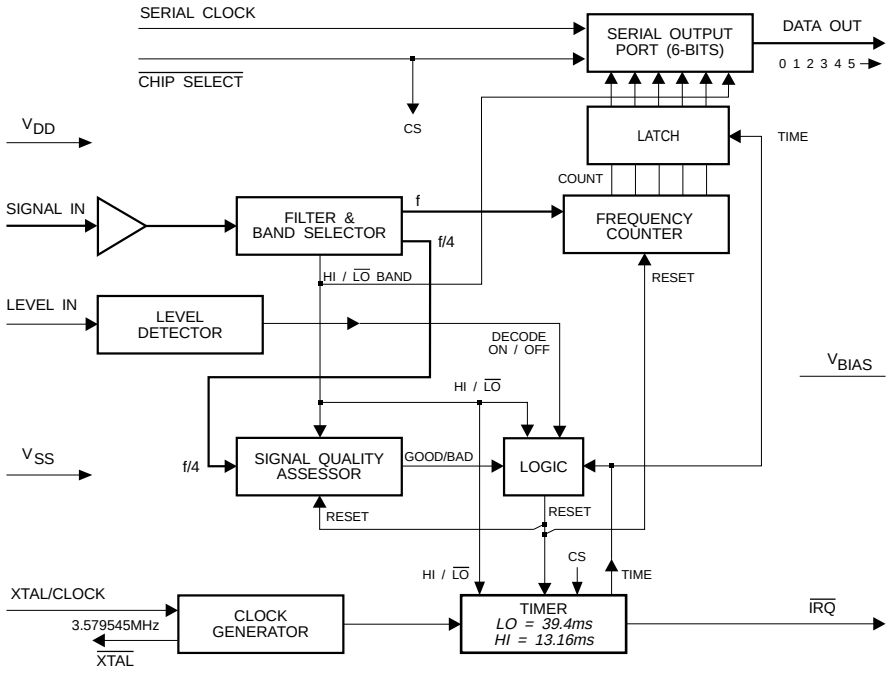


Fig.1 Functional Block Diagram

FX613

Brief Description

The FX613 is a wide-band, 'N-Tone', non-predictive tone decoder to measure telephone system call progress tones in PABX, Pay/Feature-Phone, Fax and Modem systems.

Adhering to Must/Must-Not Decode limits and able to measure inband frequencies in outband modulation, this decoder measures the frequency of input signals in the range 300Hz to 2,150Hz; the result of each measurement is presented to a system µProcessor, as a 6-bit serial word.

The decode frequency range, which covers the World's call progress application spectrum, is processed internally as two bands: LO = 300Hz to 660Hz and HI = 900Hz to 2150Hz. Frequency measurement is achieved by counting the number of cycles in a set time period (LO = 39.47ms or HI = 13.16ms). Bad signal/level quality or NOTONE results in a count-abort, timing-reset and no output from the decoder.

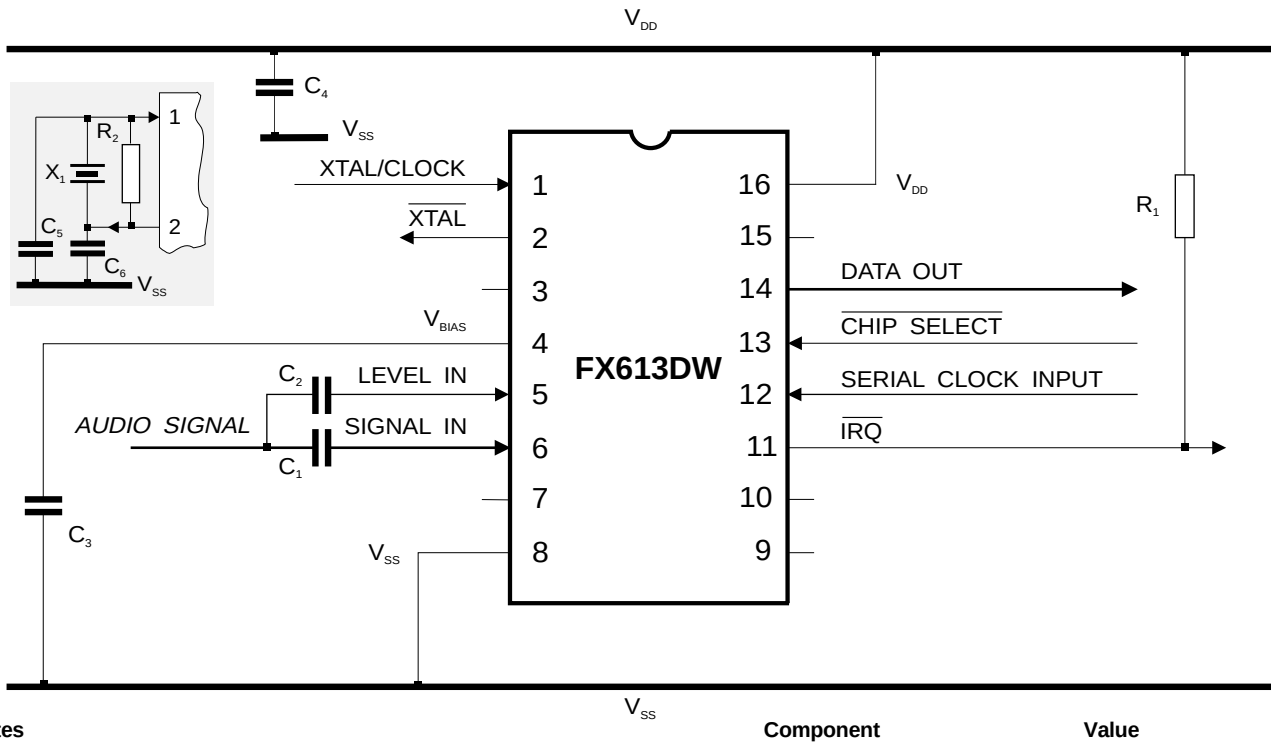
Current frequency information is output for the µProcessor using a Serial Data, Clock and Interrupt interface.

Data from the FX613 should be processed by a µProcessor whose algorithms are able to recognize the frequency, sequence and/or cadence of input signals as national call progress information; e.g.: 'Dial', 'Busy', 'Number-Unobtainable', 'Ringing' and automatic tones employed by Fax, Modem systems. Software can be simply configured to reject speech frequencies.
Due to its 'N-Tone', non-predictive decoding capability, units employing the FX613 can be redeployed under a new national standard by a simple software amendment.

Available in 16-pin plastic S.O.I.C. SMD and 14-pin plastic DIL packages, this low-cost, mixed analogue/digital microcircuit has a typical power requirement of less than 1mA at 3 volts and utilizes a telecom-system clock input of 3.579545MHz to maintain frequency accuracy.

Pin Number		Function
FX613DW	**FX613P**	
1	**1**	**Xtal/Clock**: The input to the on-chip clock oscillator inverter. A 3.579545MHz Xtal or externally derived telephone system clock (f_{XTAL}) should be connected here. Note - The operation of the FX613 without a suitable Xtal/Clock input may cause device damage.
2	**2**	$\overline{\text{Xtal}}$**:** The output of the on-chip clock oscillator inverter. See Figure 2.
3	3	No internal connection.
4	**4**	$\mathbf{V_{BIAS}}$**:** The internal circuitry bias line, held at $V_{DD}/2$ this pin must be decoupled to V_{SS}.
5	**5**	**Level In:** The input for level discrimination. This input is internally biased to V_{BIAS}, signals must be a.c. coupled. The audio signal must be fed to both this pin and the Signal In pin. Correct level detection determines the operation of this device (see Principles of Decoder Operation), however to disregard the amplitude of the input levels the FX613 may be permanently enabled by pulling this pin to V_{DD} and disabled by pulling to V_{SS}.
6	**6**	**Signal In:** The input for frequency discrimination and decoding. This input is internally biased to V_{BIAS}, signals must be a.c. coupled. The audio signal must be fed to both this pin and the Level In pin.
7		No internal connection.
8	**7**	$\mathbf{V_{SS}}$**:** Negative supply rail. Signal ground.
9	8	No internal connection.
10		No internal connection.
11	**9**	$\overline{\text{IRQ}}$**:** This Interrupt Request output from the FX613 is 'wire-OR able' allowing the interrupt outputs of other peripherals to be combined and connected to the Interrupt input of a µProcessor. This input has a low-impedance pulldown to V_{SS} when active and a high-impedance when inactive. An interrupt is produced on completion of a HI or LO frequency measurement.
12	**10**	**Serial Clock:** The serial clock from the µProcessor. Data Out is clocked into the µProcessor on the rising edge of the Serial Clock. See Data-Read Timing diagram.
13	**11**	$\overline{\text{Chip Select}}$**:** A logic "0" at this input will select this device.
14	**12**	**Data Out:** The serial data output. Under the control of the Chip Select and Serial Clock inputs, data should be read from this output in 6-bit blocks MSB (Bit-5) first. If 8 serial clock pulses are applied, two additional logic "0s" will be output after Bit-0.
15	13	No internal connection.
16	**14**	$\mathbf{V_{DD}}$**:** Positive supply rail. A single, stable supply is required. Levels and voltages within the FX613 are dependent upon this supply. This pin should be decoupled to V_{SS} by a capacitor located close to the FX613 pins.

Application Information



Notes

(1) The Xtal/Clock input may be driven from the host telephone system's 3.579545MHz clock; if a Xtal drive is required, the configuration shown INSET is recommended.

(2) The audio signal should be input to both Signal In and Level In pins via separate coupling capacitors. If it is wished to operate the device with disregard to on-chip level thresholds and permanently enable the FX613, the Level In pin should be held at V_{DD}. To disable the FX613 the Level In pin should be held at V_{SS}. Level thresholds are preset internally.

Component	Value
R_1	22.0kΩ
R_2	1.0MΩ
C_1	0.01µF
C_2	0.1µF
C_3	1.0µF
C_4	1.0µF
C_5	33.0pF
C_6	33.0pF
X_1	3.579545MHz

Tolerances: C = ± 20% R = ± 10%

Fig.2 External Component Connections

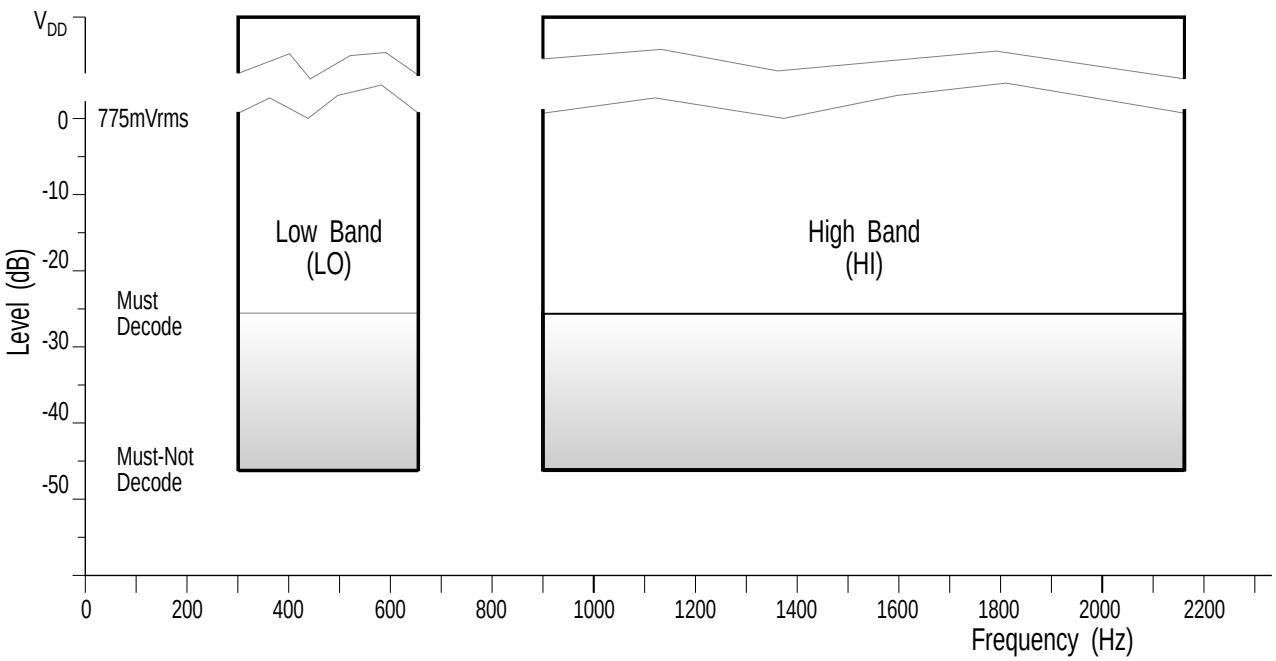


Fig.3 HI/LO Decode Bands

Application Information .....

Principles of Decoder Operation

Level Detection

As level and frequency discrimination operations take place in parallel the audio signal should, under normal circumstances, be input to both Signal In and Level In pins via coupling capacitors.

If the input signal level (Level In) is outside the preset 'Must/Must Not Decode' thresholds (Specification Page), the Universal Call Progress Decoder will be disabled.

If it is wished to disregard signal input *levels* at the Level In pin and attempt to decode under all conditions, the decoder may be permanently enabled by holding the Level In pin at V_{DD}.
The device can disabled by pulling Level In to V_{SS}.

NOTONE Recognition

The NOTONE condition can be recognized using µProcessor software timing as below.

a. Set the µP timer period to a period greater than the relevant frequency-band measurement period (13.16ms or 39.47ms).

b. Each 'Tone Measurement Complete' interrupt from the FX613 must reset the µP timer.

c. With NOTONE or white noise at the decoder input, the FX613 on-chip timer will be continually reset.

ii No 'Tone Measurement Complete' interrupt will occur - the µP timer will run.

ii The µP Timer time-out can be considered as a **NOTONE** indication.

Level In	Timer	IRQ	Data Out
In Limits	Running	Enabled	Enabled
Out of Limits	Reset	Disabled	Disabled (frozen to previous bit-5 level
V_{DD}	Running/Reset	Enabled/Disabled	Enabled (dependent upon Quality measurement)
V_{SS}	Reset	Disabled	Disabled (frozen to previous bit-5 level)

Frequency Band Discrimination

The input signal is amplified by a self-biased (zero-crossing) inverting amplifier and then 'filtered' to remove high-frequency noise and jitter.

High (HI) and Low (LO) counters are employed to determine the input frequency band (HI = 900Hz to 2150Hz, LO = 300Hz to 660Hz).

If the input frequency is in the LO Band, the device will operate as a LO Band decoder and will remain so until a HI frequency signal is detected. If the input frequency is in the HI Band, the device will operate as a HI Band decoder and will remain so until a LO frequency signal is detected.

Frequency band monitoring is continuous with the band selection taking place every 9.8ms. It will therefore take 9.8ms from Power-Up to set up the initial correct decode frequency band.

On-Chip Timer Operation

For frequency measurement, the FX613 counts the number of input cycles in a fixed time period. This fixed period, measured by the continuous on-chip timer, is set to 13.16ms for HI Band inputs and 39.47ms for LO Band inputs.

On-Chip Timer Operation .....

When the timer expires the following actions take place:

a. A HI or LO ("1" or "0") band indication bit is latched into Bit-5 of the Serial Output Port.

b. The Frequency Counter count of 5-bits is latched into the Serial Output Port (Bit-4 [MSB] to Bit-0). The Serial Output Port Contains 6-bits, if 8 Serial Clock edges are employed, two extra "0s", which should be ignored, will be output last.

c. An interrupt is generated ($\overline{IRQ}$) to the µProcessor. The contents of the Serial Output Port should be read before the next interrupt is expected; if not data will be overwritten.

When the Chip Select input is set to "0" the interrupt is reset.

The On-Chip Timer and Frequency Counter will be reset in mid-count, and therefore unable to allow a valid measurement, under the following conditions:

a. A change of decode frequency band.

b. Decoder disabled; signal input level out of specification or Level Detect input set to V_{SS}.

c. Signal Quality Assessment considered 'Bad'.

d. Input signal frequency outside limits.

Application Information .....

N = int (Frequency x Measurement Period)

Measurement Period = 39.47ms for Low Band (300Hz to 660Hz)
= 13.16ms for High Band (900Hz to 2150Hz)

Note: For input frequencies of between 661Hz and 899Hz the FX613 will give no reliable output.

Bit 5 Output First	Band Bit (5)	MSB (4)	(3)	(2)	(1)	LSB (0)	Bits 0 to 4 = N
	HI-"1"/LO-"0"	Bits 0 to 4 represent the measured frequency in the selected band					

When a 'correct' decode has been allowed and an interrupt generated, a 6-bit data word will be presented at the Serial Output Port. This 6-bit word indicates the input frequency's band and value as described below.

As an example, the following binary-word presented at the Serial Output Port **(1 1 0 1 1 0)** will indicate a frequency in the **HI Band** of between **1680Hz** and **1740Hz (Bit-5 = "1" = HI, 'N' = 22)**.

LO Band	HI Band	N	B_5	B_4	B_3	B_2	B_1	B_0	LO Band	HI Band	N	B_5	B_4	B_3	B_2	B_1	B_0
280	*840*	11	H/L	0	1	0	1	1	505	1515	19	H/L	1	0	0	1	1
285	*855*	11							510	1530	20	H/L	1	0	1	0	0
290	*870*	11							515	1545	20						
295	885	11							520	1560	20						
300	900	11							525	1575	20						
305	915	12	H/L	0	1	1	0	0	530	1590	20						
310	930	12							535	1605	21	H/L	1	0	1	0	1
315	945	12							540	1620	21						
320	960	12							545	1635	21						
325	975	12							550	1650	21						
330	990	13	H/L	0	1	1	0	1	555	1665	21						
335	1005	13							560	1680	22	H/L	1	0	1	1	0
340	1020	13							565	1695	22						
345	1035	13							570	1710	22						
350	1050	13							575	1725	22						
355	1065	14	H/L	0	1	1	1	0	580	1740	22						
360	1080	14							585	1755	23	H/L	1	0	1	1	1
365	1095	14							590	1770	23						
370	1110	14							595	1785	23						
375	1125	14							600	1800	23						
380	1140	14							605	1815	23						
385	1155	15	H/L	0	1	1	1	1	610	1830	24	H/L	1	1	0	0	0
390	1170	15							615	1845	24						
395	1185	15							620	1860	24						
400	1200	15							625	1875	24						
405	1215	15							630	1890	24						
410	1230	16	H/L	1	0	0	0	0	635	1905	25	H/L	1	1	0	0	1
415	1245	16							640	1920	25						
420	1260	16							645	1935	25						
425	1275	16							650	1950	25						
430	1290	16							655	1965	25						
435	1305	17	H/L	1	0	0	0	1	660	1980	26	H/L	1	1	0	1	0
440	1320	17							*665*	1995	26						
445	1335	17							*670*	2010	26						
450	1350	17							*675*	2025	26						
455	1365	17							*680*	2040	26						
460	1380	18	H/L	1	0	0	1	0	*685*	2055	27	H/L	1	1	0	1	1
465	1395	18							*690*	2070	27						
470	1410	18							*695*	2085	27						
475	1425	18							*700*	2100	27						
480	1440	18							*705*	2115	27						
485	1455	19	H/L	1	0	0	1	1	*710*	2130	28	H/L	1	1	1	0	0
490	1470	19							*715*	2145	28						
495	1485	19							*720*	2160	28						
500	1500	19							*725*	*2175*	28						

Table 1 Decode Frequency Data

Application Information .....

Decoder Timing

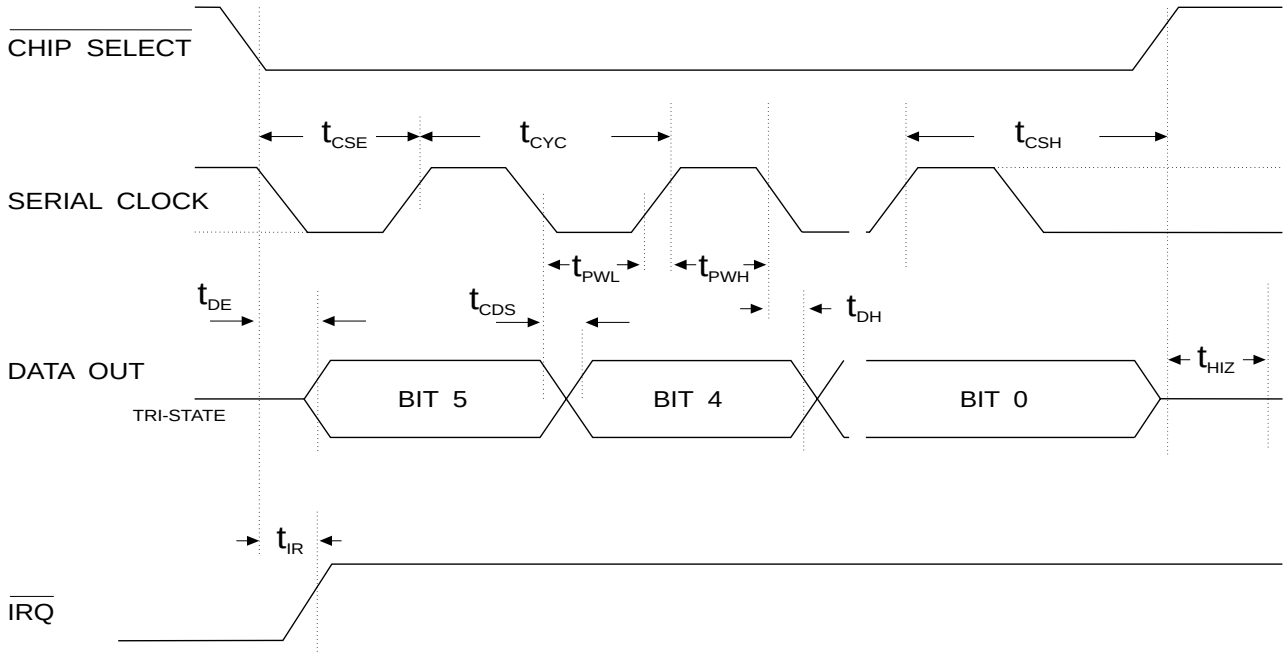


Fig.4 Data-Read Timing

Decoder Timing Characteristics

With reference to Figure 4, *Data-Read Timing*.

	Characteristics	Min.	Typ.	Max.	Unit
t_{PWH}	Serial Clock “High” Pulse Width	250	-	-	ns
t_{PWL}	Serial Clock “Low” Pulse Width	250	-	-	ns
t_{CYC}	Serial Clock-Cycle Time	600	-	-	ns
t_{CSE}	Chip Select Low to Clock “High” Edge	450	-	-	ns
t_{CSH}	Last Clock “High” Edge to CS “High”	600	-	-	ns
t_{DH}	Data Out Hold Time	0	-	-	ns
t_{CDS}	Clock Edge to Data Out Set Time	-	-	200	ns
t_{IR}	Interrupt (IRQ) Reset Time	-	-	200	ns
t_{DE}	Chip Select “Low” to Data Enable	-	-	200	ns
t_{HIZ}	Chip Select “High” to Output Tri-State	-	-	1000	ns

Notes

1 Data is output bit 5 first. Bit 5 can be clocked into the µProcessor by the first Serial Clock rising edge. If 8 Serial Clock pulses are employed the last 2 data-bits will be “0” and should be ignored by the software.

2 Chip Select should be used to react to Interrupts and then returned to a logic “1”. If Chip Select stays low there will be no further Interrupts and no Data Output update.

Specification

Absolute Maximum Ratings

Exceeding the maximum rating can result in device damage. Operation of the device outside the operating limits is not implied.

Supply voltage	-0.3 to 7.0V
Input voltage at any pin (ref V_{SS} = 0V)	-0.3 to (V_{DD} + 0.3V)
Sink/source current (supply pins)	+/- 30mA
(other pins)	+/- 20mA
Total device dissipation @ T_{AMB} 25°C	800mW Max.
Derating	10mW/°C
Storage temperature range: **FX613DW/P**	-40°C to +85°C (plastic)

Operating Limits .....

	Min.	Max.	Unit	
Supply Voltage (V_{DD})	3.0	5.5	V	at 25°C
Operating Temperature	-40	+85	°C	

All device characteristics are measured under the following conditions unless otherwise specified:

V_{DD} = 3.3V, T_{OP} = -40 to +85 °C. Audio Level 0dB ref: = 775mVrms. Xtal/Clock Frequency = 3.579545MHz

Characteristics	See Note	Min.	Typ.	Max.	Unit
Static Values					
Supply Current		-	0.3	1.0	mA
Input Logic “1”		70.0	-	100	% V_{DD}
Input Logic “0”		0	-	30.0	% V_{DD}
Output Logic “1”	1	90.0	-	100	% V_{DD}
Output Logic “0”	1	-	-	10.0	% V_{DD}
Impedances					
Chip Select and Serial Clock Input		10.0	-	-	MΩ
Signal Input		-	50.0	-	kΩ
Level Input		-	210	-	kΩ
IRQ Output (logic “0”)		-	-	500	Ω
Data Output (logic “0”)		-	500	-	Ω
(Logic “1”)		-	-	2.5	kΩ
Dynamic Values					
On-Chip Xtal Oscillator					
R_{IN}		10.0	-	-	MΩ
R_{OUT}		-	230	825	kΩ
DC Voltage Gain		25.0	42.0	-	V/V
Bandwidth at Unity Gain		5.0	11.0	-	MHz
Single Tone Operation					
Must-Decode Input Level	2	-25.2	-	-	dB
Must-Not Decode Input Level	2	-	-	-46.0	dB
LO Band Frequency Range	4	300		660	Hz
HI Band Frequency Range	4	900		2150	Hz
Frequency Resolution (Table 1)					
LO Band		-	-	25.0	Hz
HI Band		-	-	75.0	Hz
Input Signal/White-Noise Ratio (HI & LO Bands)		-	18.0	-	dB
Interrupt Rate (LO Band)	3	19.0	-	-	/sec
(HI Band)	3	57.0	-	-	/sec
False Decodes Due to Noise	6	-	1.0	-	/2 secs
Outband modulation level limits for correct decode (f_{IN} = 340Hz to 620Hz)	5	-	-	10.0	%

Notes

1. Into a high-impedance load (>1.0MΩ).
2. Must decode signal above -25.2dB; Must Not decode signal below -46.0dB. If a supply other than 3.3 volts is used, levels will change pro-rata.
3. Under ‘Pure Tone’ input conditions.
4. For input frequencies of between 661Hz and 899Hz the FX613 will provide no reliable output.
5. With an amplitude modulating frequency of between 16.0Hz and 100Hz.
6. Test noise input = 5.0kHz at 100mVrms

Package Outlines

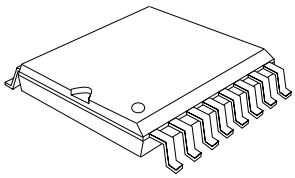
The FX613 is available in the package styles outlined below. Mechanical package diagrams and specifications are detailed in Section 10 of this document.
Pin 1 identification marking is shown on the relevant diagram and pins on all package styles number anti-clockwise when viewed from the top.

Handling Precautions

The FX613 is a CMOS LSI circuit which includes input protection. However precautions should be taken to prevent static discharges which may cause damage.

FX613DW 16-pin plastic S.O.I.C. **(D4)**

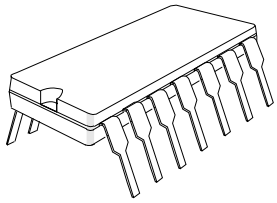
NOT TO SCALE



Max. Body Length	10.49mm
Max. Body Width	7.59mm

FX613P 14-pin plastic DIL **(P2)**

NOT TO SCALE



Max. Body Length	20.57mm
Max. Body Width	6.60mm

Ordering Information

FX613DW	16-pin plastic S.O.I.C.	**(D4)**
FX613P	14-pin plastic DIL	**(P2)**