# M62301SP,FP

## 10~12-BIT 4CH INTEGRATING A-D CONVERTER

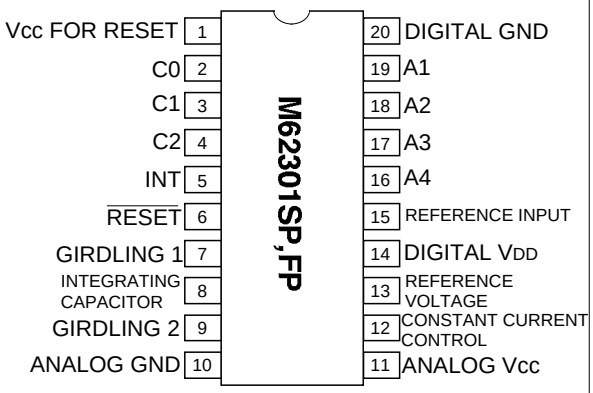
## DESCRIPTION

M62301 semiconductor integrated circuit forms an integrating A-D converter,being connected to a microcomputer unit.By using selection signals and counter clock signals from the unit,a 10~12-bit A-D converter can be created at a low cost.

The integration time and resolution can be set at the user's option by changing external parameters.In addition,the built-in circuit offset,delay time and temperature fluctuation are adjustable,enabling a wide range of applications.

M62301 has a 3 input decoder circuit,high-precision reference voltage(1.22V)generator,current supply and comparator for integration,and voltage-monitoring reset circuit for a 5V power supply.It is also equipped with girdling to prevent current leak from integration capacitor.

## PIN CONFIGURATION (TOP VIEW)




**Outline 20P4B(SP)**
**20P2N-A(FP)**

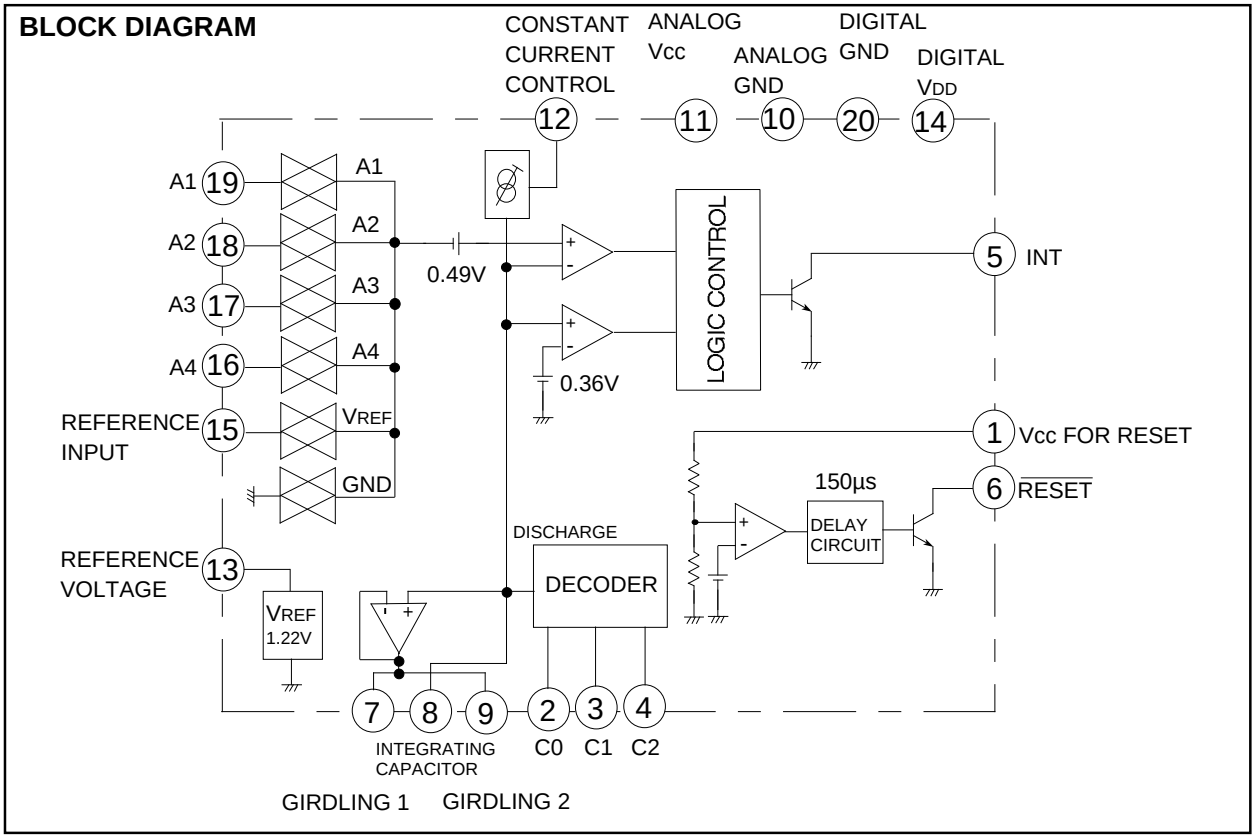
## FEATURES

- Separate power supplies for analog section and digital section.
- Low power dissipation.....2mA(typ)
  (1mA for A-D conversion and the other 1mA for reset)
- Linear error.....±0.02%(typ)
- Conversion time.....526µs/ch(typ)
- Built-in system reset.....4.45V(typ)

## APPLICATION

High-precision control systems such as temperature control and speed control

## BLOCK DIAGRAM



**ABSOLUTE MAXIMUM RATINGS**(Ta=25°C, unless otherwise noted)

| Symbol | Parameter | Conditions | Ratings | Unit |
|---|---|---|---|---|
| $V_{CC}$ | Analog section supply voltage | | 15 | V |
| $V_{DD}$ | Digital section supply voltage | | 8 | V |
| $V_{ID}$ | Digital input voltage | | -0.3~VDD+0.3 | V |
| $V_{IA}$ | Analog input voltage | | -0.3~VDD+0.3 | V |
| $I_{oINT}$ | INT output current | | 6 | mA |
| $I_{oRE}$ | Reset output current | | 6 | mA |
| $V_{INT}$ | INT output withstand voltage | | 15 | V |
| $V_{RESET}$ | Reset output withstand voltage | | 15 | V |
| $V_{RE}$ | Reset supply voltage | | 6 | V |
| Pd | Power dissipation | | 990(DIP)/660(FP) | mW |
| $K_\theta$ | Thermal derating | | 9.9(DIP)/6.6(FP) | mW/℃ |
| $T_{opr}$ | Operating temperature | | -20 ~ +75 | ℃ |
| $T_{stg}$ | Storage temperature | | -55 ~ +125 | ℃ |

**RECOMMENDED OPERATING CONDITIONS**(Ta=25°C, unless otherwise noted)

| Symbol | Parameter | Limits | | | Unit |
|---|---|---|---|---|---|
| | | Min | Typ | Max | |
| $V_{CC}$ | Analog section supply voltage | 4.5 | 8.0 | 12.0 | V |
| $V_{DD}$ | Digital section supply voltage | 4.5 | 5.0 | 5.5 | V |
| $V_{IA}$ | Analog input voltage range ($I_I$=50μA) | 0 | | No more than(Vcc-2.5V) and $V_{DD}$(Note 1) | V |
| $V_{IR}$ | Reference input voltage($I_I$=50μA) | 1 | — | No more than(Vcc-2.5V) and $V_{DD}$(Note 1) | V |
| $C_I$ | Integration capacity | 300 | — | 22000 | pF |
| $R_I$ | Resistance to determine charge current | 6 | — | 60 | kΩ |
| $I_o$ | Output current | | — | 4 | mA |

Note 1.Maximum analog input voltage is less than the difference between Vcc-2.5V as well as $V_{DD}$.

*Charging current $I_I = \frac{V_{REF}}{R1}$

**ELECTRICAL CHARACTERISTICS**(Vcc=5.0V,$V_{DD}$=5.0V,Ta=25°C, unless otherwise noted)

| | Symbol | Parameter | Test conditions | Limits | | | Unit |
|---|---|---|---|---|---|---|---|
| | | | | Min. | Typ. | Max. | |
| A-D converter | Icc | Supply current | | — | 1.0 | 2.0 | mA |
| | $V_{IA}$ | Analog input voltage range | $I_I$=100µA | 0 | | 2.5 | V |
| | | | $I_I$=200µA | | | 2.2 | |
| | $V_{REF}$ | Reference input voltage | $I_{REF}$=±5µA<br>$C_{REF}$=4700pF | 1.17 | 1.22 | 1.27 | V |
| | $I_{REF}$ ⊕ | Permissible current inflow at reference voltage | | | | 50 | µA |
| | $I_{REF}$ ⊖ | | | | | -10 | |
| | Ec | Conversion error | (Note 1)$R_I$=24kΩ | | 0.05 | 0.1 | %/FSR |
| | EL | Linear error | (Note 2)$R_I$=24kΩ | | 0.02 | 0.09 | %/FSR |
| | TT | Conversion time | $V_{IA}$=2.5V,$C_I$=0.01µF<br>$R_I$=24kΩ | | 526 | | µs |
| | Tdi | Discharge time | V 8=3V-► 0.3V<br>$C_I$=4700pF | | 3 | 17 | µs |
| | IB | Analog input current | | | -0.35 | -3.5 | µA |
| | $V_{IH}$ | Digital input “H“ level | | 3.5 | | | V |
| | $V_{IL}$ | Digital input “L“ level | | | | 0.8 | V |
| | $V_{LINT}$ | INT output “L“ level | $I_{OL}$=1mA | | 0.1 | 0.4 | V |
| | $I_{OHINT}$ | INT output leak current | V 5=15V | — | — | 1 | µA |
| Reset section | $V_{DET}$ | Detection voltage | | 4.30 | 4.45 | 4.60 | V |
| | ΔVDET | Hysteresis voltage | | 30 | 50 | 80 | mV |
| | TDE | Delay time | | 75 | 150 | 300 | µs |
| | $V_{LRE}$ | Reset output “L“ level | $I_{OL}$=1mA | | 0.1 | 0.4 | V |
| | $I_{OHRE}$ | Reset output leak current | V 5=15V | — | — | 1 | µA |
| | IRE | Supply current | VRE=5V | | 1.0 | 2.0 | mA |
| | $V_{OPL}$ | Limit operating voltage | $R_L$=2.2kΩ,$V_{\overline{LRE}}$≤0.4V | | 0.75 | 1.0 | V |
| | | | $R_L$=100kΩ,$V_{\overline{LRE}}$≤0.4V | | 0.6 | 0.8 | |

Note 1.Conversion error;Deviation from the line that links the “0“ scale point (mode 0) and reference scale point (mode 3. $V_{FSR}$=2.5V).Associated with all channels.

Note 2.Linear error;Deviation from the line that links the 0-V input point and 2.5V input point on a given channel.

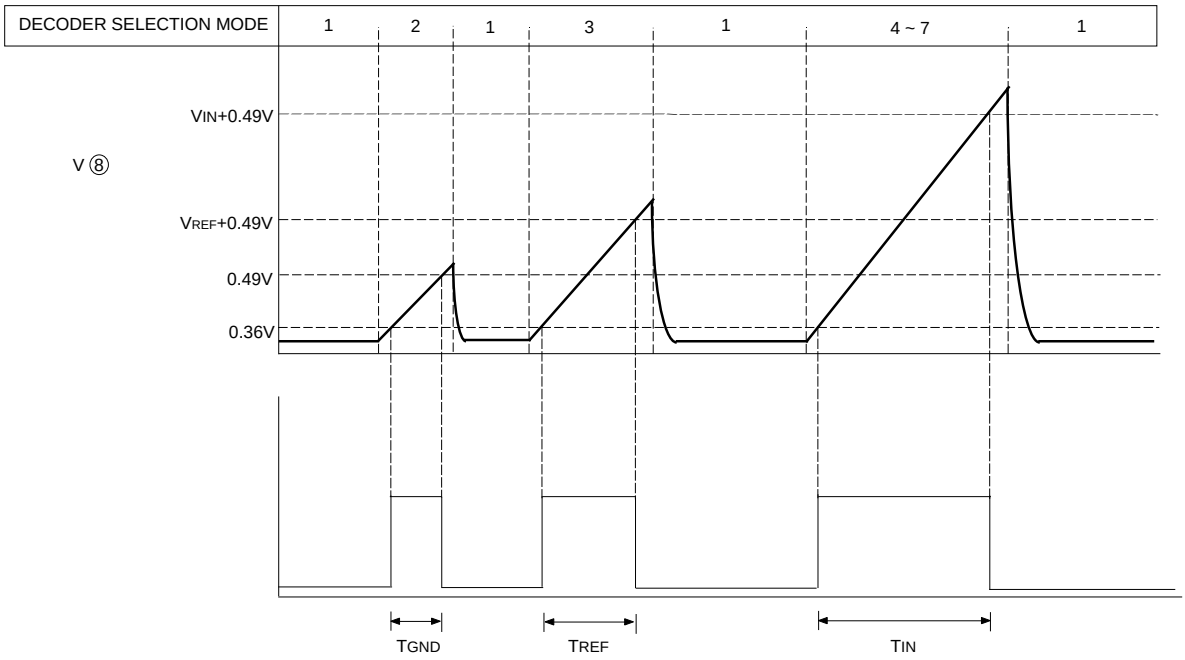
## OPERATING DESCRIPTION

### (1)Decoder

Based on digital inputs to C0,C1,C2,the analog switch is set to on,and the input of "0" scale (GND input),input of reference scale (reference voltage input),input to A1~A4,or discharge from integration capacitor ($C_I$) is performed.None of these operations is performed when the "mode 8" input is given:

| Mode | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| C0 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 |
| C1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 |
| C2 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 |
| | Discharge | GND | $V_{REF}$ | A1 | A2 | A3 | A4 | — |

### (2)A-D conversion




Multiplexer first selects $V_{GND}$,obtaining minimum pulse $T_{GND}$.It then selects $V_{REF}$,obtaining reference pulse $T_{REF}$.Input is selected next,obtaining input pulse $T_{IN}$.$V_{IN}$ is obtained by deducting $T_{GND}$,as the offset,from $T_{REF}$ and $T_{IN}$.

$$V_{IN}=V_{REF}\cdot\frac{T_{IN}-T_G}{T_{REF}-T_G}$$

By measuring voltage at the maximum input for approximately 500µs under the counter clock of 8MHz,resolution of approximately 12bits can be obtained;

$$\frac{500\mu s}{125ns}\fallingdotseq 2^{12}$$

Note. To ensure discharge from capacitor $C_I$,the decoder input as in the above diagram should stay in mode 1 at least for the period calculated above:$Tdi=(C_I\times\frac{V_{IA}max+0.49}{1mA})$

It is not necessary to measure $T_{GND}$,and $T_{REF}$ for each channel.

**(3)Constant current control**

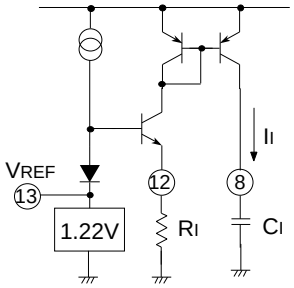
Integrating current $I_I$ can be obtained based on the reference voltage(1.22V)by the built-in high-precision generator and resistance $R_I$.

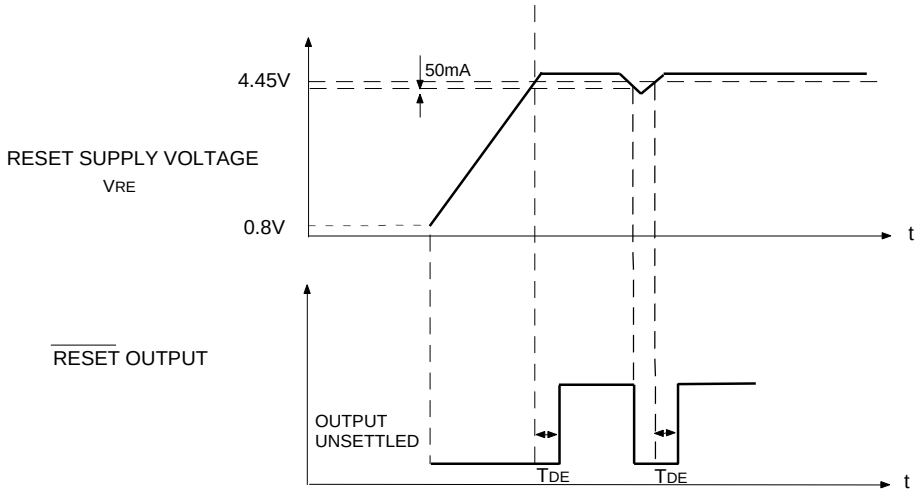
$$I_I = \frac{1.22}{R_I} \text{ (A)} \quad \text{.....(1)}$$

Integration time $T_I$ can be calculated as follows;

$$T_I = (V_{IN}+0.49)\ \frac{C_I}{I_I} \quad \text{.....(2)}$$

(However,parameters such as built-in comparator offset voltage,analog switch offset,voltage leak current and delay time are not counted.)

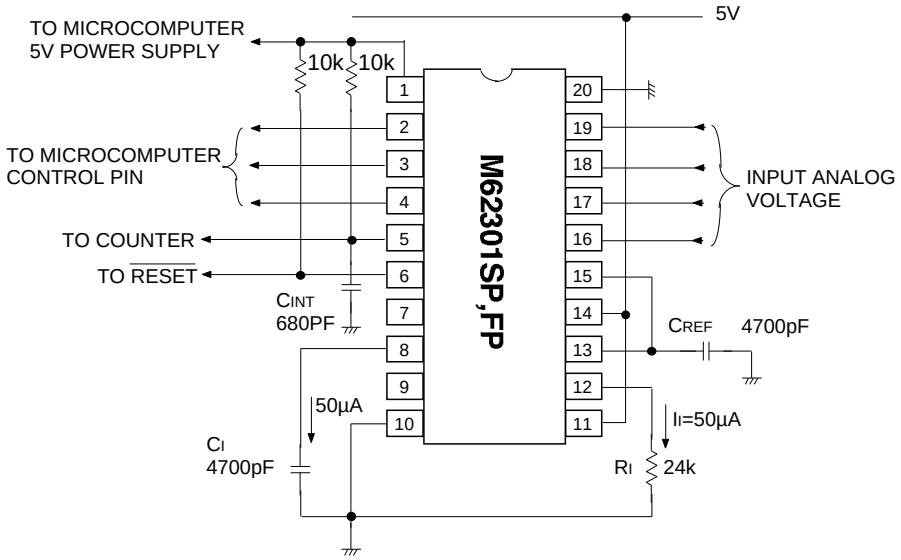



When voltage applied to pin $V_{RE}$ becomes less than 4.45V,the $\overline{\text{RESET}}$ output status becomes "L".If voltage increases over 4.50V,the $\overline{\text{RESET}}$ status becomes "H" within 150µsec.

**APPLICATION SUGGESTION**

**1.4-channel 11-bit A-D converter system**




CREF:To stabilize reference voltage, be sure to connect capacitance of approximately 4700pF.

CINT:We suggest that this capacitance be connected to prevent malfunction due to noise.

Use CI that leaks as slight current as possible.To prevent leak to the circuit board,we recommend providing girdling ⑦ , ⑨

Charge current $I_I = \frac{1.22V}{24k\Omega} \fallingdotseq 50\mu A$

Resolution depends on the number of microcomputer counter clock pulses that are generated while the INT output status is "high" at the maximum input voltage 2.5V (vcc-2.5V).

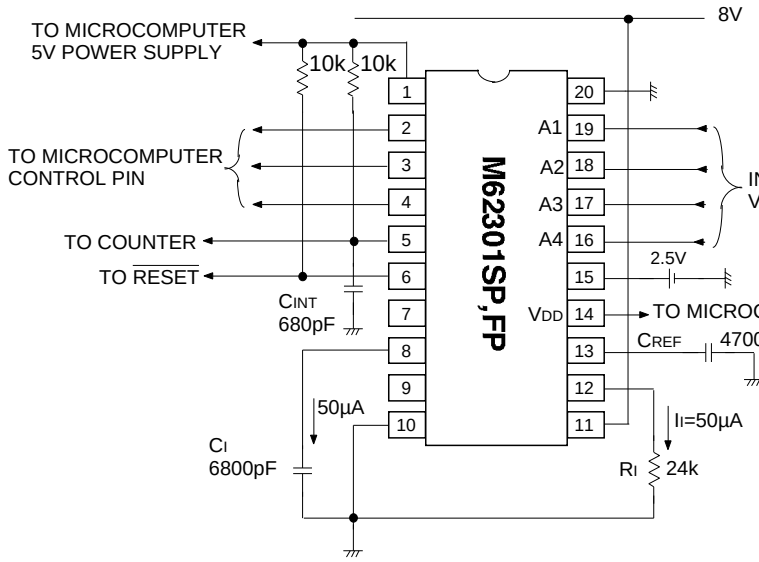
When the microcomputer counter clock frequency is 8MHz,the resolution can be calculated by using the constant calculated above,as follows;

$$\frac{4700pF \times \frac{(2.5+0.13)}{50\mu A}}{\frac{1}{8M}} \fallingdotseq 2^{11}$$

Therefore,the resolution of this system is approximately 11 bits.

**2.4-channel 12-bit A-D converter system**

Separate power supplies to analog section and digital section, analog input voltage range mode wider up to $V_{DD}$,external reference voltage for integration.




$C_{REF}$:To stabilize reference voltage, be sure to connect capacitance of approximately 4700pF.

$C_{INT}$:We suggest that this capacitance be connected to prevent malfunction due to noise.

Use CI that leaks as slight current as possible.To prevent leak to the circuit board,we recommend providing girdling ⑦ , ⑨

Because separate power supplies are provided for the analog are digital sections,the M62301 has two supply voltage Vcc and $V_{DD}$,enabling a wide analog input voltage range $V_{IA}$.The upper limit of the range is required to be no more than the difference between Vcc-2.5V as well as $V_{DD}$,therefore,the analog input voltage range in this application is 0V to 5V.

When the counter clock frequency is 8MHz,resolution is:

$$\frac{6800\text{pF} \times \dfrac{(5 + 0.13)}{50\mu\text{A}}}{\dfrac{1}{8\text{M}}} \fallingdotseq 2^{12}$$

An A-D converter system with resolution of approximately 12 bits can be formed.

**Recommended operational settings according to clock frequency,resolution,and time required for discharge(decoder mode 1)**

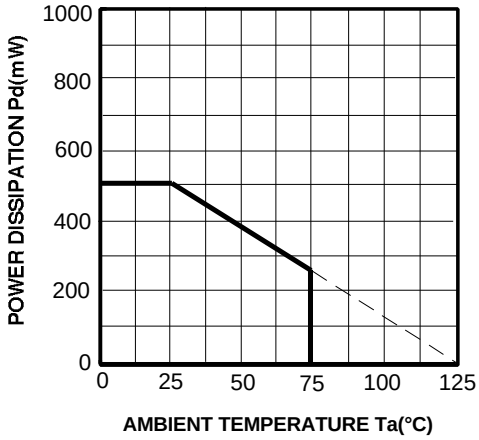
| Counter clock | Resolution | Change current $I_I$(μA) | Resistance to determine constant current $R_I$(kΩ) | Integration capacitance $C_I$ | Discharge time Tdi(μs) |
|---|---|---|---|---|---|
| 8MHz | 10-bit | 50 | 24 | 1400pF | 7.7 |
| | | 100 | 12 | 2800pF | 15.4 |
| | 11-bit | 50 | 24 | 2800pF | 15.4 |
| | | 100 | 12 | 5600pF | 30.7 |
| | 12-bit | 50 | 24 | 5600pF | 30.7 |
| | | 100 | 12 | 12000pF | 65.9 |
| 16MHz | 10-bit | 50 | 24 | 700pF | 3.9 |
| | | 100 | 12 | 1400pF | 7.7 |
| | 11-bit | 50 | 24 | 1400pF | 7.7 |
| | | 100 | 12 | 2800pF | 15.4 |
| | 12-bit | 50 | 24 | 2800pF | 15.4 |
| | | 100 | 12 | 5600pF | 30.7 |

Note 1.Discharge time $Tdi=(C_I \times \dfrac{V_{IA}max+0.49}{1mA})$

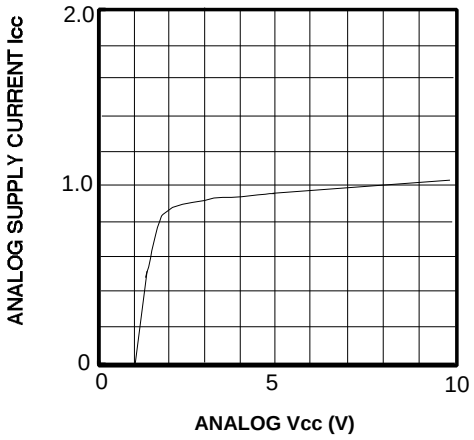
The values in this table apply when $V_{IA}$max is 5V.

## TYPICAL CHARACTERISTICS

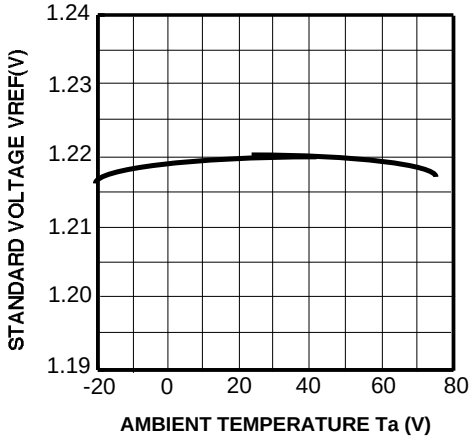
THERMAL DERATING



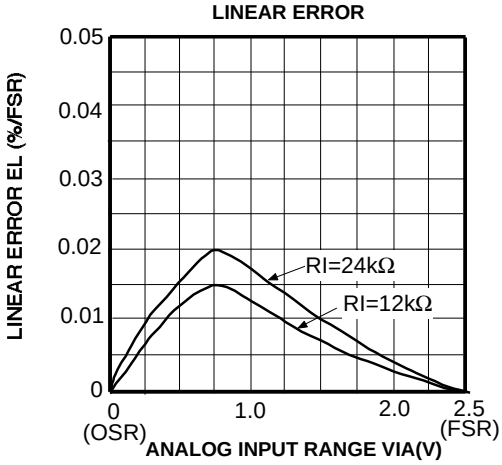

ANALOG PART SUPPLY CURRENT VS.SUPPLY VOLTAGE



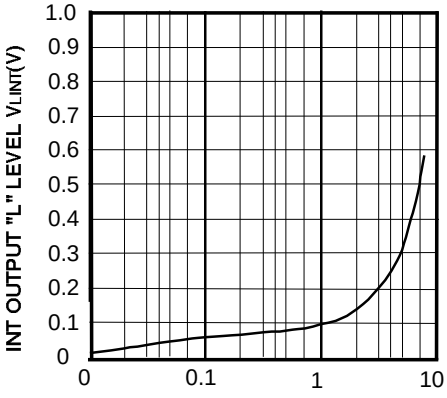

STANDARD VOLTAGE VS. AMBIENT TEMPERATURE



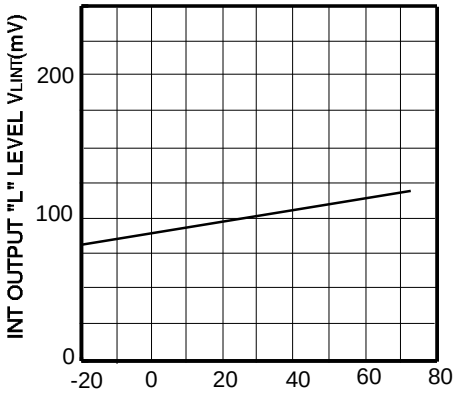

LINEAR ERROR



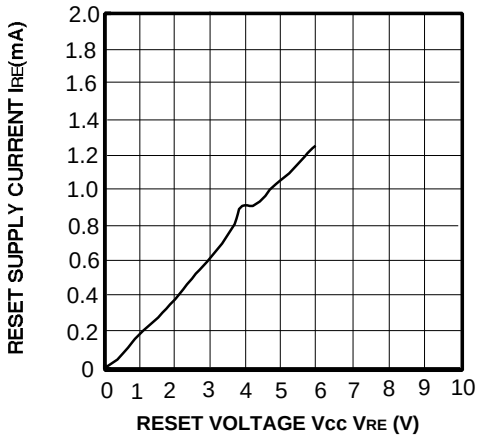

INT OUTPUT "L" LEVEL VS.OUTPUT CURRENT



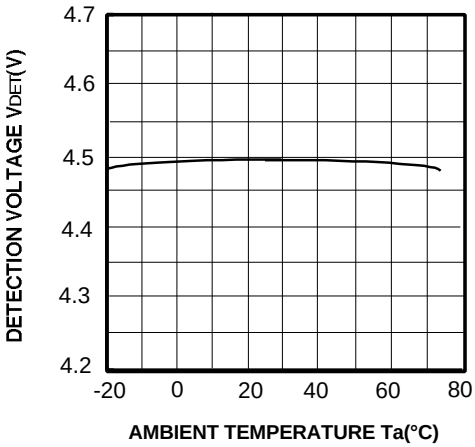

INT OUTPUT VS.AMBIENT TEMPERATURE



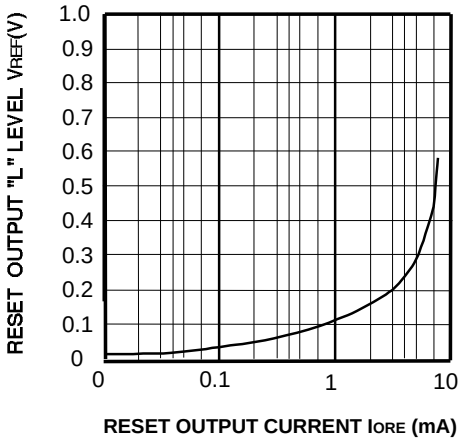
RESET SUPPLY CURRENT VS. SUPPLY VOLTAGE



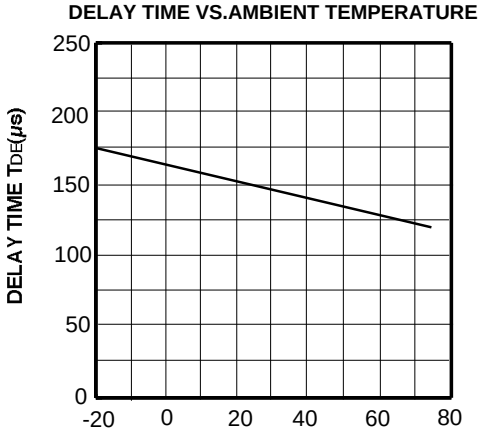

DETECTION VOLTAGE vs. AMBIENT TEMPERATURE




RESET OUTPUT "L" LEVEL VS.OUTPUT CURRENT




DELAY TIME VS.AMBIENT TEMPERATURE




LIMIT RESET VOLTAGE