CML Semiconductor Products

PRODUCT INFORMATION

FX019 Digitally Controlled Quad Amplifier Array

Features

- **4 Digitally Controlled Amplifiers**
- **15 Gain/Attenuation Steps**
- **3 Amplifiers, with a ± 3dB Range in 0.43dB Steps**
- **1 'Volume' Amplifier, with a ± 14dB Range in 2dB Steps**

- **8-Bit Serial Data Control**
- **Output Mute Function**
- **Audio and Data Gain Control Applications**
- **Telecoms, Radio and Industrial Applications**

Fig.1 Functional Block Diagram
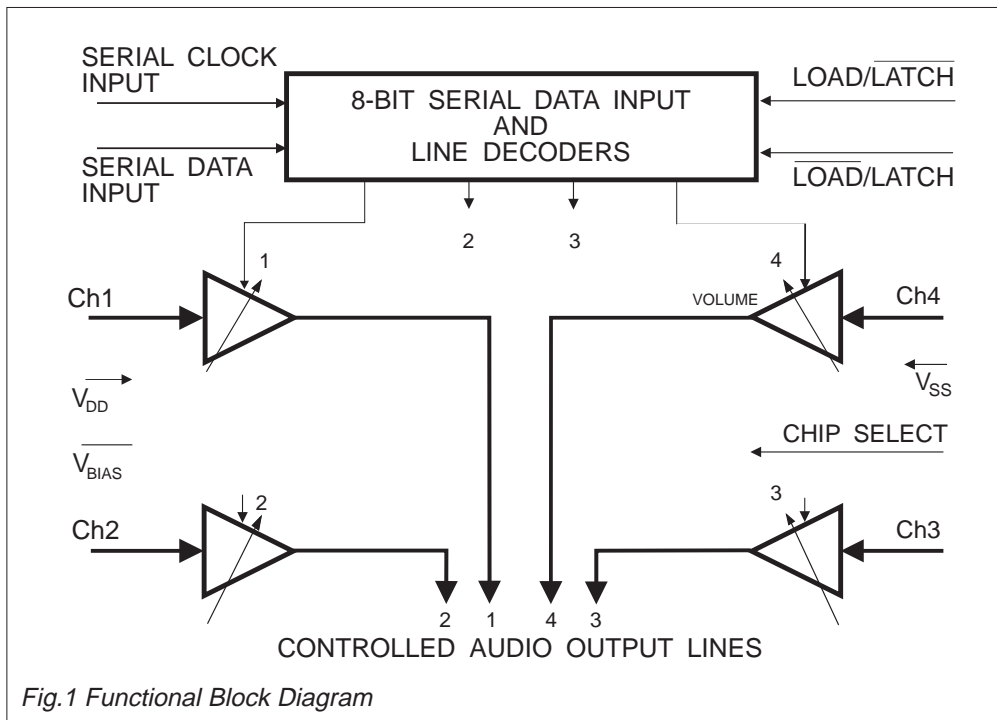
Brief Description

The FX019 Digitally Adjustable Amplifier Array is available to replace trimmer potentiometers and volume controls in Cellular, PMR, Telephony and Communications applications where d.c., voice or data signals need adjustment.

The FX019 is a single-chip LSI consisting of four digitally controlled amplifier stages, each with 15 distinct gain/attenuation steps. Control of each individual amplifier is by an 8-bit serial data stream. Three 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 suggested for volume control applications. Each amplifier includes a 16th 'Off' state which when applied, mutes the output audio from that channel. This array uses a Chip Select input to select one of two FX019s in a system.

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 during development, production/calibration and operation.

Applications include:

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

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

(iii) Fully automated servicing and re-alignment.

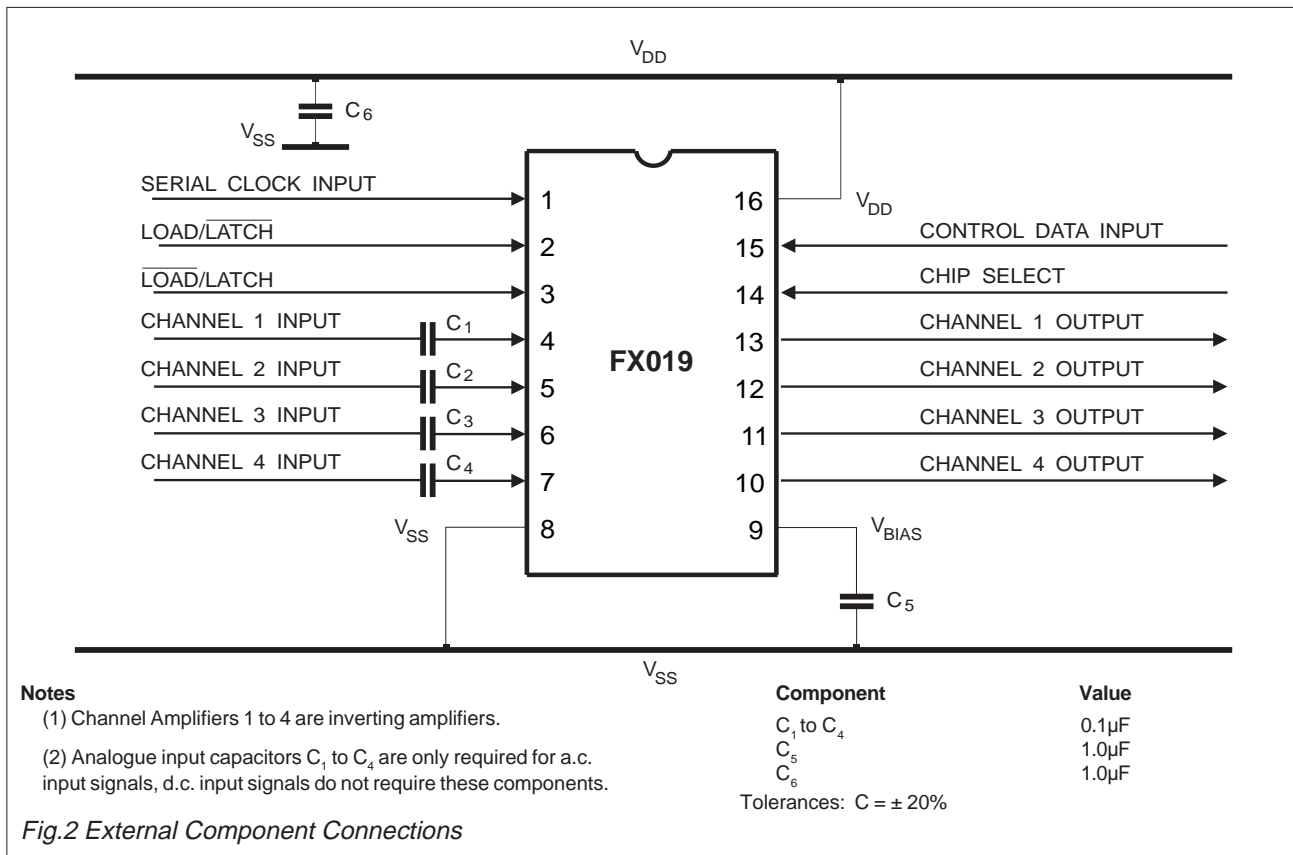The FX019 is a low-power, single 5-volt CMOS device available in plastic DIL and Small Outline (S.O.I.C.) SMD package versions.

1

Pin Number   Function

FX019DW	
FX019P	

1	**Serial Clock :** This external clock pulse input is used to "clock in" the Control Data. See Figure 4, Serial Control Data Load Timing. This input has an internal 1MΩ pullup resistor.
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 Load/$\overline{\text{Latch}}$ input is used this pin should be left open circuit. This input has an internal 1MΩ pullup resistor.
3	**$\overline{\text{Load}}$/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	**Ch1 Input :**
5	**Ch2 Input :**
6	**Ch3 Input :**
7	**Ch4 Input :**

Analogue Inputs :

These individual amplifier inputs are self-biasing, a.c. input analogue signals must be capacitively coupled to these pins, as shown in Figure 2.
Note that amplifiers Ch1 to Ch4 are 'inverting amplifiers.'

8	**V$_{SS}$:** Negative supply rail (GND).
9	**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.
10	**Ch4 Output :**
11	**Ch3 Output :**
12	**Ch2 Output :**
13	**Ch1 Output :**

Controlled Analogue Outputs :

The individual "Gain Controlled" amplifier outputs.
Ch1 to Ch3 range from -3dB to +3dB in 0.43dB steps, Ch4 could be utilized as a volume control, ranging from -14dB to +14dB in 2.0dB steps.
In the "OFF" mode there is no output from the selected amplifier.

14	**Chip Select :** A logic input to select one of two FX019 microcircuits in a system, see Table 1. This input has an internal 1MΩ pulldown resistor.
15	**Control Data Input :** Operation of the 4 amplifier channels (Ch1 – Ch4) 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.
16	**V$_{DD}$:** Positive supply rail. A single +5-volt power supply is required.

Application Notes

Notes

(1) Channel Amplifiers 1 to 4 are inverting amplifiers.

(2) Analogue input capacitors C_1 to C_4 are only required for a.c. input signals, d.c. input signals do not require these components.

Component	Value
C_1 to C_4	0.1μF
C_5	1.0μF
C_6	1.0μF

Tolerances: C = ± 20%

Fig.2 External Component Connections
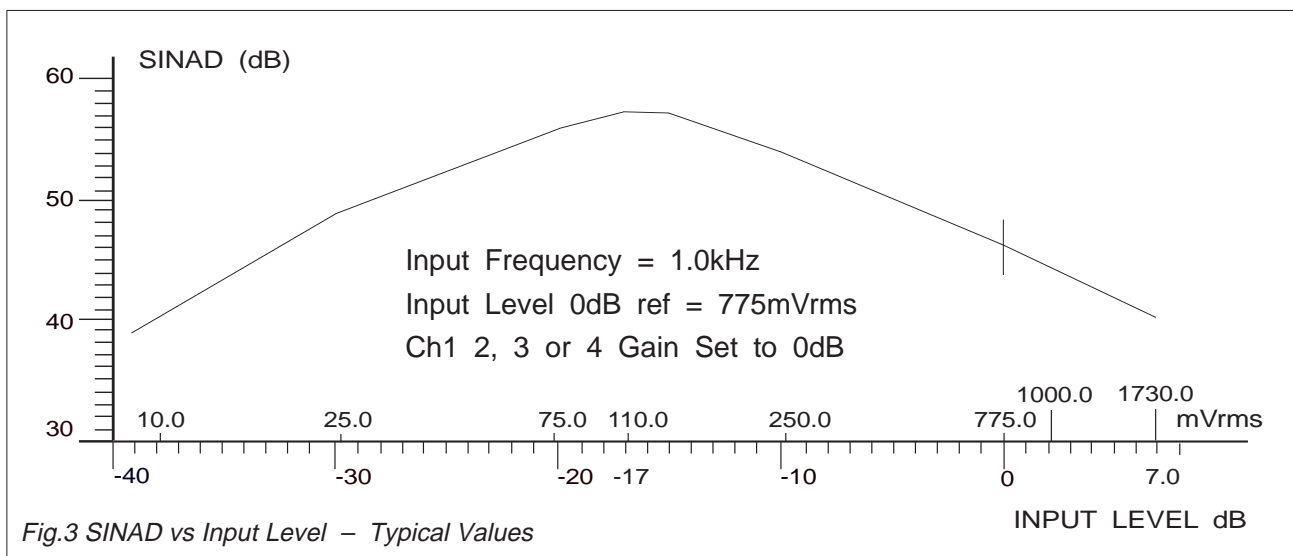
Application Recommendations

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 FX019 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.

Input Frequency = 1.0kHz

Input Level 0dB ref = 775mVrms

Ch1 2, 3 or 4 Gain Set to 0dB

Fig.3 SINAD vs Input Level – Typical Values

Control Data and Timing

The gain of each amplifier block (Channel 1 to Channel 4) in the FX019 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.
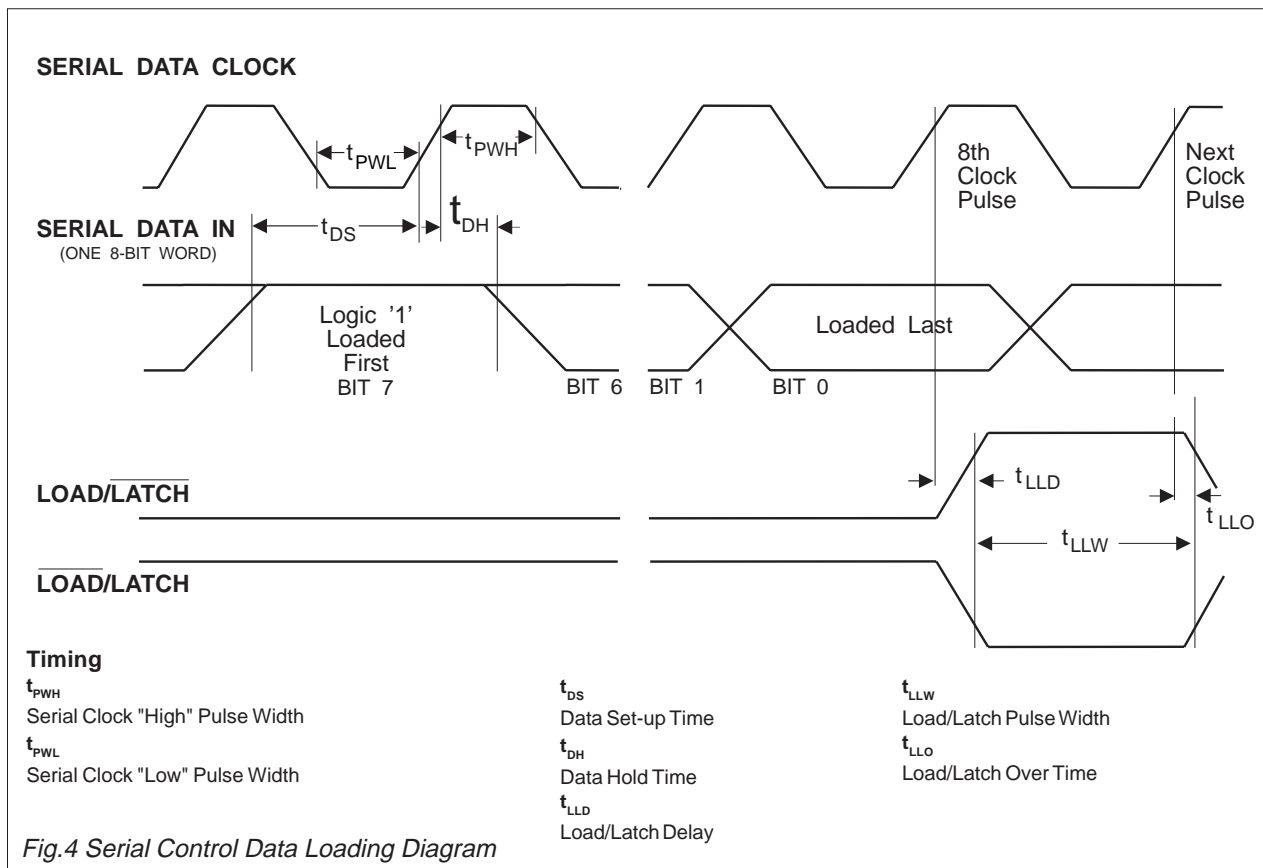
Data is loaded to the FX019 on the rising edge of the Serial Clock. Loaded data is executed on the falling (rising) edge of the Load/Latch (Load/Latch) pulse. Table 1 shows the format of each 4-bit Address word, Table 2 shows the format of each Gain Control word with Figure 4 describing the data loading operation and timing.

Table 1 Address Word Format						
Bit 7 MSB	Bit 6	Bit 5	Bit 4 LSB	Channel Selected	Chip Select	Chip Number
1	0	0	0	1	0	**Chip 1**
1	0	0	1	2	0	
1	0	1	0	3	0	
1	0	1	1	4	0	
1	1	0	0	1	1	**Chip 2**
1	1	0	1	2	1	
1	1	1	0	3	1	
1	1	1	1	4	1	

Table 2 Gain Control Word Format					
Bit 3 MSB	Bit2	Bit 1	Bit 0 LSB	Stage 1, 2, 3 (0.43dB)	Stage 4 (2.0dB)
0	0	0	0	OFF	OFF
0	0	0	1	-3.0	-14.0dB
0	0	1	0	-2.571	-12.0
0	0	1	1	-2.143	-10.0
0	1	0	0	-1.714	-8.0
0	1	0	1	-1.286	-6.0
0	1	1	0	-0.857	-4.0
0	1	1	1	-0.428	-2.0
1	0	0	0	0	0
1	0	0	1	0.428	2.0
1	0	1	0	0.857	4.0
1	0	1	1	1.286	6.0
1	1	0	0	1.714	8.0
1	1	0	1	2.143	10.0
1	1	1	0	2.571	12.0
1	1	1	1	3.0	14.0

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. The Chip Select input permits the use of two devices in a system; To facilitate this, Bit 6 can be either a logic "0" or "1." Figure 4 (below) shows the timing information required to load and operate this device.

SERIAL DATA CLOCK

t_{PWL} t_{PWH}

8th Clock Pulse   Next Clock Pulse

SERIAL DATA IN
(ONE 8-BIT WORD)

t_{DS} t_{DH}

Logic '1' Loaded First BIT 7   BIT 6   BIT 1   BIT 0

Loaded Last

LOAD/LATCH

t_{LLD}

t_{LLO}

t_{LLW}

LOAD/LATCH

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_{LLD}
Load/Latch Delay

t_{LLW}
Load/Latch Pulse Width

t_{LLO}
Load/Latch Over Time

Fig.4 Serial Control Data Loading Diagram

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
Operating temperature range: **FX019DW/P**	-40°C to +85°C (plastic)
Storage temperature range: **FX019DW/P**	-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		-	1.5	-	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		–	1.0	-	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 – Ch3)					
Gain		-3.0		+3.0	dB
Gain per Step (15 in No.)		–	0.43	–	dB
Step Error	5	–	–	±0.2	dB
Input Impedance		100.0	–	–	kΩ
"Volume" Stage (Ch4)					
Gain		-14.0		+14.0	dB
Gain per Step (15 in No.)		–	2.0	–	dB
Step Error	5	–	–	±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})		50.0	–	–	ns
Load/Latch Pulse Width (t_{LLW})		150	–	–	ns
Load/Latch Delay (t_{LLD})		200	–	–	ns
Load/Latch Over (t_{LLO})		–	–	50.0	ns
Serial Data Clock Frequency		–	–	2.0	MHz

Notes
1. Gain Set 0dB, Input Level 1kHz -3.0dB (549mVrms).
2. With an a.c short-circuit input, measured in a 30kHz bandwidth.
3. See Figure 3.
4. Over the temperature and supply voltage range.
5. With reference to a 1.0kHz signal.
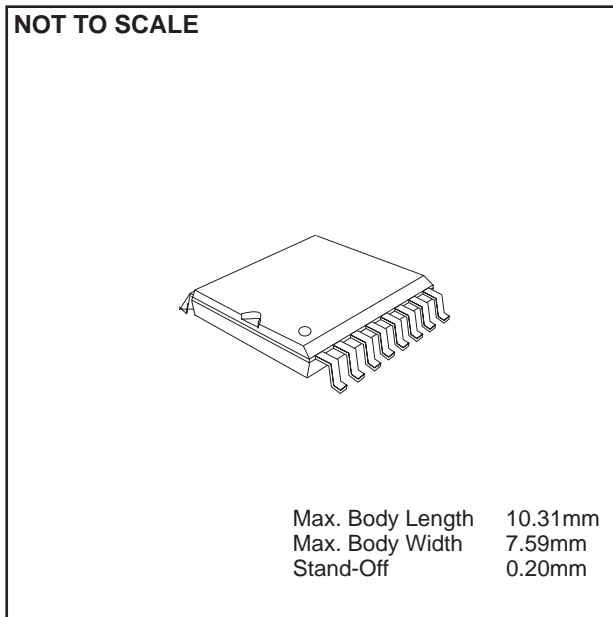
Package Outlines

The FX019 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.
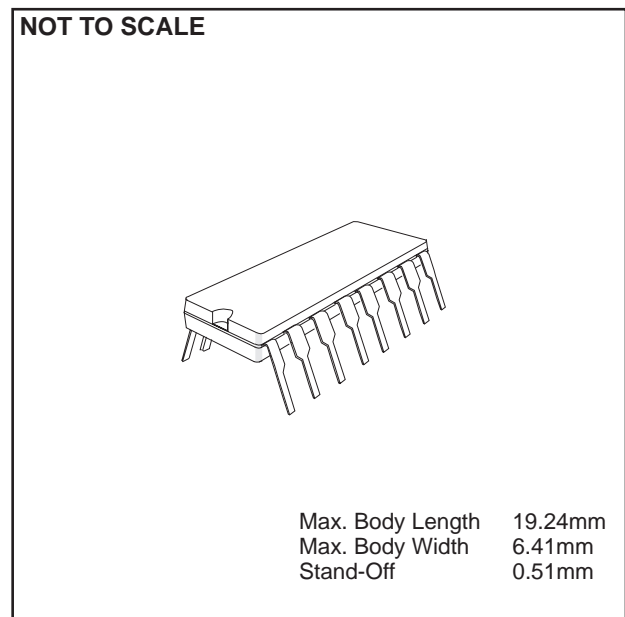
Handling Precautions

The FX019 is a CMOS LSI circuit which includes input protection. However precautions should be taken to prevent static discharges which may cause damage.

FX019DW 16-pin plastic S.O.I.C.   **(D4)**

NOT TO SCALE

Max. Body Length	10.31mm
Max. Body Width	7.59mm
Stand-Off	0.20mm

FX019P   16-pin plastic DIL   **(P3)**

NOT TO SCALE

Max. Body Length	19.24mm
Max. Body Width	6.41mm
Stand-Off	0.51mm

Ordering Information

FX019DW   **16-pin plastic S.O.I.C.**   **(D4)**

FX019P   **16-pin plastic DIL**   **(P3)**

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:

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