

# CML Semiconductor Products

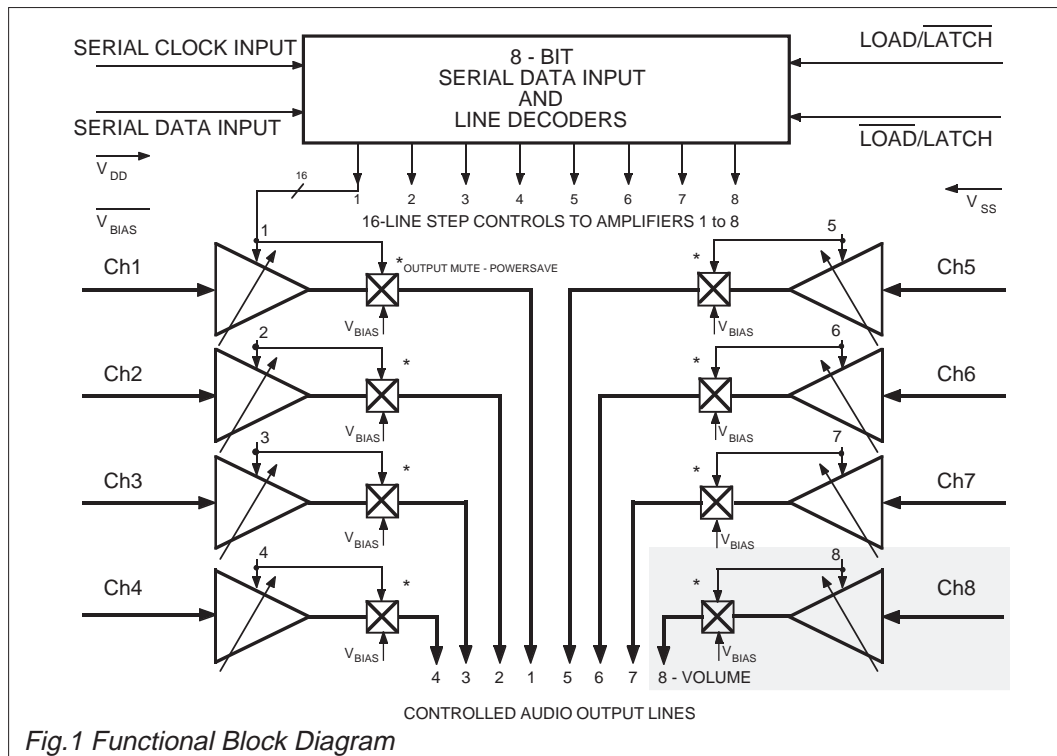
PRODUCT INFORMATION

## FX009A Low-Noise Digitally Controlled Amplifier Array

Publication D/009A/3 July 1994

### Features/Applications

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



# FX009A

### Brief Description

The FX009A 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 FX009A is a low-noise 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  $\pm 3\text{dB}$  range in steps of 0.43dB, whilst the remaining amplifier offers a  $\pm 14\text{dB}$  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:

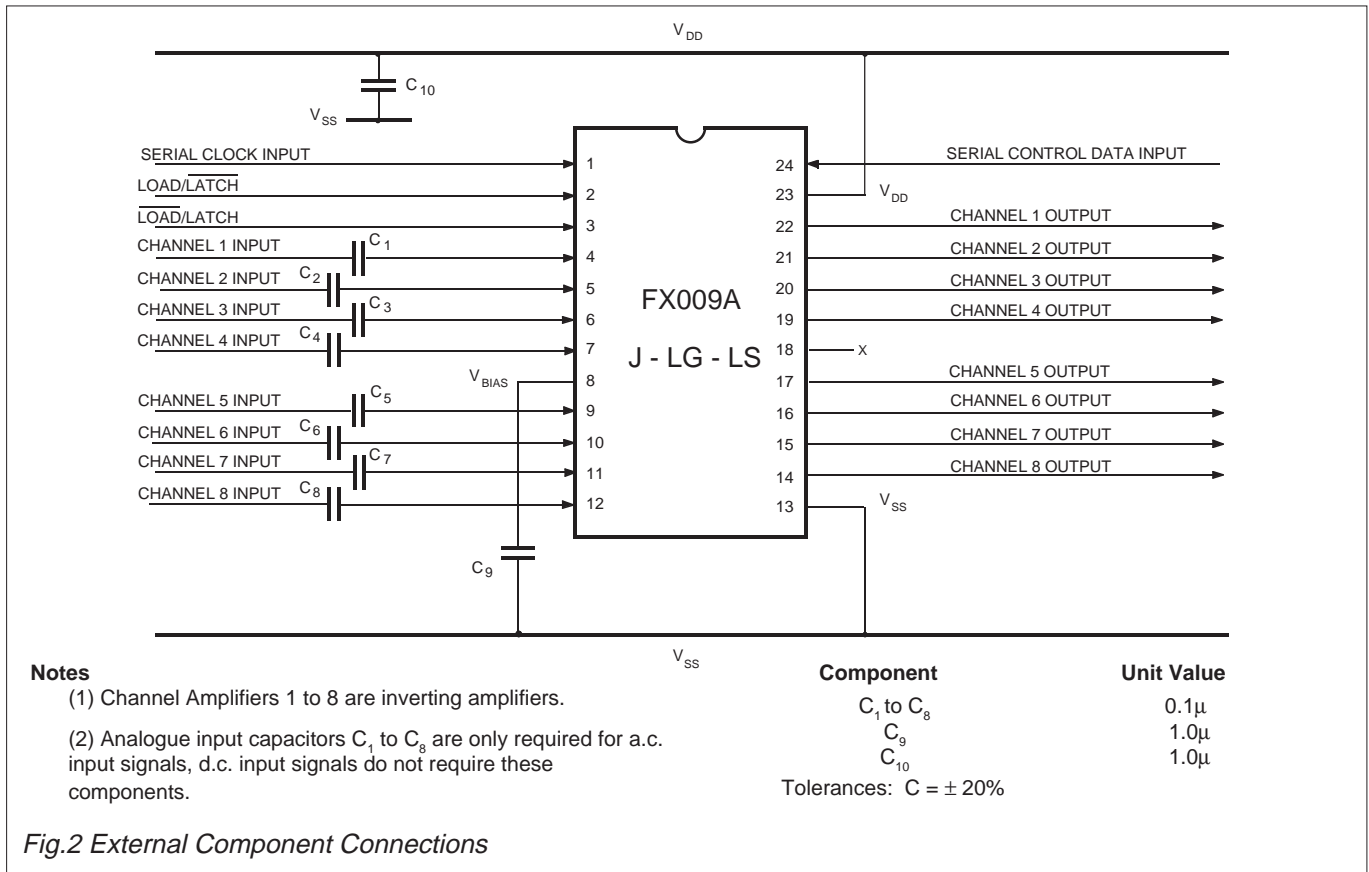
- Control, adjustment and set-up of communications equipment by an Intelligent ATE without manual intervention – eg. Deviation, Microphone and L/S Level, Rx Audio Level etc.
- Automatic Dynamic Compensation of drift caused by variations in temperature, linearity, etc.
- Fully automated servicing and re-alignment.

The FX009A is a low-power, single 5-volt CMOS device available in both 24-pin DIL and SMD package versions.

**Pin Number      Function**

FX009A J	FX009A LG/LS	
1	1	<b>Serial Clock</b> : 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	<b>Load/Latch</b> : 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 Load/Latch input is used this pin should be left open circuit. This input has an internal 1MΩ pullup resistor.
3	3	<b>Load/Latch</b> : The inverted Load/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/Latch input is used this pin should be left open circuit. This input has an internal 1MΩ pulldown resistor.
4	4	<b>Ch1 Input :</b> <b>Analogue Inputs :</b>
5	5	<b>Ch2 Input :</b> These individual amplifier inputs are self-biasing, a.c. input
6	6	<b>Ch3 Input :</b> analogue signals must be capacitively coupled to these pins, as shown in Figure 2.
7	7	<b>Ch4 Input :</b> In the powersave modes the inputs are biased at $V_{DD}/2$ .
8	8	<b>Ch5 Input :</b> Note that amplifiers Ch1 to Ch8 are 'inverting amplifiers.'
9	9	<b>V<sub>BIAS</sub></b> : 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.
10	10	<b>Ch6 Input :</b> <b>Analogue Inputs :</b>
11	11	<b>Ch7 Input :</b>
12	12	<b>Ch8 Input :</b>
13	13	<b>V<sub>SS</sub></b> : Negative supply rail (GND).
14	14	<b>Ch8 Output :</b> <b>Analogue Outputs :</b>
15	15	<b>Ch7 Output :</b> The individual "Gain Controlled" amplifier outputs.
16	16	<b>Ch6 Output :</b> Ch1 to Ch7 range from -3dB to +3dB in 0.43dB steps, Ch8 could be utilized as a volume control, ranging from -14dB to +14dB in 2.0dB steps.
17	17	<b>Ch5 Output :</b> In the powersave mode the selected output is biased at $V_{DD}/2$ .
18	18	No internal connection. Do not use.
19	19	<b>Ch4 Output :</b> <b>Analogue Outputs</b>
20	20	<b>Ch3 Output :</b> Note that amplifiers Ch1 to Ch8 are 'inverting amplifiers.'
21	21	<b>Ch2 Output :</b>
22	22	<b>Ch1 Output :</b>
23	23	<b>V<sub>DD</sub></b> : Positive supply rail. A single +5-volt power supply is required.
24	24	<b>Control Data Input</b> : 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.

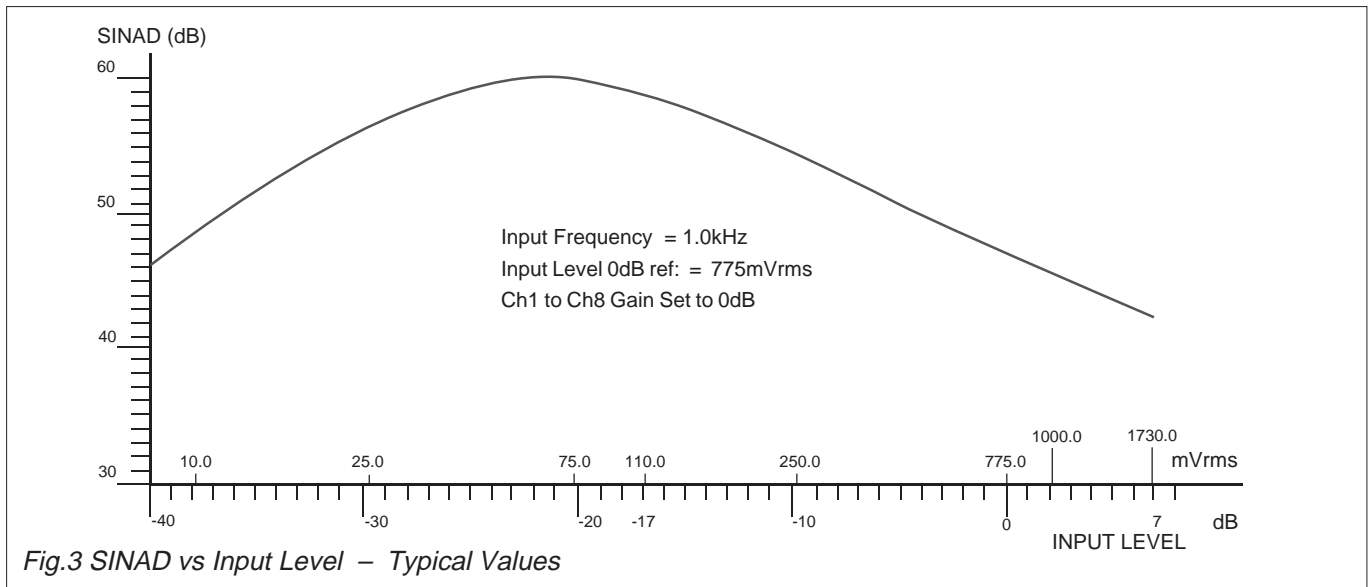
# Application Notes



## 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 FX009A 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.



The gain of each amplifier block (Channel 1 to Channel 8) in the FX009A 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 FX009A on the rising edge of the Serial Clock. Loaded data is executed on the falling (rising) edge of the Load/Latch (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*

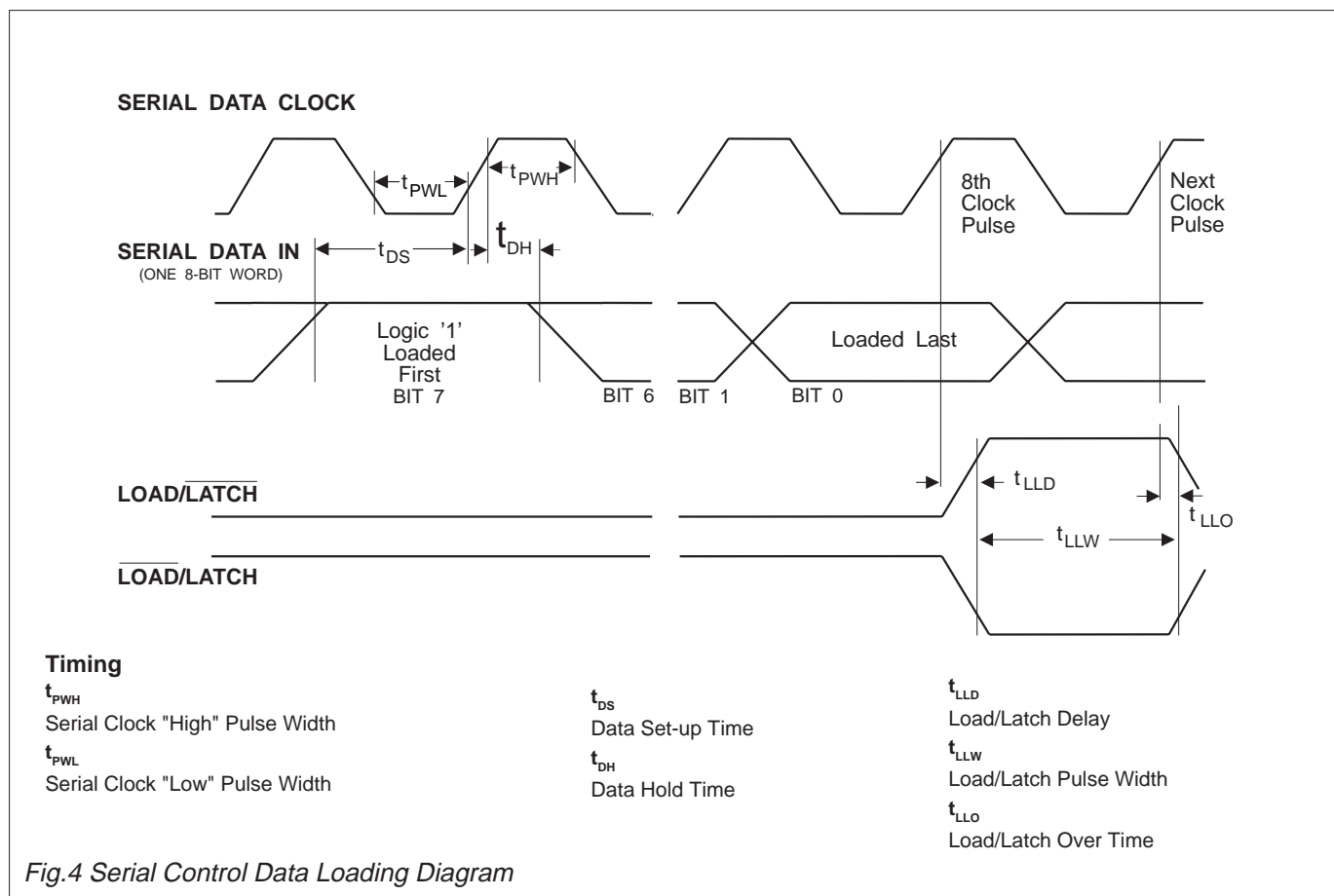
Bit 7 MSB	Bit 6	Bit 5	Bit 4 LSB	Channel Selected
1	0	0	0	1
1	0	0	1	2
1	0	1	0	3
1	0	1	1	4
1	1	0	0	5
1	1	0	1	6
1	1	1	0	7
1	1	1	1	8

*Table 2 Gain Control Word Format*

Bit 3 MSB	Bit 2	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.



## 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 @ $T_{AMB} = 25^{\circ}C$	800mW Max.
Derating	10mW/ $^{\circ}C$
Operating temperature range:	<b>FX009A J</b> -30 $^{\circ}C$ to +85 $^{\circ}C$ (cerdip)
	<b>FX009A LG/LS</b> -30 $^{\circ}C$ to +70 $^{\circ}C$ (plastic)
Storage temperature range:	<b>FX009A J</b> -55 $^{\circ}C$ to +125 $^{\circ}C$ (cerdip)
	<b>FX009A LG/LS</b> -40 $^{\circ}C$ to +85 $^{\circ}C$ (plastic)

### Operating Limits

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

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

Characteristics	See Note	Min.	Typ.	Max.	Unit
<b>Static Values</b>					
Supply Voltage ( $V_{DD}$ )		4.5	5.0	5.5	V
Supply Current –					
– All Stages Quiescent		–	0.16	–	mA
– All Stages Operating		–	3.75	–	mA
<b>Dynamic Values</b>					
<b>Control Functions</b>					
Input Logic '1'		3.5	–	–	V
Input Logic '0'		–	–	1.5	V
Digital Input Impedances		0.5	1.0	–	M $\Omega$
<b>Amplifier Stages (General)</b>					
Bandwidth (-3dB)		15.0	–	–	kHz
Output Impedance		–	0.8	3.0	k $\Omega$
Total Harmonic Distortion	1	–	0.35	0.5	%
Output Noise Level (per stage)	2	–	65.0	–	$\mu$ Vrms
Onset of Clipping	3	–	1.73	–	Vrms
Gain Variation	4	–	–	0.1	dB
Interstage Isolation		–	60.0	–	dB
<b>“Trimmer” Stages (Ch1 – Ch7)</b>					
Gain		-3.0	–	+3.0	dB
Gain per Step (15 in No.)		–	0.43	–	dB
Step Error	5	–	–	$\pm 0.2$	dB
Input Impedance		100.0	–	–	k $\Omega$
<b>“Volume” Stage (Ch8)</b>					
Gain		-14.0	–	+14.0	dB
Gain per Step (15 in No.)		–	2.0	–	dB
Step Error	5	–	–	$\pm 0.4$	dB
Input Impedance		50.0	–	–	k $\Omega$
<b>Timing (Figure 4)</b>					
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 Over Time ( $t_{LLO}$ )		–	–	50.0	ns
Load/Latch Delay ( $t_{LLD}$ )		200	–	–	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.
5. With reference to a 1.0kHz signal.

## Package Outlines

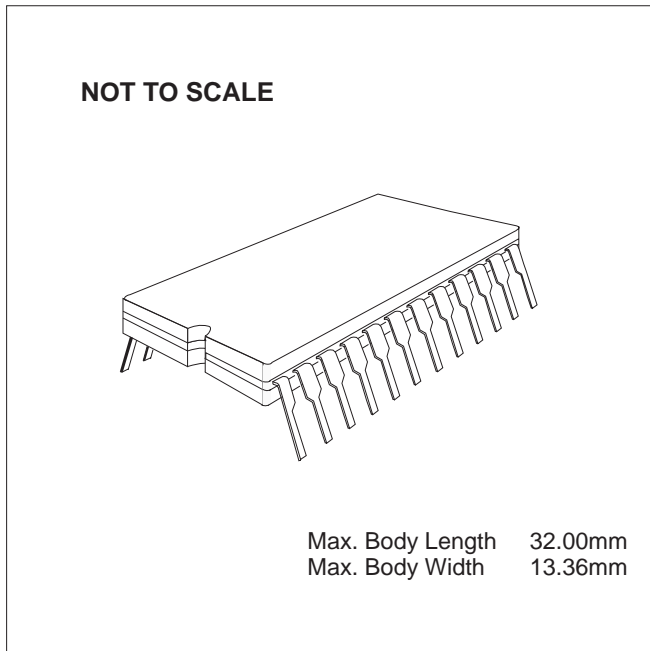
The FX009A is available in the package styles outlined below. Mechanical package diagrams and specifications are detailed in Section 10 of this document.

Pin 1 identification marking is shown on the relevant diagrams and pins on all package styles number anti-clockwise when viewed from the top.

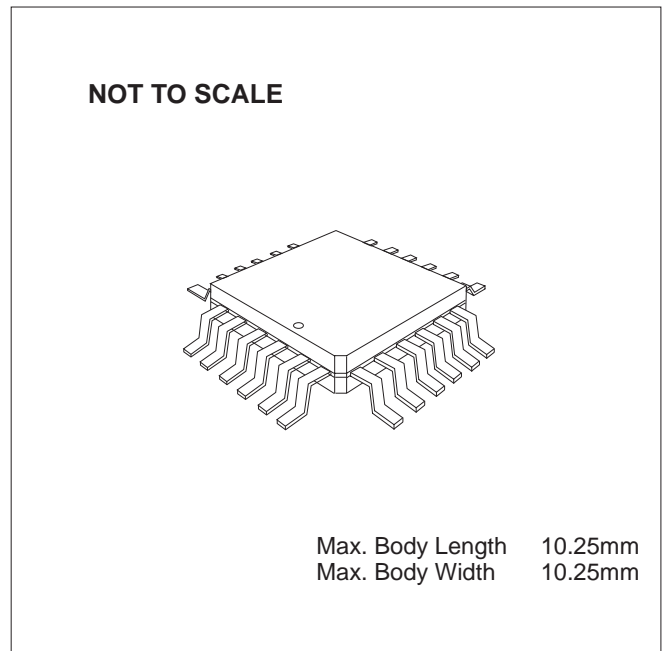
## Handling Precautions

The FX009A is a CMOS LSI circuit which includes input protection. However precautions should be taken to prevent static discharges which may cause damage.

### FX009AJ 24-pin cerdip DIL (J4)



### FX009ALG 24-pin quad plastic encapsulated bent and cropped (L1)



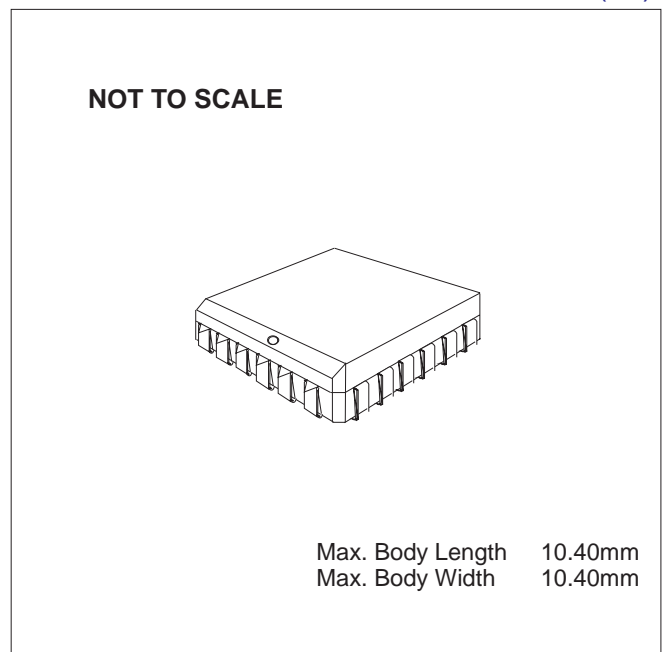
## Ordering Information

**FX009AJ** 24-pin cerdip DIL (J4)

**FX009ALG** 24-pin quad plastic encapsulated bent and cropped (L1)

**FX009ALS** 24-lead plastic leaded chip carrier (L2)

### FX009ALS 24-lead plastic leaded chip carrier (L2)



CML does not assume any responsibility for the use of any circuitry described. No circuit patent licences are implied and CML reserves the right at any time without notice to change the said circuitry.



**CML Microcircuits**

COMMUNICATION SEMICONDUCTORS

## CML Product Data

In the process of creating a more global image, the three standard product semiconductor companies of CML Microsystems Plc (*Consumer Microcircuits Limited (UK)*, *MX-COM, Inc (USA)* and *CML Microcircuits (Singapore) Pte Ltd*) have undergone name changes and, whilst maintaining their separate new names (*CML Microcircuits (UK) Ltd*, *CML Microcircuits (USA) Inc* and *CML Microcircuits (Singapore) Pte Ltd*), now operate under the single title **CML Microcircuits**.

These companies are all 100% owned operating companies of the CML Microsystems Plc Group and these changes are purely changes of name and do not change any underlying legal entities and hence will have no effect on any agreements or contacts currently in force.

### CML Microcircuits Product Prefix Codes

Until the latter part of 1996, the differentiator between products manufactured and sold from MXCOM, Inc. and Consumer Microcircuits Limited were denoted by the prefixes MX and FX respectively. These products use the same silicon etc. and today still carry the same prefixes. In the latter part of 1996, both companies adopted the common prefix: CMX.

This notification is relevant product information to which it is attached.

Company contact information is as below:



**CML Microcircuits  
(UK) Ltd**

COMMUNICATION SEMICONDUCTORS

Oval Park, Langford, Maldon,  
Essex, CM9 6WG, England  
Tel: +44 (0)1621 875500  
Fax: +44 (0)1621 875600  
uk.sales@cmlmicro.com  
www.cmlmicro.com



**CML Microcircuits  
(USA) Inc.**

COMMUNICATION SEMICONDUCTORS

4800 Bethania Station Road,  
Winston-Salem, NC 27105, USA  
Tel: +1 336 744 5050,  
0800 638 5577  
Fax: +1 336 744 5054  
us.sales@cmlmicro.com  
www.cmlmicro.com



**CML Microcircuits  
(Singapore) Pte Ltd**

COMMUNICATION SEMICONDUCTORS

No 2 Kallang Pudding Road, 09-05/  
06 Mactech Industrial Building,  
Singapore 349307  
Tel: +65 7450426  
Fax: +65 7452917  
sg.sales@cmlmicro.com  
www.cmlmicro.com