CONSUMER MICROCIRCUITS LTD

PRODUCT INFORMATION

FX009 Digitally Controlled Amplifier Array

Publication D/009/3 December 1991
Provisional Issue

- **8 Digitally Controlled Amplifiers**
- **15 Gain/Attenuation Steps**
- **7 Trimmers, with a ± 3dB Range in 0.43dB Steps**
- **1 'Volume' Trimmer, with a ± 14dB Range in 2.0dB Steps**
- **8-Bit Serial Data Control**
- **Output Mute/Powersave Function**
- **Audio and Data Gain Control Applications**
- **Cellular, PMR, PABX Applications**

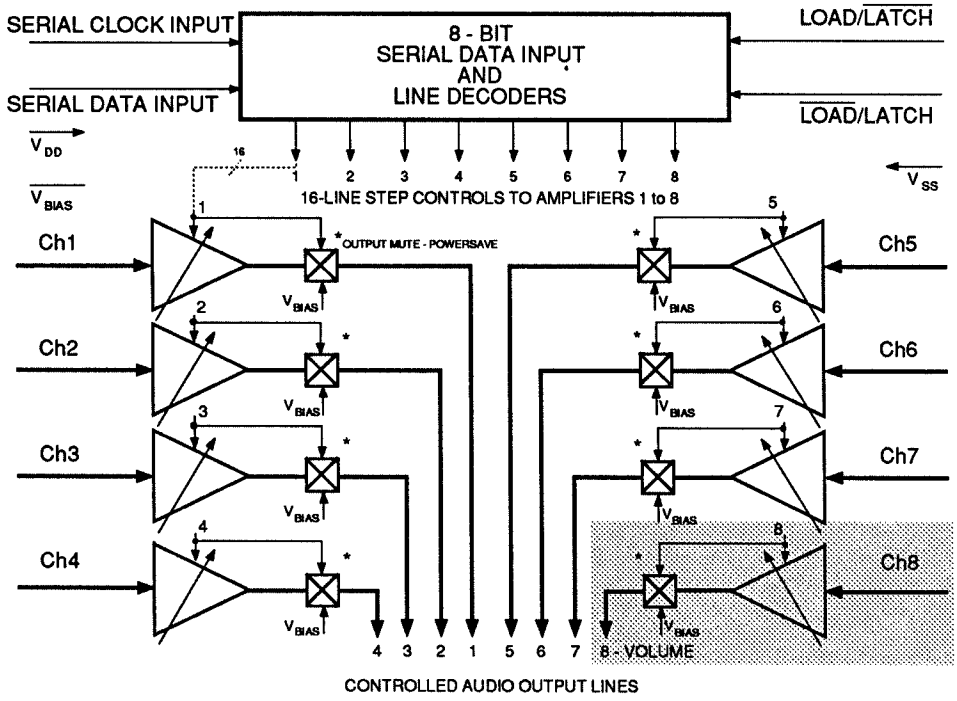


Fig.1 Functional Block Diagram

FX009

The FX009 Digitally Adjustable Amplifier Array is intended to replace trimmer potentiometers and volume controls in Cellular, PMR, Telephony and Communications applications where d.c., voice or data signals need adjustment.

The FX009 is a single-chip LSI consisting eight digitally controlled amplifier stages, each with 15 distinct gain/attenuation steps. Control of each individual amplifier is by an 8-bit serial data stream. Seven of the amplifier stages offer a +/-3dB range in steps of 0.43dB, whilst the remaining amplifier offers a +/-14dB range in steps of 2dB, and is intended for volume control applications. Each amplifier includes a 16th 'Mute' state which sets the output to bias ($V_{DD}/2$) and powersaves the entire section. Minimum current drain may be achieved by muting all eight sections.

This product replaces the need for manual trimming of audible signals by using the host microprocessor to digitally control the set-up of all audio levels.

Applications include:

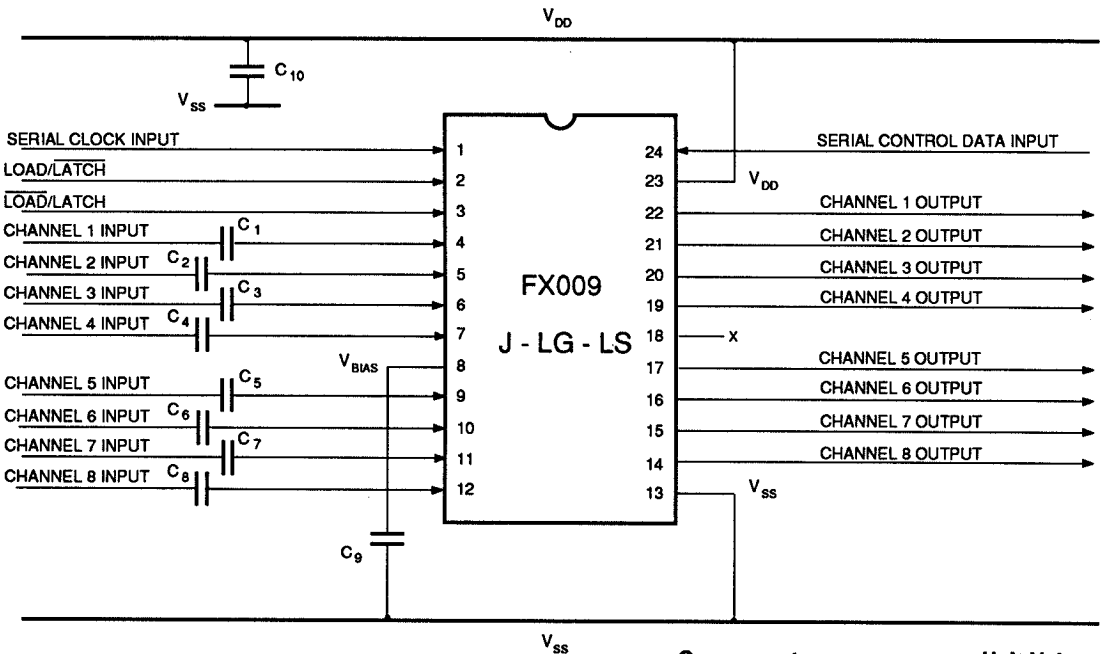
(i) Control, adjustment and set-up of communications equipment by an Intelligent ATE without manual intervention – eg. Deviation, Microphone and L/S Level, Rx Audio Level etc.

(ii) Automatic Dynamic Compensation of drift caused by variations in temperature, linearity, etc.

(iii) Fully automated servicing and re-alignment.

The FX009 is a low-power, single 5-volt CMOS device available in both 24-pin DIL and SMD package versions.

DIL FX009J	Quad FX009LG/LS	
1	1	**Serial Clock :** This external clock pulse input is used to "clock in" the Control Data. See Figure 4, Data Load Timing. This input has an internal 1MΩ pullup resistor.
2	2	**Load/$\overline{\text{Latch}}$:** Governs the loading and execution of the control data. During serial data loading this input should be kept at a logical '0' to ensure that data rippling past the latches has no effect. When all 8 bits have been loaded, this input should be strobed '0' ⇒ '1' ⇒ '0' to latch the new data in. Data is executed on the falling edge of the strobe. If the $\overline{\text{Load}}$/Latch input is used this pin should be left open circuit. This input has an internal 1MΩ pullup resistor.
3	3	**$\overline{\text{Load}}$/$\overline{\text{Latch}}$:** The inverted Load/$\overline{\text{Latch}}$ input. This function governs the loading and execution of the control data. During serial data loading this input should be kept at a logical '1' to ensure that data rippling past the latches has no effect. When all 8 bits have been loaded, this input should be strobed '1' ⇒ '0' ⇒ '1' to latch the new data in. Data is executed on the rising edge of the strobe. If the Load/$\overline{\text{Latch}}$ input is used this pin should be left open circuit. This input has an internal 1MΩ pulldown resistor.
4	4	**Ch1 Input :** **Analogue Inputs :**
5	5	**Ch2 Input :** These individual amplifier inputs are self-biasing, a.c. input analogue signals must be capacitively coupled to these pins, as shown in Figure 2.
6	6	**Ch3 Input :** In the powersave modes the inputs are biased at $V_{DD}/2$.
7	7	**Ch4 Input :** Note that amplifiers Ch1 to Ch8 are 'inverting amplifiers.'
8	8	V_{BIAS} : The output of the on-chip bias circuitry, held at $V_{DD}/2$. This pin should be decoupled to V_{SS} as shown in Figure 2.
9	9	**Ch5 Input :** **Analogue Inputs :**
10	10	**Ch6 Input :**
11	11	**Ch7 Input :**
12	12	**Ch8 Input :**
13	13	V_{SS} : Negative supply rail (GND).
14	14	**Ch8 Output :** **Analogue Outputs :**
15	15	**Ch7 Output :** The individual "Gain Controlled" amplifier outputs. Ch1 to Ch7 range from -3dB to +3dB in 0.43dB steps, Ch8
16	16	**Ch6 Output :** could be utilized as a volume control, ranging from -14dB to +14dB in 2.0dB steps.
17	17	**Ch5 Output :** In the powersave mode the selected output is biased at $V_{DD}/2$.
18	18	No internal connection. Do not use.
19	19	**Ch4 Output :** **Analogue Outputs**
20	20	**Ch3 Output :** Note that amplifiers Ch1 to Ch8 are 'inverting amplifiers.'
21	21	**Ch2 Output :**
22	22	**Ch1 Output :**
23	23	V_{DD} : Positive supply rail. A single +5-volt power supply is required.
24	24	**Control Data Input :** Operation of the 8 amplifier channels (Ch1 – Ch8) is controlled by the 8 bits of data entered serially at this pin . The data is entered (bit 7 to bit 0) on the rising edge of the external Serial Clock. The data format is described in Tables 1, 2 and Figure 4. This input has an internal 1MΩ pullup resistor.



Notes

(1) Channel Amplifiers 1 to 8 are inverting amplifiers.

(2) Analogue input capacitors C_1 to C_8 are only required for a.c. input signals, d.c. input signals do not require these components.

Component	Unit Value
C_1 to C_8	0.1µ
C_9	1.0µ
C_{10}	1.0µ

Tolerances: C = ± 20%

Fig.2 External Component Connections

Application Recommendations

To avoid excess noise and instability in the final installation it is recommended that the following points be noted.

(a) A noisy or badly regulated power supply can cause instability and/or variance of selected gains.

(b) Care should be taken on the design and layout of the printed circuit board.

(c) All external components (Figure 2) should be kept close to the FX009 package.

(d) Inputs and outputs should be screened wherever possible.

(e) Tracks should be kept short.

(f) Analogue tracks should not run parallel to digital tracks.

(g) A "Ground Plane" connected to V_{SS} will assist in eliminating external pick-up on the channel input and output pins.

(h) Do not run high-level output tracks close to low-level input tracks.

(i) Input signal amplitudes should be applied with due regard to Figure 3.

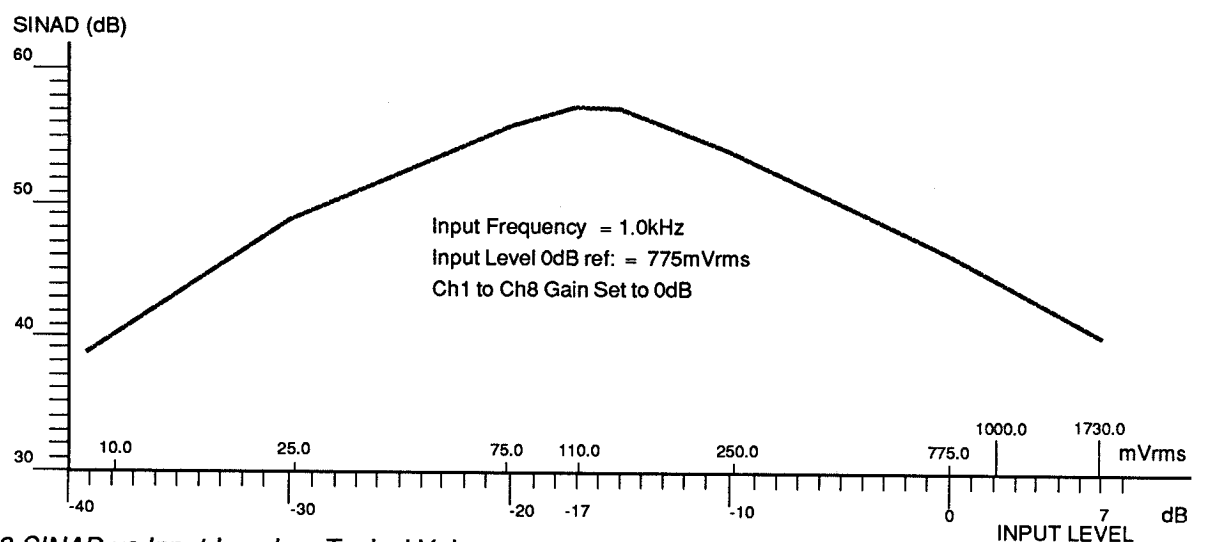


Fig.3 SINAD vs Input Level – Typical Values

The gain of each amplifier block (Channel 1 to Channel 8) in the FX009 is set by a separate 8-bit data word (bit 7 to bit 0). This 8-bit word, consisting of 4 Address bits (bit 7 to bit 4) and 4 Gain Control bits (bit 3 to bit 0), is loaded to the Control Data Input in serial format using the external data clock.

Data is loaded to the FX009 on the rising edge of the Serial Clock. Loaded data is executed on the falling (rising) edge of the Load/Latch ($\overline{\text{Load/Latch}}$) pulse. Table 1 shows the format of each 4-bit Address word, Table 2 shows the format of each Gain Control word with Figure 4 describing the data loading operation and timing.

Table 1 Address Word Format

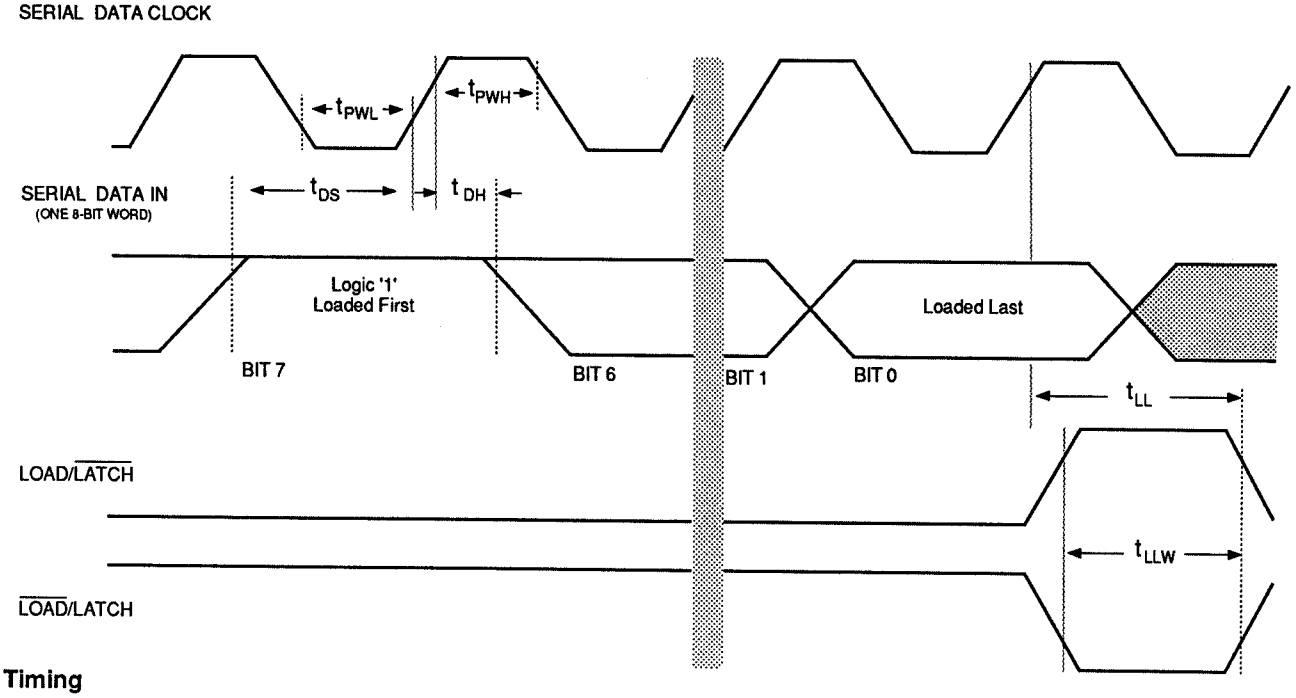
Bit 7 MSB	Bit 6	Bit 5	Bit 4 LSB	Channel Selected
1	0	0	0	1
1	0	0	1	2
1	0	1	0	3
1	0	1	1	4
1	1	0	0	5
1	1	0	1	6
1	1	1	0	7
1	1	1	1	8

Table 2 Gain Control Word Format

Bit 3 MSB	Bit2	Bit 1	Bit 0 LSB	Stage 1 to 7 (0.43dB)	Stage 8 (2.0dB)
0	0	0	0	Powersave	Powersave
0	0	0	1	-3.0	-14.0 dB
0	0	1	0	-2.571	-12.0 dB
0	0	1	1	-2.143	-10.0 dB
0	1	0	0	-1.714	-8.0 dB
0	1	0	1	-1.286	-6.0 dB
0	1	1	0	-0.857	-4.0 dB
0	1	1	1	-0.428	-2.0 dB
1	0	0	0	0	0 dB
1	0	0	1	0.428	2.0 dB
1	0	1	0	0.857	4.0 dB
1	0	1	1	1.286	6.0 dB
1	1	0	0	1.714	8.0 dB
1	1	0	1	2.143	10.0 dB
1	1	1	0	2.571	12.0 dB
1	1	1	1	3.0	14.0 dB

Data Loading

The 8-bit data word is loaded *bit 7 first and bit 0* last.
Bit 7 must be a logic "1" to address the chip.
If bit 7 in the word is a logic "0" that 8-bit word will not be executed. Figure 4 (below) shows the timing information required to load and operate this device.



Timing

t_{PWH}
Serial Clock "High" Pulse Width

t_{PWL}
Serial Clock "Low" Pulse Width

t_{DS}
Data Set-up Time

t_{DH}
Data Hold Time

t_{LL}
Load/Latch Set-up Time

t_{LLW}
Load/Latch Pulse Width

Fig.4 Serial Control Data Loading Diagram

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
Operating temperature range:	**FX009J**	-30°C to +85°C (cerdip)
	FX009LG/LS	-30°C to +70°C (plastic)
Storage temperature range:	**FX009J**	-55°C to +125°C (cerdip)
	FX009LG/LS	-40°C to +85°C (plastic)

Operating Limits

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

V_{DD} = 5.0V, T_{AMB} = 25°C. Audio Level 0dB ref: = 775mVrms. Amplifier Gain Set = 0dB.

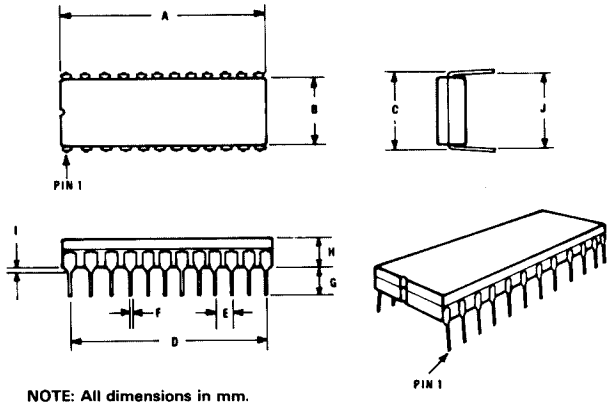
Characteristics	See Note	Min.	Typ.	Max.	Unit
Static Values					
Supply Voltage (V_{DD})		4.5	5.0	5.5	V
Supply Current –					
– All Stages Quiescent		–	0.13	–	mA
– All Stages Operating		–	2.6	–	mA
Dynamic Values					
Control Functions					
Input Logic '1'		3.5	–	–	V
Input Logic '0'		–	–	1.5	V
Digital Input Impedances		0.5	1.0	–	MΩ
Amplifier Stages (General)					
Bandwidth (-3dB)		20.0	–	–	kHz
Output Impedance		–	0.8	3.0	kΩ
Total Harmonic Distortion	1	–	0.35	0.5	%
Output Noise Level (per stage)	2	–	180.0	400.0	µVrms
Onset of Clipping	3	–	1.73	–	Vrms
Gain Variation	4	–	–	0.1	dB
Interstage Isolation		–	60.0	–	dB
"Trimmer" Stages (Ch1 – Ch7)					
Gain		-3.0		+3.0	dB
Gain per Step (15 in No.)		–	0.43	–	dB
Step Error		–	–	0.2	dB
Input Impedance		100.0	–	–	kΩ
"Volume" Stage (Ch8)					
Gain		-14.0		+14.0	dB
Gain per Step (15 in No.)		–	2.0	–	dB
Step Error		–	–	0.4	dB
Input Impedance		50.0	–	–	kΩ
Timing (Figure 4)					
Serial Clock "High" Pulse Width (t_{PWH})		250	–	–	ns
Serial Clock "Low" Pulse Width (t_{PWL})		250	–	–	ns
Data Set-up Time (t_{DS})		150	–	–	ns
Data Hold Time (t_{DH})		50	–	–	ns
Load/Latch Set-up Time (t_{LL})		250	–	–	ns
Load/Latch Pulse Width (t_{LLW})		150	–	–	ns
Serial Data Clock Frequency		–	–	2.0	MHz

Notes

1. Gain Set 0dB, Input Level 1kHz -3.0dB (549mVrms).
2. a.c short-circuit input, measured in a 30kHz bandwidth.
3. See Figure 3.
4. Over temperature and supply voltage range.

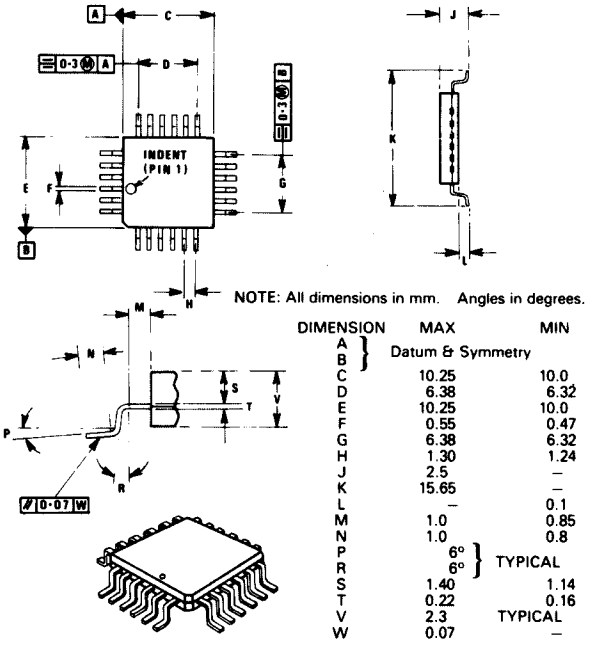
The FX009J, the cerdip package is shown in Figure 5. The 'LG' version is shown in Figure 6, and the 'LS' version in Figure 7. To allow complete identification, the FX009 LG and LS packages have an indent spot adjacent to pin 1 and a chamfered corner between pins 3 and 4.

The FX009 is a CMOS LSI circuit which includes input protection. However precautions should be taken to prevent static discharges which may cause damage.



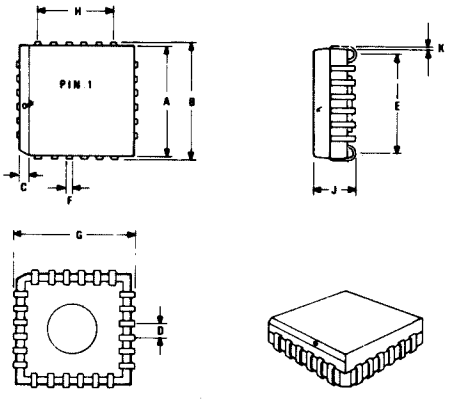
NOTE: All dimensions in mm.

DIMENSION	MAX.	MIN.
A	32.03	31.50
B	14.81	13.06
C	15.61	15.14
D	28.04	27.84
E	2.54 }	TYPICAL
F	0.46 }	
G	4.30	4.10
H	4.35	3.99
I	1.40	TYPICAL
J	18.20	16.54



NOTE: All dimensions in mm. Angles in degrees.

DIMENSION	MAX	MIN
A }	Datum & Symmetry	
B }		
C	10.25	10.0
D	6.38	6.32
E	10.25	10.0
F	0.55	0.47
G	6.38	6.32
H	1.30	1.24
J	2.5	–
K	15.65	–
L	–	0.1
M	1.0	0.85
N	1.0	0.8
P	6° }	TYPICAL
R	6° }	
S	1.40	1.14
T	0.22	0.16
V	2.3	TYPICAL
W	0.07	–



NOTE: All dimensions in mm.

DIMENSION	MAX.	MIN.
A	10.25	10.00
B	11.0	10.20
C	1.14 x 45° typical	
D	1.27 typical	
E	9.65	8.64
F	0.55	0.47
G	11.0	10.20
H	6.35 typical	
J	3.50	3.25
K	0.22	0.16

FX009J **24-pin cerdip DIL**

FX009LG **24-pin quad plastic encapsulated bent and cropped**

FX009LS **24-lead plastic leaded chip carrier**