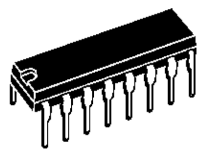
SGS-THOMSON MICROELECTRONICS

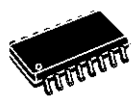
TS904

INPUT/OUTPUT **RAIL TO RAIL** QUAD CMOS OPERATIONAL AMPLIFIER (WITH **STANDBY** POSITION)

- **RAIL TO RAIL** INPUT AND OUTPUT VOLTAGE RANGES
- 2 SEPARATE **STANDBY** : REDUCED **CONSUMPTION** AND **HIGH IMPEDANCE OUTPUTS**
- SINGLE (OR DUAL) SUPPLY OPERATION FROM **2.7V TO 16V** (±1.35V to ±8V)
- EXTREMELY LOW INPUT BIAS CURRENT : **1pA** TYP
- LOW INPUT OFFSET VOLTAGE : **5mV** max.
- SPECIFIED FOR **600Ω** AND **150Ω** LOADS
- LOW SUPPLY CURRENT : 400µA/Ampli (V_{CC} = 10V)



N
DIP16
(Plastic Package)



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SO16
(Plastic Micropackage)

ORDER CODES

Part Number	Temperature Range	Package	
		N	D
TS904I/AI	-40, +125°C	•	•

DESCRIPTION

The TS904 is a RAIL TO RAIL quad CMOS operational amplifier designed to operate with single or dual supply voltage.
The input voltage range V_{icm} includes the two supply rails V_{CC}^+ and V_{CC}^-.
The output reaches :

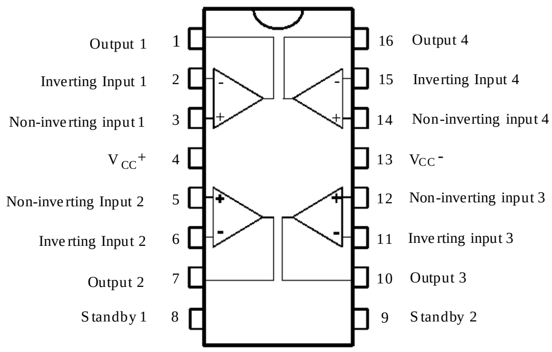
- V_{CC}^- +50mV V_{CC}^+ -50mV   with R_L = 10kΩ
- V_{CC}^- +650mV V_{CC}^+ -650mV   with R_L = 600Ω

This product offers a broad supply voltage operating range from 2.7V to 16V and a supply current of only 400µA/amp. (V_{CC} = 10V)
Source and sink output current capability is typically 60mA (at V_{CC} = 10V), fixed by an internal limitation circuit.
The TS904 offers two separate **STANDBY** pins :

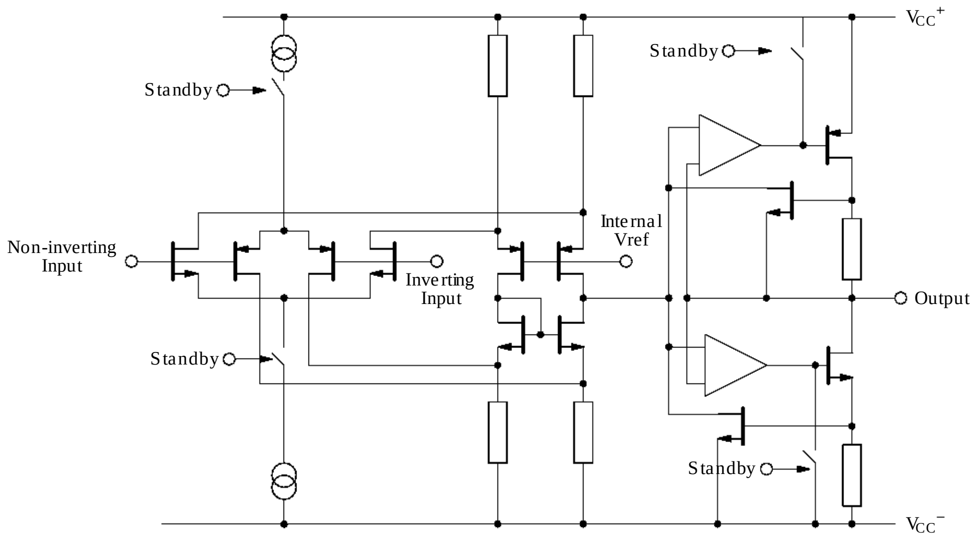
- STANDBY 1 acting on the n°2 and n°3 operators
- STANDBY 2 acting on the n°1 and n°4 operators

They reduce the consumption of the corresponding operators and put the outputs in a high impedance state.
These two STANDBY pins should never stay not connected.

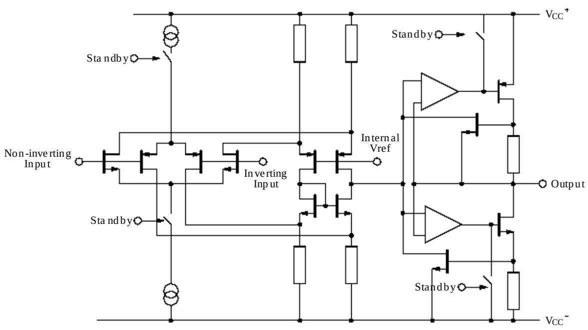
PIN CONNECTIONS (top view)



SCHEMATIC DIAGRAM (1/4 TS904)



STANDBY POSITION



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{CC}	Supply Voltage - (note 1)	18	V
V_{id}	Differential Input Voltage - (note 2)	±18	V
V_i	Input Voltage - (note 3)	-0.3 to 18	V
I_{in}	Cunnent on Inputs	±50	mA
I_o	Current on Outputs	±130	mA
T_{oper}	Operating Free Air Temperature Range TS904I/AI	-40 to +125	^oC
T_{stg}	Storage Temperature	-65 to +150	^oC

Notes : 1. All voltage values, except differential voltage are with respect to network ground terminal.
2. Differential voltages are the non-inverting input terminal with respect to the inverting input terminal.
3. The magnitude of input and output voltages must never exceed V_{CC}^+ +0.3V.

OPERATING CONDITIONS

Symbol	Parameter	Value	Unit
V_{CC}	Supply Voltage	2.7 to 16	V
V_{icm}	Common Mode Input Voltage Range	V_{CC}^- -0.2 to V_{CC}^+ +0.2	V

ELECTRICAL CHARACTERISTICS

V_{CC}^+ = 10V, V_{CC}^- = 0V, R_L,C_L connected to V_{CC}/2, pin 8 and 9 connected to V_{CC}^+, T_{amb} = 25°C (unless otherwise specified)

Symbol	Parameter		Min.	Typ.	Max.	Unit
V_{io}	Input Offset Voltage (V_{ic} = V_o = V_{CC}/2)	TS904 TS904A			10 5	mV
	$T_{min.} \leq T_{amb} \leq T_{max.}$	TS904 TS904A			12 7	
DV_{io}	Input Offset Voltage Drift			5		μV/°C
I_{io}	Input Offset Current - (note 1) $T_{min.} \leq T_{amb} \leq T_{max.}$			1	100 200	pA
I_{ib}	Input Bias Current - (note 1) $T_{min.} \leq T_{amb} \leq T_{max.}$			1	150 300	pA
I_{CC}	Supply Current (per amplifier, A_{VCL} = 1, no load) $T_{min.} \leq T_{amb} \leq T_{max.}$			400	600 700	μA
CMR	Common Mode Rejection Ratio	V_{ic} = 3 to 7V, V_o = 5V V_{ic} = 0 to 10V, V_o = 5V	50	75 70		dB
SVR	Supply Voltage Rejection Ratio (V_{CC}^+ = 5 to 10V, V_O = V_{CC} /2)		50	80		dB
A_{vd}	Large Signal Voltage Gain (R_L = 10kΩ, V_O = 2.5V to 7.5V) $T_{min.} \leq T_{amb} \leq T_{max.}$		20 15	60		V/mV
V_{OH}	High Level Output Voltage (V_{id} = 1V)	R_L = 10kΩ R_L = 600Ω R_L = 100Ω	9.85 9.2	9.95 9.35 7.8		V
	$T_{min.} \leq T_{amb} \leq T_{max.}$	R_L = 10kΩ R_L = 600Ω	9.8 9			
V_{OL}	Low Level Output Voltage (V_{id} = -1V)	R_L = 10kΩ R_L = 600Ω R_L = 100Ω		50 650 2300	150 800	mV
	$T_{min.} \leq T_{amb} \leq T_{max.}$	R_L = 10kΩ R_L = 600Ω			150 900	
I_o	Output Short Circuit Current (V_{id} = ±1V)	Source (V_o = V_{CC}^-) Sink (V_o = V_{CC}^+)	45 45	60 60		mA
GBP	Gain Bandwidth Product (A_{VCL} = 100, R_L = 10kΩ, C_L = 100pF, f = 100kHz)			1.3		MHz
SR^+	Positive Slew Rate (A_{VCL} = 1, R_L = 10kΩ, C_L = 100pF, V_i = 2.5V to 7.5V)			1.3		V/μs
SR^-	Negative Slew Rate (A_{VCL} = 1, R_L = 10kΩ, C_L = 100pF, V_i = 2.5V to 7.5V)			0.8		V/μs
∅m	Phase Margin			40		Degrees
e_n	Equivalent Input Noise Voltage (R_s = 100Ω, f = 1kHz)			30		$\frac{nV}{\sqrt{Hz}}$
THD	Total Harmonic Distortion (A_{VCL} = 1, R_L = 10kΩ, C_L = 100pF, V_O = 4.75V to 5.25V, f = 1kHz)			0.024		%
C_{in}	Input Capacitance			1.5		pF
V_{O1}/V_{O2}	Channel Separation (f = 1kHz)			120		dB

Note 1 : Maximum values including unavoidable inaccuracies of the industrial test.

STANDBY MODE

V_{CC}^+ = 10V, V_{CC}^- = 0V, T_{amb} = 25°C (unless otherwise specified)

Symbol	Parameter	TS904I/AI			Unit
		Min.	Typ.	Max.	
$V_{in\ SBY/ON}$	Pin 8/9 Threshold Voltage for STANDBY ON		8.2		V
$V_{in\ SBY/OFF}$	Pin 8/9 Threshold Voltage for STANDBY OFF		8.5		V
$I_{CC\ SBY}$	Total Consumption Standby 1 ON - Standby 2 OFF Standby 1 OFF - Standby 2 ON Standby 1 and 2 ON		 800 800 2		μA

TYPICAL CHARACTERISTICS (standby OFF = standby 1 and 2 OFF)
(standby ON = standby 1 and 2 ON)

Figure 1a : Supply Current (each amplifier) versus Supply Voltage

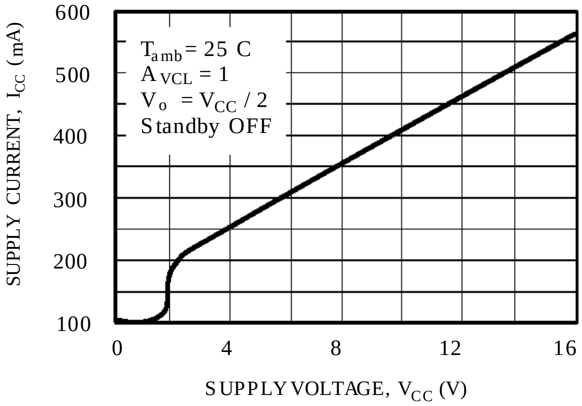


Figure 1b : Supply Current (each amplifier) versus Supply Voltage (in STANDBY)

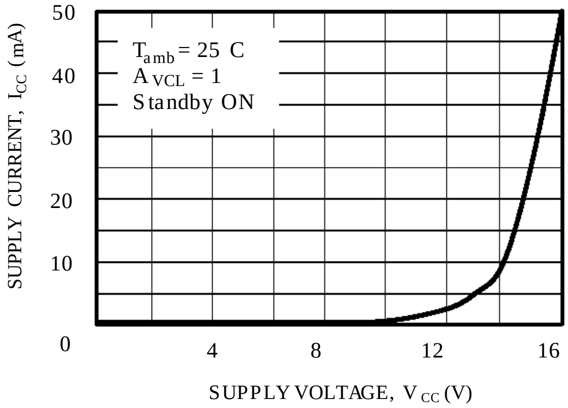


Figure 2 : Input Bias Current versus Temperature

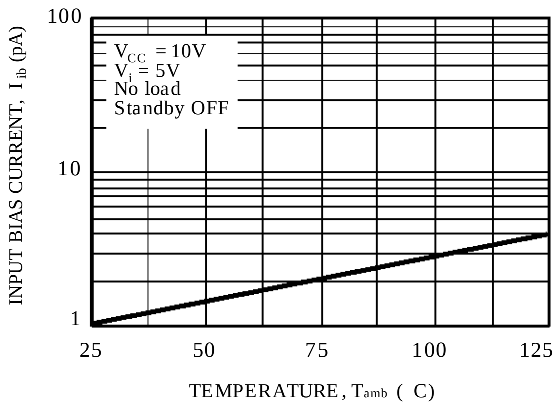


Figure 3a : High Level Output Voltage versus High Level Output Current

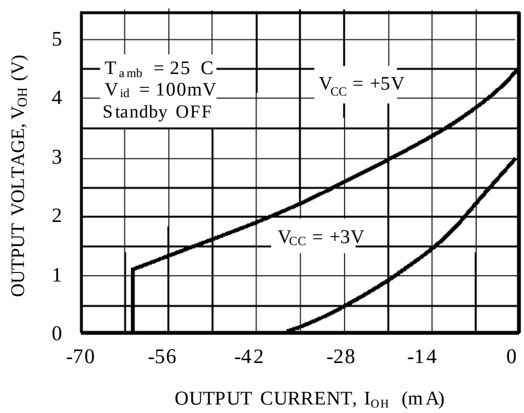


Figure 3b : High Level Output Voltage versus High Level Output Current

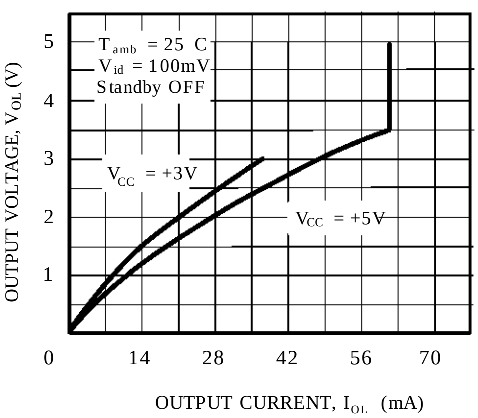


Figure 4a : Low Level Output Voltage versus Low Level Output Current

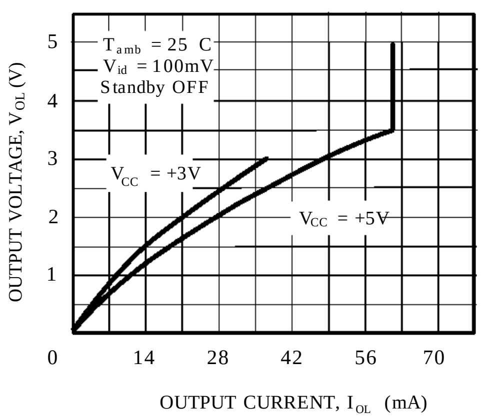


Figure 4b : Low Level Output Voltage versus Low Level Output Current

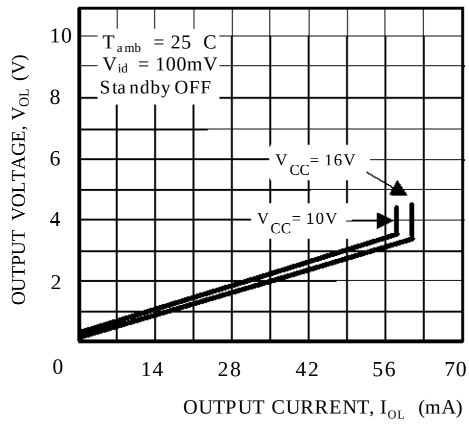


Figure 5a : Open Loop Frequency Response and Phase Shift

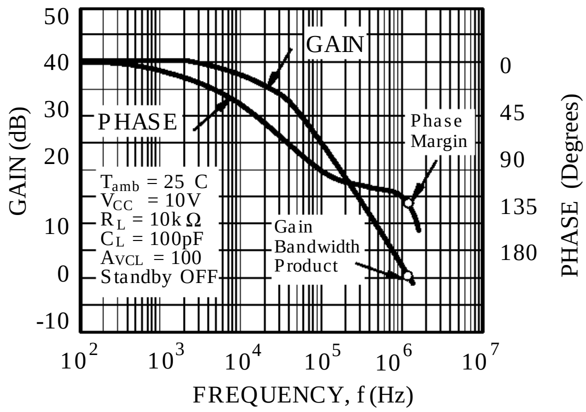


Figure 5b : Open Loop Frequency Response and Phase Shift

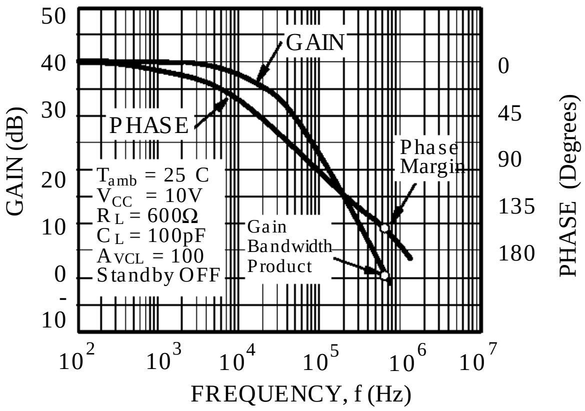


Figure 6a : Gain Bandwidth Product versus Supply Voltage

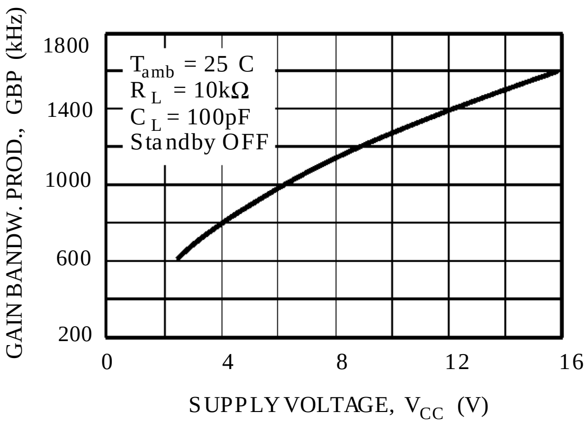


Figure 6b : Gain bandwidth Product versus Supply Voltage

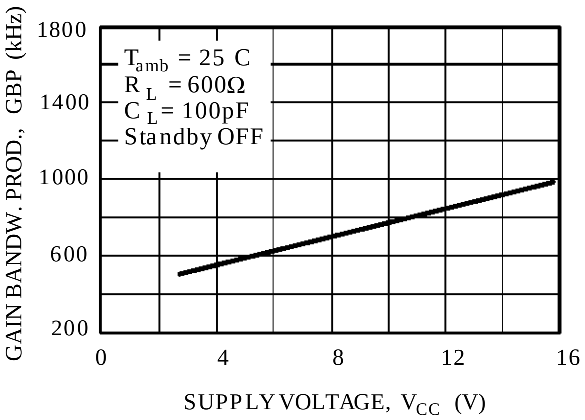


Figure 7a : Phase Margin versus Supply Voltage

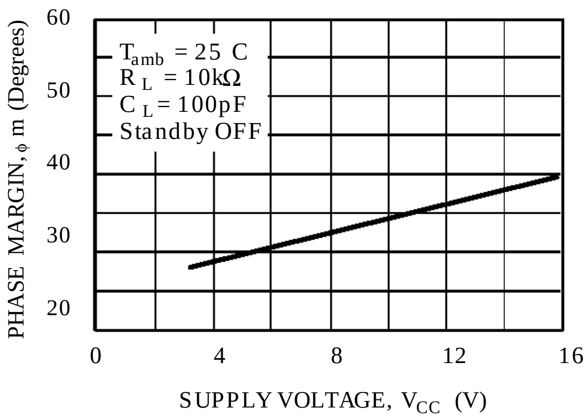


Figure 7b : Phase Margin versus Supply Voltage

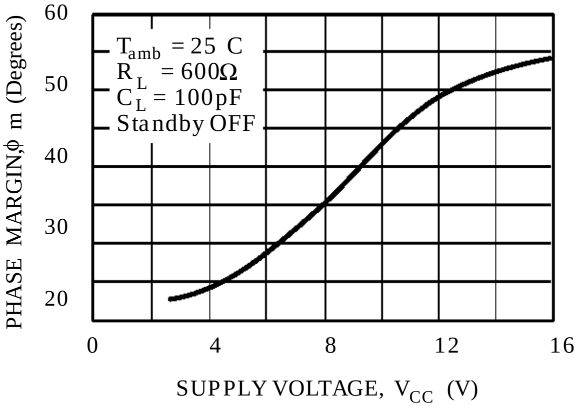
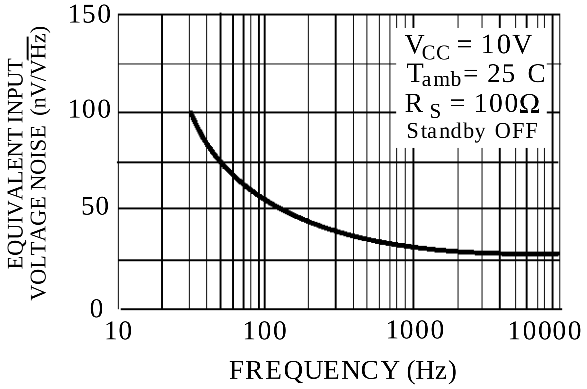


Figure 8 : Input Voltage Noise versus Frequency



STANDBY APPLICATION

The TS904 offers two separate STANDBY pins :

- **STANDBY 1** (pin 8) acting on the n°2 and n°3 operators.
- **STANDBY 2** (pin 9) acting on the n°1 and n°4 operators.

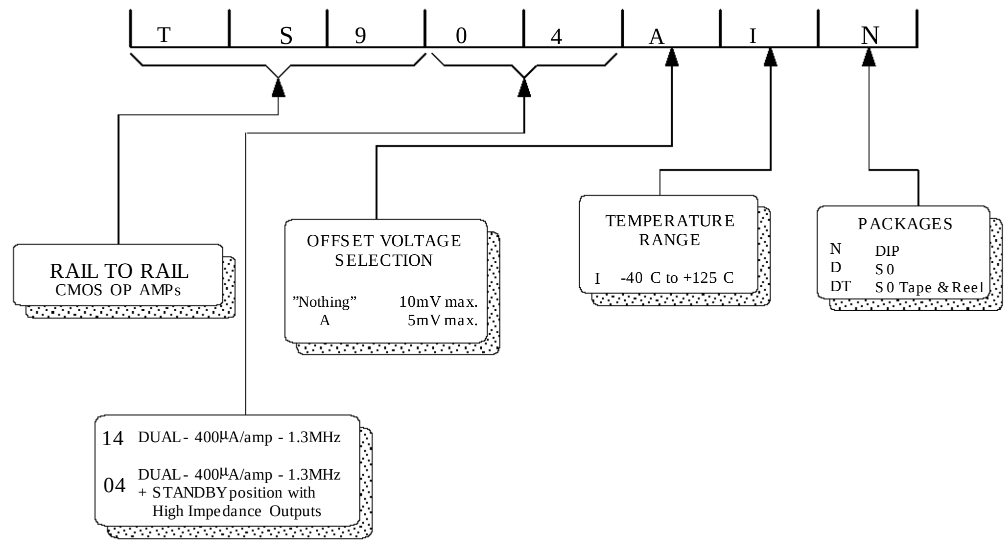
When one of these standby is activated (STANDBY ON) :

- The supply current of the corresponding operators is considerably reduced. The total consumption of the circuit is then divided by 2 (one STANDBY ON) or decreased down to 0.5µA (V_{CC} = 3V, two STANDBY ON). (ref. figure 1b).
- All the outputs of the corresponding operators are in high impedance state. No output current can then be sourced or sinked.

The standby pins 8 and 9 should never stay unconnected.

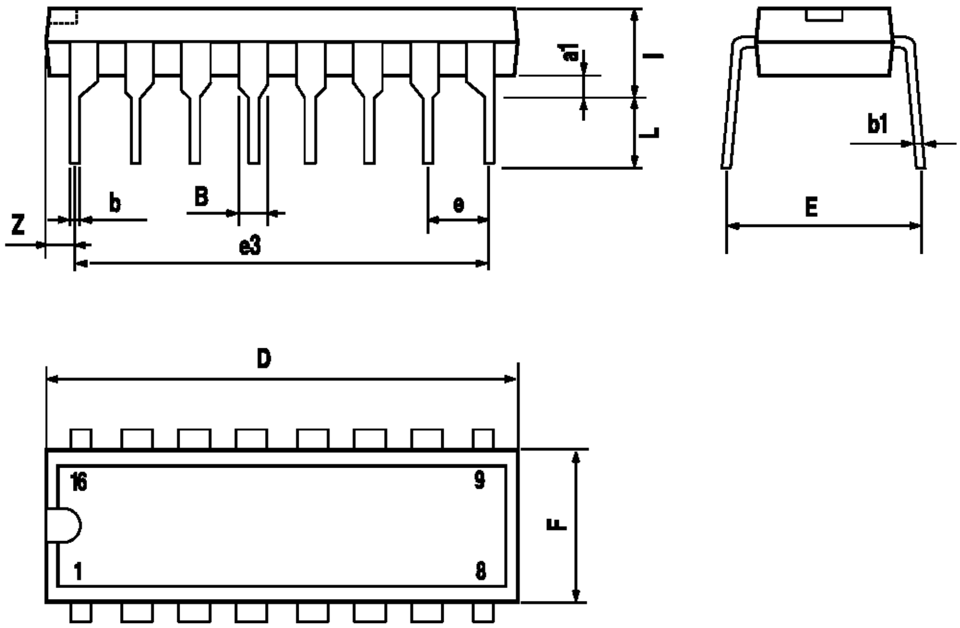
- The **"standby OFF"** state, is reached when the pins 8 or 9 voltage is **higher than $V_{in\ SBY/OFF}$**.
- The **"standby ON"** state, is assured by the pins 8 or 9 voltage **lower than $V_{in\ SBY/OFF}$**. (see electrical characteristics)

ORDERING INFORMATION



PACKAGE MECHANICAL DATA

16 PINS - PLASTIC DIP



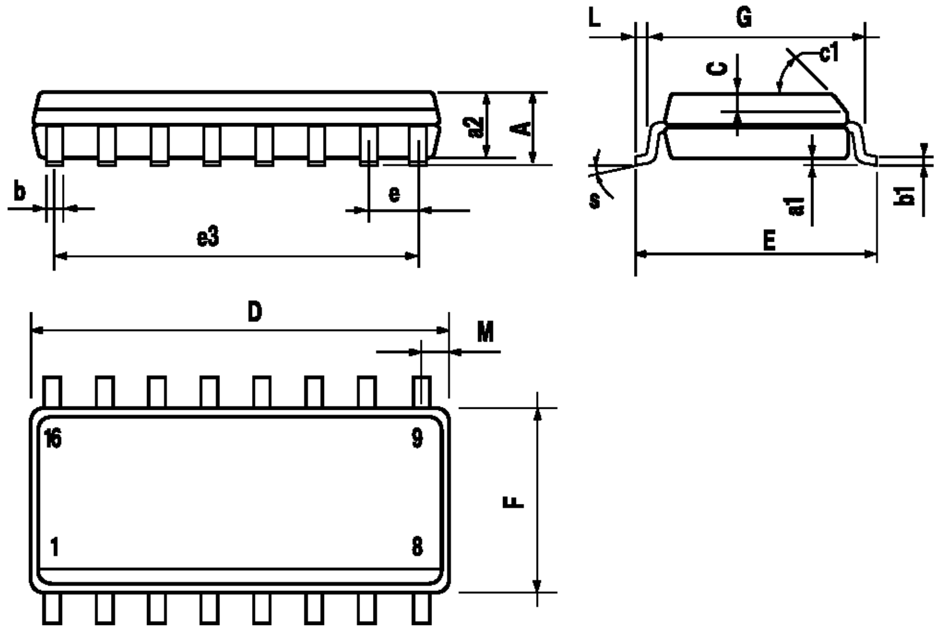
PM-DIP16.EPS

Dimensions	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
a1	0.51			0.020		
B	0.77		1.65	0.030		0.065
b		0.5			0.020	
b1		0.25			0.010	
D			20			0.787
E		8.5			0.335	
e		2.54			0.100	
e3		17.78			0.700	
F			7.1			0.280
i			5.1			0.201
L		3.3			0.130	
Z			1.27			0.050

DIP16.TBL

PACKAGE MECHANICAL DATA

16 PINS - PLASTIC MICROPACKAGE (SO)



PM-SO16.EPS

Dimensions	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			1.75			0.069
a1	0.1		0.2	0.004		0.008
a2			1.6			0.063
b	0.35		0.46	0.014		0.018
b1	0.19		0.25	0.007		0.010
C		0.5			0.020	
c1	45^o (typ.)					
D	9.8		10	0.386		0.394
E	5.8		6.2	0.228		0.244
e		1.27			0.050	
e3		8.89			0.350	
F	3.8		4.0	0.150		0.157
G	4.6		5.3	0.181		0.209
L	0.5		1.27	0.020		0.050
M			0.62			0.024
S	8^o (max.)					

SO16.TBL

ORDER CODE :