Proyecto de Fin de Carrera

Ingeniero Industrial

Sistema de control, inyección y encendido, para motores térmicos y alternativos de ciclo Otto basado en programación abierta bajo LabVIEW™

ANEXOS

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Sumario

A. Estudio de Impacto Ambiental

A.1 Introducción

El estudio del impacto ambiental está centrado en las emisiones de contaminantes que se producen en la actualidad en la realización de las prácticas de motores en el *Laboratori de Motors Tèrmics* de la ETSEIB respecto a las producidas al realizar las prácticas mediante instrumentos virtuales. Por tanto, se tiene en cuenta las horas de prácticas en las que se muestra el funcionamiento de un motor de combustión interna utilizando un motor encendido provocado. Así como las horas en las que el ordenador en el que se realiza las prácticas está encendido, que si bien no producirá una emisión de gases de forma localizada, gran parte de la generación de energía eléctrica se produce, a día de hoy, mediante fuentes contaminantes.

A.2 Emisiones de CO_2 en la actualidad

En las prácticas de motores en el *Laboratori de Motors Tèrmics* se muestra el funcionamiento de dos motores de gasolina. Un motor está extraído de un automóvil y el otro de una motocicleta. Las características de estos motores son:

- Motor automóvil
  - Cilindrada: 1193 cm^3
  - Potencia: 63 cv a 5800 r.p.m.
  - Par máximo: 90 Nm a 3500 r.p.m.
  - Velocidad máxima (montado en el automóvil de origen): 161 km / h
  - Consumo a 90 km / h: 6,0 l / 100 km
- Motor motocicleta
  - Cilindrada: 239 cm^3
  - Potencia: 18,5 cv a 7700 r.p.m.
  - Par máximo: 8,24 Nm a 6900 r.p.m.
  - Velocidad máxima (montado en la motocicleta de origen): 124 km / h
  - Consumo a 90 km / h: 3,2 l / 100 km

- Para el cálculo de las emisiones de CO_2 que se producen en las prácticas, se calcula las horas de prácticas anuales:

  - Numero de grupos: 20 grupos / cuatrimestre

  - Duración de práctica con cada motor: 0,5 h / practica

$$\frac{Pr\acute{a}cticas}{a\tilde{n}o} = \frac{20grupos}{1cuatrimestre} \cdot \frac{0{,}5h}{1grupo} \cdot \frac{2cuatrimestres}{1a\tilde{n}o} = 20\frac{horas}{a\tilde{n}o} \quad (Ec.\ A.1)$$

  Por tanto, cada uno de los motores está encendido un total de 20 horas al año.

- Cálculo de emisiones CO_2 motor automóvil:

  Debido a que el motor utilizado no es actual, el fabricante no ha publicado las emisiones de CO_2 por cada kilómetro, por este motivo, se ha de hacer el cálculo de las emisiones suponiendo que el funcionamiento del motor en las prácticas es equivalente a un régimen de 90 km / h.

  La gasolina está compuesta por diferentes hidrocarburos, pero para realizar el cálculo se hace el supuesto de que la gasolina está formada al 100% de n-Octano [CH_3-$(CH_2)_6$-CH_3] y su densidad corresponde a la gasolina Eurosuper 95 ($\rho_{gasolina}$:0,7611 kg / l):

  - Consumo volumétrico / hora: $\frac{6{,}0l}{100km} \cdot \frac{90km}{1h} = 5{,}4\frac{l}{h}$ (*Ec. A.2*)

  - Consumo másico / hora: $5{,}4\frac{l}{h} \cdot \frac{0{,}7611kg}{1l} = 4{,}11\frac{kg}{h}$ (*Ec. A.3*)

  - Reacción química teórica:

    La concentración de oxígeno y nitrógeno en el aire es de 21% O_2, 79% N_2, por tanto:

$$C_8H_{18} + 12{,}5\cdot(0_2 + 3{,}78N_2) \rightarrow 8CO_2 + 9H_2O + 47{,}25N_2 \quad (Ec.\ A.4)$$

  De la *Ec. A.4*, se desprende que por cada mol de n-Octano se producen 8 de dióxido de carbono.

  De la *Ec. A.3* se obtiene:

$$4{,}11\frac{kgC_8H_{18}}{h}\cdot\frac{1molC_8H_{18}}{0{,}114kgC_8H_{18}}\cdot\frac{8molCO_2}{1molC_8H_{18}}\cdot\frac{46grCO_2}{1molCO_2}=13{,}267\frac{kgCO_2}{h} \qquad (Ec.\ A.5)$$

La emisión de CO_2, para compararla con valores de otros motores, se muestra en gramos de CO_2 por kilómetro recorrido, *Ec. A.6*:

$$13267\frac{grCO_2}{1h}\cdot\frac{1h}{90km}=147{,}41\frac{grCO_2}{km} \qquad (Ec.\ A.6)$$

El valor obtenido en la *Ec. A.6*, es un valor del orden de magnitud de lo declarado por los fabricantes en la actualidad.

De las *Ec. A.1* y *Ec. A.5*, la emisión anual de CO_2 es de:

Emisión motor automóvil: $$13{,}267\frac{kgCO_2}{h}\cdot\frac{20h}{año}=265{,}34\frac{kgCO_2}{año} \qquad (Ec.\ A.7)$$

- Cálculo de emisiones CO_2 motor motocicleta:

Para el cálculo de emisiones de CO_2 para el caso del motor de motocicleta, se siguen los mismos argumentos expresados para el motor de automóvil:

- Consumo volumétrico / hora: $$\frac{3{,}2l}{100km}\cdot\frac{90km}{1h}=2{,}88\frac{l}{h} \qquad (Ec.\ A.8)$$

- Consumo másico / hora: $$2{,}88\frac{l}{h}\cdot\frac{0{,}7611kg}{1l}=2{,}19\frac{kg}{h} \qquad (Ec.\ A.9)$$

De la *Ec. A.9* y de la relación 1 mol de gasolina, 8 moles de CO_2:

$$2{,}19\frac{kgC_8H_{18}}{h}\cdot\frac{1molC_8H_{18}}{0{,}114kgC_8H_{18}}\cdot\frac{8molCO_2}{1molC_8H_{18}}\cdot\frac{46grCO_2}{1molCO_2}=7{,}07\frac{kgCO_2}{h} \qquad (Ec.\ A.10)$$

De las *Ec. A.1* y *Ec. A.5*, la emisión anual de CO_2 es de:

Emisión motor motocicleta: $$7{,}07\frac{kgCO_2}{h}\cdot\frac{20h}{año}=141{,}40\frac{kgCO_2}{año} \qquad (Ec.\ A.11)$$

- La emisión anual total de CO_2 en la realización de las prácticas es el obtenido de la suma de los resultados de *Ec. A.7* y *Ec. A11*:

Emisión motor total: $$265{,}34\frac{kgCO_2}{año}+141{,}40\frac{kgCO_2}{año}=406{,}74\frac{kgCO_2}{año} \qquad (Ec.\ A.12)$$

A.3 Emisiones de CO_2 al realizar las prácticas con VI

Las emisiones al realizar las prácticas mediante VI (instrumento virtual) no están localizadas en el punto de funcionamiento como pasa con los motores de combustión, pero la producción de energía eléctrica genera emisiones de CO_2 en los lugares de producción en la mayoría de los casos. Para el cálculo de CO_2 se necesitan los parámetros:

Potencia de consumo para realizar las prácticas:

Potencia de consumo PC: 400 W, factor de utilización: 1

Potencia de consumo monitor: 175 W, factor de utilización: 1

Potencia de consumo osciloscopio: 42 W, factor de utilización: 1

Potencia de consumo motor eléctrico: 370 W, factor de utilización: 0,3

Cálculo de la energía consumida / año para realizar las prácticas:

$$E.total = (0{,}4 + 0{,}175 + 0{,}042 + 0{,}37 \cdot 0{,}3)kW \cdot \frac{40 horas}{año} \cdot \frac{3600kJ}{1kWh} = 104.832kJ \qquad (Ec.\ A.13)$$

Generación de energía eléctrica en Europa (datos de IEA/OCDE *World Energy Outlook 2004*):

Nuclear: 33 %, rendimiento: 35%

Carbón: 31 %, rendimiento: 33%, PCI: 6.000 kcal / kg

Gas: 17 %, rendimiento: 55% (ciclo combinado), PCI_{GN}: 10.000 kcal / m^3

Hidroeléctrico: 10 %, rendimiento: 90%

Petróleo: 6 %, rendimiento: 33%, $PCI_{queroseno}$: 10.000 kcal / kg

Otras renovables: 3 %

Cálculo de la energía primaria consumida que es emisora de CO_2:

$$E_{Carbón} = \frac{104.832kJ \cdot 0{,}31}{0{,}33} = 98.478{,}55kJ \qquad (Ec.\ A.14)$$

$$E_{Gas} = \frac{104.832kJ \cdot 0{,}17}{0{,}55} = 32.402{,}62kJ \qquad (Ec.\ A.15)$$

$$E_{Petróleo} = \frac{104.832kJ \cdot 0,06}{0,33} = 19.060,36kJ \qquad (Ec.\ A.16)$$

Emisión de CO_2 (EIA, *Official Energy Statistics from the U. S. Government*):

Carbón: $$\frac{3000lbCO_2}{1000kgCarbón} \cdot \frac{0,454kgCO_2}{1lbCO_2} = 1,362\frac{kgCO_2}{kgCarbón} \qquad (Ec.\ A17)$$

Gas Natural: $$\frac{120,593lbCO_2}{1000\,ft^3GN} \cdot \frac{0,454kgCO_2}{1lbCO_2} \cdot \frac{1\,ft^3GN}{0,0283m^3} = 1,935\frac{kgCO_2}{m^3GN} \qquad (Ec.\ A18)$$

Queroseno: $$\frac{21,537lbCO_2}{1gallonUSA} \cdot \frac{0,454kgCO_2}{1lbCO_2} \cdot \frac{1gallonUSA}{3,76l} \cdot \frac{1l}{0,78kg} = 3,308\frac{kgCO_2}{kgquer.} \qquad (Ec.\ A19)$$

Cálculo emisiones de CO_2:

Contribución carbón: *Ec. A.14* y *Ec. A.17*

$$98.478,55\frac{kJ}{año} \cdot \frac{1kcal}{4,1868kJ} \cdot \frac{1kgCarbón}{6000kcal} \cdot \frac{1,362kgCO_2}{1kgCarbón} = 5,339\frac{kgCO_2}{año} \qquad (Ec.\ A.20)$$

Contribución gas natural: *Ec. A.15* y *Ec. A.18*

$$32.402,62\frac{kJ}{año} \cdot \frac{1kcal}{4,1868kJ} \cdot \frac{1m^3GN}{10000kcal} \cdot \frac{1,935kgCO_2}{1m^3GN} = 1,498\frac{kgCO_2}{año} \qquad (Ec.\ A.21)$$

Contribución queroseno: *Ec. A.16* y *Ec. A.19*

$$19.060,36\frac{kJ}{año} \cdot \frac{1kcal}{4,1868kJ} \cdot \frac{1kgquer.}{10000kcal} \cdot \frac{3,308kgCO_2}{1kgquer.} = 1,506\frac{kgCO_2}{año} \qquad (Ec.\ A.22)$$

Emisión total CO_2: *Ec. A.20*, *Ec. A.21* y *Ec. A.22*:

$$5,339\frac{kgCO_2}{año} + 1,498\frac{kgCO_2}{año} + 1,506\frac{kgCO_2}{año} = 8,343\frac{kgCO_2}{año} \qquad (Ec.\ A.23)$$

A.4 Comparativa

Por tanto, la relación de emisiones entre la realización de las prácticas mediante el encendido de un motor real y una simulación con un instrumento virtual es:

Motor real: $406{,}74\frac{kgCO_2}{año}$

Simulación VI: $8{,}343\frac{kgCO_2}{año}$

El ahorro en emisiones de CO_2 al realizar las prácticas mediante un instrumento virtual es de:

$$\frac{406{,}74\frac{kgCO_2}{año}}{8{,}343\frac{kgCO_2}{año}}\cdot 100 = 4.875\% \qquad (Ec.\ A.24)$$

$$406{,}74\frac{kgCO_2}{año} - 8{,}343\frac{kgCO_2}{año} = 398{,}397\frac{kgCO_2}{año} \qquad (Ec.\ A.25)$$

B. Presupuesto

B.1 Introducción

El presupuesto del presente proyecto se ha realizado desglosando los diferentes apartados para facilitar la valoración unitaria de los mismos. Se ha dividido en los siguientes apartados:

- Diseño
- Materiales
- Montaje
- Coste general

En el apartado de diseño se ha tenido en cuenta el diseño conceptual en el que se incluye la recopilación de documentación y estudio preliminar del proyecto. El diseño técnico en el que se tiene en cuenta la realización de los cálculos. El diseño de detalle que consta de la realización de los diferentes instrumentos virtuales"VI". El mecanografiado de los diferentes documentos que componen el proyecto. Y por último la reprografía.

En el apartado de materiales se detalla el precio de cada elemento clasificado según al conjunto al que pertenezca.

En el apartado de montaje se ha tenido en cuenta las diferentes horas para la realización de las partes que componen el proyecto dependiendo de su grado de dificultad.

En el apartado coste general se hace el sumatorio de los diferentes apartados anteriormente mencionados. Debido a que este proyecto no tiene un objetivo económico, ya que es un proyecto fin de carrera, no se ha añadido un porcentaje de los beneficios. Al total del coste obtenido se le ha de imputar un 16% de impuestos.

B.2 Presupuesto detallado

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PRESUPUESTO

Diseño

Nº de orden	Concepto	Nº de horas	Importe por hora	Coste total
I	Diseño conceptual	85	25,00 €	2.125,00 €
II	Diseño técnico	103	25,00 €	2.575,00 €
III	Trazado de los planos contructivos	43	20,00 €	860,00 €
IV	Mecanografiado	64	15,00 €	960,00 €
V	Reprografía	5	12,00 €	60,00 €
	TOTAL **A**................			**6.580,00 €**

Construcción

Nº de orden	Concepto	Nº de horas	Importe por hora	Coste total
	Mano de obra			
	Elaboración muy sencilla	4	12,00 €	48,00 €
	Elaboración sencilla	8	15,00 €	120,00 €
	Elaboración nomal	6	20,00 €	120,00 €
	Elaboración compleja	2	30,00 €	60,00 €
	TOTAL **B**................			**348,00 €**

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PRESUPUESTO

Materiales

Concepto	Nº de referencia	Unidades	Importe unitario	Coste total
Sensores				
Sensor Inductivo Magneti-Marelli	SEN 8K3	1	4,00 €	4,00 €
Caudalímetro de hilo caliente Bosch	0 280 218 060	1	65,00 €	65,00 €
Cable apantallado		1,5 m	2,00 €	3,00 €
Electrónica				
Resistencias 1/4W		29	0,16 €	4,66 €
Condensadores		9	0,22 €	1,98 €
Integrados		4	0,17 €	0,68 €
Resistencias variables ajuste vertical		3	0,02 €	0,05 €
Diodos		4	0,02 €	0,08 €
Diodos Zener		2	0,03 €	0,05 €
Transistores de potencia		2	0,04 €	0,08 €
Transistores		9	0,04 €	0,36 €
Led's		2	0,02 €	0,03 €
Zócalos		6	0,04 €	0,24 €
Placas de soldadura		3	1,82 €	5,46 €
Conectores		15	0,04 €	0,60 €
Actuadores				
Inyector		1	22,00 €	22,00 €
Pipeta encendido independiente		1	52,00 €	52,00 €
Batería 12 V 3A		1	8,84 €	8,84 €
Tarjeta DAQ				
NI USB-6210		1	475,00 €	475,00 €
Cableado				
Estaño		1	15,18 €	15,18 €
Cable		2 m	2,00 €	4,00 €
Motor monofásico 0,5 cv		1	69,00 €	69,00 €
TOTAL **C**...........				**732,29 €**

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UPC

Presupuesto General

Nº de orden	Concepto		Importe en Euros
A	Diseño		6.580,00 €
B	Construcción		348,00 €
C	Materiales		732,29 €
	Impuestos 16%	1.225,65 €	
			8.885,94 €

ASCIENDE EL PRESENTE PRESUPUESTO GENERAL A LA CATIDAD DE 8.885,94 €

Barcelona, a 5 de junio de 2007

C. Tarjeta NI-USB 6210

NI USB-621*x* Specifications

Specifications listed below are typical at 25 °C unless otherwise noted.

日本語で利用可能なマニュアルのリストは、`ni.com/jp/manuals` を参照してください。
(For a Japanese language version, go to `ni.com/jp/manuals`.)

Analog Input

Number of channels

- USB-6210/6211/6215 .... 8 differential or 16 single ended
- USB-6218 .... 16 differential or 32 single ended

ADC resolution .... 16 bits

DNL .... No missing codes guaranteed

INL .... Refer to the *AI Absolute Accuracy Table*

Sampling rate

- Maximum .... 250 KS/s (aggregate)
- Minimum .... 0 S/s
- Timing accuracy .... 50 ppm of sample rate
- Timing resolution .... 50 ns

Input coupling .... DC

Input range .... ±10 V, ±5 V, ±1 V, ±0.2 V

Maximum working voltage for analog inputs (signal + common mode) .... ±10.4 V of AI GND

CMRR (DC to 60 Hz) .... 100 dB

Input impedance

- Device on
  - AI+ to AI GND .... >10 GΩ in parallel with 100 pF
  - AI– to AI GND .... >10 GΩ in parallel with 100 pF
- Device off
  - AI+ to AI GND .... 1200 Ω
  - AI– to AI GND .... 1200 Ω

Input bias current .... ±100 pA

Crosstalk (at 100 kHz)

- Adjacent channels .... –75 dB
- Non-adjacent channels .... –90 dB

Small signal bandwidth (–3 dB) .... 450 kHz

Input FIFO size .... 4,095 samples

Scan list memory .... 4,095 entries

Data transfers .... USB Signal Stream, programmed I/O

Overvoltage protection (AI <0..31>, AI SENSE)

- Device on .... ±30 V for up to two AI pins
- Device off .... ±20 V for up to two AI pins

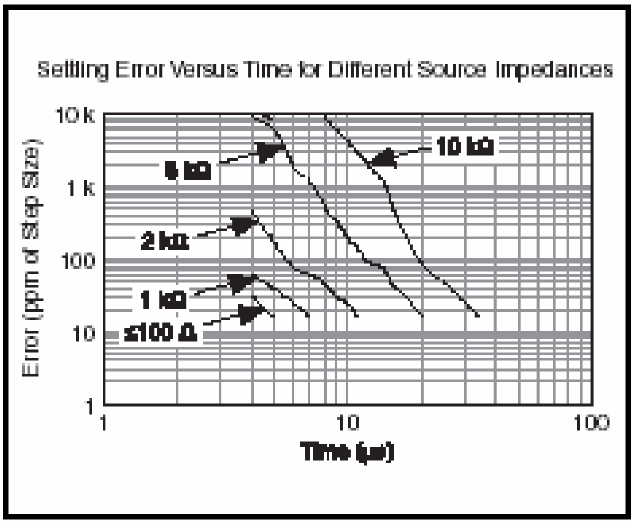
Input current during overvoltage condition .... ±20 mA max/AI pin

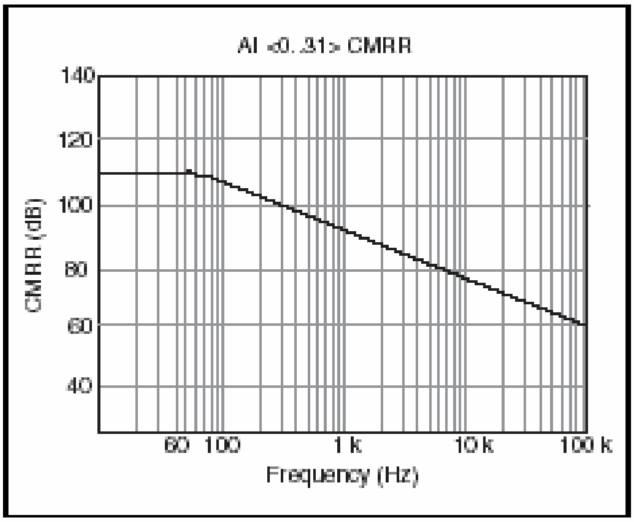
Settling Time for Multichannel Measurements

Accuracy, full scale step, all ranges

- ±90 ppm of step (±6 LSB) .... 4 µs convert interval
- ±30 ppm of step (±2 LSB) .... 5 µs convert interval
- ±15 ppm of step (±1 LSB) .... 7 µs convert interval

Typical Performance Graphs





Analog Output

Number of channels
- USB-6210 0
- USB-6211/6215/6218................ 2

DAC resolution .... 16 bits

DNL... ±1 LSB

Monotonicity .... 16 bit guaranteed

Maximum update rate
- 1 channel .... 250 kS/s
- 2 channels .... 250 kS/s per channel

Timing accuracy .... 50 ppm of sample rate

Timing resolution.......................... 50 ns

Output range .... ±10 V

Output coupling .... DC

Output impedance......................... 0.2 Ω

Output current drive...................... ±2 mA

Overdrive protection .... ±30 V

Overdrive current.......................... 2.4 mA

Power-on state.............................. ±20 mV

Power-on glitch............................. ±1 V for 200 ms

Output FIFO size .... 8,191 samples shared among channels used

Data transfers .... USB Signal Stream, programmed I/O

AO waveform modes:
- Non-periodic waveform
- Periodic waveform regeneration mode from onboard FIFO
- Periodic waveform regeneration from host buffer including dynamic update

Settling time, full scale step
15 ppm (1 LSB) .... 32 µs

Slew rate .... 10 V/µs

Glitch energy
- Magnitude.................................. 100 mV
- Duration..................................... 2.6 µs

Calibration (AI and AO)

Recommended warm-up time......... 15 minutes

Calibration interval .... 1 year

AI Absolute Accuracy Table

Nominal Range		Residual GainError (ppm of Reading)	Gain Tempco (ppm/°C)	Reference Tempco	Residual Offset Error (ppm of Range)	Offset Tempco (ppm of Range/°C)	INLError (ppm of Range)	Random Noise, σ (μVrms)	Absolute Accuracy at Full Scale[1] (μV)	Sensitivity[2] (μV)
Positive Full Scale	Negative Full Scale									
10	–10	75	7.3	5	20	34	76	229	2,690	91.6
5	–5	85	7.3	5	20	36	76	118	1,410	47.2
1	–1	95	7.3	5	25	49	76	26	310	10.4
0.2	–0.2	135	7.3	5	40	116	76	12	88	4.8

$$AbsoluteAccuracy = Reading \cdot (GainError) + Range \cdot (OffsetError) + NoiseUncertainty$$

$$GainError = ResidualAIGainError + GainTempco \cdot (TempChangeFromLastInternalCal) + ReferenceTempco \cdot (TempChangeFromLastExternalCal)$$

$$OffsetError = ResidualAIOffsetError + OffsetTempco \cdot (TempChangeFromLastInternalCal) + INL\_Error$$

$$NoiseUncertainty = \frac{RandomNoise \cdot 3}{\sqrt{100}}$$ For a coverage factor of 3 σ and averaging 100 points.

[1] Absolute accuracy at full scale on the analog input channels is determined using the following assumptions:

$TempChangeFromLastExternalCal = 10\ °C$

$TempChangeFromLastInternalCal = 1\ °C$

$number\_of\_readings = 100$

$CoverageFactor = 3\ \sigma$

For example, on the 10 V range, the absolute accuracy at full scale is as follows:

$GainError = 75\ ppm + 7.3\ ppm \cdot 1 + 5\ ppm \cdot 10$ $GainError = 132\ ppm$

$OffsetError = 20\ ppm + 34\ ppm \cdot 1 + 76\ ppm$ $OffsetError = 130\ ppm$

$NoiseUncertainty = \frac{229\ \mu V \cdot 3}{\sqrt{100}}$ $NoiseUncertainty = 68.7\ \mu V$

$AbsoluteAccuracy = 10\ V \cdot (GainError) + 10\ V \cdot (OffsetError) + NoiseUncertainty$ $AbsoluteAccuracy = 2{,}690\ \mu V$

[2] Sensitivity is the smallest voltage change that can be detected. It is a function of noise.

Accuracies listed are valid for up to one year from the device external calibration.

AO Absolute Accuracy Table

Nominal Range		Residual Gain Error (ppm of Reading)	Gain Tempco (ppm/°C)	Reference Tempco	Residual Offset Error (ppm of Range)	Offset Tempco (ppm of Range/°C)	INL Error (ppm of Range)	Absolute Accuracy at Full Scale[1] (µV)
Positive Full Scale	Negative Full Scale							
10	–10	90	11	5	60	12	128	3,512

[1] Absolute Accuracy at full scale numbers is valid immediately following internal calibration and assumes the device is operating within 10 °C of the last external calibration. Accuracies listed are valid for up to one year from the device external calibration.

AbsoluteAccuracy = OutputValue · (GainError) + Range · (OffsetError)

GainError = ResidualGainError + GainTempco · (TempChangeFromLastInternalCal) + ReferenceTempco · (TempChangeFromLastExternalCal)

OffsetError = ResidualOffsetError + AOOffsetTempco · (TempChangeFromLastInternalCal) + INL_Error

Digital I/O/PFI

Static Characteristics

Number of channels

Digital input

USB-6210/6211/6215 .... 4 (PFI <0..3>/P0.<0..3>)

USB-6218 .... 8 (PFI <0..3>/P0.<0..3>, PFI <8..11>/P0.<4..7>)

Digital output

USB-6210/6211/6215 .... 4 (PFI <4..7>/P1.<0..3>)

USB-6218 .... 8 (PFI <4..7>/P1.<0..3>, PFI <12..15>/P1.<4..7>)

Ground reference .... D GND

Pull-down resistor .... 47 kΩ ±1%

Input voltage protection[1] .... ±20 V on up to 8 pins

PFI/Port 0/Port 1 Functionality

PFI <0..3>, PFI <8..11>/Port 0

Functionality............................ Static digital input, timing input

Debounce filter settings............. 125 ns, 6.425 µs, 2.54 ms, disable; high and low transitions; selectable per input

PFI <4..7>, PFI <12..15>/Port 1 functionality .... Static digital output, timing output

Timing output sources .... Many AI, AO, counter timing signals

Maximum Operation Conditions

Level	Min	Max
I_{OL} output low current	—	16 mA
I_{OH} output high current	—	–16 mA

Digital Input Characteristics

Level	Min	Max
V_{IL} input low voltage	0 V	0.8 V
V_{IH} input high voltage	2 V	5.25 V
I_{IL} input low current (V_{in} = 0 V)	—	–10 µA
I_{IH} input high current (V_{in} = 5 V)	—	120 µA

Digital Output Characteristics

Parameter	Voltage Level	Current Level
V_{OL}	0.6 V	6 mA
V_{OH}	2.7 V	–16 mA
	3.8 V	–6 mA

[1] Stresses beyond those listed under *Input voltage protection* may cause permanent damage to the device.

General-Purpose Counter/Timers

Number of counter/timers	2
Resolution	32 bits
Counter measurements	Edge counting, pulse, semi-period, period, two-edge separation
Position measurements	X1, X2, X4 quadrature encoding with Channel Z reloading; two-pulse encoding
Output applications	Pulse, pulse train with dynamic updates, frequency division, equivalent time sampling
Internal base clocks	80 MHz, 20 MHz, 0.1 MHz
External base clock frequency	0 MHz to 20 MHz
Base clock accuracy	50 ppm
Inputs	Gate, Source, HW_Arm, Aux, A, B, Z, Up_Down
Routing options for inputs	PFI <0..3>, PFI <8..11>, many internal signals
FIFO	1,023 samples
Data transfers	USB Signal Stream, programmed I/O

Frequency Generator

Number of channels	1
Base clocks	10 MHz, 100 kHz
Divisors	1 to 16
Base clock accuracy	50 ppm

Output can be available on any PFI <4..7> or PFI <12..15> terminal.

External Digital Triggers

Source	PFI <0..3>, PFI <8..11>
Polarity	Software-selectable for most signals
Analog input function	Start Trigger, Reference Trigger, Pause Trigger, Sample Clock, Convert Clock, Sample Clock Timebase
Analog output function	Start Trigger, Pause Trigger, Sample Clock, Sample Clock Timebase
Counter/timer functions	Gate, Source, HW_Arm, Aux, A, B, Z, Up_Down,

Bus Interface

USB	USB 2.0 Hi-Speed or full-speed[1]
USB Signal Stream (USB)	4, can be used for analog input, analog output, counter/timer 0, counter/timer 1

Power Requirements

USB	
Input voltage on USB-621x USB port	4.5 to 5.25 V in configured state
Maximum inrush current	500 mA
No load typical current	320 mA at 4.5 V
Maximum load	
Typical current	400 mA at 4.5 V
Suspend current	260 µA, typical
+5V terminal as output	
Voltage	4.6 to 5.2 V
Current (internally limited)	50 mA max, shared with digital outputs

[1] If you are using a USB M Series device in full-speed mode, device performance will be lower and you will not be able to achieve maximum sampling/update rates.

+5V terminal as input

Voltage .... 4.75 to 5.35 V

Current .... 350 mA max, self-resetting fuse

Caution Do *not* exceed 16 mA per DIO pin.

Protection.................................. ±10 V

Maximum Working Voltage[1]

USB-6210/6211

Channel-to-earth ground................ 11 V, Measurement Category I

Caution Do *not* use for measurements within Categories II, III, or IV.

USB-6215/6218

Channel-to-earth ground[2]

Continuous.................................. ≤30 Vrms/60 VDC, Measurement Category I[3]

Withstand.................................... ≤840 Vrms/1200 VDC, verified by a 5 s dielectric withstand test

Channel-to-bus[4]

Continuous.................................. ≤30 Vrms/60 VDC, Measurement Category I[3]

Withstand.................................... ≤1400 Vrms/1950 VDC, verified by a 5 s dielectric withstand test

Analog channel to AI GND/AO GND (in Figure 1, $|V_a - V_c|$)................ ≤11 V, Measurement Category I[3]

Digital channel to D GND (in Figure 1, $V_b - V_c$)...................... ≤5.25 V, Measurement Category I[3]

Caution This device is rated for Measurement Category I and the voltage across the isolation barrier is limited to no greater than 30 Vrms/60 VDC/42.4 V_{pk} continuous. Do *not* use for measurements within Categories II, III, or IV.

Figure 1 illustrates the maximum working voltage specifications.

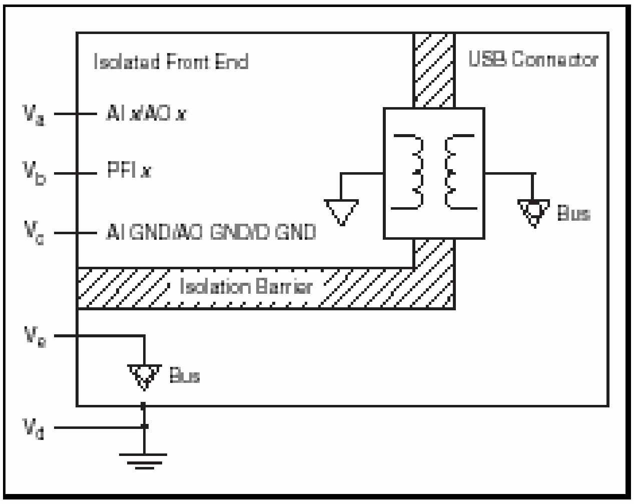


Figure 1. USB-6215/6218 Maximum Working Voltage

Environmental

Operating temperature..................... 0 to 45 °C

Storage temperature........................ –20 to 70 °C

Humidity... 10 to 90% RH, noncondensing

Maximum altitude .... 2,000 m

Pollution Degree (indoor use only)............................ 2

1 *Maximum working voltage* refers to the signal voltage plus the common-mode voltage.

2 In Figure 1, $|V_a - V_d|$, $|V_b - V_d|$, and $|V_c - V_d|$.

3 Measurement Category I is for measurements performed on circuits not directly connected to the electrical distribution system referred to as *MAINS* voltage. MAINS is a hazardous live electrical supply system that powers equipment. This category is for measurements of voltages from specially protected secondary circuits. Such voltage measurements include signal levels, special equipment, limited-energy parts of equipment, circuits powered by regulated low-voltage sources, and electronics.

4 In Figure 1, $|V_a - V_e|$, $|V_b - V_e|$, and $|V_c - V_e|$.

Physical Characteristics

Enclosure dimensions (includes connectors)....................16.9 × 9.4 × 3.1 cm (6.65 × 3.70 × 1.20 in.)

Weight
USB-6210/6211/6215/6218............205 g (7.23 oz)

I/O connectors
- USB-6210/6211/6215 ....Two 16-position combicon
- USB-6218 ....Four 16-position combicon

USB connector ....Series B receptacle

Screw terminal wiring....................16 to 28 AWG

Torque for screw terminals.............0.22–0.25 N · m (2.0–2.2 lb · in.)

Safety

This product is designed to meet the requirements of the following standards of safety for electrical equipment for measurement, control, and laboratory use:

- IEC 61010-1, EN-61010-1
- UL 61010-1, CAN/CSA-C22.2 No. 61010-1

Note For UL and other safety certifications, refer to the product label or visit `ni.com/certification`, search by model number or product line, and click the appropriate link in the Certification column.

Electromagnetic Compatibility

This product is designed to meet the requirements of the following standards of EMC for electrical equipment for measurement, control, and laboratory use:

- EN 61326 EMC requirements; Minimum Immunity
- EN 55011 Emissions; Group 1, Class A
- CE, C-Tick, ICES, and FCC Part 15 Emissions; Class A

Note For EMC compliance, operate this device with shielded cabling.

CE Compliance

This product meets the essential requirements of applicable European Directives, as amended for CE marking, as follows:

- 73/23/EEC; Low-Voltage Directive (safety)
- 89/336/EEC; Electromagnetic Compatibility Directive (EMC)

Note Refer to the Declaration of Conformity (DoC) for this product for any additional regulatory compliance information. To obtain the DoC for this product, visit `ni.com/certification`, search by model number or product line, and click the appropriate link in the Certification column.

Waste Electrical and Electronic Equipment (WEEE)

EU Customers At the end of their life cycle, all products must be sent to a WEEE recycling center. For more information about WEEE recycling centers and National Instruments WEEE initiatives, visit `ni.com/environment/weee.htm`.

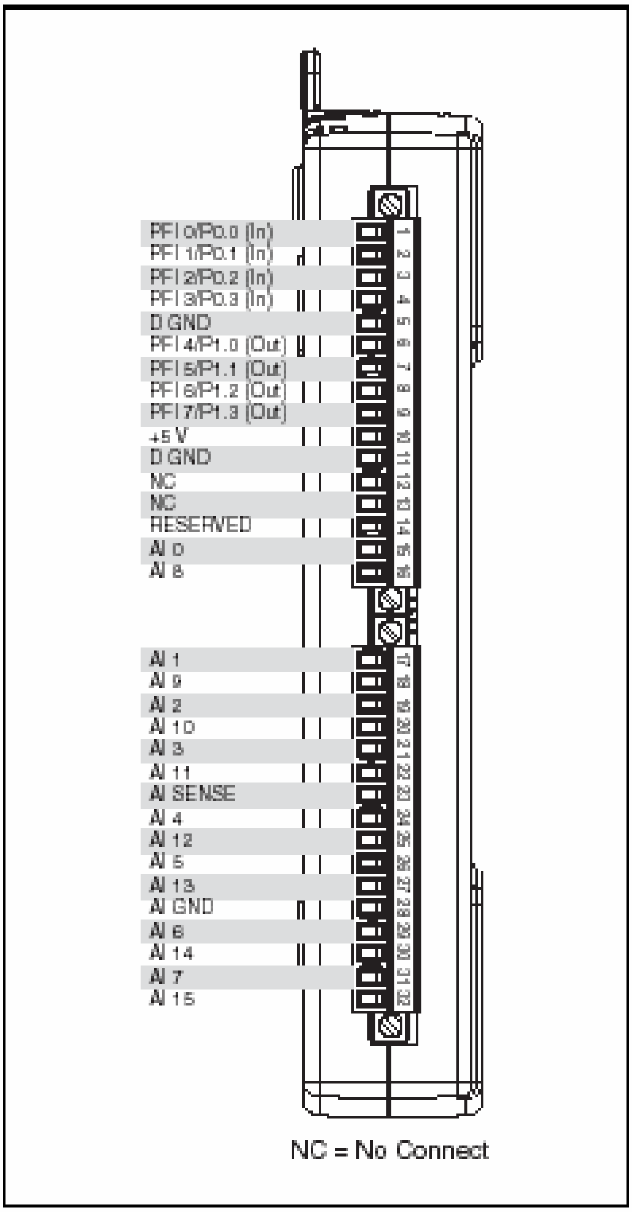


Figure 2. USB-6210 Pinout

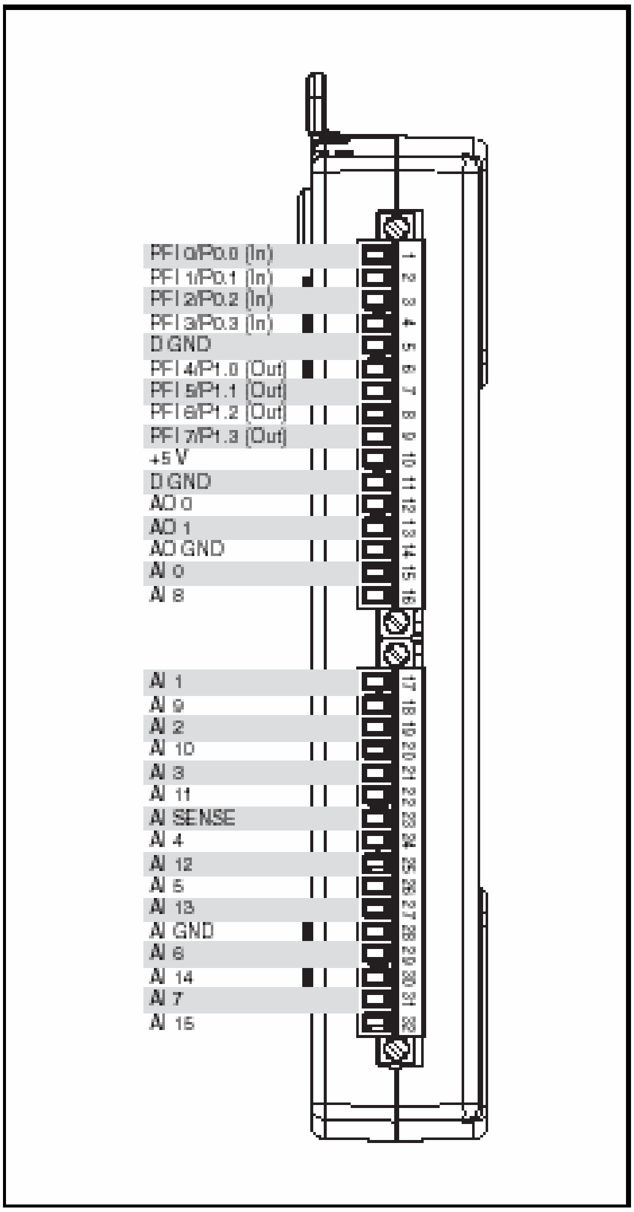


Figure 3. USB-6211/6215 Pinout

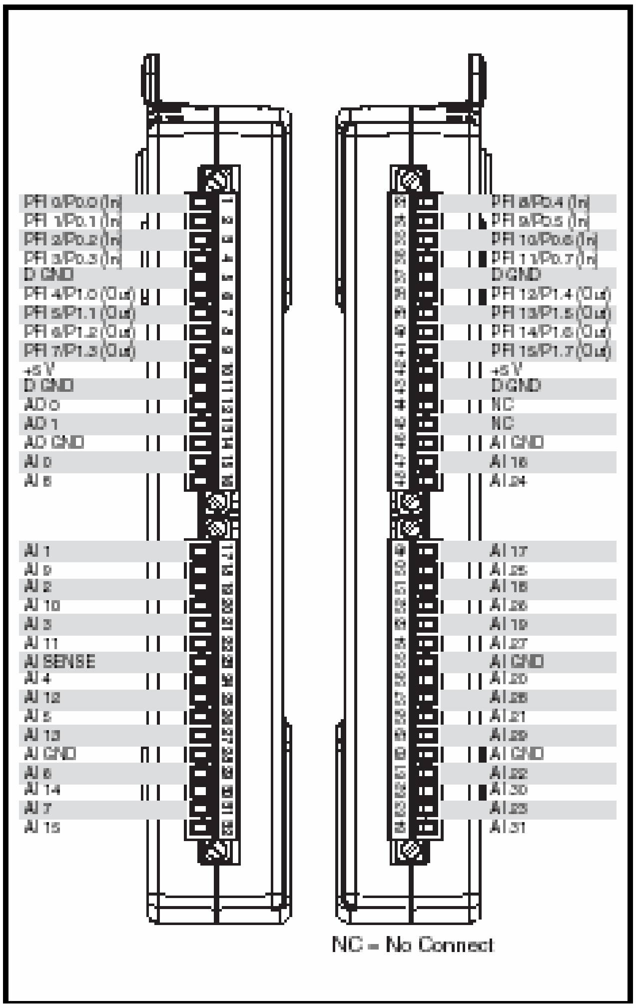


Figure 4. USB-6218 Pinout

371932C-01 Dec06

D. Componentes electrónicos

D.1 74HC00 NAND

DATA SHEET

74HC00; 74HCT00
Quad 2-input NAND gate

Product specification
Supersedes data of 1997 Aug 26

2003 Jun 30

Philips
Semiconductors

PHILIPS

Quad 2-input NAND gate 74HC00; 74HCT00

FEATURES

- Complies with JEDEC standard no. 8-1A
- ESD protection:
  HBM EIA/JESD22-A114-A exceeds 2000 V
  MM EIA/JESD22-A115-A exceeds 200 V
- Specified from –40 to +85 °C and –40 to +125 °C.

DESCRIPTION

The 74HC00/74HCT00 are high-speed Si-gate CMOS devices and are pin compatible with low power Schottky TTL (LSTTL). They are specified in compliance with JEDEC standard no. 7A.

The 74HC00/74HCT00 provide the 2-input NAND function.

QUICK REFERENCE DATA

GND = 0 V; T_{amb} = 25 °C; t_r = t_f = 6 ns.

SYMBOL	PARAMETER	CONDITIONS	TYPICAL		UNIT
			74HC00	74HCT00	
t_{PHL}/t_{PLH}	propagation delay nA, nB to nY	C_L = 15 pF; V_{CC} = 5 V	7	10	ns
C_I	input capacitance		3.5	3.5	pF
C_{PD}	power dissipation capacitance per gate	notes 1 and 2	22	22	pF

Notes

1. C_{PD} is used to determine the dynamic power dissipation (P_D in μW).
   $P_D = C_{PD} \times V_{CC}^2 \times f_i \times N + \Sigma(C_L \times V_{CC}^2 \times f_o)$ where:
   f_i = input frequency in MHz;
   f_o = output frequency in MHz;
   C_L = output load capacitance in pF;
   V_{CC} = supply voltage in Volts;
   N = total load switching outputs;
   $\Sigma(C_L \times V_{CC}^2 \times f_o)$ = sum of the outputs.
2. For 74HC00 the condition is V_I = GND to V_{CC}.
   For 74HCT00 the condition is V_I = GND to V_{CC} – 1.5 V.

FUNCTION TABLE

See note 1.

INPUT		OUTPUT
nA	nB	nY
L	L	H
L	H	H
H	L	H
H	H	L

Note

1. H = HIGH voltage level;
   L = LOW voltage level.

ORDERING INFORMATION

TYPE NUMBER	PACKAGE				
	TEMPERATURE RANGE	PINS	PACKAGE	MATERIAL	CODE
74HC00N	–40 to +125 °C	14	DIP14	plastic	SOT27-1
74HCT00N	–40 to +125 °C	14	DIP14	plastic	SOT27-1
74HC00D	–40 to +125 °C	14	SO14	plastic	SOT108-1
74HCT00D	–40 to +125 °C	14	SO14	plastic	SOT108-1
74HC00DB	–40 to +125 °C	14	SSOP14	plastic	SOT337-1
74HCT00DB	–40 to +125 °C	14	SSOP14	plastic	SOT337-1
74HC00PW	–40 to +125 °C	14	TSSOP14	plastic	SOT402-1
74HCT00PW	–40 to +125 °C	14	TSSOP14	plastic	SOT402-1
74HC00BQ	–40 to +125 °C	14	DHVQFN14	plastic	SOT762-1
74HCT00BQ	–40 to +125 °C	14	DHVQFN14	plastic	SOT762-1

PINNING

PIN	SYMBOL	DESCRIPTION
1	1A	data input
2	1B	data input
3	1Y	data output
4	2A	data input
5	2B	data input
6	2Y	data output
7	GND	ground (0 V)
8	3Y	data output
9	3A	data input
10	3B	data input
11	4Y	data output
12	4A	data input
13	4B	data input
14	V_{CC}	supply voltage

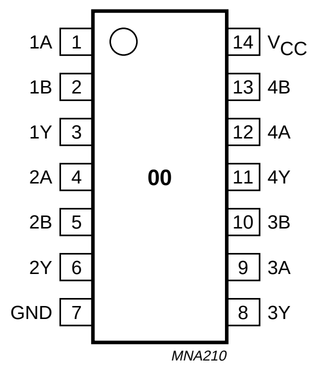
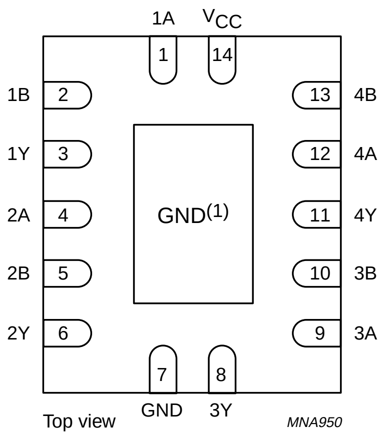


Fig.1 Pin configuration DIP14, SO14 and (T)SSOP14.



(1) The die substrate is attached to this pad using conductive die attach material. It can not be used as a supply pin or input.

Fig.2 Pin configuration DHVQFN14.

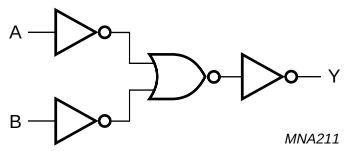


Fig.3 Logic diagram (one gate).

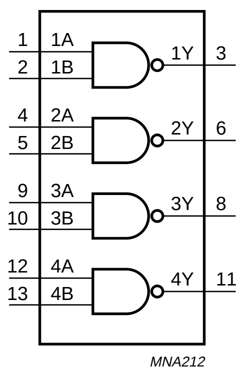


Fig.4 Function diagram.

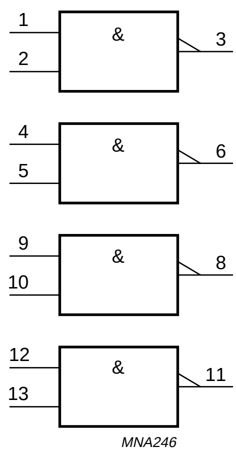


Fig.5 IEC logic symbol.

RECOMMENDED OPERATING CONDITIONS

SYMBOL	PARAMETER	CONDITIONS	74HC00			74HCT00			UNIT
			MIN.	TYP.	MAX.	MIN.	TYP.	MAX.	
V_{CC}	supply voltage		2.0	5.0	6.0	4.5	5.0	5.5	V
V_I	input voltage		0	–	V_{CC}	0	–	V_{CC}	V
V_O	output voltage		0	–	V_{CC}	0	–	V_{CC}	V
T_{amb}	operating ambient temperature	see DC and AC characteristics per device	–40	+25	+125	–40	+25	+125	°C
t_r, t_f	input rise and fall times	V_{CC} = 2.0 V	–	–	1000	–	–	–	ns
		V_{CC} = 4.5 V	–	6.0	500	–	6.0	500	ns
		V_{CC} = 6.0 V	–	–	400	–	–	–	ns

LIMITING VALUES

In accordance with the Absolute Maximum Rating System (IEC 60134); voltages are referenced to GND (ground = 0 V).

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
V_{CC}	supply voltage		–0.5	+7.0	V
I_{IK}	input diode current	V_I < –0.5 V or V_I > V_{CC} + 0.5 V	–	±20	mA
I_{OK}	output diode current	V_O < –0.5 V or V_O > V_{CC} + 0.5 V	–	±20	mA
I_O	output source or sink current	–0.5 V < V_O < V_{CC} + 0.5 V	–	±25	mA
I_{CC}, I_{GND}	V_{CC} or GND current		–	±50	mA
T_{stg}	storage temperature		–65	+150	°C
P_{tot}	power dissipation	T_{amb} = –40 to +125 °C; note 1	–	500	mW

Note

1. For DIP14 packages: above 70 °C derate linearly with 12 mW/K.
   For SO14 packages: above 70 °C derate linearly with 8 mW/K.
   For SSOP14 and TSSOP14 packages: above 60 °C derate linearly with 5.5 mW/K.
   For DHVQFN14 packages: above 60 °C derate linearly with 4.5 mW/K.

DC CHARACTERISTICS

Type 74HC00

At recommended operating conditions; voltages are referenced to GND (ground = 0 V).

SYMBOL	PARAMETER	TEST CONDITIONS		MIN.	TYP.	MAX.	UNIT
		OTHER	V_{CC} (V)				
T_{amb} = –40 to +85 °C; note 1							
V_{IH}	HIGH-level input voltage		2.0	1.5	1.2	–	V
			4.5	3.15	2.4	–	V
			6.0	4.2	3.2	–	V
V_{IL}	LOW-level input voltage		2.0	–	0.8	0.5	V
			4.5	–	2.1	1.35	V
			6.0	–	2.8	1.8	V
V_{OH}	HIGH-level output voltage	$V_I = V_{IH}$ or V_{IL}					
		I_O = –20 µA	2.0	1.9	2.0	–	V
		I_O = –20 µA	4.5	4.4	4.5	–	V
		I_O = –20 µA	6.0	5.9	6.0	–	V
		I_O = –4.0 mA	4.5	3.84	4.32	–	V
		I_O = –5.2 mA	6.0	5.34	5.81	–	V
V_{OL}	LOW-level output voltage	$V_I = V_{IH}$ or V_{IL}					
		I_O = 20 µA	2.0	–	0	0.1	V
		I_O = 20 µA	4.5	–	0	0.1	V
		I_O = 20 µA	6.0	–	0	0.1	V
		I_O = 4.0 mA	4.5	–	0.15	0.33	V
		I_O = 5.2 mA	6.0	–	0.16	0.33	V
I_{LI}	input leakage current	$V_I = V_{CC}$ or GND	6.0	–	–	±1.0	µA
I_{OZ}	3-state output OFF current	$V_I = V_{IH}$ or V_{IL}; $V_O = V_{CC}$ or GND	6.0	–	–	±.5.0	µA
I_{CC}	quiescent supply current	$V_I = V_{CC}$ or GND; I_O = 0	6.0	–	–	20	µA

SYMBOL	PARAMETER	TEST CONDITIONS		MIN.	TYP.	MAX.	UNIT
		OTHER	V_{CC} (V)				
T_{amb} = –40 to +125 °C							
V_{IH}	HIGH-level input voltage		2.0	1.5	–	–	V
			4.5	3.15	–	–	V
			6.0	4.2	–	–	V
V_{IL}	LOW-level input voltage		2.0	–	–	0.5	V
			4.5	–	–	1.35	V
			6.0	–	–	1.8	V
V_{OH}	HIGH-level output voltage	$V_I = V_{IH}$ or V_{IL}					
		I_O = –20 μA	2.0	1.9	–	–	V
		I_O = –20 μA	4.5	4.4	–	–	V
		I_O = –20 μA	6.0	5.9	–	–	V
		I_O = –4.0 mA	4.5	3.7	–	–	V
		I_O = –5.2 mA	6.0	5.2	–	–	V
V_{OL}	LOW-level output voltage	$V_I = V_{IH}$ or V_{IL}					
		I_O = 20 μA	2.0	–	–	0.1	V
		I_O = 20 μA	4.5	–	–	0.1	V
		I_O = 20 μA	6.0	–	–	0.1	V
		I_O = 4.0 mA	4.5	–	–	0.4	V
		I_O = 5.2 mA	6.0	–	–	0.4	V
I_{LI}	input leakage current	$V_I = V_{CC}$ or GND	6.0	–	–	±1.0	μA
I_{OZ}	3-state output OFF current	$V_I = V_{IH}$ or V_{IL}; $V_O = V_{CC}$ or GND	6.0	–	–	±10.0	μA
I_{CC}	quiescent supply current	$V_I = V_{CC}$ or GND; I_O = 0	6.0	–	–	40	μA

Note

1. All typical values are measured at T_{amb} = 25 °C.

Type 74HCT00

At recommended operating conditions; voltages are referenced to GND (ground = 0 V).

SYMBOL	PARAMETER	TEST CONDITIONS		MIN.	TYP.	MAX.	UNIT
		OTHER	V_{CC} (V)				
T_{amb} = –40 to +85 °C; note 1							
V_{IH}	HIGH-level input voltage		4.5 to 5.5	2.0	1.6	–	V
V_{IL}	LOW-level input voltage		4.5 to 5.5	–	1.2	0.8	V
V_{OH}	HIGH-level output voltage	$V_I = V_{IH}$ or V_{IL}					
		I_O = –20 μA	4.5	4.4	4.5	–	V
		I_O = –4.0 mA	4.5	3.84	4.32	–	V
V_{OL}	LOW-level output voltage	$V_I = V_{IH}$ or V_{IL}					
		I_O = 20 μA	4.5	–	0	0.1	V
		I_O = 4.0 mA	4.5	–	0.15	0.33	V
I_{LI}	input leakage current	$V_I = V_{CC}$ or GND	5.5	–	–	±1.0	μA
I_{OZ}	3-state output OFF current	$V_I = V_{IH}$ or V_{IL}; $V_O = V_{CC}$ or GND; I_O = 0	5.5	–	–	±5.0	μA
I_{CC}	quiescent supply current	$V_I = V_{CC}$ or GND; I_O = 0	5.5	–	–	20	μA
ΔI_{CC}	additional supply current per input	$V_I = V_{CC}$ – 2.1 V; I_O = 0	4.5 to 5.5	–	150	675	μA
T_{amb} = –40 to +125 °C							
V_{IH}	HIGH-level input voltage		4.5 to 5.5	2.0	–	–	V
V_{IL}	LOW-level input voltage		4.5 to 5.5	–	–	0.8	V
V_{OH}	HIGH-level output voltage	$V_I = V_{IH}$ or V_{IL}					
		I_O = –20 μA	4.5	4.4	–	–	V
		I_O = –4.0 mA	4.5	3.7	–	–	V
V_{OL}	LOW-level output voltage	$V_I = V_{IH}$ or V_{IL}					
		I_O = 20 μA	4.5	–	–	0.1	V
		I_O = 4.0 mA	4.5	–	–	0.4	V
I_{LI}	input leakage current	$V_I = V_{CC}$ or GND	5.5	–	–	±1.0	μA
I_{OZ}	3-state output OFF current	$V_I = V_{IH}$ or V_{IL}; $V_O = V_{CC}$ or GND; I_O = 0	5.5	–	–	±10	μA
I_{CC}	quiescent supply current	$V_I = V_{CC}$ or GND; I_O = 0	5.5	–	–	40	μA
ΔI_{CC}	additional supply current per input	$V_I = V_{CC}$ – 2.1 V; I_O = 0	4.5 to 5.5	–	–	735	μA

Note

1. All typical values are measured at T_{amb} = 25 °C.

AC CHARACTERISTICS

Type 74HC00

GND = 0 V; $t_r = t_f = 6$ ns; $C_L = 50$ pF.

SYMBOL	PARAMETER	TEST CONDITIONS		MIN.	TYP.	MAX.	UNIT
		WAVEFORMS	V_{CC} (V)				
T_{amb} = –40 to +85 °C; note 1							
t_{PHL}/t_{PLH}	propagation delay nA, nB to nY	see Fig.6	2.0	–	25	115	ns
		see Fig.6	4.5	–	9	23	ns
		see Fig.6	6.0	–	7	20	ns
t_{THL}/t_{TLH}	output transition time		2.0	–	19	95	ns
			4.5	–	7	19	ns
			6.0	–	6	16	ns
T_{amb} = –40 to +125 °C							
t_{PHL}/t_{PLH}	propagation delay nA, nB to nY	see Fig.6	2.0	–	–	135	ns
		see Fig.6	4.5	–	–	27	ns
		see Fig.6	6.0	–	–	23	ns
t_{THL}/t_{TLH}	output transition time		2.0	–	–	110	ns
			4.5	–	–	22	ns
			6.0	–	–	19	ns

Note

1. All typical values are measured at T_{amb} = 25 °C.

Type 74HCT00

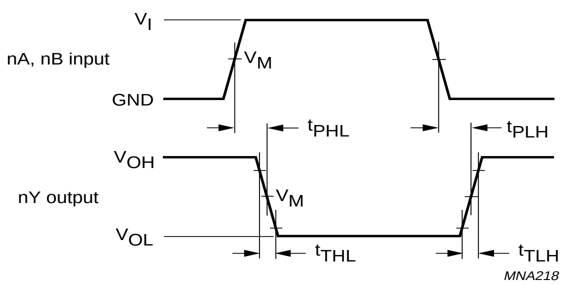
GND = 0 V; $t_r = t_f = 6$ ns; $C_L = 50$ pF

SYMBOL	PARAMETER	TEST CONDITIONS		MIN.	TYP	MAX.	UNIT
		WAVEFORMS	V_{CC} (V)				
T_{amb} = –40 to +85 °C; note 1							
t_{PHL}/t_{PLH}	propagation delay nA, nB to nY	see Fig.6	4.5	–	12	24	ns
t_{THL}/t_{TLH}	output transition time		4.5	–	–	29	ns
T_{amb} = –40 to +125 °C							
t_{PHL}/t_{PLH}	propagation delay nA, nB to nY	see Fig.6	4.5	–	–	29	ns
t_{THL}/t_{TLH}	output transition time		4.5	–	–	22	ns

Note

1. All typical values are measured at T_{amb} = 25 °C.

AC WAVEFORMS

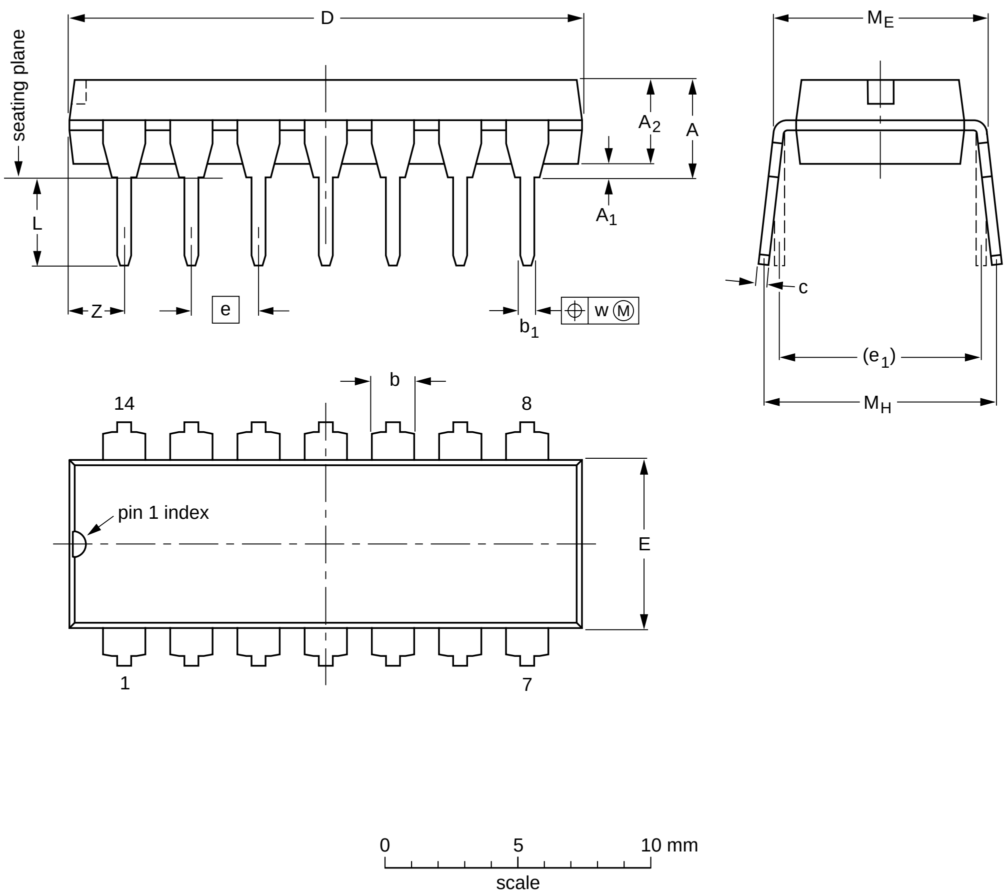


74HC00: V_M = 50%; V_I = GND to V_{CC}.
74HCT00: V_M = 1.3 V; V_I = GND to 3 V.

Fig.6 Waveforms showing the input (nA, nB) to output (nY) propagation delays.

PACKAGE OUTLINES

DIP14: plastic dual in-line package; 14 leads (300 mil) **SOT27-1**



DIMENSIONS (inch dimensions are derived from the original mm dimensions)

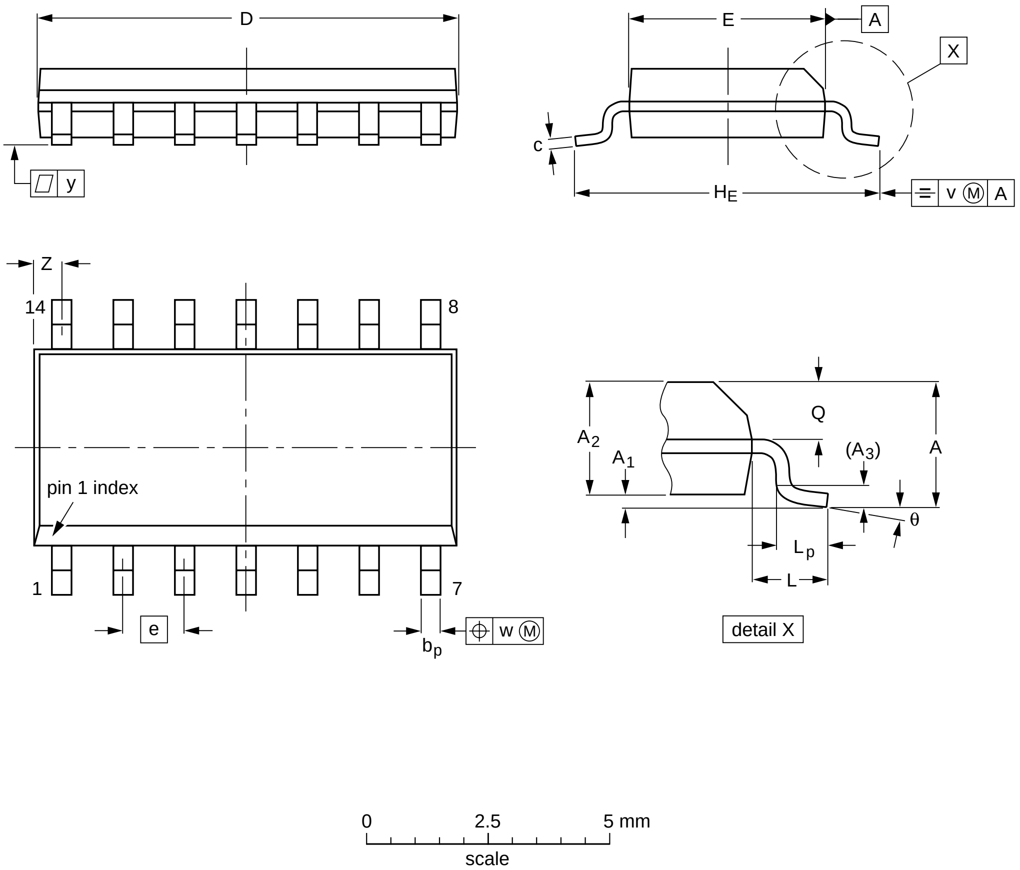
UNIT	A max.	A_1 min.	A_2 max.	b	b_1	c	D (1)	E (1)	e	e_1	L	M_E	M_H	w	Z (1) max.
mm	4.2	0.51	3.2	1.73 1.13	0.53 0.38	0.36 0.23	19.50 18.55	6.48 6.20	2.54	7.62	3.60 3.05	8.25 7.80	10.0 8.3	0.254	2.2
inches	0.17	0.02	0.13	0.068 0.044	0.021 0.015	0.014 0.009	0.77 0.73	0.26 0.24	0.1	0.3	0.14 0.12	0.32 0.31	0.39 0.33	0.01	0.087

Note

1. Plastic or metal protrusions of 0.25 mm (0.01 inch) maximum per side are not included.

OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	JEITA			
SOT27-1	050G04	MO-001	SC-501-14			~~99-12-27~~ 03-02-13

SO14: plastic small outline package; 14 leads; body width 3.9 mm | **SOT108-1**



DIMENSIONS (inch dimensions are derived from the original mm dimensions)

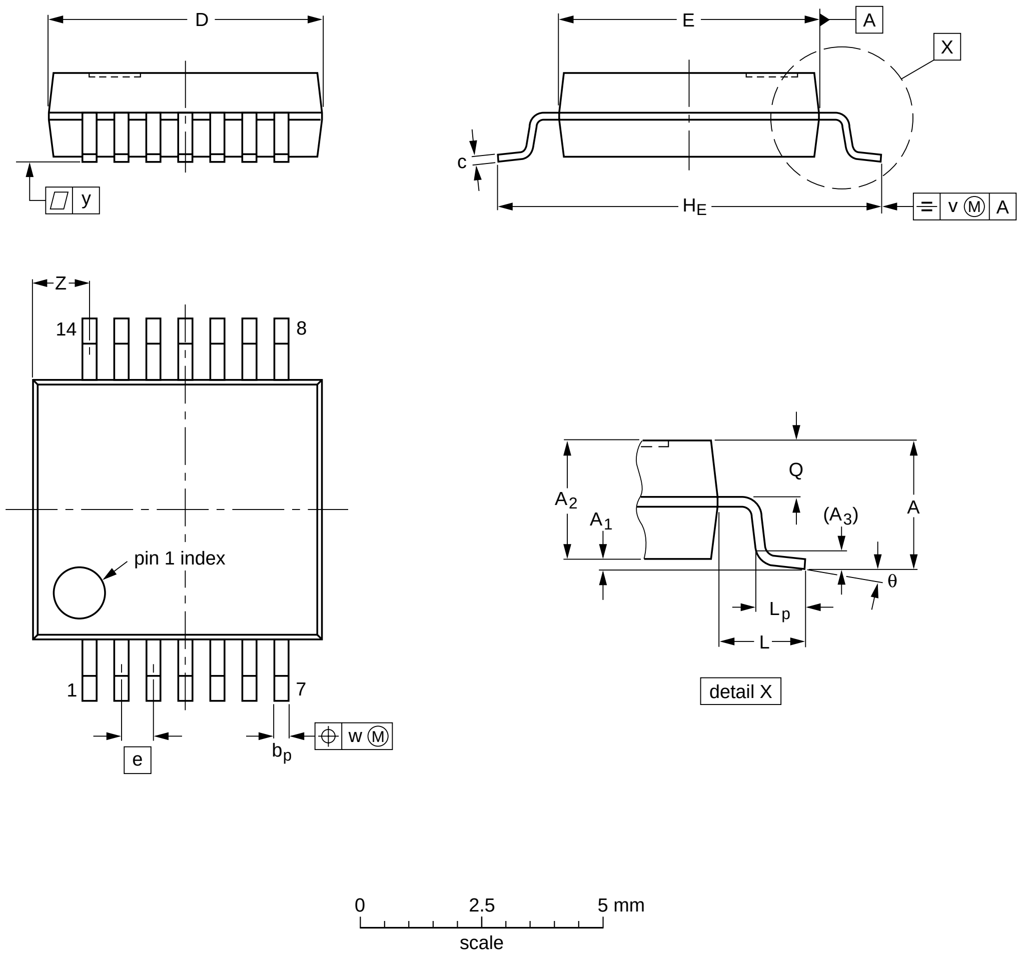
UNIT	A max.	A_1	A_2	A_3	b_p	c	D[(1)]	E[(1)]	e	H_E	L	L_p	Q	v	w	y	Z[(1)]	θ
mm	1.75	0.25 0.10	1.45 1.25	0.25	0.49 0.36	0.25 0.19	8.75 8.55	4.0 3.8	1.27	6.2 5.8	1.05	1.0 0.4	0.7 0.6	0.25	0.25	0.1	0.7 0.3	8° 0°
inches	0.069	0.010 0.004	0.057 0.049	0.01	0.019 0.014	0.0100 0.0075	0.35 0.34	0.16 0.15	0.05	0.244 0.228	0.041	0.039 0.016	0.028 0.024	0.01	0.01	0.004	0.028 0.012	

Note

1. Plastic or metal protrusions of 0.15 mm (0.006 inch) maximum per side are not included.

OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	JEITA			
SOT108-1	076E06	MS-012				~~99-12-27~~ 03-02-19

SSOP14: plastic shrink small outline package; 14 leads; body width 5.3 mm **SOT337-1**



DIMENSIONS (mm are the original dimensions)

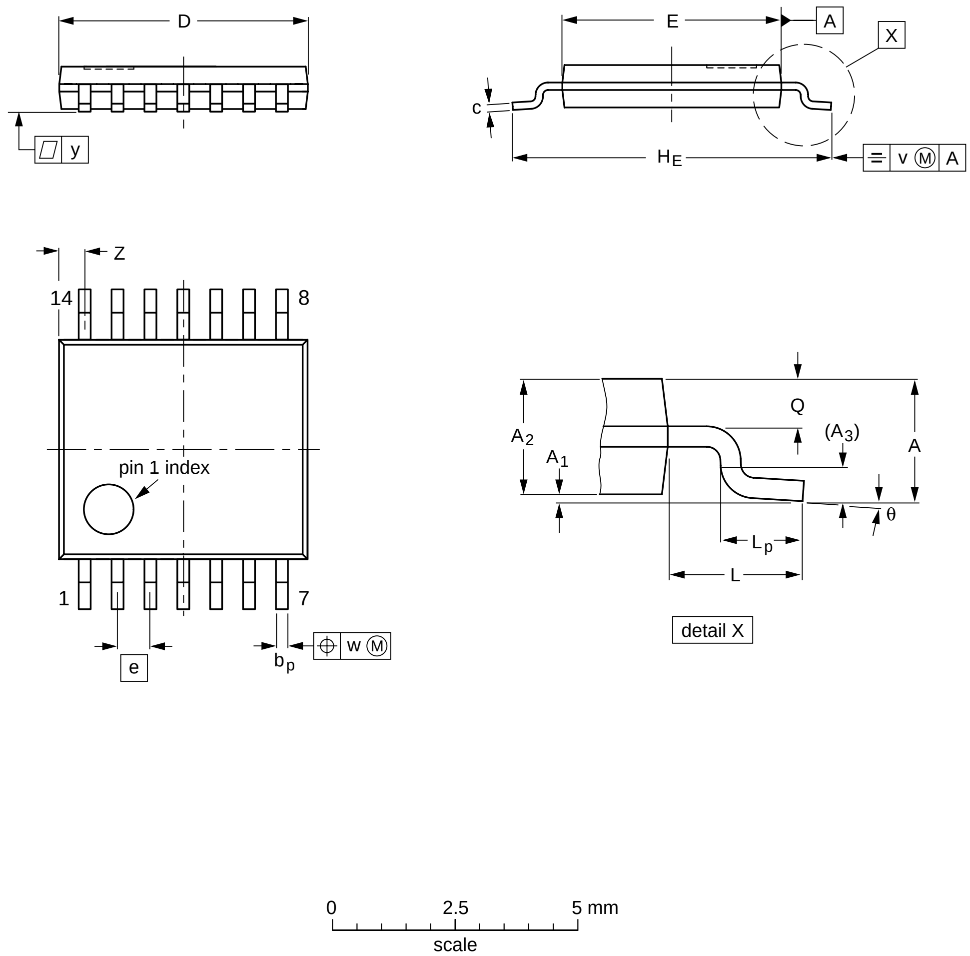
UNIT	A max.	A_1	A_2	A_3	b_p	c	D (1)	E (1)	e	H_E	L	L_p	Q	v	w	y	Z (1)	θ
mm	2	0.21 0.05	1.80 1.65	0.25	0.38 0.25	0.20 0.09	6.4 6.0	5.4 5.2	0.65	7.9 7.6	1.25	1.03 0.63	0.9 0.7	0.2	0.13	0.1	1.4 0.9	8° 0°

Note

1. Plastic or metal protrusions of 0.25 mm maximum per side are not included.

OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	JEITA			
SOT337-1		MO-150				~~99-12-27~~ 03-02-19

TSSOP14: plastic thin shrink small outline package; 14 leads; body width 4.4 mm **SOT402-1**



DIMENSIONS (mm are the original dimensions)

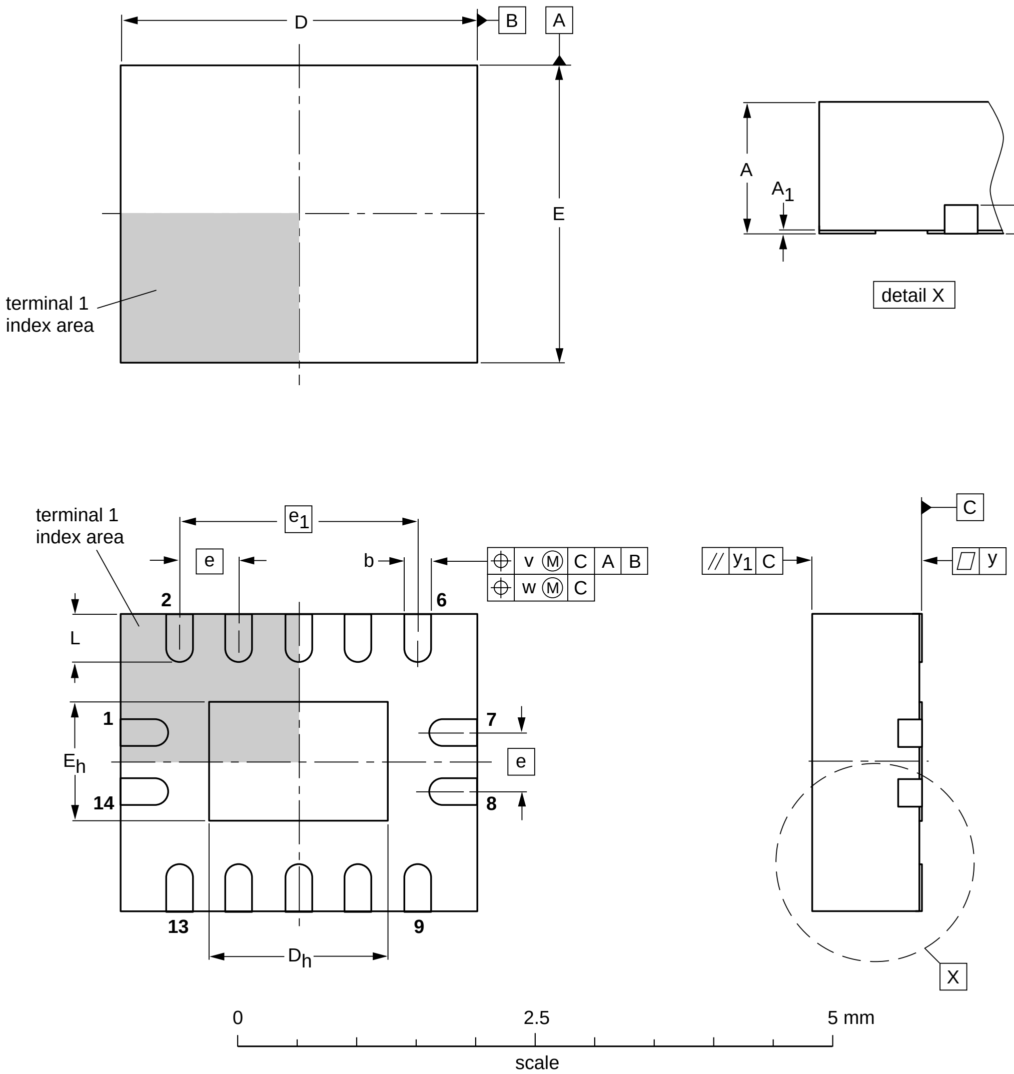
UNIT	A max.	A_1	A_2	A_3	b_p	c	D [(1)]	E [(2)]	e	H_E	L	L_p	Q	v	w	y	Z [(1)]	θ
mm	1.1	0.15 0.05	0.95 0.80	0.25	0.30 0.19	0.2 0.1	5.1 4.9	4.5 4.3	0.65	6.6 6.2	1	0.75 0.50	0.4 0.3	0.2	0.13	0.1	0.72 0.38	8^o 0^o

Notes

1. Plastic or metal protrusions of 0.15 mm maximum per side are not included.
2. Plastic interlead protrusions of 0.25 mm maximum per side are not included.

OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	JEITA			
SOT402-1		MO-153				~~99-12-27~~ 03-02-18

DHVQFN14: plastic dual in-line compatible thermal enhanced very thin quad flat package; no leads; 14 terminals; body 2.5 x 3 x 0.85 mm **SOT762-1**



DIMENSIONS (mm are the original dimensions)

UNIT	$A^{(1)}$ max.	A_1	b	c	$D^{(1)}$	D_h	$E^{(1)}$	E_h	e	e_1	L	v	w	y	y_1
mm	1	0.05 0.00	0.30 0.18	0.2	3.1 2.9	1.65 1.35	2.6 2.4	1.15 0.85	0.5	2	0.5 0.3	0.1	0.05	0.05	0.1

Note

1. Plastic or metal protrusions of 0.075 mm maximum per side are not included.

OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	JEITA			
SOT762-1	- - -	MO-241	- - -			~~02-10-17~~ 03-01-27

DATA SHEET STATUS

LEVEL	DATA SHEET STATUS[1]	PRODUCT STATUS[2][3]	DEFINITION
I	Objective data	Development	This data sheet contains data from the objective specification for product development. Philips Semiconductors reserves the right to change the specification in any manner without notice.
II	Preliminary data	Qualification	This data sheet contains data from the preliminary specification. Supplementary data will be published at a later date. Philips Semiconductors reserves the right to change the specification without notice, in order to improve the design and supply the best possible product.
III	Product data	Production	This data sheet contains data from the product specification. Philips Semiconductors reserves the right to make changes at any time in order to improve the design, manufacturing and supply. Relevant changes will be communicated via a Customer Product/Process Change Notification (CPCN).

Notes

1. Please consult the most recently issued data sheet before initiating or completing a design.
2. The product status of the device(s) described in this data sheet may have changed since this data sheet was published. The latest information is available on the Internet at URL http://www.semiconductors.philips.com.
3. For data sheets describing multiple type numbers, the highest-level product status determines the data sheet status.

DEFINITIONS

Short-form specification — The data in a short-form specification is extracted from a full data sheet with the same type number and title. For detailed information see the relevant data sheet or data handbook.

Limiting values definition — Limiting values given are in accordance with the Absolute Maximum Rating System (IEC 60134). Stress above one or more of the limiting values may cause permanent damage to the device. These are stress ratings only and operation of the device at these or at any other conditions above those given in the Characteristics sections of the specification is not implied. Exposure to limiting values for extended periods may affect device reliability.

Application information — Applications that are described herein for any of these products are for illustrative purposes only. Philips Semiconductors make no representation or warranty that such applications will be suitable for the specified use without further testing or modification.

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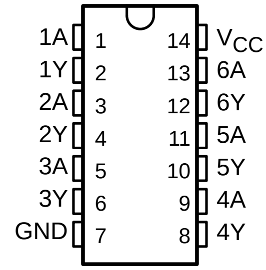
D.2 74LS04 Inversor

- **Dependable Texas Instruments Quality and Reliability**

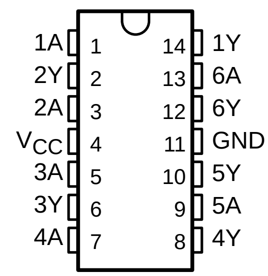
description

These devices contain six independent inverters.

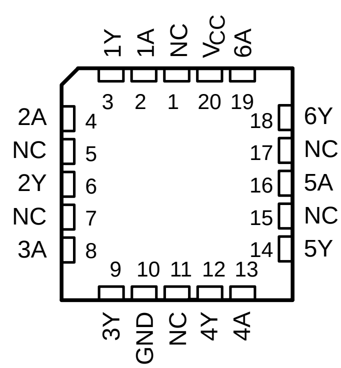
SN5404 . . . J PACKAGE
SN54LS04, SN54S04 . . . J OR W PACKAGE
SN7404 . . . D, N, OR NS PACKAGE
SN74LS04 . . . D, DB, N, OR NS PACKAGE
SN74S04 . . . D OR N PACKAGE
(TOP VIEW)



SN5404 . . . W PACKAGE
(TOP VIEW)



SN54LS04, SN54S04 . . . FK PACKAGE
(TOP VIEW)



NC – No internal connection

ORDERING INFORMATION

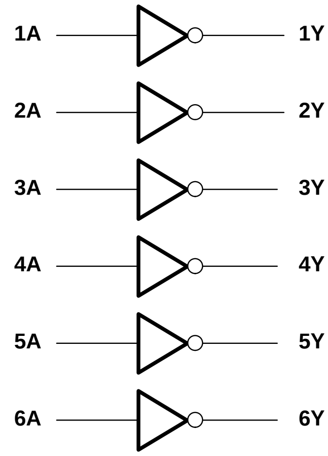
T_A	PACKAGE†		ORDERABLE PART NUMBER	TOP-SIDE MARKING
0°C to 70°C	PDIP – N	Tube	SN7404N	SN7404N
		Tube	SN74LS04N	SN74LS04N
		Tube	SN74S04N	SN74S04N
	SOIC – D	Tube	SN7404D	7404
		Tube	SN74LS04D	LS04
		Tape and reel	SN74LS04DR	
		Tube	SN74S04D	S04
		Tape and reel	SN74S04DR	
	SOP – NS	Tape and reel	SN7404NSR	SN7404
		Tape and reel	SN74LS04NSR	74LS04
	SSOP – DB	Tape and reel	SN74LS04DBR	LS04
–55°C to 125°C	CDIP – J	Tube	SN5404J	SN5404J
		Tube	SNJ5404J	SNJ5404J
		Tube	SN54LS04J	SN54LS04J
		Tube	SN54S04J	SN54S04J
		Tube	SNJ54LS04J	SNJ54LS04J
		Tube	SNJ54S04J	SNJ54S04J
	CFP – W	Tube	SNJ5404W	SNJ5404W
		Tube	SNJ54LS04W	SNJ54LS04W
		Tube	SNJ54S04W	SNJ54S04W
	LCCC – FK	Tube	SNJ54LS04FK	SNJ54LS04FK
		Tube	SNJ54S04FK	SNJ54S04FK

† Package drawings, standard packing quantities, thermal data, symbolization, and PCB design guidelines are available at www.ti.com/sc/package.

FUNCTION TABLE
(each inverter)

INPUT A	OUTPUT Y
H	L
L	H

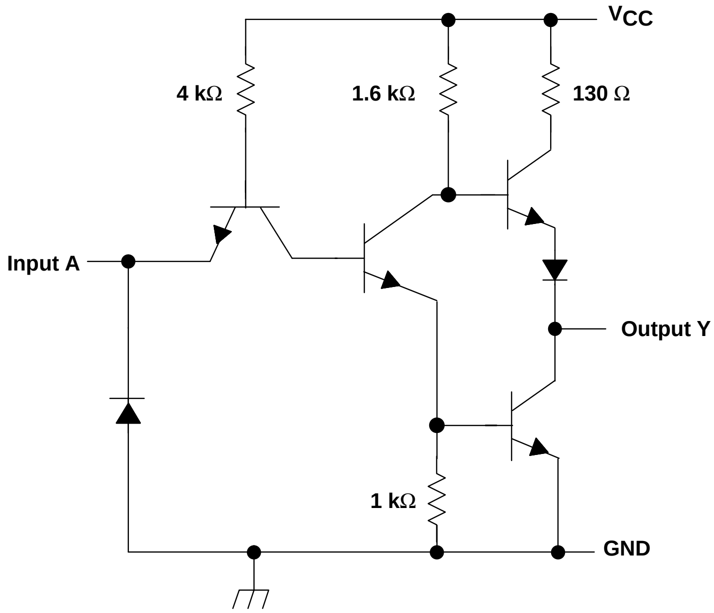
logic diagram (positive logic)



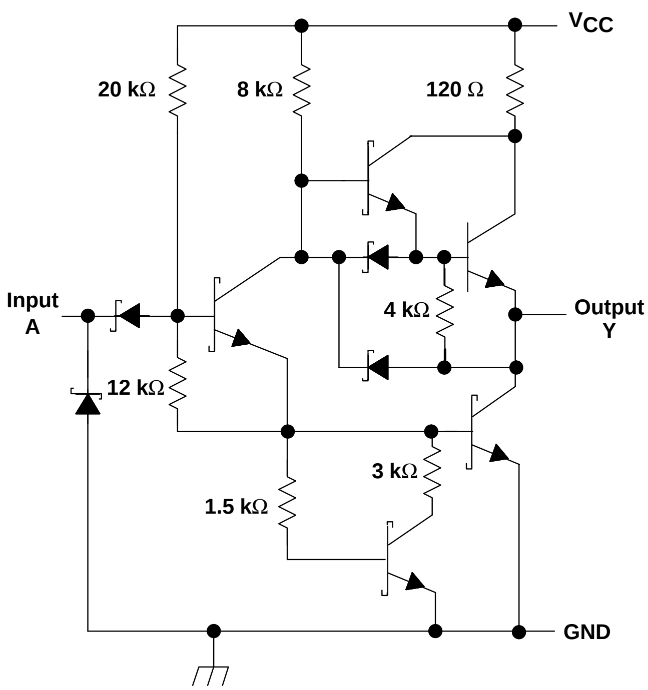
$Y = \overline{A}$

schematics (each gate)

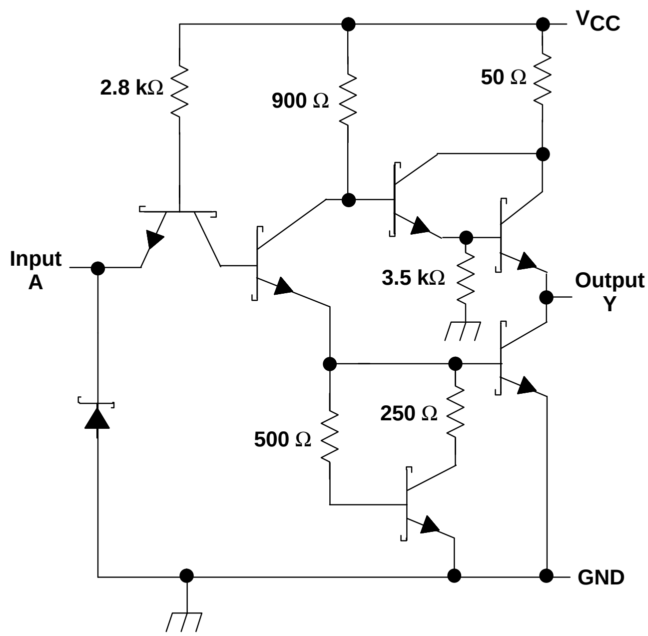
’04



’LS04



’S04



Resistor values shown are nominal.

absolute maximum ratings over operating free-air temperature range (unless otherwise noted)†

Supply voltage, V_{CC} (see Note 1) . . . 7 V
Input voltage, V_I: ’04, ’S04 . . . 5.5 V
’LS04 . . . 7 V
Package thermal impedance, θ_{JA} (see Note 2): D package . . . 86°C/W
DB package . . . 96°C/W
N package . . . 80°C/W
NS package . . . 76°C/W
Storage temperature range, T_{stg} . . . –65°C to 150°C

† Stresses beyond those listed under “absolute maximum ratings” may cause permanent damage to the device. This are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under “recommended operating conditions” is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

NOTES: 1. Voltage values are with respect to network ground terminal.
2. The package thermal impedance is calculated in accordance with JESD 51-7.

recommended operating conditions

		SN5404			SN7404			UNIT
		MIN	NOM	MAX	MIN	NOM	MAX	
V_{CC}	Supply voltage	4.5	5	5.5	4.75	5	5.25	V
V_{IH}	High-level input voltage	2			2			V
V_{IL}	Low-level input voltage			0.8			0.8	V
I_{OH}	High-level output current			–0.4			–0.4	mA
I_{OL}	Low-level output current			16			16	mA
T_A	Operating free-air temperature	–55		125	0		70	°C

electrical characteristics over recommended operating free-air temperature range (unless otherwise noted)

PARAMETER	TEST CONDITIONS‡			SN5404			SN7404			UNIT
				MIN	TYP§	MAX	MIN	TYP§	MAX	
V_{IK}	V_{CC} = MIN,	I_I = –12 mA				–1.5			–1.5	V
V_{OH}	V_{CC} = MIN,	V_{IL} = 0.8 V,	I_{OH} = –0.4 mA	2.4	3.4		2.4	3.4		V
V_{OL}	V_{CC} = MIN,	V_{IH} = 2 V,	I_{OL} = 16 mA		0.2	0.4		0.2	0.4	V
I_I	V_{CC} = MAX,	V_I = 5.5 V				1			1	mA
I_{IH}	V_{CC} = MAX,	V_I = 2.4 V				40			40	µA
I_{IL}	V_{CC} = MAX,	V_I = 0.4 V				–1.6			–1.6	mA
I_{OS}¶	V_{CC} = MAX			–20		–55	–18		–55	mA
I_{CCH}	V_{CC} = MAX,	V_I = 0 V			6	12		6	12	mA
I_{CCL}	V_{CC} = MAX,	V_I = 4.5 V			18	33		18	33	mA

‡ For conditions shown as MIN or MAX, use the appropriate value specified under recommended operating conditions.
§ All typical values are at V_{CC} = 5 V, T_A = 25°C.
¶ Not more than one output should be shorted at a time.

switching characteristics, V_{CC} = 5 V, T_A = 25°C (see Figure 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	TEST CONDITIONS		SN5404 SN7404			UNIT
					MIN	TYP	MAX	
t_{PLH}	A	Y	R_L = 400 Ω,	C_L = 15 pF		12	22	ns
t_{PHL}						8	15	

recommended operating conditions

		SN54LS04			SN74LS04			UNIT
		MIN	NOM	MAX	MIN	NOM	MAX	
V_{CC}	Supply voltage	4.5	5	5.5	4.75	5	5.25	V
V_{IH}	High-level input voltage	2			2			V
V_{IL}	Low-level input voltage			0.7			0.8	V
I_{OH}	High-level output current			–0.4			–0.4	mA
I_{OL}	Low-level output current			4			8	mA
T_A	Operating free-air temperature	–55		125	0		70	°C

electrical characteristics over recommended operating free-air temperature range (unless otherwise noted)

PARAMETER	TEST CONDITIONS†			SN54LS04			SN74LS04			UNIT
				MIN	TYP‡	MAX	MIN	TYP‡	MAX	
V_{IK}	V_{CC} = MIN,	I_I = –18 mA				–1.5			–1.5	V
V_{OH}	V_{CC} = MIN,	V_{IL} = MAX,	I_{OH} = –0.4 mA	2.5	3.4		2.7	3.4		V
V_{OL}	V_{CC} = MIN,	V_{IH} = 2 V	I_{OL} = 4 mA		0.25	0.4			0.4	V
			I_{OL} = 8 mA					0.25	0.5	
I_I	V_{CC} = MAX,	V_I = 7 V				0.1			0.1	mA
I_{IH}	V_{CC} = MAX,	V_I = 2.7 V				20			20	μA
I_{IL}	V_{CC} = MAX,	V_I = 0.4 V				–0.4			–0.4	mA
I_{OS}§	V_{CC} = MAX			–20		–100	–20		–100	mA
I_{CCH}	V_{CC} = MAX,	V_I = 0 V			1.2	2.4		1.2	2.4	mA
I_{CCL}	V_{CC} = MAX,	V_I = 4.5 V			3.6	6.6		3.6	6.6	mA

† For conditions shown as MIN or MAX, use the appropriate value specified under recommended operating conditions.
‡ All typical values are at V_{CC} = 5 V, T_A = 25°C.
§ Not more than one output should be shorted at a time and the duration of the short-circuit should not exceed one second.

switching characteristics, V_{CC} = 5 V, T_A = 25°C (see Figure 2)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	TEST CONDITIONS		SN54LS04 SN74LS04			UNIT
					MIN	TYP	MAX	
t_{PLH}	A	Y	R_L = 2 kΩ,	C_L = 15 pF		9	15	ns
t_{PHL}						10	15	

recommended operating conditions

		SN54S04			SN74S04			UNIT
		MIN	NOM	MAX	MIN	NOM	MAX	
V_{CC}	Supply voltage	4.5	5	5.5	4.75	5	5.25	V
V_{IH}	High-level input voltage	2			2			V
V_{IL}	Low-level input voltage			0.8			0.8	V
I_{OH}	High-level output current			–1			–1	mA
I_{OL}	Low-level output current			20			20	mA
T_A	Operating free-air temperature	–55		125	0		70	°C

electrical characteristics over recommended operating free-air temperature range (unless otherwise noted)

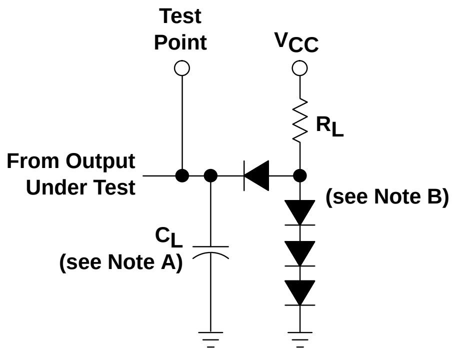
PARAMETER	TEST CONDITIONS†			SN54S04			SN74S04			UNIT
				MIN	TYP‡	MAX	MIN	TYP‡	MAX	
V_{IK}	V_{CC} = MIN,	I_I = –18 mA				–1.2			–1.2	V
V_{OH}	V_{CC} = MIN,	V_{IL} = 0.8 V,	I_{OH} = –1 mA	2.5	3.4		2.7	3.4		V
V_{OL}	V_{CC} = MIN,	V_{IH} = 2 V,	I_{OL} = 20 mA			0.5			0.5	V
I_I	V_{CC} = MAX,	V_I = 5.5 V				1			1	mA
I_{IH}	V_{CC} = MAX,	V_I = 2.7 V				50			50	μA
I_{IL}	V_{CC} = MAX,	V_I = 0.5 V				–2			–2	mA
I_{OS}§	V_{CC} = MAX			–40		–100	–40		–100	mA
I_{CCH}	V_{CC} = MAX,	V_I = 0 V			15	24		15	24	mA
I_{CCL}	V_{CC} = MAX,	V_I = 4.5 V			30	54		30	54	mA

† For conditions shown as MIN or MAX, use the appropriate value specified under recommended operating conditions.
‡ All typical values are at V_{CC} = 5 V, T_A = 25°C.
§ Not more than one output should be shorted at a time and the duration of the short-circuit should not exceed one second.

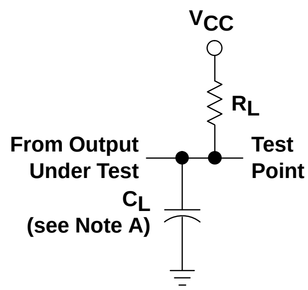
switching characteristics, V_{CC} = 5 V, T_A = 25°C (see Figure 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	TEST CONDITIONS		SN54S04 SN74S04			UNIT
					MIN	TYP	MAX	
t_{PLH}	A	Y	R_L = 280 Ω,	C_L = 15 pF		3	4.5	ns
t_{PHL}						3	5	
t_{PLH}	A	Y	R_L = 280 Ω,	C_L = 50 pF		4.5		ns
t_{PHL}						5		

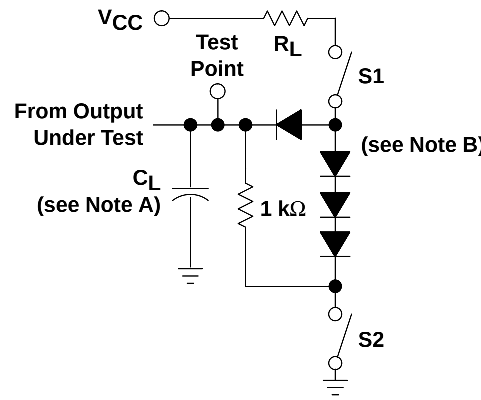
PARAMETER MEASUREMENT INFORMATION
SERIES 54/74 AND 54S/74S DEVICES



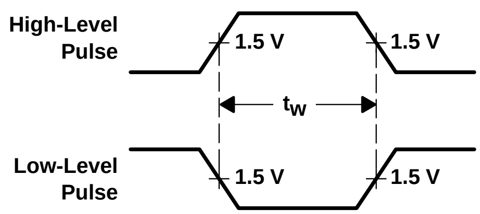
**LOAD CIRCUIT
FOR 2-STATE TOTEM-POLE OUTPUTS**



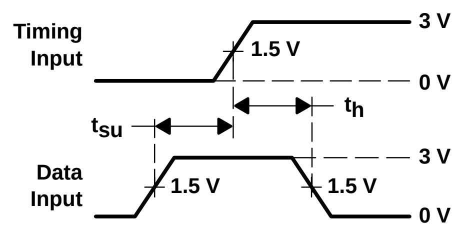
**LOAD CIRCUIT
FOR OPEN-COLLECTOR OUTPUTS**



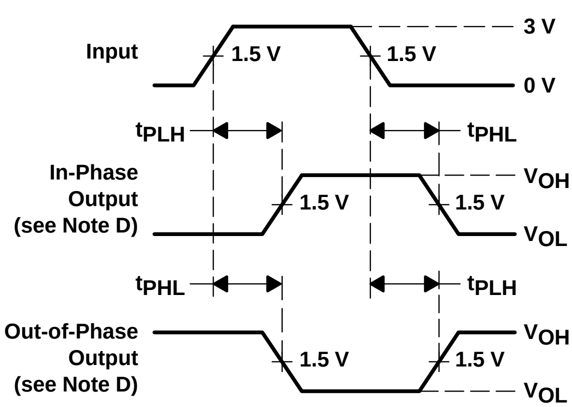
**LOAD CIRCUIT
FOR 3-STATE OUTPUTS**



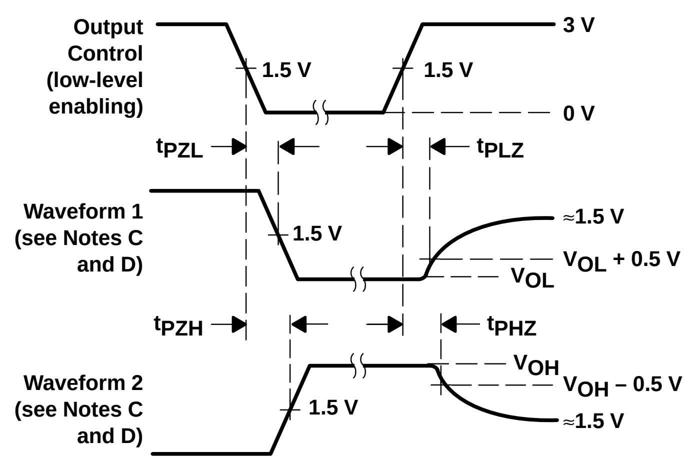
**VOLTAGE WAVEFORMS
PULSE DURATIONS**



**VOLTAGE WAVEFORMS
SETUP AND HOLD TIMES**



**VOLTAGE WAVEFORMS
PROPAGATION DELAY TIMES**



**VOLTAGE WAVEFORMS
ENABLE AND DISABLE TIMES, 3-STATE OUTPUTS**

NOTES:
A. C_L includes probe and jig capacitance.
B. All diodes are 1N3064 or equivalent.
C. Waveform 1 is for an output with internal conditions such that the output is low except when disabled by the output control. Waveform 2 is for an output with internal conditions such that the output is high except when disabled by the output control.
D. S1 and S2 are closed for t_{PLH}, t_{PHL}, t_{PHZ}, and t_{PLZ}; S1 is open and S2 is closed for t_{PZH}; S1 is closed and S2 is open for t_{PZL}.
E. All input pulses are supplied by generators having the following characteristics: PRR ≤ 1 MHz, $Z_O \approx 50\ \Omega$; t_r and $t_f \le 7$ ns for Series 54/74 devices and t_r and $t_f \le 2.5$ ns for Series 54S/74S devices.
F. The outputs are measured one at a time with one input transition per measurement.

Figure 1. Load Circuits and Voltage Waveforms

D.3 74HC04 Inversor

DATA SHEET

74HC04; 74HCT04
Hex inverter

Product specification
Supersedes data of 1993 Sep 01

2003 Jul 23

Philips Semiconductors

PHILIPS

Hex inverter 74HC04; 74HCT04

FEATURES

- Complies with JEDEC standard no. 8-1A
- ESD protection:
  HBM EIA/JESD22-A114-A exceeds 2000 V
  MM EIA/JESD22-A115-A exceeds 200 V.
- Specified from –40 to +85 °C and –40 to +125 °C.

DESCRIPTION

The 74HC/HCT04 are high-speed Si-gate CMOS devices and are pin compatible with low power Schottky TTL (LSTTL). They are specified in compliance with JEDEC standard no. 7A. The 74HC/HCT04 provide six inverting buffers.

QUICK REFERENCE DATA

GND = 0 V; T_{amb} = 25 °C; $t_r = t_f \leq 6.0$ ns.

SYMBOL	PARAMETER	CONDITIONS	TYPICAL		UNIT
			HC04	HCT04	
t_{PHL}/t_{PLH}	propagation delay nA to nY	C_L = 15 pF; V_{CC} = 5 V	7	8	ns
C_I	input capacitance		3.5	3.5	pF
C_{PD}	power dissipation capacitance per gate	notes 1 and 2	21	24	pF

Notes

1. C_{PD} is used to determine the dynamic power dissipation (P_D in μW).
   $P_D = C_{PD} \times V_{CC}^2 \times f_i \times N + \Sigma(C_L \times V_{CC}^2 \times f_o)$ where:
   f_i = input frequency in MHz;
   f_o = output frequency in MHz;
   C_L = output load capacitance in pF;
   V_{CC} = supply voltage in Volts;
   N = total load switching outputs;
   $\Sigma(C_L \times V_{CC}^2 \times f_o)$ = sum of the outputs.
2. For 74HC04: the condition is V_I = GND to V_{CC}.
   For 74HCT04: the condition is V_I = GND to V_{CC} – 1.5 V.

FUNCTION TABLE

See note 1.

INPUT	OUTPUT
nA	nY
L	H
H	L

Note

1. H = HIGH voltage level;
   L = LOW voltage level.

ORDERING INFORMATION

TYPE NUMBER	PACKAGE				
	TEMPERATURE RANGE	PINS	PACKAGE	MATERIAL	CODE
74HC04N	–40 to +125 °C	14	DIP14	plastic	SOT27-1
74HCT04N	–40 to +125 °C	14	DIP14	plastic	SOT27-1
74HC04D	–40 to +125 °C	14	SO14	plastic	SOT108-1
74HCT04D	–40 to +125 °C	14	SO14	plastic	SOT108-1
74HC04DB	–40 to +125 °C	14	SSOP14	plastic	SOT337-1
74HCT04DB	–40 to +125 °C	14	SSOP14	plastic	SOT337-1
74HC04PW	–40 to +125 °C	14	TSSOP14	plastic	SOT402-1
74HCT04PW	–40 to +125 °C	14	TSSOP14	plastic	SOT402-1
74HC04BQ	–40 to +125 °C	14	DHVQFN14	plastic	SOT762-1
74HCT04BQ	–40 to +125 °C	14	DHVQFN14	plastic	SOT762-1

PINNING

PIN	SYMBOL	DESCRIPTION
1	1A	data input
2	1Y	data output
3	2A	data input
4	2Y	data output
5	3A	data input
6	3Y	data output
7	GND	ground (0 V)
8	4Y	data output
9	4A	data input
10	5Y	data output
11	5A	data input
12	6Y	data output
13	6A	data input
14	V_{CC}	supply voltage

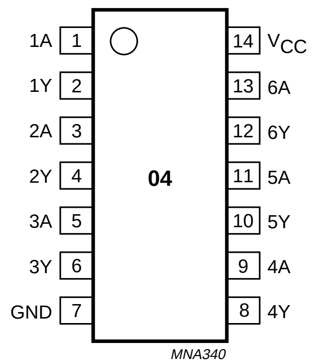
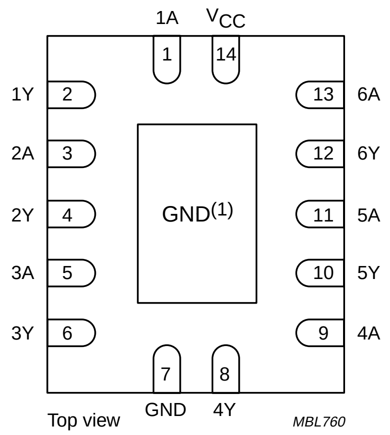


Fig.1 Pin configuration DIP14, SO14 and (T)SSOP14.



(1) The die substrate is attached to this pad using conductive die attach material. It can not be used as a supply pin or input.

Fig.2 Pin configuration DHVQFN14.

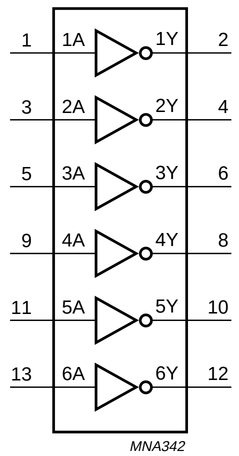


Fig.3 Logic symbol.

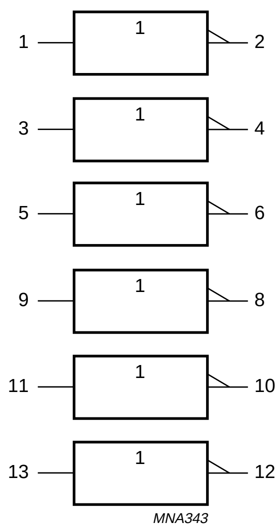


Fig.4 IEC logic symbol.

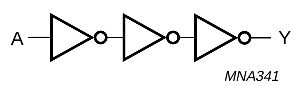


Fig.5 Logic diagram (one inverter).

RECOMMENDED OPERATING CONDITIONS

SYMBOL	PARAMETER	CONDITIONS	74HC04			74HCT04			UNIT
			MIN.	TYP.	MAX.	MIN.	TYP.	MAX.	
V_{CC}	supply voltage		2.0	5.0	6.0	4.5	5.0	5.5	V
V_I	input voltage		0	–	V_{CC}	0	–	V_{CC}	V
V_O	output voltage		0	–	V_{CC}	0	–	V_{CC}	V
T_{amb}	ambient temperature	see DC and AC characteristics per device	–40	+25	+125	–40	+25	+125	°C
t_r, t_f	input rise and fall times	V_{CC} = 2.0 V	–	–	1000	–	–	–	ns
		V_{CC} = 4.5 V	–	6.0	500	–	6.0	500	ns
		V_{CC} = 6.0 V	–	–	400	–	–	–	ns

LIMITING VALUES

In accordance with the Absolute Maximum Rating System (IEC 60134); voltages are referenced to GND (ground = 0 V).

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
V_{CC}	supply voltage		–0.5	+7.0	V
I_{IK}	input diode current	$V_I < -0.5$ V or $V_I > V_{CC} + 0.5$ V	–	±20	mA
I_{OK}	output diode current	$V_O < -0.5$ V or $V_O > V_{CC} + 0.5$ V	–	±20	mA
I_O	output source or sink current	-0.5 V $< V_O < V_{CC} + 0.5$ V	–	±25	mA
I_{CC}, I_{GND}	V_{CC} or GND current		–	±50	mA
T_{stg}	storage temperature		–65	+150	°C
P_{tot}	power dissipation				
	DIP14 package	T_{amb} = –40 to +125 °C; note 1	–	750	mW
	other packages	T_{amb} = –40 to +125 °C; note 2	–	500	mW

Notes

1. For DIP14 packages: above 70 °C derate linearly with 12 mW/K.
2. For SO14 packages: above 70 °C derate linearly with 8 mW/K.
   For SSOP14 and TSSOP14 packages: above 60 °C derate linearly with 5.5 mW/K.
   For DHVQFN14 packages: above 60 °C derate linearly with 4.5 mW/K.

DC CHARACTERISTICS

Type 74HC04

At recommended operating conditions; voltages are referenced to GND (ground = 0 V).

SYMBOL	PARAMETER	TEST CONDITIONS		MIN.	TYP.	MAX.	UNIT
		OTHER	V_{CC} (V)				
T_{amb} = 25 °C							
V_{IH}	HIGH-level input voltage		2.0	1.5	1.2	–	V
			4.5	3.15	2.4	–	V
			6.0	4.2	3.2	–	V
V_{IL}	LOW-level input voltage		2.0	–	0.8	0.5	V
			4.5	–	2.1	1.35	V
			6.0	–	2.8	1.8	V
V_{OH}	HIGH-level output voltage	$V_I = V_{IH}$ or V_{IL}					
		I_O = –20 μA	2.0	1.9	2.0	–	V
		I_O = –20 μA	4.5	4.4	4.5	–	V
		I_O = –4.0 mA	4.5	3.98	4.32	–	V
		I_O = –20 μA	6.0	5.9	6.0	–	V
		I_O = –5.2 mA	6.0	5.48	5.81	–	V
V_{OL}	LOW-level output voltage	$V_I = V_{IH}$ or V_{IL}					
		I_O = 20 μA	2.0	–	0	0.1	V
		I_O = 20 μA	4.5	–	0	0.1	V
		I_O = 4.0 mA	4.5	–	0.15	0.26	V
		I_O = 20 μA	6.0	–	0	0.1	V
		I_O = 5.2 mA	6.0	–	0.16	0.26	V
I_{LI}	input leakage current	$V_I = V_{CC}$ or GND	6.0	–	0.1	±0.1	μA
I_{OZ}	3-state output OFF current	$V_I = V_{IH}$ or V_{IL}; $V_O = V_{CC}$ or GND	6.0	–	–	±.0.5	μA
I_{CC}	quiescent supply current	$V_I = V_{CC}$ or GND; I_O = 0	6.0	–	–	2	μA

SYMBOL	PARAMETER	TEST CONDITIONS		MIN.	TYP.	MAX.	UNIT
		OTHER	V_{CC} (V)				
T_{amb} = −40 to +85 °C							
V_{IH}	HIGH-level input voltage		2.0	1.5	–	–	V
			4.5	3.15	–	–	V
			6.0	4.2	–	–	V
V_{IL}	LOW-level input voltage		2.0	–	–	0.5	V
			4.5	–	–	1.35	V
			6.0	–	–	1.8	V
V_{OH}	HIGH-level output voltage	$V_I = V_{IH}$ or V_{IL}					
		I_O = −20 μA	2.0	1.9	–	–	V
		I_O = −20 μA	4.5	4.4	–	–	V
		I_O = −4.0 mA	4.5	3.84	–	–	V
		I_O = −20 μA	6.0	5.9	–	–	V
		I_O = −5.2 mA	6.0	5.34	–	–	V
V_{OL}	LOW-level output voltage	$V_I = V_{IH}$ or V_{IL}					
		I_O = 20 μA	2.0	–	–	0.1	V
		I_O = 20 μA	4.5	–	–	0.1	V
		I_O = 4.0 mA	4.5	–	–	0.33	V
		I_O = 20 μA	6.0	–	–	0.1	V
		I_O = 5.2 mA	6.0	–	–	0.33	V
I_{LI}	input leakage current	$V_I = V_{CC}$ or GND	6.0	–	–	±1.0	μA
I_{OZ}	3-state output OFF current	$V_I = V_{IH}$ or V_{IL}; $V_O = V_{CC}$ or GND	6.0	–	–	±.5.0	μA
I_{CC}	quiescent supply current	$V_I = V_{CC}$ or GND; I_O = 0	6.0	–	–	20	μA

SYMBOL	PARAMETER	TEST CONDITIONS		MIN.	TYP.	MAX.	UNIT
		OTHER	V_{CC} (V)				
T_{amb} = –40 to +125 °C							
V_{IH}	HIGH-level input voltage		2.0	1.5	–	–	V
			4.5	3.15	–	–	V
			6.0	4.2	–	–	V
V_{IL}	LOW-level input voltage		2.0	–	–	0.5	V
			4.5	–	–	1.35	V
			6.0	–	–	1.8	V
V_{OH}	HIGH-level output voltage	$V_I = V_{IH}$ or V_{IL}					
		I_O = –20 µA	2.0	1.9	–	–	V
		I_O = –20 µA	4.5	4.4	–	–	V
		I_O = –20 µA	6.0	5.9	–	–	V
		I_O = –4.0 mA	4.5	3.7	–	–	V
		I_O = –5.2 mA	6.0	5.2	–	–	V
V_{OL}	LOW-level output voltage	$V_I = V_{IH}$ or V_{IL}					
		I_O = 20 µA	2.0	–	–	0.1	V
		I_O = 20 µA	4.5	–	–	0.1	V
		I_O = 20 µA	6.0	–	–	0.1	V
		I_O = 4.0 mA	4.5	–	–	0.4	V
		I_O = 5.2 mA	6.0	–	–	0.4	V
I_{LI}	input leakage current	$V_I = V_{CC}$ or GND	6.0	–	–	±1.0	µA
I_{OZ}	3-state output OFF current	$V_I = V_{IH}$ or V_{IL}; $V_O = V_{CC}$ or GND	6.0	–	–	±10.0	µA
I_{CC}	quiescent supply current	$V_I = V_{CC}$ or GND; $I_O = 0$	6.0	–	–	40	µA

Type 74HCT04

At recommended operating conditions; voltages are referenced to GND (ground = 0 V).

SYMBOL	PARAMETER	TEST CONDITIONS		MIN.	TYP.	MAX.	UNIT
		OTHER	V_{CC} (V)				
T_{amb} = 25 °C							
V_{IH}	HIGH-level input voltage		4.5 to 5.5	2.0	1.6	–	V
V_{IL}	LOW-level input voltage		4.5 to 5.5	–	1.2	0.8	V
V_{OH}	HIGH-level output voltage	$V_I = V_{IH}$ or V_{IL}					
		$I_O = -20\ \mu A$	4.5	4.4	4.5	–	V
		$I_O = -4.0$ mA	4.5	3.84	4.32	–	V
V_{OL}	LOW-level output voltage	$V_I = V_{IH}$ or V_{IL}					
		$I_O = 20\ \mu A$	4.5	–	0	0.1	V
		$I_O = 4.0$ mA	4.5	–	0.15	0.26	V
I_{LI}	input leakage current	$V_I = V_{CC}$ or GND	5.5	–	–	±0.1	μA
I_{OZ}	3-state output OFF current	$V_I = V_{IH}$ or V_{IL}; $V_O = V_{CC}$ or GND; $I_O = 0$	5.5	–	–	±0.5	μA
I_{CC}	quiescent supply current	$V_I = V_{CC}$ or GND; $I_O = 0$	5.5	–	–	2	μA
ΔI_{CC}	additional supply current per input	$V_I = V_{CC} - 2.1$ V; $I_O = 0$	4.5 to 5.5	–	120	432	μA
T_{amb} = –40 to +85 °C							
V_{IH}	HIGH-level input voltage		4.5 to 5.5	2.0	–	–	V
V_{IL}	LOW-level input voltage		4.5 to 5.5	–	–	0.8	V
V_{OH}	HIGH-level output voltage	$V_I = V_{IH}$ or V_{IL}			–		
		$I_O = -20\ \mu A$	4.5	4.4	–	–	V
		$I_O = -4.0$ mA	4.5	3.84	–	–	V
V_{OL}	LOW-level output voltage	$V_I = V_{IH}$ or V_{IL}			–		
		$I_O = 20\ \mu A$	4.5	–	–	0.1	V
		$I_O = 4.0$ mA	4.5	–	–	0.33	V
I_{LI}	input leakage current	$V_I = V_{CC}$ or GND	5.5	–	–	±1.0	μA
I_{OZ}	3-state output OFF current	$V_I = V_{IH}$ or V_{IL}; $V_O = V_{CC}$ or GND; $I_O = 0$	5.5	–	–	±5.0	μA
I_{CC}	quiescent supply current	$V_I = V_{CC}$ or GND; $I_O = 0$	5.5	–	–	20	μA
ΔI_{CC}	additional supply current per input	$V_I = V_{CC} - 2.1$ V; $I_O = 0$	4.5 to 5.5	–	–	540	μA

SYMBOL	PARAMETER	TEST CONDITIONS		MIN.	TYP.	MAX.	UNIT
		OTHER	V_{CC} (V)				
T_{amb} = –40 to +125 °C							
V_{IH}	HIGH-level input voltage		4.5 to 5.5	2.0	–	–	V
V_{IL}	LOW-level input voltage		4.5 to 5.5	–	–	0.8	V
V_{OH}	HIGH-level output voltage	$V_I = V_{IH}$ or V_{IL}					
		I_O = –20 μA	4.5	4.4	–	–	V
		I_O = –4.0 mA	4.5	3.7	–	–	V
V_{OL}	LOW-level output voltage	$V_I = V_{IH}$ or V_{IL}					
		I_O = 20 μA	4.5	–	–	0.1	V
		I_O = 4.0 mA	4.5	–	–	0.4	V
I_{LI}	input leakage current	$V_I = V_{CC}$ or GND	5.5	–	–	±1.0	μA
I_{OZ}	3-state output OFF current	$V_I = V_{IH}$ or V_{IL}; $V_O = V_{CC}$ or GND; $I_O = 0$	5.5	–	–	±10	μA
I_{CC}	quiescent supply current	$V_I = V_{CC}$ or GND; $I_O = 0$	5.5	–	–	40	μA
ΔI_{CC}	additional supply current per input	$V_I = V_{CC}$ – 2.1 V; $I_O = 0$	4.5 to 5.5	–	–	590	μA

AC CHARACTERISTICS

Family 74HC04

GND = 0 V; $t_r = t_f \leq 6.0$ ns; $C_L = 50$ pF.

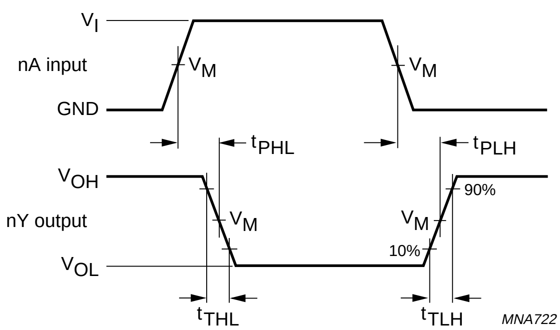
SYMBOL	PARAMETER	TEST CONDITIONS		MIN.	TYP.	MAX.	UNIT
		WAVEFORMS	V_{CC} (V)				
T_{amb} = 25 °C							
t_{PHL}/t_{PLH}	propagation delay nA to nY	see Figs 6 and 7	2.0	–	25	85	ns
			4.5	–	9	17	ns
			6.0	–	7	14	ns
t_{THL}/t_{TLH}	output transition time	see Figs 6 and 7	2.0	–	19	75	ns
			4.5	–	7	15	ns
			6.0	–	6	13	ns
T_{amb} = –40 to +85 °C							
t_{PHL}/t_{PLH}	propagation delay nA to nY	see Figs 6 and 7	2.0	–	–	105	ns
			4.5	–	–	21	ns
			6.0	–	–	18	ns
t_{THL}/t_{TLH}	output transition time	see Figs 6 and 7	2.0	–	–	95	ns
			4.5	–	–	19	ns
			6.0	–	–	16	ns
T_{amb} = –40 to +125 °C							
t_{PHL}/t_{PLH}	propagation delay nA to nY	see Figs 6 and 7	2.0	–	–	130	ns
			4.5	–	–	26	ns
			6.0	–	–	22	ns
t_{THL}/t_{TLH}	output transition time	see Figs 6 and 7	2.0	–	–	110	ns
			4.5	–	–	22	ns
			6.0	–	–	19	ns

Family 74HCT04

GND = 0 V; $t_r = t_f \leq 6.0$ ns; $C_L = 50$ pF.

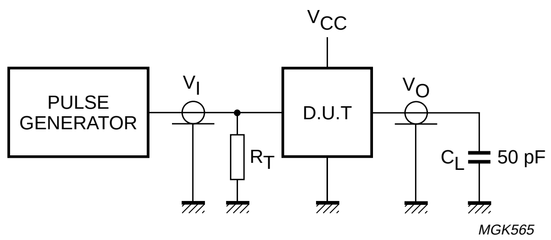
SYMBOL	PARAMETER	TEST CONDITIONS		MIN.	TYP.	MAX.	UNIT
		WAVEFORMS	V_{CC} (V)				
T_{amb} = 25 °C							
t_{PHL}/t_{PLH}	propagation delay nA to nY	see Figs 6 and 7	4.5	–	10	19	ns
t_{THL}/t_{TLH}	output transition time	see Figs 6 and 7	4.5	–	7	15	ns
T_{amb} = –40 to +85 °C							
t_{PHL}/t_{PLH}	propagation delay nA to nY	see Figs 6 and 7	4.5	–	–	24	ns
t_{THL}/t_{TLH}	output transition time	see Figs 6 and 7	4.5	–	–	19	ns
T_{amb} = –40 to +125 °C							
t_{PHL}/t_{PLH}	propagation delay nA to nY	see Figs 6 and 7	4.5	–	–	29	ns
t_{THL}/t_{TLH}	output transition time	see Figs 6 and 7	4.5	–	–	22	ns

AC WAVEFORMS



For 74HC04: V_M = 50%; V_I = GND to V_{CC}.
For 74HCT04: V_M = 1.3 V; V_I = GND to 3.0 V.

Fig.6 Waveforms showing the data input (nA) to data output (nY) propagation delays and the output transition times.



Definitions for test circuit:

C_L = Load capacitance including jig and probe capacitance.

R_T = Termination resistance should be equal to the output impedance Z_o of the pulse generator.

Fig.7 Load circuitry for switching times.

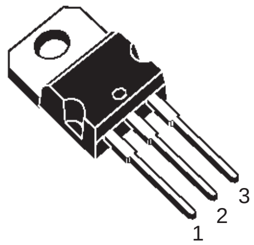
D.4 Integrado BUZ 10

BUZ10

N - CHANNEL 50V - 0.06Ω - 23A TO-220 STripFET™ MOSFET

TYPE	V_{DSS}	$R_{DS(on)}$	I_D
BUZ10	50 V	< 0.07 Ω	23 A

- TYPICAL $R_{DS(on)}$ = 0.06 Ω
- AVALANCHE RUGGED TECHNOLOGY
- 100% AVALANCHE TESTED
- HIGH CURRENT CAPABILITY
- 175°C OPERATING TEMPERATURE

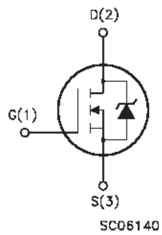


TO-220

APPLICATIONS

- HIGH CURRENT, HIGH SPEED SWITCHING
- SOLENOID AND RELAY DRIVERS
- REGULATORS
- DC-DC & DC-AC CONVERTERS
- MOTOR CONTROL, AUDIO AMPLIFIERS
- AUTOMOTIVE ENVIRONMENT (INJECTION, ABS, AIR-BAG, LAMPDRIVERS, Etc.)

INTERNAL SCHEMATIC DIAGRAM



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{DS}	Drain-source Voltage (V_{GS} = 0)	50	V
V_{DGR}	Drain- gate Voltage (R_{GS} = 20 kΩ)	50	V
V_{GS}	Gate-source Voltage	± 20	V
I_D	Drain Current (continuous) at T_c = 25 °C	23	A
I_{DM}	Drain Current (pulsed)	92	A
P_{tot}	Total Dissipation at T_c = 25 °C	75	W
T_{stg}	Storage Temperature	-65 to 175	°C
T_j	Max. Operating Junction Temperature	175	°C
	DIN HUMIDITY CATEGORY (DIN 40040)	E	
	IEC CLIMATIC CATEGORY (DIN IEC 68-1)	55/150/56	

First digit of the datecode being Z or K identifies silicon characterized in this datasheet.

THERMAL DATA

$R_{thj\text{-}case}$	Thermal Resistance Junction-case	Max	2.0	$^oC/W$
$R_{thj\text{-}amb}$	Thermal Resistance Junction-ambient	Max	62.5	$^oC/W$

AVALANCHE CHARACTERISTICS

Symbol	Parameter	Value	Unit
I_{AR}	Avalanche Current, Repetitive or Not-Repetitive (pulse width limited by T_j max, $\delta < 1\%$)	10	A
E_{AS}	Single Pulse Avalanche Energy (starting $T_j = 25\ ^oC$, $I_D = I_{AR}$, $V_{DD} = 30$ V)	150	mJ

ELECTRICAL CHARACTERISTICS ($T_{case} = 25\ ^oC$ unless otherwise specified)

OFF

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$V_{(BR)DSS}$	Drain-source Breakdown Voltage	$I_D = 250\ \mu A$ $V_{GS} = 0$	50			V
I_{DSS}	Zero Gate Voltage Drain Current ($V_{GS} = 0$)	V_{DS} = Max Rating V_{DS} = Max Rating $T_j = 125\ ^oC$			1 10	μA μA
I_{GSS}	Gate-body Leakage Current ($V_{DS} = 0$)	$V_{GS} = \pm 20$ V			± 100	nA

ON (∗)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$V_{GS(th)}$	Gate Threshold Voltage	$V_{DS} = V_{GS}$ $I_D = 1$ mA	2.1	3	4	V
$R_{DS(on)}$	Static Drain-source On Resistance	$V_{GS} = 10V$ $I_D = 14$ A		0.06	0.07	Ω

DYNAMIC

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
g_{fs} (∗)	Forward Transconductance	$V_{DS} = 25$ V $I_D = 14$ A	6	11		S
C_{iss} C_{oss} C_{rss}	Input Capacitance Output Capacitance Reverse Transfer Capacitance	$V_{DS} = 25$ V f = 1 MHz $V_{GS} = 0$		900 130 40		pF pF pF

SWITCHING

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$t_{d(on)}$ t_r $t_{d(off)}$ t_f	Turn-on Time Rise Time Turn-off Delay Time Fall Time	$V_{DD} = 30$ V $I_D = 10$ A $R_{GS} = 4.7\ \Omega$ $V_{GS} = 10$ V		20 45 48 10		ns ns ns ns

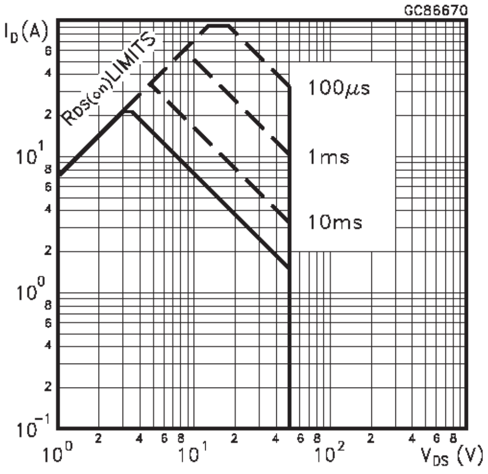
ELECTRICAL CHARACTERISTICS (continued)

SOURCE DRAIN DIODE

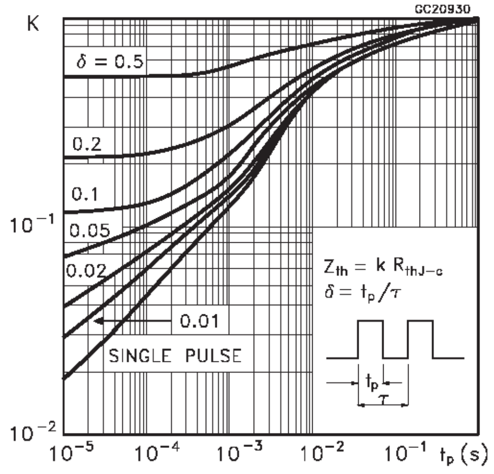
Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
I_{SD} I_{SDM}	Source-drain Current Source-drain Current (pulsed)				23 92	A A
V_{SD} (∗)	Forward On Voltage	I_{SD} = 46 A V_{GS} = 0			1.9	V
t_{rr} Q_{rr}	Reverse Recovery Time Reverse Recovery Charge	I_{SD} = 23 A di/dt = 100 A/µs V_{DD} = 30 V T_j = 150 °C		50 0.17		ns µC

(∗) Pulsed: Pulse duration = 300 µs, duty cycle 1.5 %

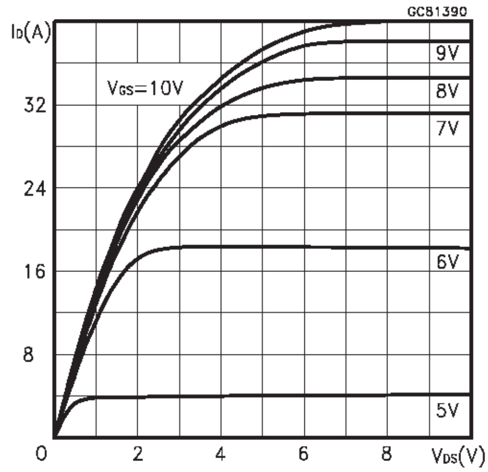
Safe Operating Area



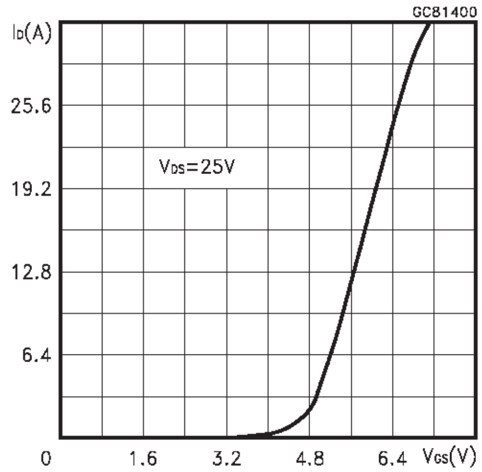
Thermal Impedance



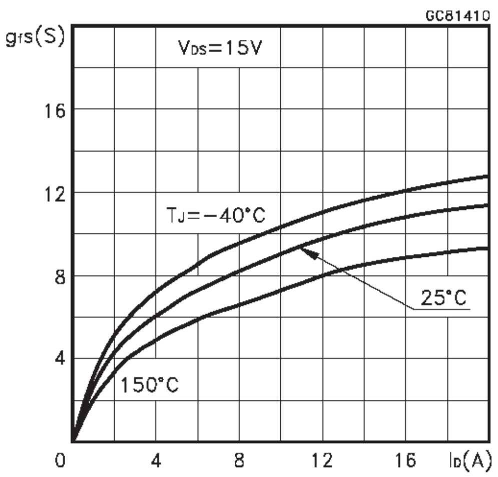
Output Characteristics



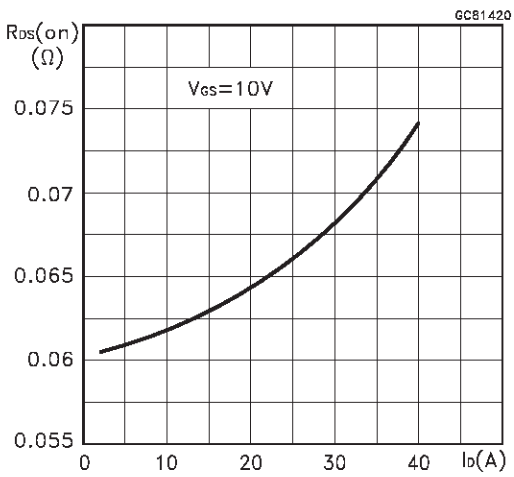
Transfer Characteristics



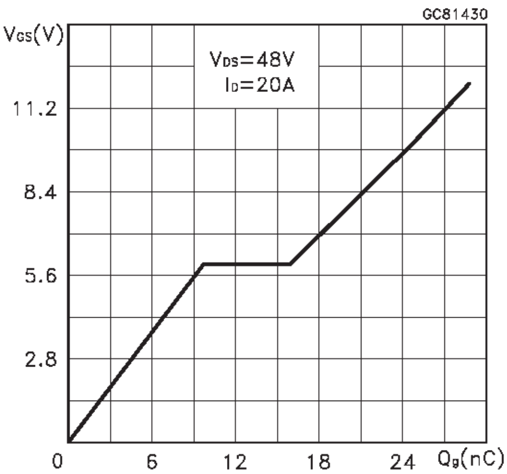
Transconductance



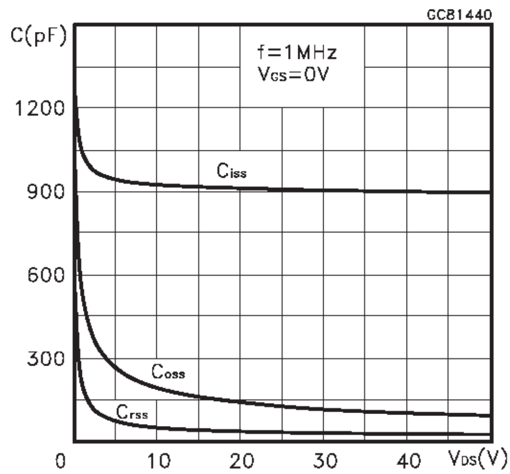
Static Drain-source On Resistance



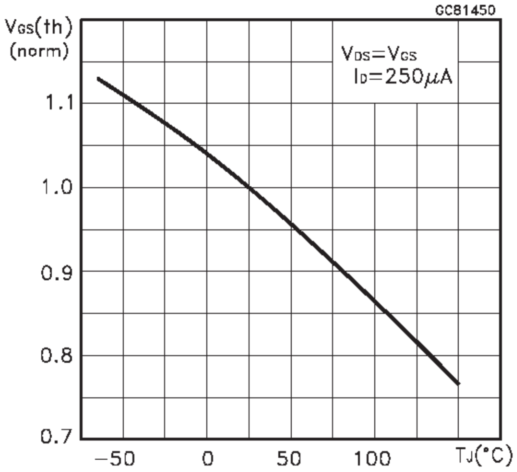
Gate Charge vs Gate-source Voltage



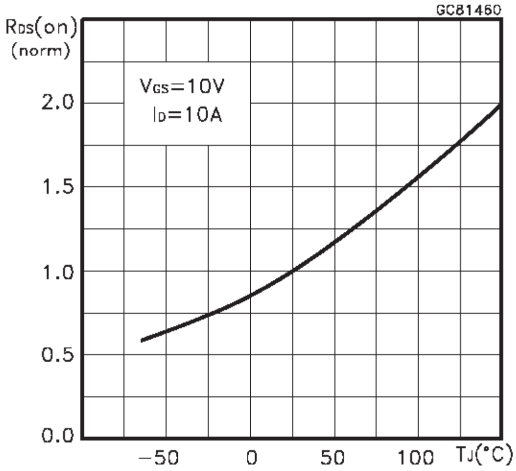
Capacitance Variations



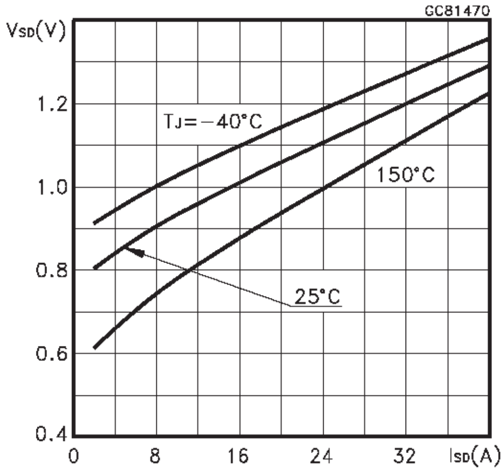
Normalized Gate Threshold Voltage vs Temperature



Normalized On Resistance vs Temperature

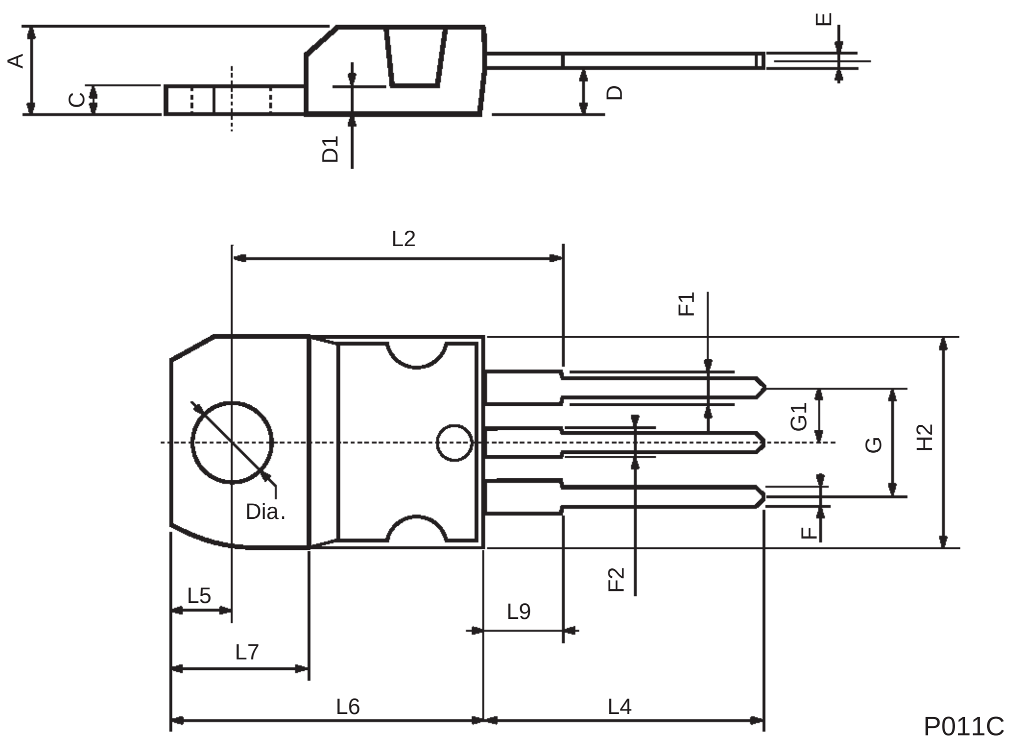


Source-drain Diode Forward Characteristics



TO-220 MECHANICAL DATA

DIM.	mm			inch		
	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.
A	4.40		4.60	0.173		0.181
C	1.23		1.32	0.048		0.051
D	2.40		2.72	0.094		0.107
D1		1.27			0.050	
E	0.49		0.70	0.019		0.027
F	0.61		0.88	0.024		0.034
F1	1.14		1.70	0.044		0.067
F2	1.14		1.70	0.044		0.067
G	4.95		5.15	0.194		0.203
G1	2.4		2.7	0.094		0.106
H2	10.0		10.40	0.393		0.409
L2		16.4			0.645	
L4	13.0		14.0	0.511		0.551
L5	2.65		2.95	0.104		0.116
L6	15.25		15.75	0.600		0.620
L7	6.2		6.6	0.244		0.260
L9	3.5		3.93	0.137		0.154
DIA.	3.75		3.85	0.147		0.151



D.5 NE555 Timer

Timer | NE/SA/SE555/SE555C

DESCRIPTION

The 555 monolithic timing circuit is a highly stable controller capable of producing accurate time delays, or oscillation. In the time delay mode of operation, the time is precisely controlled by one external resistor and capacitor. For a stable operation as an oscillator, the free running frequency and the duty cycle are both accurately controlled with two external resistors and one capacitor. The circuit may be triggered and reset on falling waveforms, and the output structure can source or sink up to 200mA.

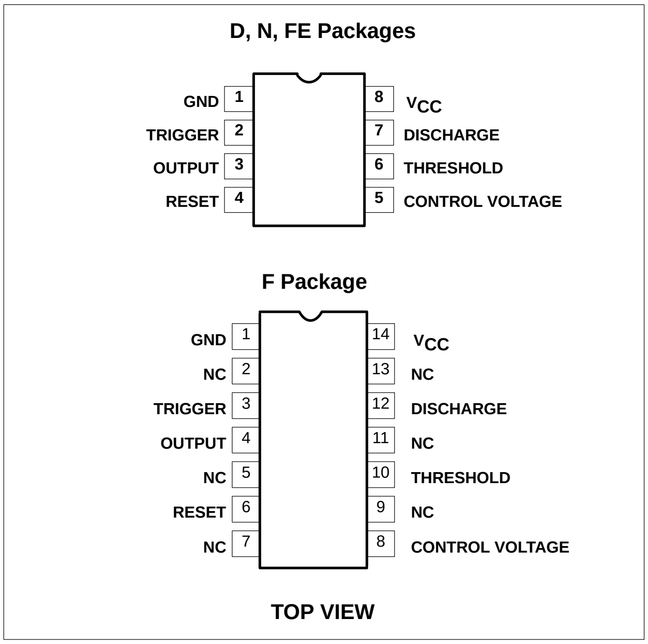
FEATURES

- Turn-off time less than 2µs
- Max. operating frequency greater than 500kHz
- Timing from microseconds to hours
- Operates in both astable and monostable modes
- High output current
- Adjustable duty cycle
- TTL compatible
- Temperature stability of 0.005% per °C

APPLICATIONS

- Precision timing
- Pulse generation
- Sequential timing
- Time delay generation
- Pulse width modulation

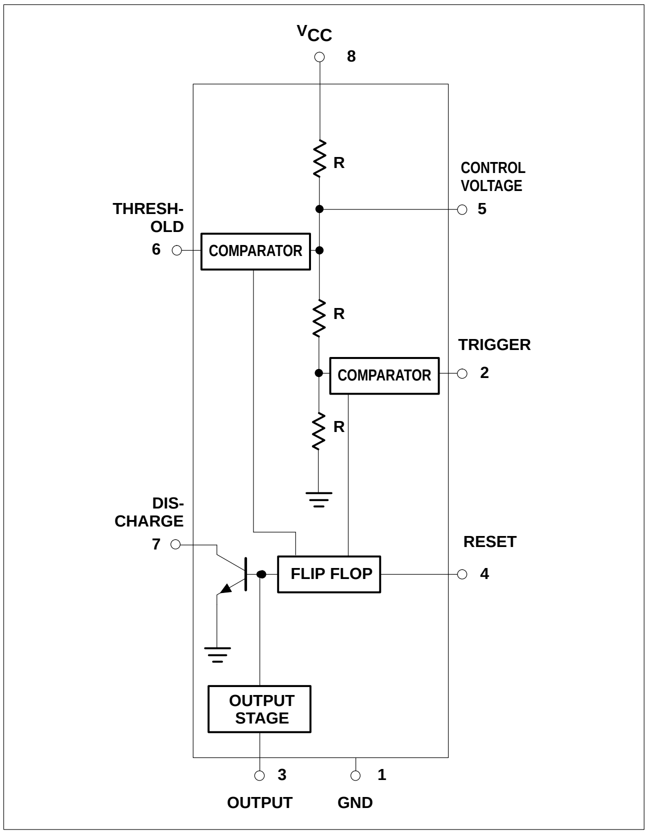
PIN CONFIGURATIONS



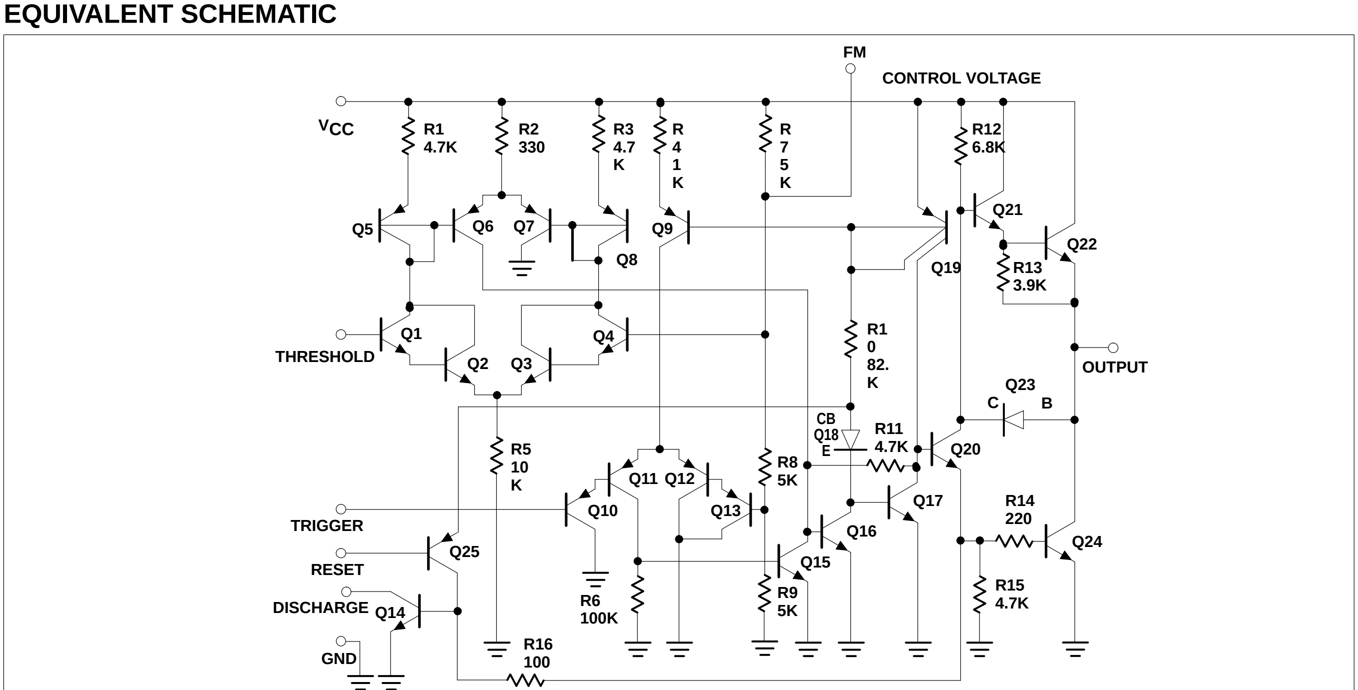
ORDERING INFORMATION

DESCRIPTION	TEMPERATURE RANGE	ORDER CODE	DWG #
8-Pin Plastic Small Outline (SO) Package	0 to +70°C	NE555D	0174C
8-Pin Plastic Dual In-Line Package (DIP)	0 to +70°C	NE555N	0404B
8-Pin Plastic Dual In-Line Package (DIP)	-40°C to +85°C	SA555N	0404B
8-Pin Plastic Small Outline (SO) Package	-40°C to +85°C	SA555D	0174C
8-Pin Hermetic Ceramic Dual In-Line Package (CERDIP)	-55°C to +125°C	SE555CFE	
8-Pin Plastic Dual In-Line Package (DIP)	-55°C to +125°C	SE555CN	0404B
14-Pin Plastic Dual In-Line Package (DIP)	-55°C to +125°C	SE555N	0405B
8-Pin Hermetic Cerdip	-55°C to +125°C	SE555FE	
14-Pin Ceramic Dual In-Line Package (CERDIP)	0 to +70°C	NE555F	0581B
14-Pin Ceramic Dual In-Line Package (CERDIP)	-55°C to +125°C	SE555F	0581B
14-Pin Ceramic Dual In-Line Package (CERDIP)	-55°C to +125°C	SE555CF	0581B

BLOCK DIAGRAM



EQUIVALENT SCHEMATIC



NOTE: Pin numbers are for 8-Pin package

ABSOLUTE MAXIMUM RATINGS

SYMBOL	PARAMETER	RATING	UNIT
V_{CC}	Supply voltage		
	SE555	+18	V
	NE555, SE555C, SA555	+16	V
P_D	Maximum allowable power dissipation[1]	600	mW
T_A	Operating ambient temperature range		
	NE555	0 to +70	°C
	SA555	-40 to +85	°C
	SE555, SE555C	-55 to +125	°C
T_{STG}	Storage temperature range	-65 to +150	°C
T_{SOLD}	Lead soldering temperature (10sec max)	+300	°C

NOTES:

1. The junction temperature must be kept below 125°C for the D package and below 150°C for the FE, N and F packages. At ambient temperatures above 25°C, where this limit would be derated by the following factors:
   D package 160°C/W
   FE package 150°C/W
   N package 100°C/W
   F package 105°C/W

DC AND AC ELECTRICAL CHARACTERISTICS

T_A = 25°C, V_{CC} = +5V to +15 unless otherwise specified.

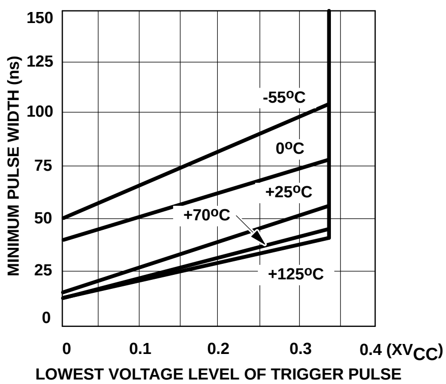
SYMBOL	PARAMETER	TEST CONDITIONS	SE555			NE555/SE555C			UNIT
			Min	Typ	Max	Min	Typ	Max	
V_{CC}	Supply voltage		4.5		18	4.5		16	V
I_{CC}	Supply current (low state)[1]	V_{CC}=5V, R_L=∞		3	5		3	6	mA
		V_{CC}=15V, R_L=∞		10	12		10	15	mA
	Timing error (monostable)	R_A=2kΩ to 100kΩ							
t_M	Initial accuracy[2]	C=0.1µF		0.5	2.0		1.0	3.0	%
$\Delta t_M/\Delta T$	Drift with temperature			30	100		50	150	ppm/°C
$\Delta t_M/\Delta V_S$	Drift with supply voltage			0.05	0.2		0.1	0.5	%/V
	Timing error (astable)	R_A, R_B=1kΩ to 100kΩ							
t_A	Initial accuracy[2]	C=0.1µF		4	6		5	13	%
$\Delta t_A/\Delta T$	Drift with temperature	V_{CC}=15V			500			500	ppm/°C
$\Delta t_A/\Delta V_S$	Drift with supply voltage			0.15	0.6		0.3	1	%/V
V_C	Control voltage level	V_{CC}=15V	9.6	10.0	10.4	9.0	10.0	11.0	V
		V_{CC}=5V	2.9	3.33	3.8	2.6	3.33	4.0	V
V_{TH}	Threshold voltage	V_{CC}=15V	9.4	10.0	10.6	8.8	10.0	11.2	V
		V_{CC}=5V	2.7	3.33	4.0	2.4	3.33	4.2	V
I_{TH}	Threshold current[3]			0.1	0.25		0.1	0.25	µA
V_{TRIG}	Trigger voltage	V_{CC}=15V	4.8	5.0	5.2	4.5	5.0	5.6	V
		V_{CC}=5V	1.45	1.67	1.9	1.1	1.67	2.2	V
I_{TRIG}	Trigger current	V_{TRIG}=0V		0.5	0.9		0.5	2.0	µA
V_{RESET}	Reset voltage[4]	V_{CC}=15V, V_{TH} =10.5V	0.3		1.0	0.3		1.0	V
I_{RESET}	Reset current	V_{RESET}=0.4V		0.1	0.4		0.1	0.4	mA
	Reset current	V_{RESET}=0V		0.4	1.0		0.4	1.5	mA
V_{OL}	Output voltage (low)	V_{CC}=15V							
		I_{SINK}=10mA		0.1	0.15		0.1	0.25	V
		I_{SINK}=50mA		0.4	0.5		0.4	0.75	V
		I_{SINK}=100mA		2.0	2.2		2.0	2.5	V
		I_{SINK}=200mA		2.5			2.5		V
		V_{CC}=5V							
		I_{SINK}=8mA		0.1	0.25		0.3	0.4	V
		I_{SINK}=5mA		0.05	0.2		0.25	0.35	V
V_{OH}	Output voltage (high)	V_{CC}=15V							
		I_{SOURCE}=200mA		12.5			12.5		V
		I_{SOURCE}=100mA	13.0	13.3		12.75	13.3		V
		V_{CC}=5V							
		I_{SOURCE}=100mA	3.0	3.3		2.75	3.3		V
t_{OFF}	Turn-off time[5]	V_{RESET}=V_{CC}		0.5	2.0		0.5	2.0	µs
t_R	Rise time of output			100	200		100	300	ns
t_F	Fall time of output			100	200		100	300	ns
	Discharge leakage current			20	100		20	100	nA

NOTES:

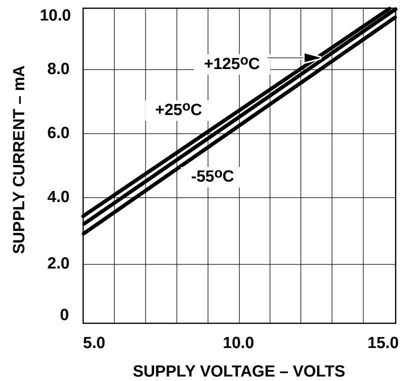
1. Supply current when output high typically 1mA less.
2. Tested at V_{CC}=5V and V_{CC}=15V.
3. This will determine the max value of R_A+R_B, for 15V operation, the max total R=10MΩ, and for 5V operation, the max. total R=3.4MΩ.
4. Specified with trigger input high.
5. Time measured from a positive going input pulse from 0 to 0.8×V_{CC} into the threshold to the drop from high to low of the output. Trigger is tied to threshold.

TYPICAL PERFORMANCE CHARACTERISTICS

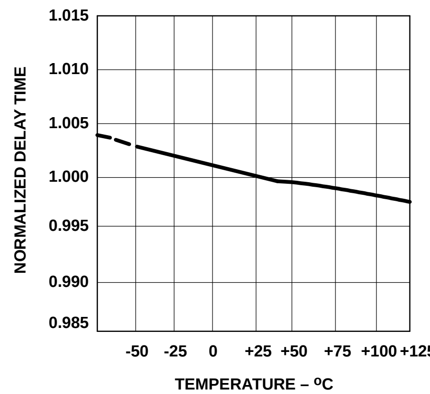
Minimum Pulse Width Required for Triggering



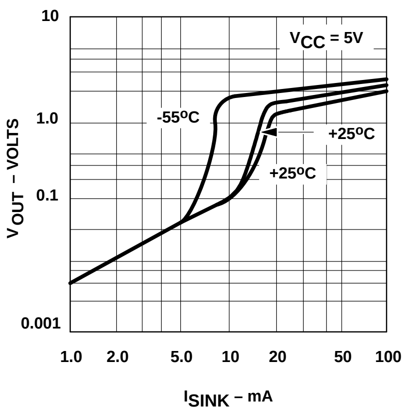
Supply Current vs Supply Voltage



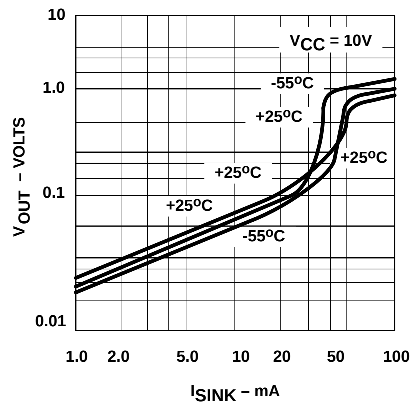
Delay Time vs Temperature



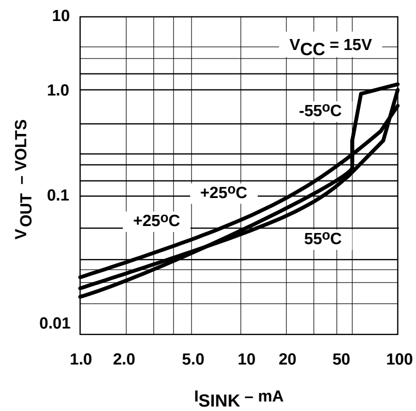
Low Output Voltage vs Output Sink Current



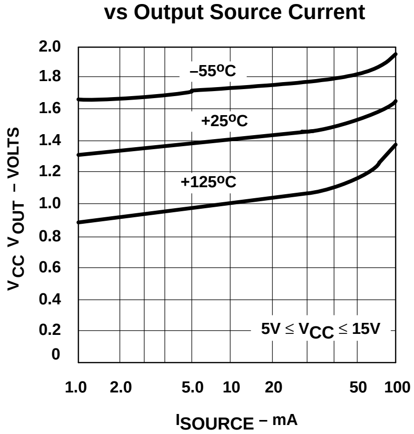
Low Output Voltage vs Output Sink Current



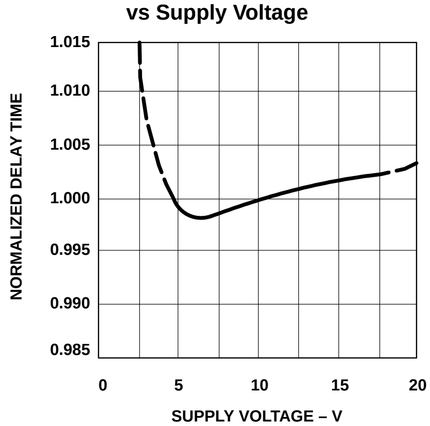
Low Output Voltage vs Output Sink Current



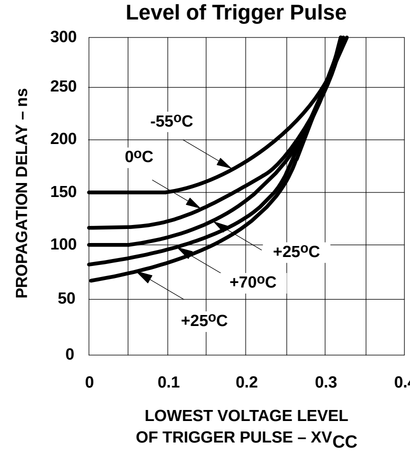
High Output Voltage Drop vs Output Source Current



Delay Time vs Supply Voltage



Propagation Delay vs Voltage Level of Trigger Pulse

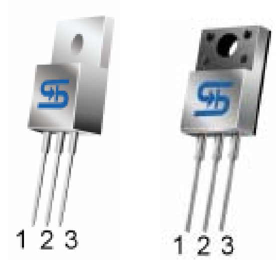


D.6 Integrado TS7805

TS7800 series

3-Terminal Fixed Positive Voltage Regulator

TO-220 ITO-220



Pin assignment:
1. Input
2. Ground
3. Output

(Heatsink surface connected to Pin 2)

Voltage Range 5V to 24V
Output Current up to 1A

General Description

These voltage regulators are monolithic integrated circuits designed as fixed-voltage regulators for a wide variety of applications including local, on-card regulation. These regulators employ internal current limiting, thermal shutdown, and safe-area compensation. With adequate heatsink they can deliver output currents up to 1 ampere.

Although designed primarily as a fixed voltage regulator, these devices can be used with external components to obtain adjustable voltages and currents.

This series is offered in 3-pin TO-220, ITO-220 package.

Features

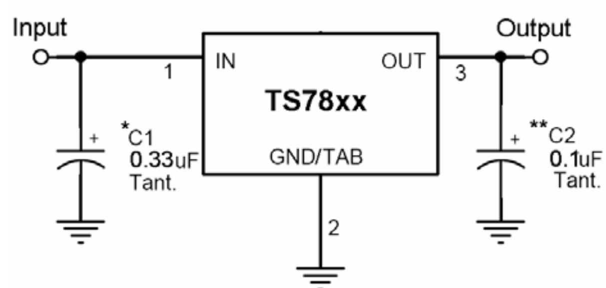
- ✧ Output current up to 1A
- ✧ No external components required
- ✧ Internal thermal overload protection
- ✧ Internal short-circuit current limiting
- ✧ Output transistor safe-area compensation
- ✧ Output voltage offered in 4% tolerance

Ordering Information

Part No.	Operating Temp. (Ambient)	Package
TS78xxCZ	-20 ~ +85°C	TO-220
TS78xxCI		ITO-220

Note: Where xx denotes voltage option.

Standard Application



A common ground is required between the input and the output voltages. The input voltage must remain typically 2.0V above the output voltage even during the low point on the Input ripple voltage.

XX = these two digits of the type number indicate voltage.

* = Cin is required if regulator is located an appreciable distance from power supply filter.

** = Co is not needed for stability; however, it does improve transient response.

Absolute Maximum Rating

Input Voltage	Vin *	35	V
Input Voltage	Vin **	40	V
Power Dissipation TO-220	Without heatsink	2	W
TO-220	Pt ***	15	W
ITO-220	Without heatsink	10	W
Operating Junction Temperature Range	T_J	0 ~ +150	°C
Storage Temperature Range	T_{STG}	-65 ~ +150	°C

Note : * TS7805 to TS7818
** TS7824
*** Follow the derating curve

TS7805 Electrical Characteristics

(Vin=10V, Iout=500mA, 0°C≤Tj≤125°C, Cin=0.33uF, Cout=0.1uF; unless otherwise specified.)

Parameter	Symbol	Test Conditions		Min	Typ	Max	Unit
Output voltage	Vout	Tj=25°C		4.80	5	5.20	V
		7.5V≤Vin≤20V, 10mA≤Iout≤1A, PD≤15W		4.75	5	5.25	
Line Regulation	REGline	Tj=25°C	7.5V≤Vin≤25V	--	3	100	mV
			8V≤Vin≤12V	--	1	50	
Load Regulation	REGload	Tj=25°C	10mA≤Iout≤1A	--	15	100	
			250mA≤Iout≤750mA	--	5	50	
Quiescent Current	Iq	Iout=0, Tj=25°C		--	4.2	8	mA
Quiescent Current Change	ΔIq	7.5V≤Vin≤25V		--	--	1.3	
		10mA≤Iout≤1A		--	--	0.5	
Output Noise Voltage	Vn	10Hz≤f≤100KHz, Tj=25°C		--	40	--	uV
Ripple Rejection Ratio	RR	f=120Hz, 8V≤Vin≤18V		62	78	--	dB
Voltage Drop	Vdrop	Iout=1.0A, Tj=25°C		--	2	--	V
Output Resistance	Rout	f=1KHz		--	17	--	mΩ
Output Short Circuit Current	Ios	Tj=25°C		--	750	--	mA
Peak Output Current	Io peak	Tj=25°C		--	2.2	--	A
Temperature Coefficient of Output Voltage	ΔVout/ ΔTj	Iout=10mA, 0°C≤Tj≤125°C		--	-0.6	--	mV/ °C

TS7806 Electrical Characteristics

(Vin=11V, Iout=500mA, 0°C≤Tj≤125°C, Cin=0.33uF, Cout=0.1uF; unless otherwise specified.)

Parameter	Symbol	Test Conditions		Min	Typ	Max	Unit
Output Voltage	Vout	Tj=25°C		5.75	6	6.25	V
		8.5V≤Vin≤21V, 10mA≤Iout≤1A, PD≤15W		6.3	6	6.3	
Line Regulation	REGline	Tj=25°C	8.5V≤Vin≤25V	--	5	120	mV
			9V≤Vin≤13V	--	1.5	60	
Load Regulation	REGload	Tj=25°C	10mA≤Iout≤1A	--	14	120	
			250mA≤Iout≤750mA	--	4	60	
Quiescent Current	Iq	Iout=0, Tj=25°C		--	4.3	8	mA
Quiescent Current Change	ΔIq	8.5V≤Vin≤25V		--	--	1.3	
		10mA≤Iout≤1A		--	--	0.5	
Output Noise Voltage	Vn	10Hz≤f≤100KHz, Tj=25°C		--	45	--	uV
Ripple Rejection Ratio	RR	f=120Hz, 9V≤Vin≤19V		59	75	--	dB
Voltage Drop	Vdrop	Iout=1.0A, Tj=25°C		--	2	--	V
Output Resistance	Rout	f=1KHz		--	19	--	mΩ
Output Short Circuit Current	Ios	Tj=25°C		--	550	--	mA
Peak Output Current	Io peak	Tj=25°C		--	2.2	--	A
Temperature Coefficient of Output Voltage	ΔVout/ ΔTj	Iout=10mA, 0°C≤Tj≤125°C		--	-0.7	--	mV/ °C

- Pulse testing techniques are used to maintain the junction temperature as close to the ambient temperature as possible, and thermal effects must be taken into account separately.
- This specification applies only for DC power dissipation permitted by absolute maximum ratings.

TSC

TS7808 Electrical Characteristics

(Vin=14V, Iout=500mA, 0°C≤Tj≤125°C, Cin=0.33uF, Cout=0.1uF; unless otherwise specified.)

Parameter	Symbol	Test Conditions		Min	Typ	Max	Unit
Output Voltage	Vout	Tj=25°C		7.69	8	8.32	V
		10.5V≤Vin≤23V, 10mA≤Iout≤1A, PD≤15W		7.61	8	8.40	
Line Regulation	REGline	Tj=25°C	10.5V≤Vin≤25V	--	6	160	mV
			11V≤Vin≤17V	--	2	80	
Load Regulation	REGload	Tj=25°C	10mA≤Iout≤1A	--	12	160	
			250mA≤Iout≤750mA	--	4	80	
Quiescent Current	Iq	Iout=0, Tj=25°C		--	4.3	8	mA
Quiescent Current Change	ΔIq	10.5V≤Vin≤25V		--	--	1	
		10mA≤Iout≤1A		--	--	0.5	
Output Noise Voltage	Vn	10Hz≤f≤100KHz, Tj=25°C		--	52	--	uV
Ripple Rejection Ratio	RR	f=120Hz, 11V≤Vin≤21V		56	72	--	dB
Voltage Drop	Vdrop	Iout=1.0A, Tj=25°C		--	2	--	V
Output Resistance	Rout	f=1KHz		--	16	--	mΩ
Output Short Circuit Current	Ios	Tj=25°C		--	450	--	mA
Peak Output Current	Io peak	Tj=25°C		--	2.2	--	A
Temperature Coefficient of Output Voltage	ΔVout/ ΔTj	Iout=10mA, 0°C≤Tj≤125°C		--	-0.8	--	mV/°C

TS7809 Electrical Characteristics

(Vin=15V, Iout=500mA, 0°C≤Tj≤125°C, Cin=0.33uF, Cout=0.1uF; unless otherwise specified.)

Parameter	Symbol	Test Conditions		Min	Typ	Max	Unit
Output Voltage	Vout	Tj=25°C		8.65	9	9.36	V
		11.5V≤Vin≤23V, 10mA≤Iout≤1A, PD≤15W		8.57	9	9.45	
Line Regulation	REGline	Tj=25°C	11.5V≤Vin≤26V	--	6	180	mV
			12V≤Vin≤17V	--	2	90	
Load Regulation	REGload	Tj=25°C	10mA≤Iout≤1A	--	12	180	
			250mA≤Iout≤750mA	--	4	90	
Quiescent Current	Iq	Iout=0, Tj=25°C		--	4.3	8	mA
Quiescent Current Change	ΔIq	11.5V≤Vin≤26V		--	--	1	
		10mA≤Iout≤1A		--	--	0.5	
Output Noise Voltage	Vn	10Hz≤f≤100KHz, Tj=25°C		--	52	--	uV
Ripple Rejection Ratio	RR	f=120Hz, 12V≤Vin≤22V		55	72	--	dB
Voltage Drop	Vdrop	Iout=1.0A, Tj=25°C		--	2	--	V
Output Resistance	Rout	f=1KHz		--	16	--	mΩ
Output Short Circuit Current	Ios	Tj=25°C		--	450	--	mA
Peak Output Current	Io peak	Tj=25°C		--	2.2	--	A
Temperature Coefficient of Output Voltage	ΔVout/ ΔTj	Iout=10mA, 0°C≤Tj≤125°C		--	-1	--	mV/°C

- Pulse testing techniques are used to maintain the junction temperature as close to the ambient temperature as possible, and thermal effects must be taken into account separately.
- This specification applies only for DC power dissipation permitted by absolute maximum ratings.

TS7810 Electrical Characteristics

(Vin=16V, Iout=500mA, 0°C≤Tj≤125°C, Cin=0.33uF, Cout=0.1uF; unless otherwise specified.)

Parameter	Symbol	Test Conditions		Min	Typ	Max	Unit
Output Voltage	Vout	Tj=25°C		9.6	10	10.4	V
		12.5V≤Vin≤25V, 10mA≤Iout≤1A, PD≤15W		9.5	10	10.5	
Line Regulation	REGline	Tj=25°C	12.5V≤Vin≤28V	--	7	200	mV
			13V≤Vin≤17V	--	2	100	
Load Regulation	REGload	Tj=25°C	10mA≤Iout≤1A	--	12	200	
			250mA≤Iout≤750mA	--	4	100	
Quiescent Current	Iq	Iout=0, Tj=25°C		--	4.3	8	mA
Quiescent Current Change	ΔIq	12.5V≤Vin≤28V		--	--	1	
		10mA≤Iout≤1A		--	--	0.5	
Output Noise Voltage	Vn	10Hz≤f≤100KHz, Tj=25°C		--	70	--	uV
Ripple Rejection Ratio	RR	f=120Hz, 13V≤Vin≤23V		55	71	--	dB
Voltage Drop	Vdrop	Iout=1.0A, Tj=25°C		--	2	--	V
Output Resistance	Rout	f=1KHz		--	18	--	mΩ
Output Short Circuit Current	Ios	Tj=25°C		--	400	--	mA
Peak Output Current	Io peak	Tj=25°C		--	2.2	--	A
Temperature Coefficient of Output Voltage	ΔVout/ ΔTj	Iout=10mA, 0°C≤Tj≤125°C		--	-1	--	mV/°C

TS7812 Electrical Characteristics

(Vin=19V, Iout=500mA, 0°C≤Tj≤125°C, Cin=0.33uF, Cout=0.1uF; unless otherwise specified.)

Parameter	Symbol	Test Conditions		Min	Typ	Max	Unit
Output Voltage	Vout	Tj=25°C		11.53	12	12.48	V
		14.5V≤Vin≤27V, 10mA≤Iout≤1A, PD ≤15W		11.42	12	12.60	
Line Regulation	REGline	Tj=25°C	14.5V≤Vin≤30V	--	10	240	mV
			15V≤Vin≤19V	--	3	120	
Load Regulation	REGload	Tj=25°C	10mA≤Iout≤1A	--	12	240	
			250mA≤Iout≤750mA	--	4	120	
Quiescent Current	Iq	Tj=25°C, Iout=0		--	4.3	8	mA
Quiescent Current Change	ΔIq	14.5V≤Vin≤30V		--	--	1	
		10mA≤Iout≤1A		--	--	0.5	
Output Noise Voltage	Vn	10Hz≤f≤100KHz, Tj=25°C		--	75	--	uV
Ripple Rejection Ratio	RR	f=120Hz, 15V≤Vin≤25V		55	71	--	dB
Voltage Drop	Vdrop	Iout=1.0A, Tj=25°C		--	2	--	V
Output Resistance	Rout	f=1KHz		--	18	--	mΩ
Output Short Circuit Current	Ios	Tj=25°C		--	350	--	mA
Peak Output Current	Io peak	Tj=25°C		--	2.2	--	A
Temperature Coefficient of Output Voltage	ΔVout/ ΔTj	Iout=10mA, 0°C≤Tj≤125°C		--	-1	--	mV/°C

- Pulse testing techniques are used to maintain the junction temperature as close to the ambient temperature as possible, and thermal effects must be taken into account separately.
- This specification applies only for DC power dissipation permitted by absolute maximum ratings.

TS7815 Electrical Characteristics

(Vin=23V, Iout=500mA, $0^oC \le Tj \le 125^oC$, Cin=0.33uF, Cout=0.1uF; unless otherwise specified.)

Parameter	Symbol	Test Conditions		Min	Typ	Max	Unit
Output Voltage	Vout	$Tj=25^oC$		14.42	15	15.60	V
		$17.5V \le Vin \le 30V$, $10mA \le Iout \le 1A$, PD ≤15W		14.28	15	15.75	
Line Regulation	REGline	$Tj=25^oC$	$17.5V \le Vin \le 30V$	--	12	300	mV
			$18V \le Vin \le 22V$	--	3	150	
Load Regulation	REGload	$Tj=25^oC$	$10mA \le Iout \le 1A$	--	12	300	
			$250mA \le Iout \le 750mA$	--	4	150	
Quiescent Current	Iq	$Tj=25^oC$, Iout=0		--	4.3	8	mA
Quiescent Current Change	ΔIq	$17.5V \le Vin \le 30V$		--	--	1	
		$10mA \le Iout \le 1A$		--	--	0.5	
Output Noise Voltage	Vn	$10Hz \le f \le 100KHz$, $Tj=25^oC$		--	90	--	uV
Ripple Rejection Ratio	RR	f=120Hz, $18V \le Vin \le 28V$		54	70	--	dB
Voltage Drop	Vdrop	Iout=1.0A, $Tj=25^oC$		--	2	--	V
Output Resistance	Rout	f=1KHz		--	19	--	mΩ
Output Short Circuit Current	Ios	$Tj=25^oC$		--	230	--	mA
Peak Output Current	Io peak	$Tj=25^oC$		--	2.2	--	A
Temperature Coefficient of Output Voltage	ΔVout/ ΔTj	Iout=10mA, $0^oC \le Tj \le 125^oC$		--	-1	--	mV/ ^oC

TS7818 Electrical Characteristics

(Vin=27V, Iout=500mA, $0^oC \le Tj \le 125^oC$, Cin=0.33uF, Cout=0.1uF; unless otherwise specified.)

Parameter	Symbol	Test Conditions		Min	Typ	Max	Unit
Output Voltage	Vout	$Tj=25^oC$		17.30	18	18.72	V
		$21V \le Vin \le 33V$, $10mA \le Iout \le 1A$, PD ≤15W		17.14	18	18.90	
Line Regulation	REGline	$Tj=25^oC$	$21V \le Vin \le 33V$	--	15	360	mV
			$22V \le Vin \le 26V$	--	5	180	
Load Regulation	REGload	$Tj=25^oC$	$10mA \le Iout \le 1A$	--	12	360	
			$250mA \le Iout \le 750mA$	--	4	180	
Quiescent Current	Iq	$Tj=25^oC$, Iout=0		--	4.5	8	mA
Quiescent Current Change	ΔIq	$21V \le Vin \le 33V$		--	--	1	
		$10mA \le Iout \le 1A$		--	--	0.5	
Output Noise Voltage	Vn	$10Hz \le f \le 100KHz$, $Tj=25^oC$		--	110	--	uV
Ripple Rejection Ratio	RR	f=120Hz, $21V \le Vin \le 31V$		54	70	--	dB
Voltage Drop	Vdrop	Iout=1.0A, $Tj=25^oC$		--	2	--	V
Output Resistance	Rout	f=1KHz		--	22	--	mΩ
Output Short Circuit Current	Ios	$Tj=25^oC$		--	200	--	mA
Peak Output Current	Io peak	$Tj=25^oC$		--	2.2	--	A
Temperature Coefficient of Output Voltage	ΔVout/ ΔTj	Iout=10mA, $0^oC \le Tj \le 125^oC$		--	-1	--	mV/ ^oC

- Pulse testing techniques are used to maintain the junction temperature as close to the ambient temperature as possible, and thermal effects must be taken into account separately.
- This specification applies only for DC power dissipation permitted by absolute maximum ratings.

Electrical Characteristics Curve

FIGURE 1 - Worst Case Power Dissipation v.s. Ambient Temperature

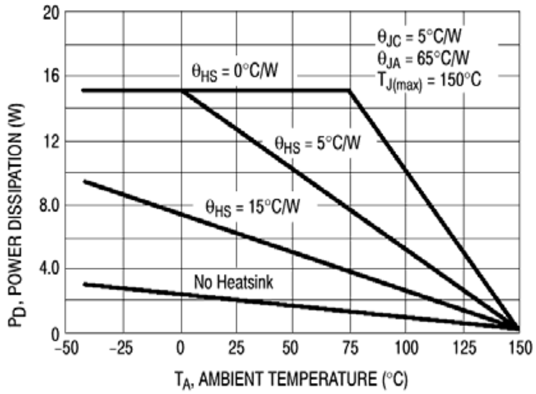


FIGURE 2 - Peak Output Current v.s. Input-Output Differential Voltage

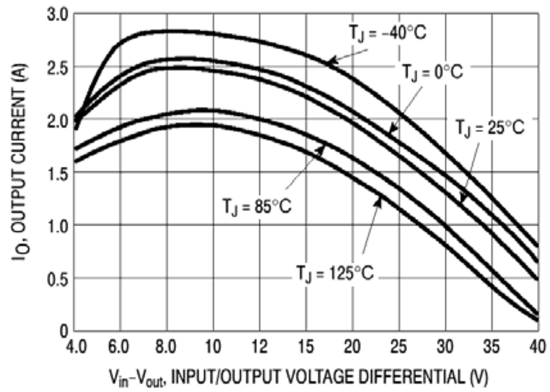


FIGURE 3 – Quiescent Current v.s. Junction Temperature

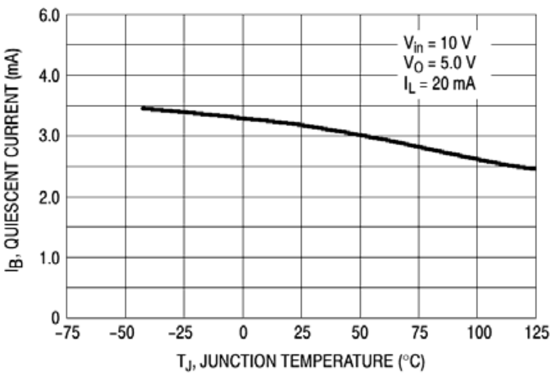


FIGURE 4 – Input Output Differential v.s. Junction Temperature

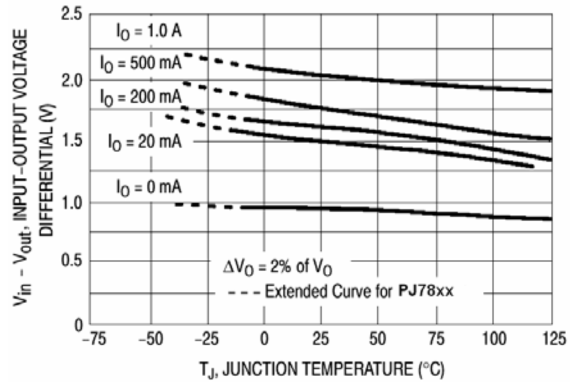


FIGURE 5 – Output Voltage v.s. Junction Temperature

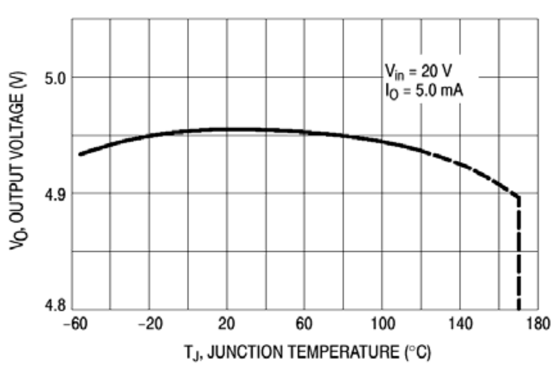
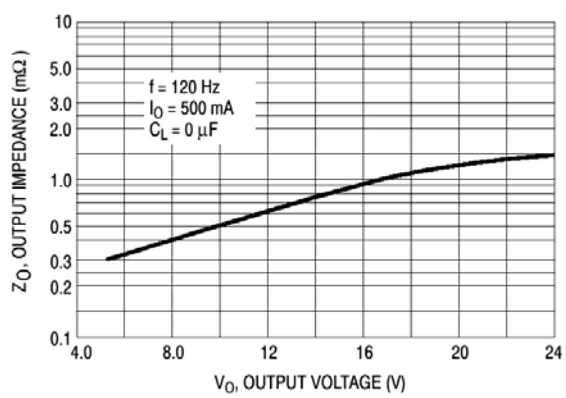


FIGURE 6 – Output Impedance v.s. Output Voltage



Electrical Characteristics Curve

FIGURE 7 – Ripple Rejection v.s. Output Voltage

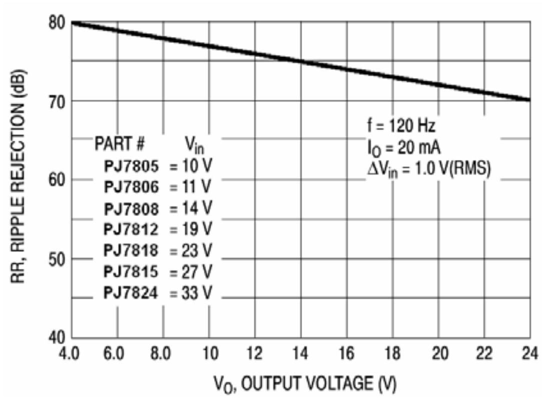
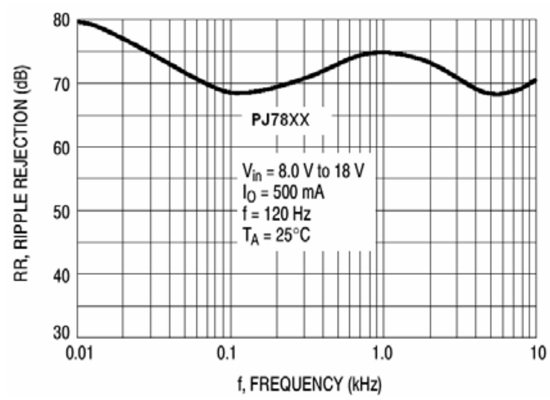
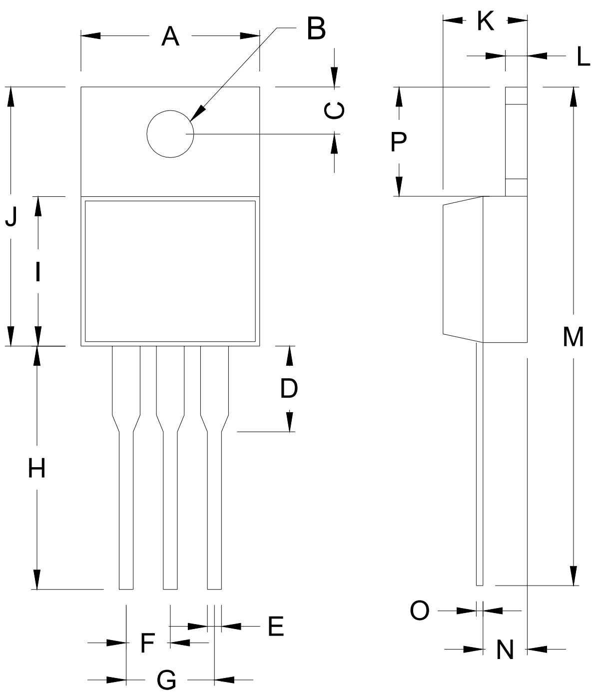


FIGURE 8 – Ripple Rejection v.s. Frequency

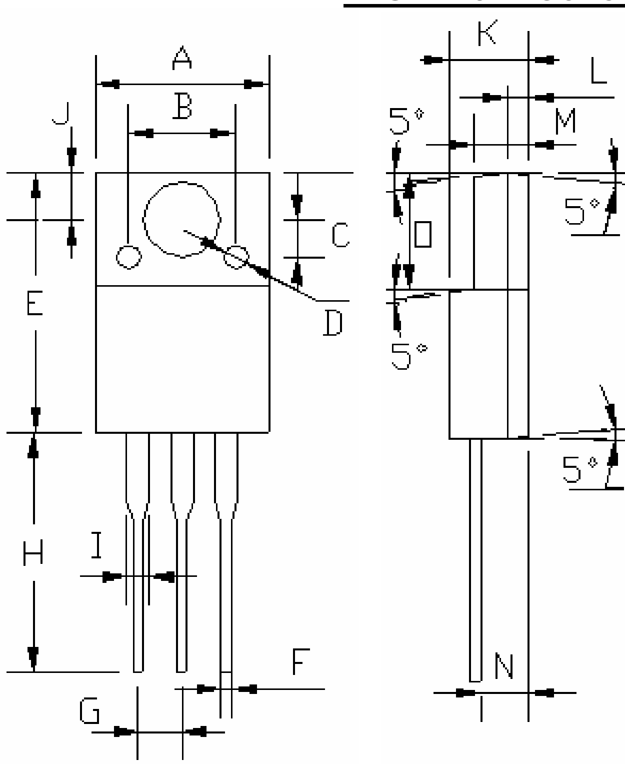


TO-220 Mechanical Drawing



TO-220 DIMENSION				
DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	10.000	10.500	0.394	0.413
B	3.240	4.440	0.128	0.175
C	2.440	2.940	0.096	0.116
D	-	6.350	-	0.250
E	0.381	1.106	0.015	0.040
F	2.345	2.715	0.092	0.058
G	4.690	5.430	0.092	0.107
H	12.700	14.732	0.500	0.581
I	8.382	9.017	0.330	0.355
J	14.224	16.510	0.560	0.650
K	3.556	4.826	0.140	0.190
L	0.508	1.397	0.020	0.055
M	27.700	29.620	1.060	1.230
N	2.032	2.921	0.080	0.115
O	0.255	0.610	0.010	0.024
P	5.842	6.858	0.230	0.270

ITO-220 Mechanical Drawing



ITO-220 DIMENSION				
DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	10.04	10.07	0.395	0.396
B	6.20 (typ.)		0.244 (typ.)	
C	2.20 (typ.)		0.087 (typ.)	
D	□1.40 (typ.)		□0.055 (typ.)	
E	15.0	15.20	0.591	0.598
F	0.52	0.54	0.020	0.021
G	2.35	2.73	0.093	0.107
H	13.50	13.55	0.531	0.533
I	1.11	1.49	0.044	0.058
J	2.60	2.80	0.102	0.110
K	4.49	4.50	0.176	0.177
L	1.15 (typ.)		0.045 (typ.)	
M	3.03	3.05	0.119	0.120
N	2.60	2.80	0.102	0.110
O	6.55	6.65	0.258	0.262

D.7 74HC139 Demultiplexor

DATA SHEET

For a complete data sheet, please also download:

- The IC06 74HC/HCT/HCU/HCMOS Logic Family Specifications
- The IC06 74HC/HCT/HCU/HCMOS Logic Package Information
- The IC06 74HC/HCT/HCU/HCMOS Logic Package Outlines

74HC/HCT139
Dual 2-to-4 line decoder/demultiplexer

Product specification
File under Integrated Circuits, IC06

September 1993

Philips
Semiconductors

PHILIPS

Dual 2-to-4 line decoder/demultiplexer 74HC/HCT139

FEATURES

- Demultiplexing capability
- Two independent 2-to-4 decoders
- Multifunction capability
- Active LOW mutually exclusive outputs
- Output capability: standard
- I_{CC} category: MSI

GENERAL DESCRIPTION

The 74HC/HCT139 are high-speed Si-gate CMOS devices and are pin compatible with low power Schottky TTL (LSTTL). It is specified in compliance with JEDEC standard no. 7A.

The 74HC/HCT139 are high-speed, dual 2-to-4 line decoder/multiplexers. This device has two independent decoders, each accepting two binary weighted inputs (nA_0 and nA_1) and providing four mutually exclusive active LOW outputs ($n\overline{Y}_0$ to $n\overline{Y}3$). Each decoder has an active LOW enable input ($n\overline{E}$).
When $n\overline{E}$ is HIGH, every output is forced HIGH. The enable can be used as the data input for a 1-to-4 demultiplexer application.
The “139” is identical to the HEF4556 of the HE4000B family.

QUICK REFERENCE DATA

GND = 0 V; T_{amb} = 25 °C; $t_r = t_f$ = 6 ns

SYMBOL	PARAMETER	CONDITIONS	TYPICAL		UNIT
			HC	HCT	
t_{PHL}/ t_{PLH}	propagation delay	C_L = 15 pF; V_{CC} = 5 V			
	nA_n to $n\overline{Y}_n$		11	13	ns
	$n\overline{E}_3$ to $n\overline{Y}_n$		10	13	ns
C_I	input capacitance		3.5	3.5	pF
C_{PD}	power dissipation capacitance per multiplexer	notes 1 and 2	42	44	pF

Notes

1. C_{PD} is used to determine the dynamic power dissipation (P_D in μW):

   $P_D = C_{PD} \times V_{CC}^2 \times f_i + \sum (C_L \times V_{CC}^2 \times f_o)$ where:

   f_i = input frequency in MHz

   f_o = output frequency in MHz

   $\sum (C_L \times V_{CC}^2 \times f_o)$ = sum of outputs

   C_L = output load capacitance in pF

   V_{CC} = supply voltage in V

2. For HC the condition is V_I = GND to V_{CC}
   For HCT the condition is V_I = GND to V_{CC} – 1.5 V

APPLICATIONS

- Memory decoding or data-routing
- Code conversion

ORDERING INFORMATION

See *“74HC/HCT/HCU/HCMOS Logic Package Information”*.

PIN DESCRIPTION

PIN NO.	SYMBOL	NAME AND FUNCTION
1, 15	$1\overline{E}$, $2\overline{E}$	enable inputs (active LOW)
2, 3	$1A_0$, $1A_1$	address inputs
4, 5, 6, 7	$1\overline{Y}_0$ to $1\overline{Y}_3$	outputs (active LOW)
8	GND	ground (0 V)
12, 11, 10, 9	$2\overline{Y}_0$ to $2\overline{Y}_3$	outputs (active LOW)
14, 13	$2A_0$, $2A_1$	address inputs
16	V_{CC}	positive supply voltage

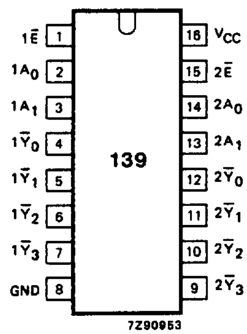


Fig.1 Pin configuration.

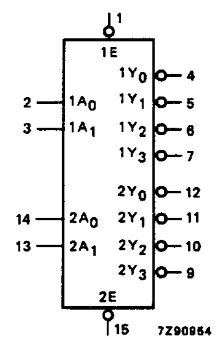


Fig.2 Logic symbol.

(a) (b)

Fig.3 IEC logic symbol.

Dual 2-to-4 line decoder/demultiplexer 74HC/HCT139

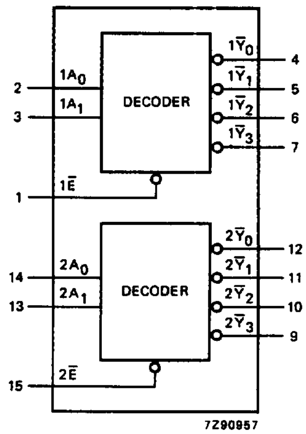


Fig.4 Functional diagram.

FUNCTION TABLE

INPUTS			OUTPUTS			
$n\overline{E}$	nA_0	nA_1	$n\overline{Y}_0$	$n\overline{Y}_1$	$n\overline{Y}_2$	$n\overline{Y}_3$
H	X	X	H	H	H	H
L	L	L	L	H	H	H
L	H	L	H	L	H	H
L	L	H	H	H	L	H
L	H	H	H	H	H	L

Notes

1. H = HIGH voltage level
   L = LOW voltage level
   X = don't care

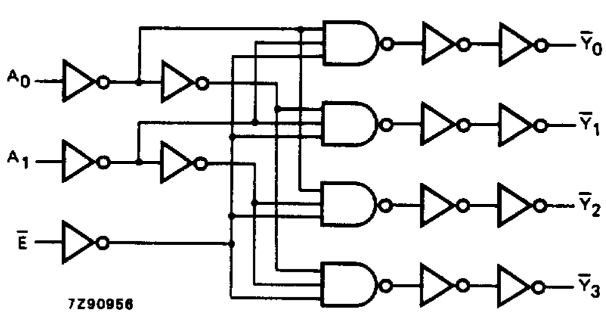


Fig.5 Logic diagram (one decoder/demultiplexer).

DC CHARACTERISTICS FOR 74HC

For the DC characteristics see *"74HC/HCT/HCU/HCMOS Logic Family Specifications"*.

Output capability: standard
I_{CC} category: MSI

AC CHARACTERISTICS FOR 74HC

GND = 0 V; $t_r = t_f = 6$ ns; $C_L = 50$ pF

SYMBOL	PARAMETER	T_{amb} (°C)							UNIT	TEST CONDITIONS	
		74HC								V_{CC} (V)	WAVEFORMS
		+25			−40 to +85		−40 to +125				
		min.	typ.	max.	min.	max.	min.	max.			
t_{PHL}/ t_{PLH}	propagation delay nA_n to $\overline{Y}_n$		39 14 11	145 29 25		180 36 31		220 44 38	ns	2.0 4.5 6.0	Fig.6
t_{PHL}/ t_{PLH}	propagation delay $n\overline{E}$ to $n\overline{Y}_n$		33 12 10	135 27 23		170 34 29		205 41 35	ns	2.0 4.5 6.0	Fig.7
t_{THL}/ t_{TLH}	output transition time		19 7 6	75 15 13		95 19 16		110 22 19	ns	2.0 4.5 6.0	Figs 6 and 7

DC CHARACTERISTICS FOR HCT

For the DC characteristics see *"74HC/HCT/HCU/HCMOS Logic Family Specifications"*.

Output capability: standard
I_{CC} category: MSI

Note to HCT types

The value of additional quiescent supply current (ΔI_{CC}) for a unit load of 1 is given in the family specifications.
To determine ΔI_{CC} per input, multiply this value by the unit load coefficient shown in the table below.

INPUT	UNIT LOAD COEFFICIENT
$1A_n$	0.70
$2A_n$	0.70
$n\overline{E}$	1.35

AC CHARACTERISTICS FOR 74HCT

GND = 0 V; $t_r = t_f = 6$ ns; $C_L = 50$ pF

SYMBOL	PARAMETER	T_{amb} (°C)							UNIT	TEST CONDITIONS	
		74HCT								V_{CC} (V)	WAVEFORMS
		+25			−40 to +85		−40 to +125				
		min.	typ.	max.	min.	max.	min.	max.			
t_{PHL}/ t_{PLH}	propagation delay nA_n to $\overline{Y}_n$		16	34		43		51	ns	4.5	Fig.6
t_{PHL}/ t_{PLH}	propagation delay $n\overline{E}$ to $n\overline{Y}_n$		16	34		43		51	ns	4.5	Fig.7
t_{THL}/ t_{TLH}	output transition time		7	15		19		22	ns	4.5	Figs 6 and 7

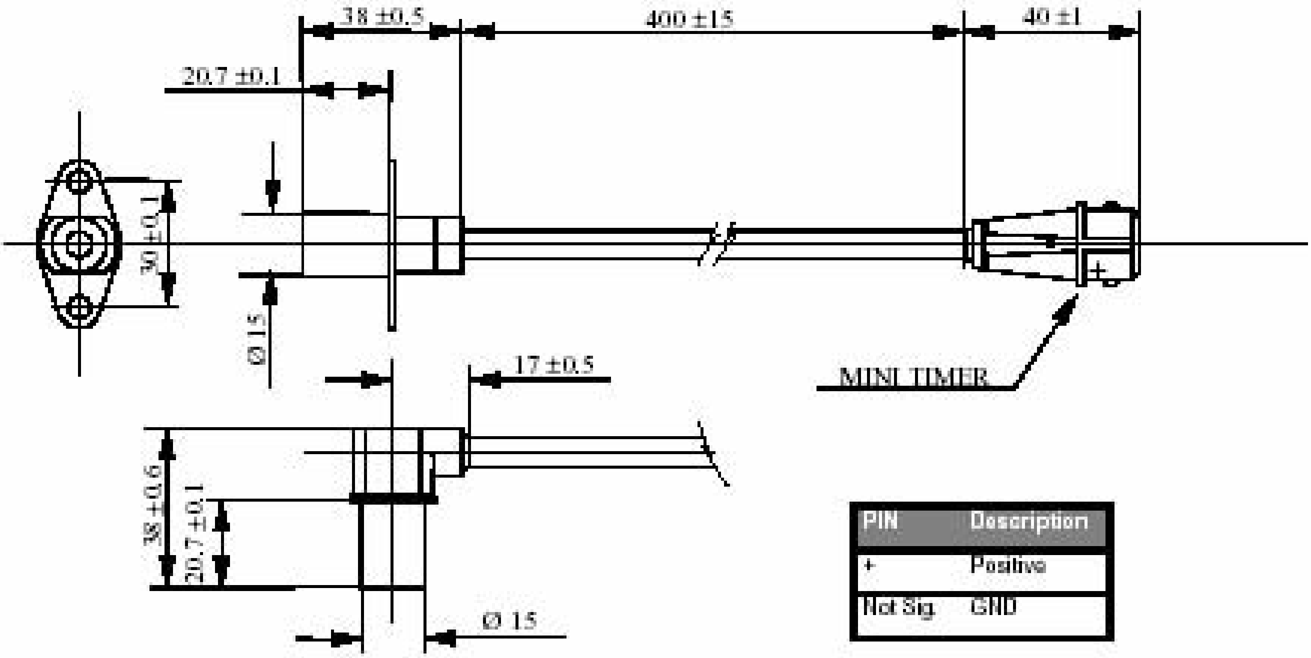
E. Sensores

E.1 Sensor inductivo

SEN 8D-8K

Ø 15 mm VR revolution sensor

Dimensions



PIN	Description
+	Positive
Not Sig.	GND

Dimensions in millimetres

Technical Characteristics

Typical application .... Crank, Cam, Wheel

Max. operating temperature .... 125 °C

Air gap .... 0.5 to 1 mm

Speed range .... 40 to 12000 rpm

Output @ 40 rpm (peak to peak) .... > 400 mV

Weight .... 60 g

Application Schematics

For further information, please contact:

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http://www.magnetimarelli.com

E.2 Caudalímetro

Hot-film air-mass meter, Type HFM 5

Measurement of air-mass throughflow up to 1000 kg/h

Q_m / U

- Compact design.
- Low weight.
- Rapid response.
- Low power input.
- Return-flow detection.

Application
In order to comply with the vehicle emission limits demanded by law, it is necessary to maintain a given air/fuel ratio exactly.
This requires sensors which precisely register the actual air-mass flow and output a corresponding electrical signal to the open and closed-loop control electronics.

Design
The micromechanical sensor element is located in the plug-in sensor's flow passage. This plug-in sensor is suitable for incorporating in the air filter or, using a measurement venturi, in the air-intake passages. There are different sizes of measurement venturi available depending upon the air throughflow. The micromechanical measuring system uses a hybrid circuit, and by evaluating the measuring data is able to detect when return flow takes place during air-flow pulsation.

Operating principle
The heated sensor element in the air-mass meter dissipates heat to the incoming air. The higher the air flow, the more heat is dissipated. The resulting temperature differential is a measure for the air mass flowing past the sensor.
An electronic hybrid circuit evaluates this measuring data so that the air-flow quantity can be measured precisely, and its direction of flow.
Only part of the air-mass flow is registered by the sensor element. The total air mass flowing through the measuring tube is determined by means of calibration, known as the characteristic-curve definition.

Technical data / range

Nominal supply voltage U_N	14 V
Supply-voltage range U_V	8...17 V
Output voltage U_A	0...5 V
Input current I_V	< 0.1 A
Permissible vibration acceleration	≤ 150 ms^{-2}
Time constant τ_{63} 1)	≤ 15 ms
Time constant τ_Δ 2)	≤ 30 ms
Temperature range	–40...+120 °C 3)

Part number	**0 280 217 123**	**0 280 218 019**	**0 280 217 531**	**0 280 218 008**	**0 281 002 421**
Measuring range Q_m	8...370 kg/h	10...480 kg/h	12...640 kg/h	12...850 kg/h	15...1000 kg/h
Accuracy 4)	≤ 3%	≤ 3%	≤ 3%	≤ 3%	≤ 3%
Fitting length L_E	22 mm	22 mm	22 mm	16 mm	22 mm
Fitting length L_A	20 mm	20 mm	20 mm	16 mm	20 mm
Installation length L	96 mm	96 mm	130 mm	100 mm	130 mm
Connection diam. D	60 mm	70 mm	80 mm	86/84 mm 6)	92 mm
Venturi ID	50 mm	62 mm	71 mm	78 mm	82 mm
Pressure drop at nominal air mass 5)	< 20 hPa	< 15 hPa	< 15 hPa	< 15 hPa	< 15 hPa
Temperature sensor	Yes	Yes	Yes	No	Yes
Version	1	2	3	4	5

1) In case of sudden increase of the air-mass flow from 10 kg · h^{-1} auf 0,7 $Q_{m\,nominal}$, time required to reach 63% of the final value of the air-mass signal.
2) Period of time in case of a throughflow jump of the air mass | Δ m/m | ≤ 5%.
3) For a short period up to +130 °C.
4) $|\Delta Q_m/Q_m|$: The measurement deviation ΔQ_m from the exact value, referred to the measured value Q_m.
5) Measured between input and output
6) Inflow/outflow end

Accessories for connector

Plug housing	Contact pins	Individual gaskets	For conductor cross-section
1 928 403 836	**1 987 280 103**	**1 987 280 106**	0.5...1 mm^2
	1 987 280 105	**1 987 280 107**	1.5...2.5 mm^2

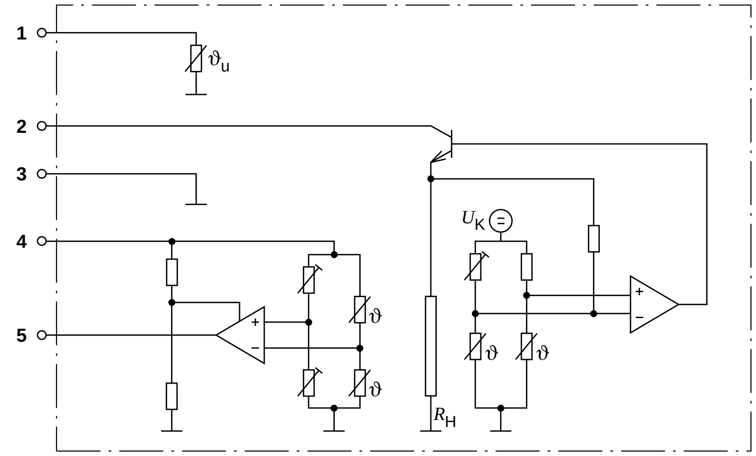
Note: Each 5-pole plug requires 1 plug housing, 5 contact pins, and 5 individual gaskets.
For automotive applications, original AMP crimping tools must be used.

Application
In internal-combustion engines, this sensor is used for measuring the air-mass flow so that the injected fuel quantity can be adapted to the presently required power, to the air pressure, and to the air temperature.

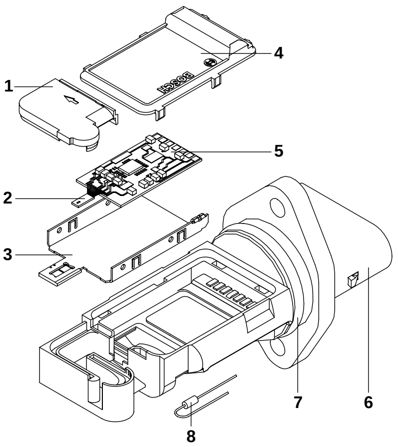
Explanation of symbols

Q_m	Air-mass flow rate
ΔQ_m	Absolute accuracy
$\Delta Q_m/Q_m$	Relative accuracy
τ_Δ	Time until measuring error is ≤ 5%
τ_{63}	Time until measured-value change 63%

Function diagram with connector-pin assignment.
1 Additional temperature sensor ϑ_u (not on version 4, Part number 0 280 218 008),
2 Supply voltage U_V, **3** Signal ground, **4** Reference voltage 5 V, **5** Measurement signal U_A.
ϑ Temperature-dependence of the resistor, R_H Heater resistor, U_K Constant voltage



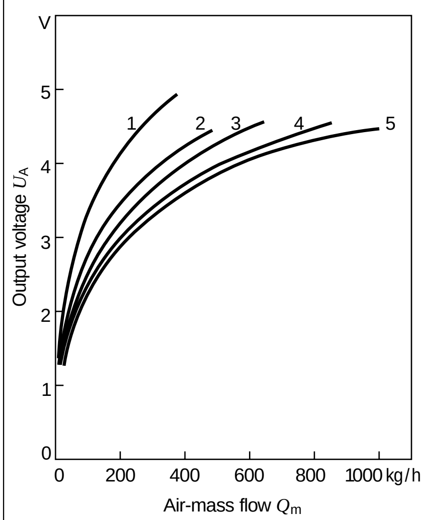
HFM 5 plug-in sensor design.
1 Measuring-passage cover, **2** Sensor,
3 Mounting plate, **4** Hybrid-circuit cover,
5 Hybrid, **6** Plug-in sensor, **7** O-ring,
8 Auxiliary temperature sensor.



Output voltage U_A = f(Q_m) of the air-mass meter

Part number	0 280 217 123	0 280 218 019	0 280 217 531	0 280 218 008	0 280 002 421
Characteristic curve	1	2	3	4	5
Q_m/kg/h	U_A/V	U_A/V	U_A/V	U_A/V	U_A/V
8	1.4837	1.2390	–	–	–
10	1.5819	1.3644	1.2695	–	–
15	1.7898	1.5241	1.4060	1.3395	1.2315
30	2.2739	1.8748	1.7100	1.6251	1.4758
60	2.8868	2.3710	2.1563	2.0109	1.8310
120	3.6255	2.9998	2.7522	2.5564	2.3074
250	4.4727	3.7494	3.5070	3.2655	2.9212
370	4.9406	4.1695	3.9393	3.6717	3.2874
480	–	4.4578	4.2349	3.9490	3.5461
640	–	–	4.5669	4.2600	3.8432
850	–	–	–	4.5727	4.1499
1000	–	–	–	–	4.3312

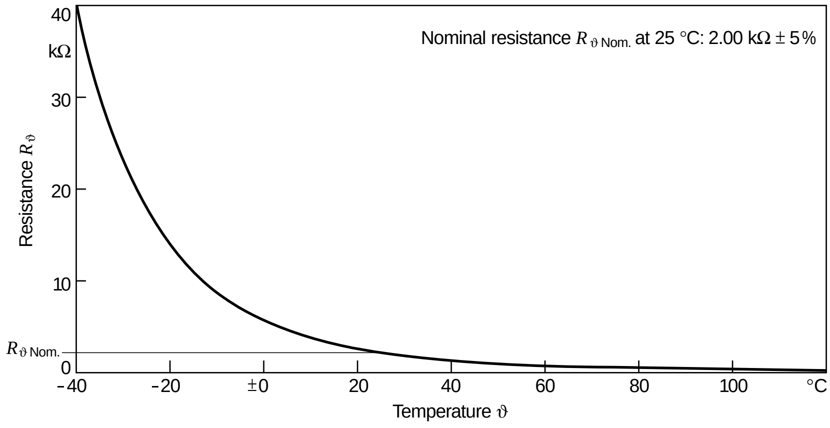
Air-mass meter output voltage.



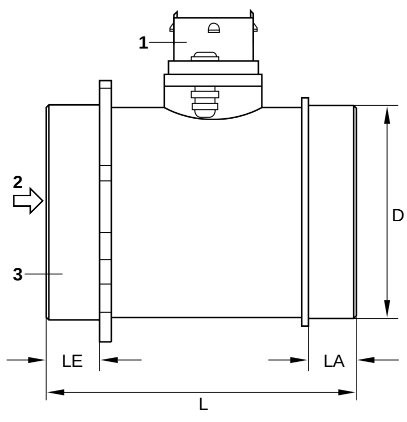
Temperature-dependence R_ϑ = f(ϑ) of the temperature sensor

Temperature ϑ	°C	–40	–30	–20	–10	±0	10	20	30	40
Resistance R_ϑ	kΩ	39.26	22.96	13.85	8.609	5.499	3.604	2.420	1.662	1.166
Temperature ϑ	°C	50	60	70	80	90	100	110	120	130
Resistance R_ϑ	Ω	835	609	452	340	261	202	159	127	102

Temperature-resistance diagram of the temperature sensor.



Dimensions overview of the HFM 5.
1 Plug-in sensor, **2** Throughflow direction,
3 Measurement venturi.



E.3 Sensores diversos

Inductive rotational-speed sensors

Incremental* measurement of angles and rotational speeds

n / *U*

- Non-contacting (proximity) and thus wear-free, rotational-speed measurement.
- Sturdy design for exacting demands.
- Powerful output signal.
- Measurement dependent on direction of rotation.

Application

Inductive rotational-speed sensors of this type are suitable for numerous applications involving the registration of rotational speeds. Depending on design, they measure engine speeds and wheel speeds for ABS systems, and convert these speeds into electric signals.

Design and function

The soft-iron core of the sensor is surrounded by a winding, and located directly opposite a rotating toothed pulse ring with only a narrow air gap separating the two. The soft-iron core is connected to a permanent magnet, the magnetic field of which extends into the ferromagnetic pulse ring and is influenced by it. A tooth located directly opposite the sensor concentrates the magnetic field and amplifies the magnetic flux in the coil, whereas the magnetic flux is attenuated by a tooth space. These two conditions constantly follow on from one another due to the pulse ring rotating with the wheel. Changes in magnetic flux are generated at the transitions between the tooth space and tooth (leading tooth edge) and at the transitions between tooth and tooth space (trailing tooth edge). In line with Faraday's Law, these changes in magnetic flux induce an AC voltage in the coil, the frequency of which is suitable for determining the rotational speed.

Wheel-speed sensor (principle).
1 Shielded cable, **2** Permanent magnet,
3 Sensor housing, **4** Housing block,
5 Soft-iron core, **6** Coil, **7** Air gap,
8 Toothed pulse ring with reference mark.

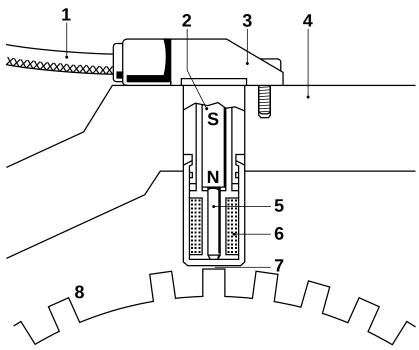
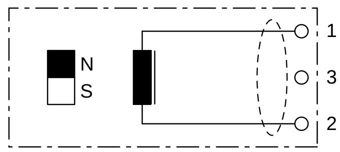
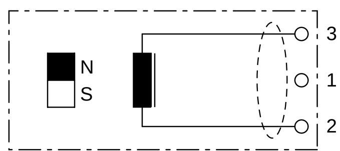


Diagram.
Connections:
1 Output voltage,
2 Ground, **3** Shield.

0 281 002 214, ..104



0 261 210 147



Range

Cable length with plug	Fig./ Dimension drawing	Order No.
360 ± 15	1	**0 261 210 104**
553 ± 10	2	**0 261 210 147**
450 ± 15	3	**0 281 002 214**

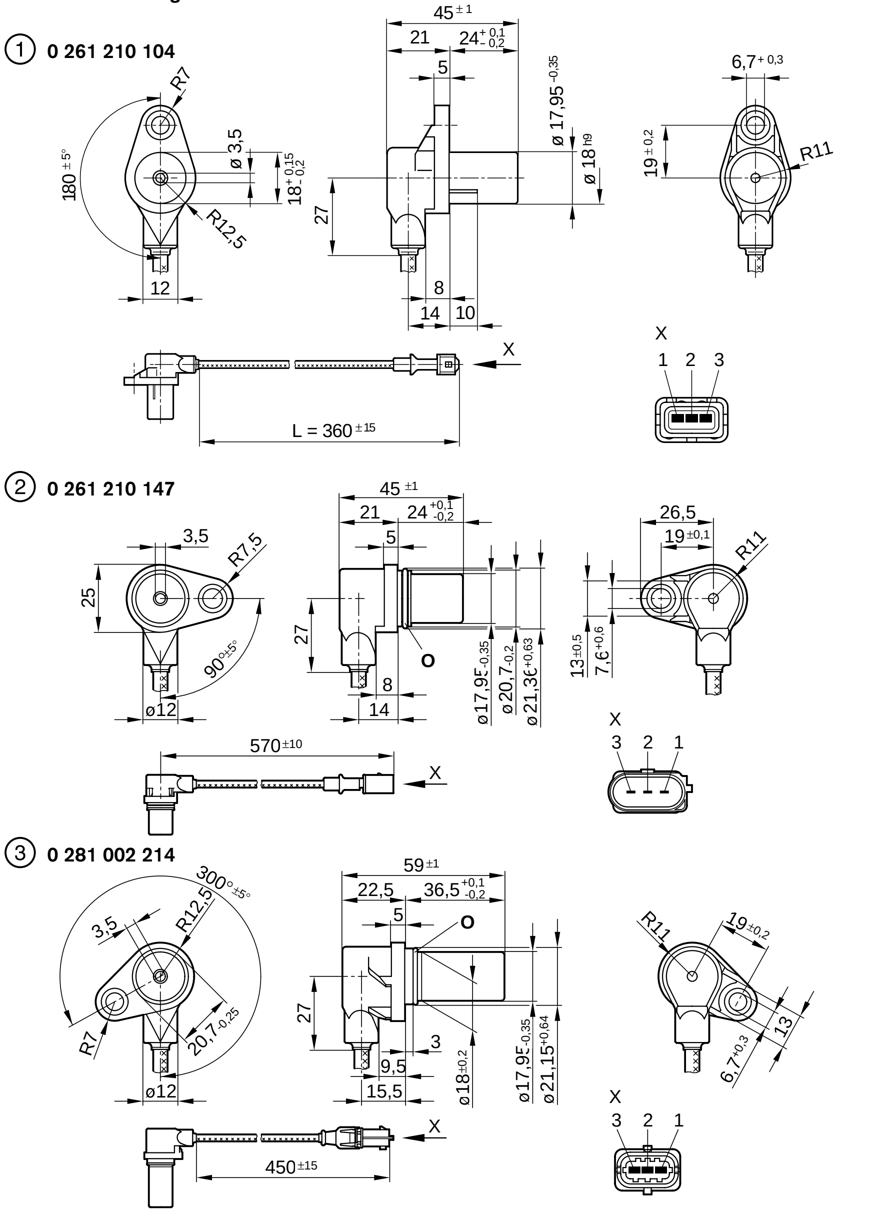
* A continuously changing variable is replaced by a frequency proportional to it.

Technical Data

Rotational-speed range *n* ¹)	min^{-1}	≈ 20...7000
Permanent ambient temperature in the cable area		
For 0 261 210 104, 0 281 002 214	°C	–40...+120
For 0 261 210 147	°C	–40...+130
Permanent ambient temperature in the coil area	°C	–40...+150
Vibration stress max.	$\text{m} \cdot \text{s}^{-2}$	1200
Number of turns		4300 ±10
Winding resistance at 20 °C ²)	Ω	860 ±10 %
Inductance at 1 kHz	mH	370 ±15 %
Degree of protection		IP 67
Output voltage U_A ¹)	V	0...200

¹) Referred to the associated pulse ring.
²) Change factor $k = 1+0.004\ (\vartheta_W - 20\ °C)$; ϑ_W winding temperature

Dimension drawings.



The sensor generates one output pulse per tooth. The pulse amplitude is a function of the air gap, together with the toothed ring's rotational speed, the shape of its teeth, and the materials used in its manufacture. Not only the output-signal amplitude increases with speed, but also its frequency. This means that a minimum rotational speed is required for reliable evaluation of even the smallest voltages.
A reference mark on the pulse ring in the form of a large "tooth space" makes it possible not only to perform rotational-speed measurement, but also to determine the pulse ring's position. Since the toothed pulse ring is an important component of the rotational-speed measuring system, exacting technical demands are made upon it to ensure that reliable, precise information is obtained. Pulse-ring specifications are available on request.

Explanation of symbols

U_A Output voltage
n Rotational speed
s Air gap

Accessories

For rot-speed sensor	From offer drawing	Plug part number
0 261 210 104	A 928 000 019	**1 928 402 412**
	A 928 000 012	**1 928 402 579**
0 261 210 147		Enquire at AMP
0 261 002 214	A 928 000 453	**1 928 402 966**

Hall-effect rotational-speed sensors

Digital measurement of rotational speeds

n, φ, s / U

- Precise and reliable digital measurement of rotational speed, angle, and distance travelled.
- Non-contacting (proximity) measurement.
- Hall-IC in sensor with open-collector output.
- Insensitive to dirt and contamination.
- Resistant to mineral-oil products (fuel, engine lubricant).

Design
Hall sensors comprise a semiconductor wafer with integrated driver circuits (e.g. Schmitt-Trigger) for signal conditioning, a transistor functioning as the output driver, and a permanent magnet. These are all hermetically sealed inside a plastic plug-type housing.

Application
Hall-effect rotational-speed sensors are used for the non-contacting (proximity), and therefore wear-free, measurement of rotational speeds, angles, and travelled distances. Compared to inductive-type sensors, they have an advantage in their output signal being independent of the rotational speed or relative speed of the rotating trigger-wheel vane. The position of the tooth is the decisive factor for the output signal.
Adaptation to almost every conceivable application requirement is possible by appropriate tooth design. In automotive engineering, Hall-effect sensors are used for information on the momentary wheel speed and wheel position as needed for braking and drive systems (ABS/TCS), for measuring the steering-wheel angle as required for the vehicle dynamics control system (Electronic Stability Program, ESP), and for cylinder identification.

Operating principle
Measurement is based upon the Hall effect which states that when a current is passed through a semiconductor wafer the so-called Hall voltage is generated at right angles to the direction of current. The magnitude of this voltage is proportional to the magnetic field through the semiconductor. Protective circuits, signal conditioning circuits, and output drivers are assembled directly on this semiconductor.
If a magnetically conductive tooth (e.g. of soft iron) is moved in front of the sensor, the magnetic field is influenced arbitrarily as a function of the trigger-wheel vane shape. In other words, the output signals are practically freely selectable.

Technical Data [1] / Range

Part number		**0 232 103 021**	**0 232 103 022**
Minimum rotational speed of trigger wheel n_{min}		0 min^{-1}	10 min^{-1}
Maximum rotational-speed of trigger wheel $n_{max.}$		4000 min^{-1}	4500 min^{-1}
Minimum working air gap		0.1 mm	0.1 mm
Maximum working air gap		1.8 mm	1.5 mm
Supply voltage U_N		5 V	12 V
Supply-voltage range U_V		4.75...5.25 V [2]	4.5...24 V
Supply current I_V	Typical	5.5 mA	10 mA
Output current I_A		0...20 mA	0...20 mA
Output voltage U_A		0... U_V	0... U_V
Output saturation voltage U_S		≤ 0.5 V	≤ 0.5 V
Switching time t_f [3] at $U_A = U_N$, I_A = 20 mA (ohmic load)		≤ 1 µs	≤ 1 µs
Switching time t_r [4] at $U_A = U_N$, I_A = 20 mA (ohmic load)		≤ 15 µs	≤ 15 µs
Sustained temperature in the sensor and transition region		–40...+150 °C	–30...+130 °C [5]
Sustained temperature in the plug area		–40...+130 °C	–30...+120 °C [6]

[1]) At ambient temperature 23 ±5 °C. [2]) Maximum supply voltage for 1 hour: 16.5 V
[3]) Time from HIGH to LOW, measured between the connections (0) and (–) from 90% to 10%
[4]) Time from LOW to HIGH, measured between the connections (0) and (–) from 10% to 90%
[5]) Short-time –40...+150 °C permissible. [6]) Short-time –40...+130 °C permissible.

Accessories for connector

Plug housing	Contact pins	Individual gaskets	For cable cross section
1 928 403 110	**1 987 280 103**	**1 987 280 106**	0.5...1 mm²
	1 987 280 105	**1 987 280 107**	1.5...2.5 mm²

Note: For a 3-pin plug, 1 plug housing, 3 contact pins, and 3 individual gaskets are required.
For automotive applications, original AMP crimping tools must be used.

Installation information
– Standard installation conditions guarantee full sensor functioning.
– Route the connecting cables in parallel in order to prevent incoming interference.
– Protect the sensor against destruction by static discharge (CMOS components).
– The information on the right of this page must be observed in the design of the trigger wheel.

Symbol explanation
n_{min} = 0: Static operation possible.
n_{min} > 0: Only dynamic operation possible.
U_S: Max. output voltage at LOW with
I_A: Output current = 20 mA.
I_V: Supply current for the Hall sensor.
t_f: Fall time (trailing signal edge).
t_r: Rise time (leading signal edge).

Trigger-wheel design
0 232 103 021
The trigger wheel must be designed as a 2-track wheel. The phase sensor must be installed dead center. Permissible center offset: ±0.5 mm.
Segment shape:

Mean diameter	≥ 45 mm
Segment width	≥ 5 mm
Segment length	≥ 10 mm
Segment height	≥ 3.5 mm

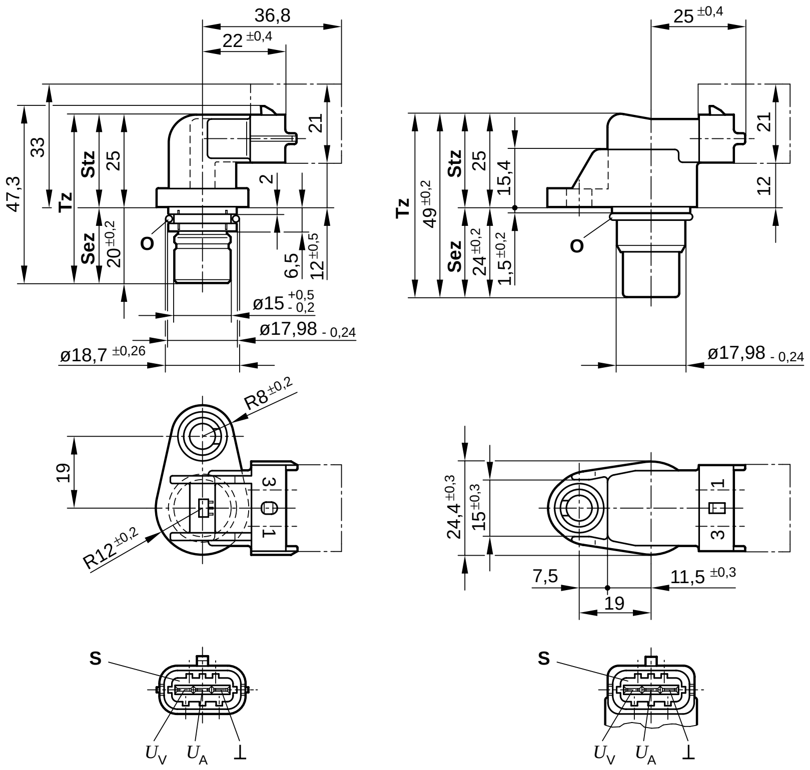
0 232 103 022
The trigger wheel is scanned radially.
Segment shape:

Diameter	≥ 30 mm
Tooth depth	≥ 4.5 mm
Tooth width	≥ 10 mm
Material thickness	≥ 3.5 mm

Dimension drawings.

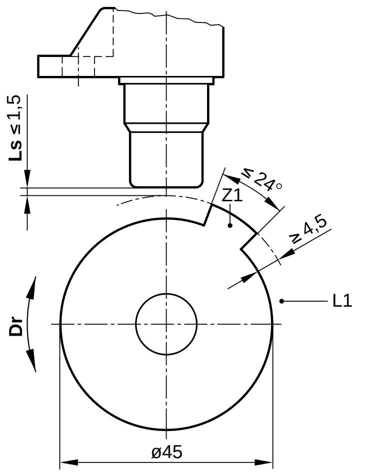
S 3-pin plug-in connection
Sez Sensor area
Stz Plug area
Tz Temperature area
O O-ring

0 232 103 021 | **0 232 103 022**

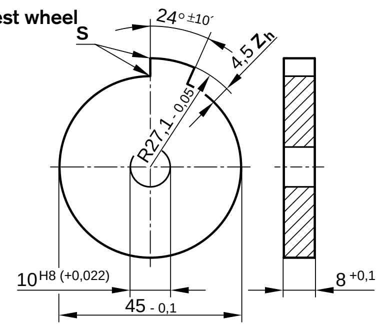


Installation stipulation 0 232 103 022.

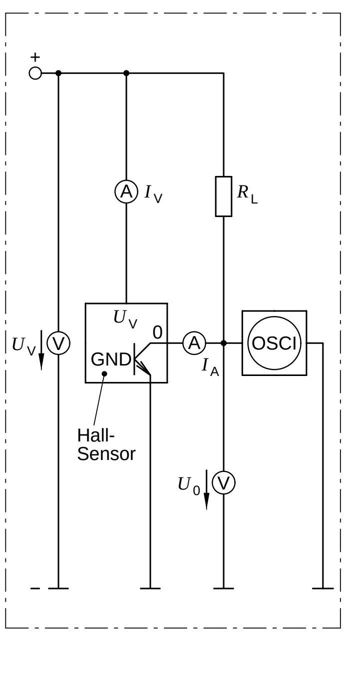
Dr Direction of rotation
Ls Air gap
S Sharp-edged
Zh Tooth height



Test wheel



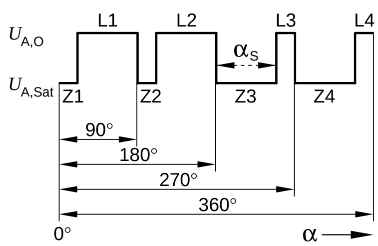
Block diagram.



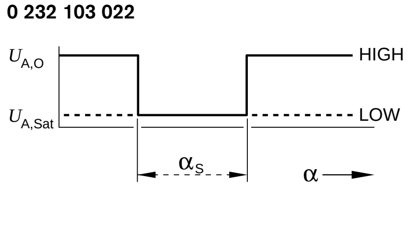
Output-signal shape.

$U_{A,O}$ Output voltage
$U_{A,SAT}$ Output saturation voltage
α Angle of rotation
α_S Signal width

0 232 103 021

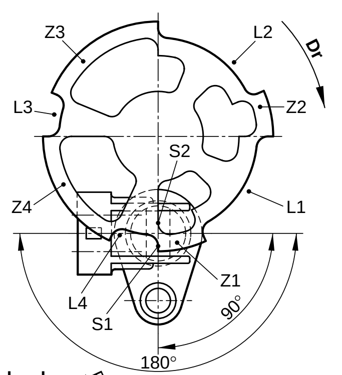


0 232 103 022

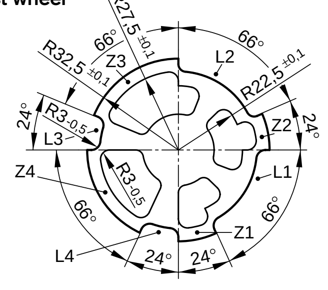


Installation stipulation 0 232 103 021.

Dr Direction of rotation

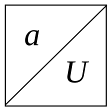


Test wheel



Piezoelectric vibration sensors

Measurement of structure-borne noise/acceleration



- Reliable detection of structure-borne noise for protecting machines and engines.
- Piezo-ceramic with high degree of measurement sensitivity.
- Sturdy compact design.

Applications
Vibration sensors of this type are suitable for the detection of structure-borne acoustic oscillations as can occur for example in case of irregular combustion in engines and on machines. Thanks to their ruggedness, these vibration sensors can be used even under the most severe operating conditions.

Areas of application
- Knock control for internal-combustion engines
- Protection of machine tools
- Detection of cavitation
- Monitoring of bearings
- Theft-deterrent systems

Design and function
On account of its inertia, a mass exerts compressive forces on a ring-shaped piezo-ceramic element in time with the oscillation which generates the excitation. Within the ceramic element, these forces result in charge transfer within the ceramic and a voltage is generated between the top and bottom of the ceramic element. This voltage is picked-off using contact discs – in many cases it is filtered and integrated – and made available as a measuring signal. In order to route the vibration directly into the sensor, vibration sensors are securely bolted to the object on which measurements take place.

Measurement sensitivity
Every vibration sensor has its own individual response characteristic which is closely linked to its measurement sensitivity. The measurement sensitivity is defined as the output voltage per unit of acceleration due to gravity (see characteristic curve). The production-related sensitivity scatter is acceptable for applications where the primary task is to record that vibration is occurring, and not so much to measure its severity.
The low voltages generated by the sensor can be evaluated using a high-impedance AC amplifier.

Technical data

Frequency range		1...20 kHz
Measuring range		≈ 0.1...400 g [1])
Sensitivity at 5 kHz		26 ±8 mV/g
Linearity between 5...15 kHz at resonances		+20/–10 % of 5 kHz-value (15...41 mV/g)
Dominant resonant frequency		> 25 kHz
Self-impedance		> 1 MΩ
Capacitance range		800...1400 pF
Temperature dependence of the sensitivity		≤ 0.06 mV/(g · °C)
Operating-temperature range: Type 0 261 231 118		–40...+150 °C
Type 0 261 231 148		–40...+150 °C
Type 0 261 231 153		–40...+130 °C
Permissible oscillations	Sustained	≤ 80 g
	Short-term	≤ 400 g

Installation

Fastening screw	Grey cast iron	M 8 x 25; quality 8.8
	Aluminum	M 8 x 30; quality 8.8
Tightening torque (oiled permitted)		20 ±5 N · m
Mounting position		Arbitrary

[1]) Acceleration due to gravity $g = 9.81\ m \cdot s^{-2}$.
Resistant to saline fog and industrial climate.

Range

Vibration sensor

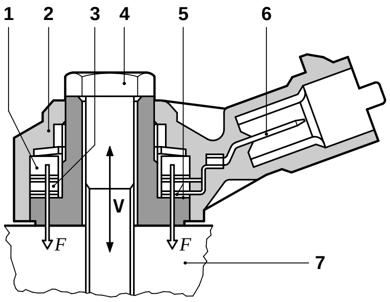
2-pole without cable	**0 261 231 148**
2-pole, with cable, length 480 mm, up to +130 °C	**0 261 231 153**
3-pole, with cable, length 410 mm, up to +150 °C	**0 261 231 118**

Accessories

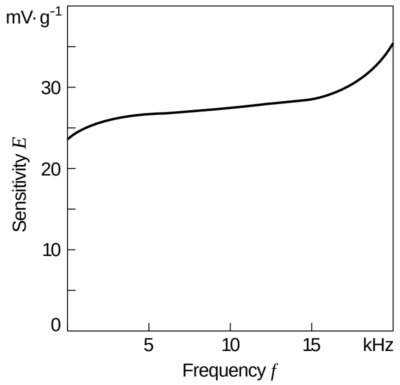
Sensor	Plug housing	Contact pins	Individual gasket	For cable cross section
0 261 231 148	**1 928 403 137**	**1 987 280 103**	**1 987 280 106**	0.5...1.0 mm²
		1 987 280 105	**1 987 280 107**	1.5...2.5 mm²
0 261 231 153	**1 928 403 826**	**1 928 498 060**	**1 928 300 599**	0.5...1.0 mm²
		1 928 498 061	**1 928 300 600**	1.5...2.5 mm²
0 261 231 118	**1 928 403 110**	**1 987 280 103**	**1 987 280 106**	0.5...1.0 mm²
		1 987 280 105	**1 987 280 107**	1.5...2.5 mm²

Note: A 3-pole plug requires 1 plug housing, 3 contact pins, and 3 individual gaskets.
In automotive applications, original AMP crimping tools must be used.

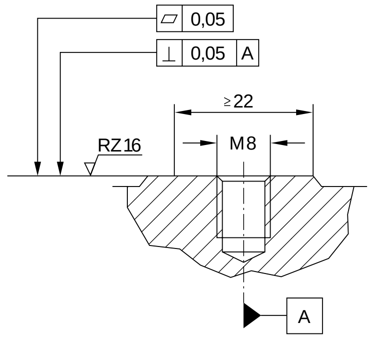
Vibration sensor (design).
1 Seismic mass with compressive forces F, **2** Housing, **3** Piezo-ceramic, **4** Screw, **5** Contact, **6** Electrical connection, **7** Machine block, **V** Vibration.



Response characteristic as a function of frequency.

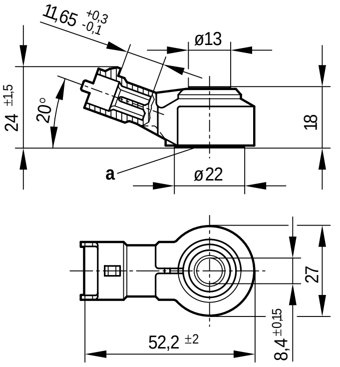


Mounting hole.



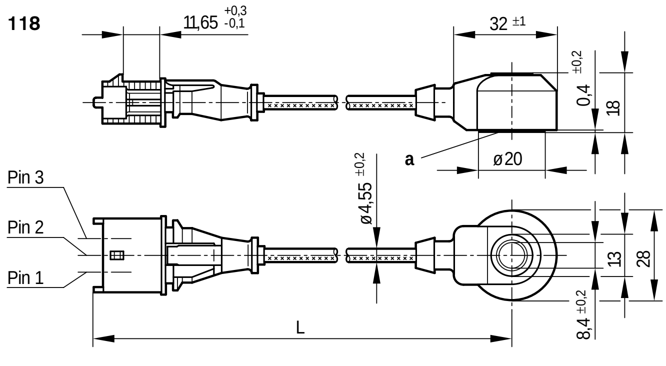
Dimension drawings.
a Contact surface.

0 261 231 148

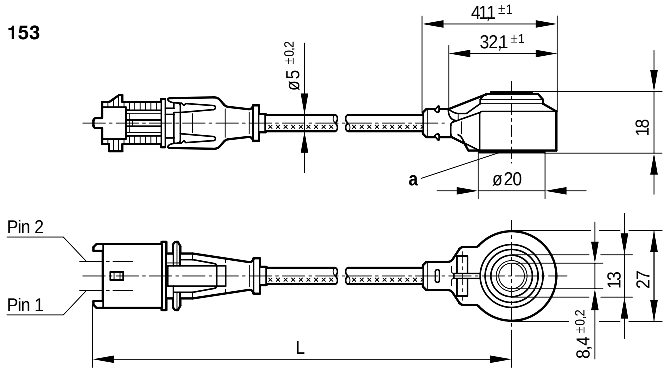


Part number	L mm
.. 118	410 ±10
.. 153	430 ±10

0 261 231 118



0 261 231 153



Evaluation
The sensor's signals can be evaluated using an electronic module.
This is described on Pages 26/27.

Installation instructions
The sensor's metal surfaces must make direct contact. No washers of any type are to be used when fastening the sensors. The mounting-hole contact surface should be of high quality to ensure low-resonance sensor coupling at the measuring point. The sensor cable is to be laid such that there is no possibility of sympathetic oscillations being generated. The sensor must not come into contact with liquids for longer periods.

Explanation of symbols
E	Sensitivity
f	Frequency
g	Acceleration due to gravity

Connector-pin assignments
Pin 1, 2	Measuring signal
Pin 3	Shield, dummy

Micromechanical differential-pressure sensors Hybrid design

Measurement of pressure in gases from –100 kPa to 5 kPa

p / U

- High accuracy.
- EMC protection better than 100 V m⁻¹.
- Temperature-compensated.

Applications
On internal-combustion engines, this sensor is used to measure the differential pressure between the intake-manifold pressure of the drawn-in air and a reference pressure which is inputted through a hose.

Design and function
The piezoresistive pressure-sensor element and suitable electronic circuitry for signal amplification and temperature compensation are mounted on a silicon chip. The measured pressure is applied to the rear side of the silicon diaphragm. The reference pressure is applied from above to the diaphragm's active surface. Thanks to a special coating, both sides of the diaphragm are insensitive to the gases and liquids which are present in the intake manifold.

Installation information
The sensor is designed for mounting on a horizontal surface of the vehicle's intake manifold. The pressure fitting extends into the manifold and is sealed-off to atmosphere by an O-ring. Care must be taken, by ensuring appropriate mounting, that condensate does not form in the pressure cell or in the reference opening. Generally speaking, installation is to be such that liquids cannot accumulate in either the sensor or the pressure hose. Water in the sensor leads to malfunctions when it freezes.

Range

Pressure range kPa (p_1...p_2)	Order No.
–80...5	**B 261 260 314** [1])
–100...0	**B 261 260 318** [1])

[1]) Provisional draft number, order number available upon enquiry. Deliverable as from about the end of 2001.

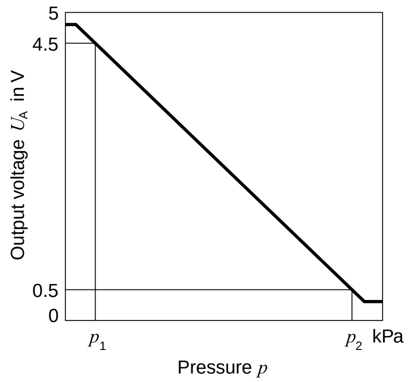
Technical data

			min.	typ.	max.
Pressure-measuring range	p_e	kPa	–100	–	0
Operating temperature	ϑ_B	°C	–40	–	+130
Supply voltage	U_V	V	4.5	5.0	5.5
Current consumption at U_V = 5 V	I_V	mA	6.0	9.0	12.5
Load current at output	I_L	mA	–1.0	–	0.1
Load resistance to U_V or ground	$R_{pull-up}$	kΩ	5	680	–
	$R_{pull-down}$	kΩ	50.0	100	–
Response time	$t_{10/90}$	ms	–	1.0	–
Voltage limitation at U_V = 5 V					
Lower limit	$U_{A\,min}$	V	0.25	0.3	0.35
Upper limit	$U_{A\,max}$	V	4.75	4.8	4.85
Limit data					
Supply voltage	$U_{V\,max}$	V	–	–	+16
Pressure	p_e	kPa	–500	–	+500
Storage temperature	ϑ_L	°C	–40	–	+130

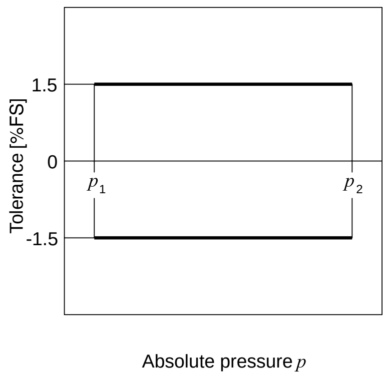
Accessories

Plug housing	Qty. required: 1	**1 928 403 966**
Contact pins	Qty. required: 3	**1 928 498 060**
Individual gaskets	Qty. required: 3	**1 928 300 599**

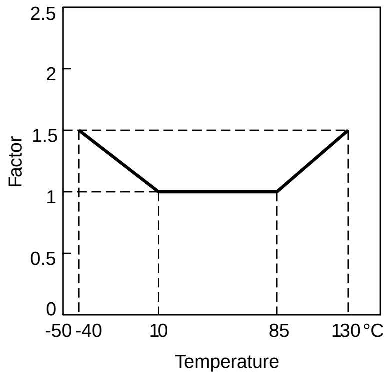
Characteristic curve.



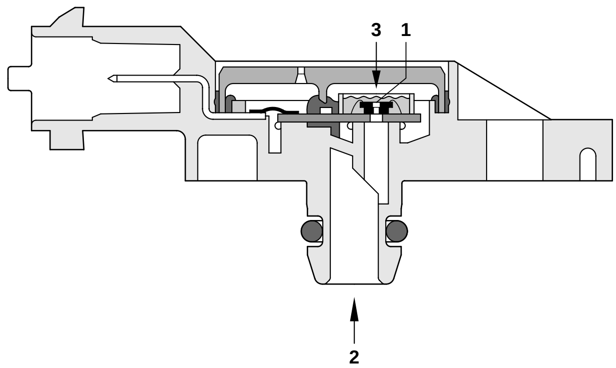
Characteristic-curve tolerance.



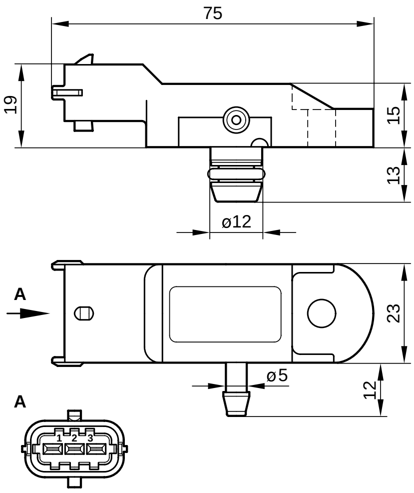
Tolerance-extension factor.



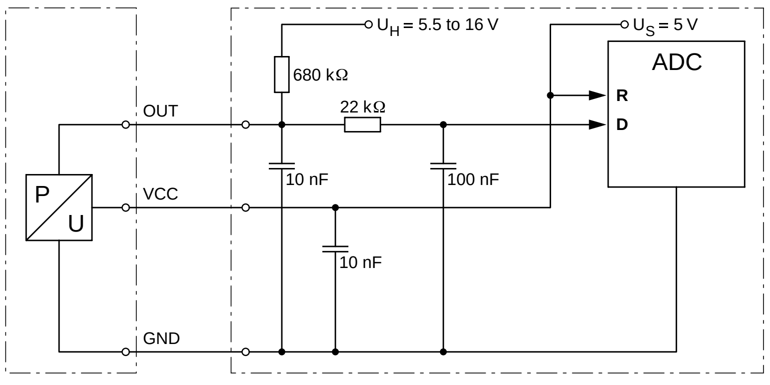
Section drawing (overall system).
1 Sensor cell, **2** Measured pressure, **3** Reference pressure



Dimension drawings.
Pin assignment
Pin 1 +5 V
Pin 2 Ground
Pin 3 Output signal



Signal evaluation: Recommendation.
D Pressure signal, **R** Reference



Signal evaluation: Recommendation

The pressure sensor's electrical output is so designed that malfunctions caused by cable open-circuits or short circuits can be detected by a suitable circuit in the following electronic circuitry. The diagnosis areas situated outside the characteristic-curve limits are provided for fault diagnosis. The circuit diagram shows an example for detection of all malfunctions via signal outside the characteristic-curve limitation.

Differential-pressure sensors

Measurement of pressures in gases and liquid mediums from –2.5 kPa to +3.75 kPa

p/U

- Resistant to the monitored medium.
- Piezoresistive sensor element.
- Integrated protection against humidity.

Application
In automotive applications, this type of pressure sensor is used for measuring fuel-tank pressure. In the process, a differential pressure is established referred to the ambient pressure.

Design and function
A micromechanical pressure element with diaphragm and connector fitting is the most important component in this differential-pressure sensor.
The diaphragm is resistant to the effects of the monitored medium. The measurement is carried out by routing the monitored medium through the pressure connector and applying the prevailing pressure to the piezoresistive sensor element. This sensor element is integrated on a silicon chip together with electronic circuitry for signal amplification and temperature compensation. The silicon chip is surrounded by a TO-type housing which forms the inner sensor cell. The surrounding pressure is applied to the active surface through an opening in the cap and a reference fitting. The active surface is protected against moisture by Silicagel. The pressure sensor generates an analog signal which is ratiometric referred to the supply voltage.

Installation instructions
The sensor is designed for horizontal mounting on a horizontal surface.
In case of non-horizontal mounting, each case must be considered individually. Generally speaking, installation is to be such that liquids cannot accumulate in the sensor or in the pressure hose. Water in the sensor leads to malfunctions when it freezes.

Range

Pressure range kPa (p_1...p_2)	Characteristics	Dimension drawing	Part No.
–2.50...2.50	–	①	**0 261 230 015**
–2.50...2.50	with protective cover	②	**0 261 230 026**
–3.75...1.25	–	①	**B 261 260 317** [1])

Technical data

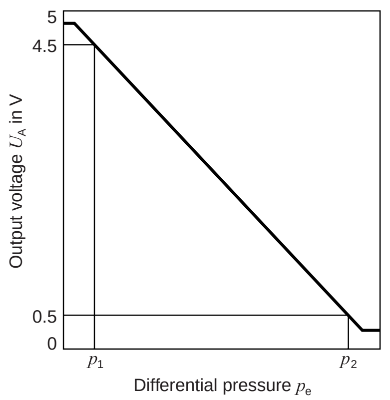
			min	typ	max
Pressure-measuring range	p_e	kPa	–2.5	–	+2.5
Operating temperature	ϑ_B	°C	–40	–	+80
Supply voltage U_V	U_V	V	4.75	5.0	5.25
Input current at U_V = 5 V	I_V	mA	–	9.0	12.5
Load current at output	I_L	mA	–0.1	–	+0.1
Load resistance to ground or U_V	R_L	kΩ	50	–	–
Response time	$t_{10/90}$	ms	–	0.2	–
Voltage limitation at U_V = 5 V					
Lower limit	$U_{A\,min}$	V	0.25	0.3	0.35
Upper limit	$U_{A\,max}$	V	4.75	4.8	4.85
Recommendation for signal evaluation					
Load resistance to U_H = 5.5...16 V	$R_{L,H}$	kΩ	–	680	–
Limit data					
Supply voltage (1 min)	U_{Vmax}	V	–	–	16
Pressure measurement	$P_{e,\,max}$	KPa	–30	–	+30
Storage temperature	ϑ_L	°C	–40	–	+80

Accessories

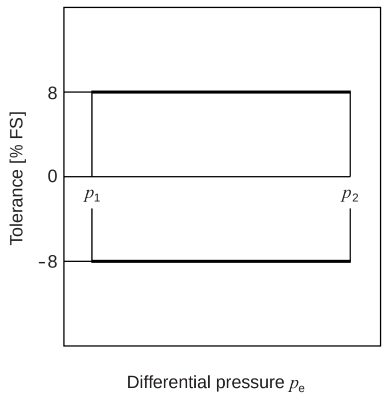
Plug housing	Qty. required: 1	**1 928 403 110**
Contact pins	Qty. required: 3 [3])	AMP-Nummer **929 939-3** [2])
Contact pins	Qty. required: 3 [4])	AMP-Nummer **2-929 939-1** [2])
Individual gaskets	Qty. required: 3	AMP-Nummer **828 904** [2])

[1]) Provisional draft number, Order No. available upon request. Available as from the end of 2001.
[2]) To be obtained from AMP Deutschland GmbH, Amperestr. 7–11, D-63225 Langen, Tel. 0 61 03/7 09-0, Fax 0 61 03/7 09 12 23, E-Mail: AMP.Kontakt@tycoelectronics.com
[3]) Contacts for 0 261 230 026
[4]) Contacts for 0 261 230 015, B 261 260 317

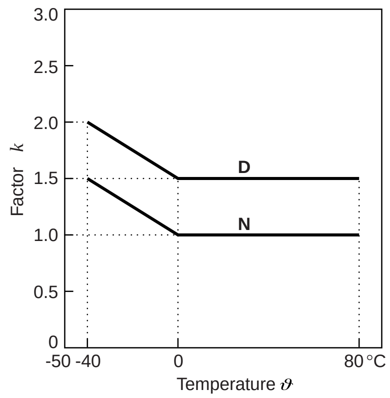
Characteristic-curve.



Characteristic-curve tolerance.



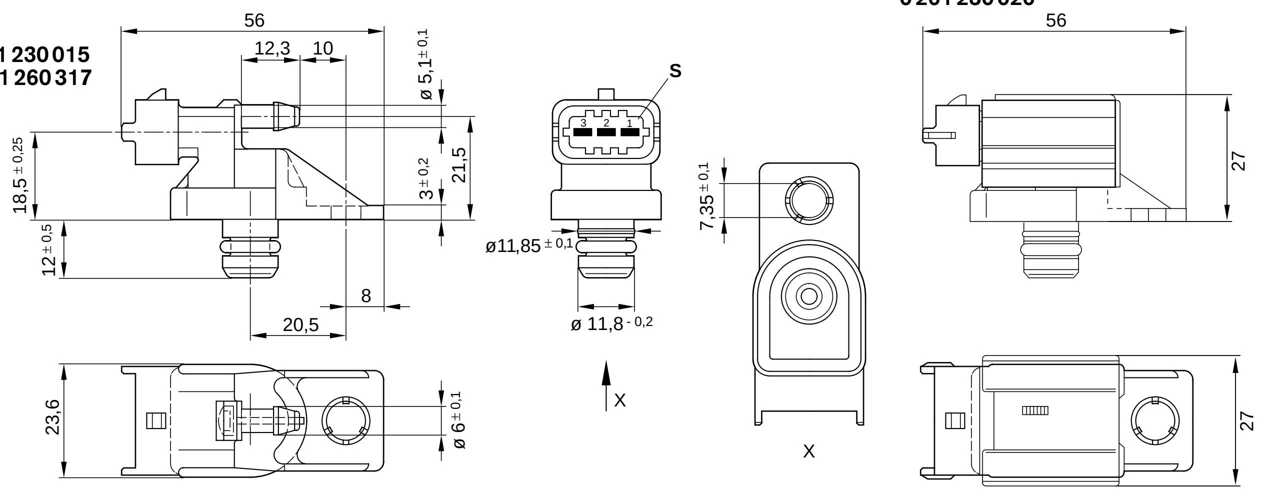
Temperature-error multiplier.
D After endurance test
N In as-new state



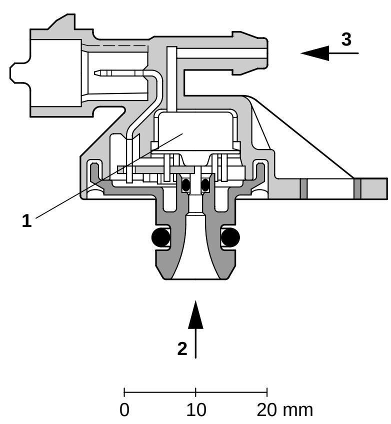
Dimension drawings.
S 3-pole plug

① **0 261 230 015**
B 261 260 317

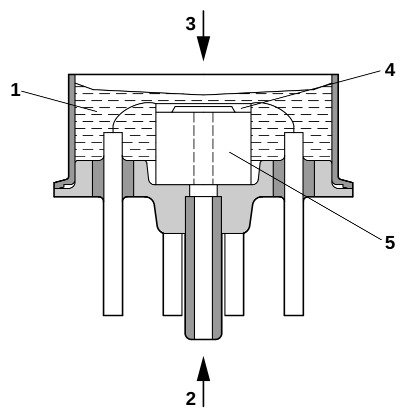
② **0 261 230 026**



Sectional drawing of pressure sensor (overall system).
1 Sensor cell, **2** Applied pressure,
3 Reference pressure.



Sectional drawing of sensor cell.
1 Silicagel, **2** Applied pressure, **3** Reference pressure, **4** Sensor chip, **5** Glass base.



Explanation of symbols

p_e	Differential pressure
U_A	Output voltage (signal voltage)
U_V	Supply voltage
k	Tolerance multiplier
D	Following endurance test
N	As-new state

Connector-pin assignment

Pin 1	+5 V (U_V)
Pin 2	Ground
Pin 3	Output signal

Piezoresistive absolute-pressure sensor with moulded cable

Measurement of pressures in gases up to 400 kPa

- Pressure-measuring element with silicon diaphragm ensures extremely high accuracy and long-term stability.
- Integrated evaluation circuit for signal amplification and characteristic-curve adjustment.
- Very robust construction.

Applications
This type of absolute-pressure sensor is highly suitable for measuring the boost pressure in the intake manifold of turbocharged diesel engines. They are needed in such engine assemblies for boost-pressure control and smoke limitation.

Design and function
The sensors are provided with a pressure-connection fitting with O-ring so that they can be fitted directly at the measurement point without the complication and costs of installing special hoses. They are extremely robust and insensitive to aggressive media such as oils, fuels, brake fluids, saline fog, and industrial climate.
In the measuring process, pressure is applied to a silicon diaphragm to which are attached piezoresistive resistors. Using their integrated electronic circuitry, the sensors provide an output signal the voltage of which is proportional to the applied pressure.

Installation information
The metal bushings at the fastening holes are designed for tightening torques of maximum 10 N · m.
When installed, the pressure fitting must point downwards. The pressure fitting's angle referred to the vertical must not exceed 60°.

Tolerances
In the basic temperature range, the maximum pressure-measuring error Δp (referred to the excursion: 400 kPa–50 kPa = 350 kPa) is as follows:
Pressure range 70...360 kPa
 As-new state ±1.0 %
 After endurance test ±1.2 %
Pressure range < 70 and > 360 kPa (linear increase)
 As-new state ±1.8 %
 After endurance test ±2.0 %

Technical data / Range

Part number	**0 281 002 257**
Measuring range	50...400 kPa
Basic measuring range with enhanced accuracy	70...360 kPa
Resistance to overpressure	600 kPa
Ambient temperature range/sustained temperature range	–40...+120 °C
Basic range with enhanced accuracy	+20...+110 °C
Limit-temperature range, short-time	≤ 140 °C
Supply voltage U_V	5 V ±10 %
Current input I_V	≤ 12 mA
Polarity-reversal strength at $I_V \leq$ 100 mA	$-U_V$
Short-circuit strength, output	To ground and U_V
Permissible loading	
Pull down	≥ 100 kΩ
	≤ 100 nF
Response time $t_{10/90}$	≤ 5 ms
Vibration loading max.	20 g
Protection against water	
Strong hose water at increased pressure	IPX6K
High-pressure and steam-jet cleaning	IPX9K
Protection against dust	IP6KX

Throughout the complete temperature range, the permissible temperature error results from multiplying the maximum permissible pressure measuring error by the temperature-error multiplier corresponding to the temperature in question.

Basic temperature range	+20...+110 °C	1.0 [1])
	+20... – 40 °C	3.0 [1])
	+110...+120 °C	1.6 [1])
	+120...+140 °C	2.0 [1])

[1]) In each case, increasing linearly to the given value.

Accessories

Connector	**1 237 000 039**

Pressure sensors

For pressures up to 1800 bar (180 Mpa)

- Ratiometric signal evaluation (referred to supply voltage).
- Self-monitoring of offset and sensitivity.
- Protection against polarity reversal, overvoltage, and short circuit of output to supply voltage or ground.
- High level of compatibility with media since this only comes into contact with stainless steel.
- Resistant to brake fluids, mineral oils, water, and air.

Application
Pressure sensors of this type are used to measure the pressures in automotive braking systems, or in the fuel-distributor rail of a gasoline direct-injection engine, or in a diesel engine with Common Rail injection.

Design and function
Pressure measurement results from the bending of a steel diaphragm on which are located polysilicon strain-gauge elements. These are connected in the form of a Wheatstone bridge. This permits high signal utilisation and good temperature compensation.
The measurement signal is amplified in an evaluation IC and corrected with respect to offset and sensitivity. At this point, temperature compensation again takes place so that the calibrated unit comprising measuring cell and ASIC only has a very low temperature-dependence level.
Part of the evaluation IC is applied for a diagnostic function which can detect the following potential defects:
- Fracture of a bonding wire to the measuring cell.
- Fracture anywhere on any of the signal lines.
- Fracture of the bridge supply and ground.

Only for 0 265 005 303
This sensor differs from conventional sensors due to the following diagnostic functions:
- Offset errors
- Amplification errors

can be detected by comparing two signal paths in the sensor.

Storage conditions

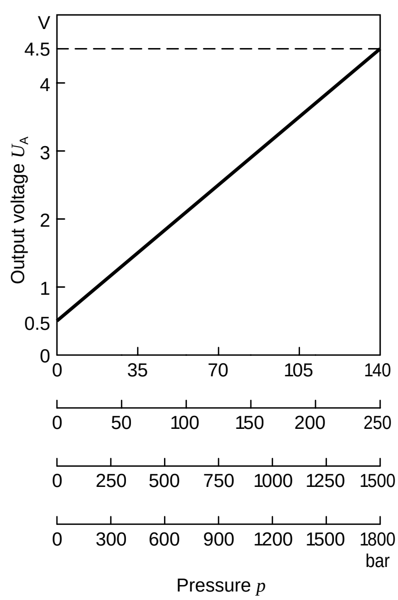
Temperature range	–30...+60 °C
Relative air humidity	0...80 %
Maximum storage period	5 years

Through compliance with the above storage conditions, it is ensured that the sensor functions remain unchanged.
If the maximum storage conditions are exceeded, the sensors should no longer be used.

Explanation of symbols

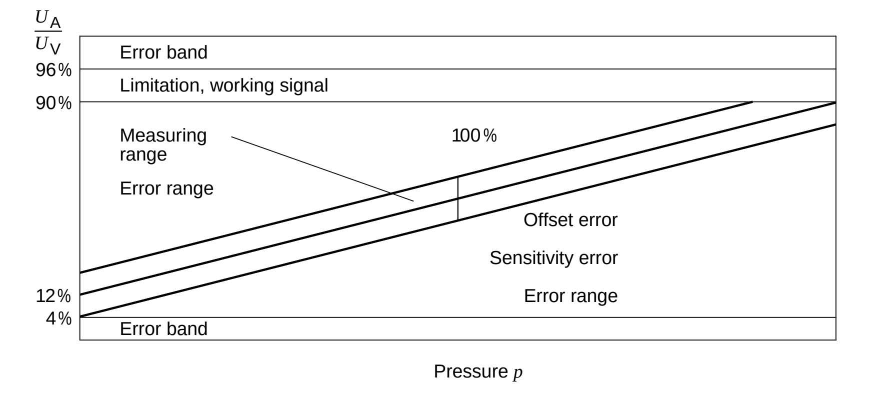
U_A	Output voltage
U_V	Supply voltage
bar	Pressure

Characteristic curve.
$U_A = (0.8 \cdot p / p_{Nom.} + 0.1) U_V$

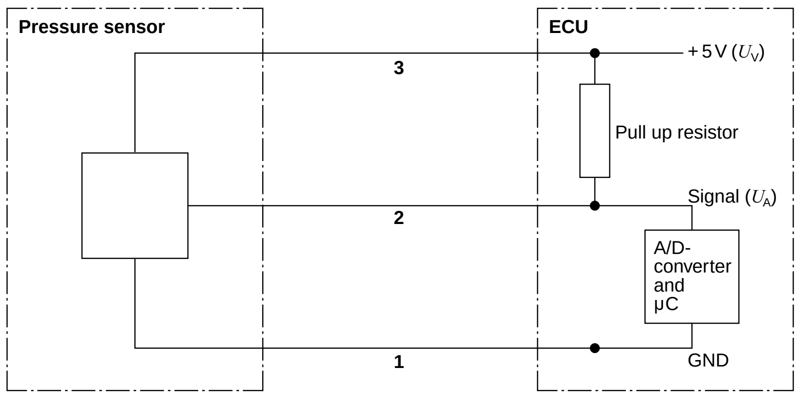


Pressure sensors (contd.)
For pressures up to 1800 bar (180 MPa)

Self-monitoring. Offset and sensitivity. Only for 0 265 005 303.



Measuring circuit.



Diagnostic function during self-test (following switch-on). Only for 0 265 005 303.
– Correctness of the calibration values
– Function of the sensor signal path from the sensor to the A/D converter of the evaluation unit
– Check of the supply lines.
Diagram:
Characteristic of the output voltage following switch-on
– Function of the signal and alarm paths
– Detection of offset errors
– Detection of short circuits in wiring harness
– Detection of overvoltage and undervoltage
– If an error is detected during the sensor's self-test, the signal output is switched to the voltage range > 96 % U_V.

Diagnostic function during normal operation.
Only for 0 265 005 303.
– Detection of offset errors
– Detection of sensitivity errors (with pressure applied)
– Wiring-harness function, detection of wiring-harness short circuits
– Detection of overvoltage and undervoltage
– If an error is detected during the sensor's self-test, the signal output is switched to the voltage range >96 % U_V.

Range

Pressure range bar	(MPa)	Sensor Type	Thread	Connector	Pin	Dimens. drawing	Page	Part number
140	(14)	KV2 BDE	M 10x1	Compact 1.1	Gold-plated	1	47	**0 261 545 006**
250	(25)	–	M 10x1	PSA	–	2	48	**0 265 005 303**
1500	(150)	RDS2	M 12x1.5	Working circuit	Silber-plated	3	48	**0 281 002 238**
			M 12x1.5	Compact 1.1	Gold-plated	4	48	**0 281 002 405**
		RDS3	M 12x1.5	Working circuit	Silber-plated	5	48	**0 281 002 498**
			M 12x1.5	Compact 1.1	Gold-plated	6	49	**0 281 002 522**
1800	(180)	RDS2	M 12x1.5	Compact 1.1	Gold-plated	4	48	**0 281 002 398**
			M 18x1.5	Compact 1.1	Gold-plated	7	49	**0 281 002 472**
		RDS3	M 18x1.5	Compact 1.1	Gold-plated	8	49	**0 281 002 534**
			M 18x1.5	Working circuit	Silber-plated	9	49	**0 281 002 504**

Accessories

For 0 265 005 303

Plug housing	–	Quantity required: 1	AMP No.	**2-967 642-1** 1)
Contact pins	for 0.75 mm²	Quantity required:3	AMP No.	**965 907-1** 1)
Gaskets	for 1.4...1.9 mm²	Quantity required: 3	AMP No.	**967 067-1** 1)

1) To be obtained from AMP Deutschland GmbH, Amperestr. 7–11, D-63225 Langen,
Tel. 0 61 03/7 09-0, Fax 0 61 03/7 09 12 23, E-Mail: AMP.Kontakt@tycoelectronics.com

Technical data

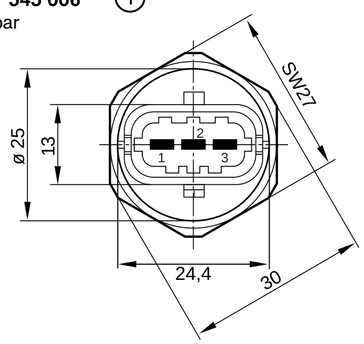
Pressure sensor		0 261 545 006	0 265 005 303	0 281 002 238 0 281 002 405	0 281 002 498 0 281 002 522	0 281 002 398 0 281 002 472	0 281 002 534 0 281 002 504
Pressure-sensor type		KV2 BDE	–	RDS2	RDS3	RDS2	RDS3
Application/Medium		Unlead. fuel	Brake fluid	Diesel fuel or RME [1])	Diesel fuel or RME [1])	Diesel fuel or RME [1])	Diesel fuel or RME [1])
Pressure range	bar (MPa)	140 (14)	250 (25)	1500 (150)	1500 (150)	1800 (180)	1800 (180)
Offset accuracy	U_V	0.7 % FS	2.0 %	1.0 % FS 1.5 % FS	0.7 % FS	1.0 % FS	0.7 % FS
Sensitivity accuracy at 5 V							
In range 0...35 bar	FS [2]) of	–	≤ 0.7 %	1.0 % FS 1.5 % FS	0.7 % FS	1.0 % FS	0.7 % FS
In range 35...140 bar	meas-	1.5 %	–	–	–	–	–
In range 35...250 bar	ured	–	≤ 5.0 % [3])	–	–	–	–
In range 35...1500 bar	value	–	–	2.0 % FS 2.5 % FS	1.5 % FS	–	–
In range 35...1800 bar		–	–	–	–	2.3 % FS	1.5 % FS
Input voltage, max. U_s	V	16	–	16	16	16	16
Power-supply voltage U_V	V	5 ±0.25	5 ±0.25	5 ±0.25	5 ±0.25	5 ±0.25	5 ±0.25
Power-supply current I_V	mA	9...15	≤ 20	9...15	9...15	9...15	9...15
Output current I_A	µA...mA	–	–100...3	2.5 mA [4])	–	2.5 mA [4])	–
Load capacity to ground	nF	13	–	10	13	10	13
Temperature range	°C	–40...+130	–40...+120	–40...+120 [5])	–40...+130	–40...+120 [5])	–40...+130
Overpressure max. p_{max}	bar	180	350	1800	2200	2100	2200
Burst pressure p_{burst}	bar	> 300	> 500	3000	4000	3500	4000
Tightening torque M_a	Nm	22 ±2	20 ±2	35 ±5	35 ±5	70 ±2	70 ±2
Response time $T_{10/90}$	ms	2	–	5	2	5	2

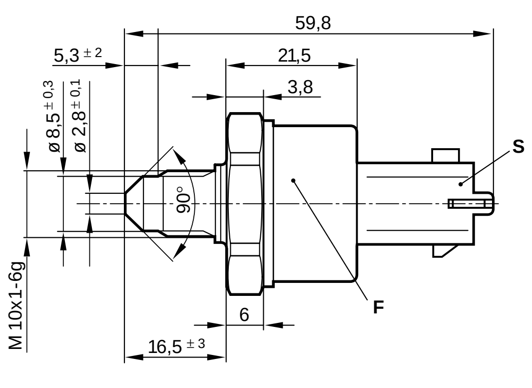
Note: All data are typical values
[1]) RME = Rapeseed methyl ester
[2]) FS = Full Scale
[3]) Of measured value
[4]) Output current with pull-up resistor
[5]) +140 °C for max. 250 h

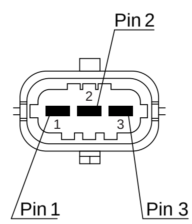
Dimension drawings
Space required by plug, approx. 25 mm
Space required when plugging/unplugging, approx. 50 mm
SW = A/F size

Connector-pin assignment
Pin 1 Ground
Pin 2 Output voltage U_A
Pin 3 Supply voltage U_V

0 261 545 006 ①
140 bar







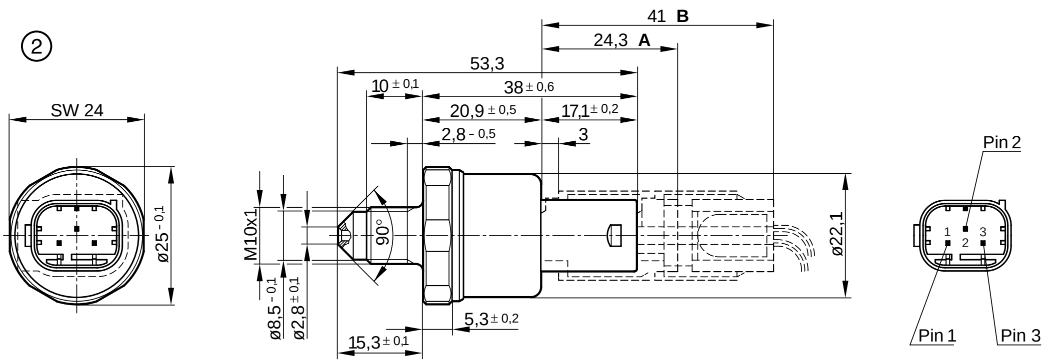
Pressure sensors (contd.)
For pressures up to 1800 bar (180 MPa)

Dimension drawings
Space required by plug, approx. 25 mm
Space required when plugging/unplugging, approx. 50 mm
SW = A/F size

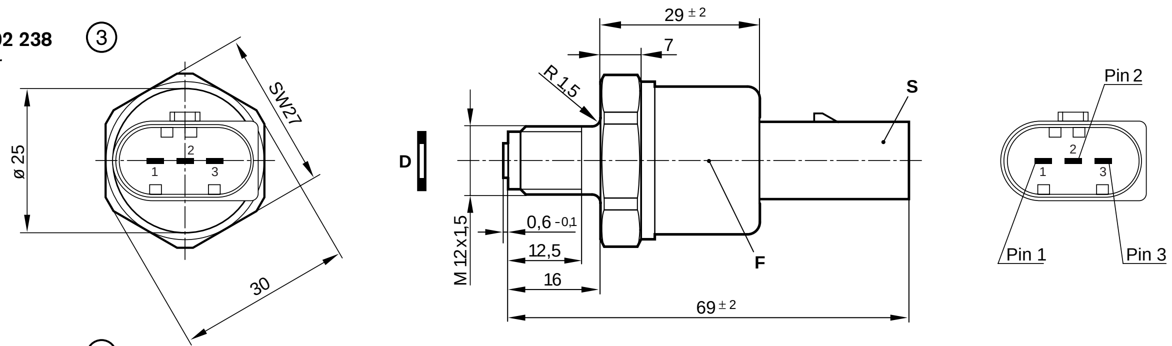
D Gasket
F Date of manufacture
S 3-pin plug

Connector-pin assignment
Pin 1 Ground
Pin 2 Output voltage U_A
Pin 3 Supply voltage U_V

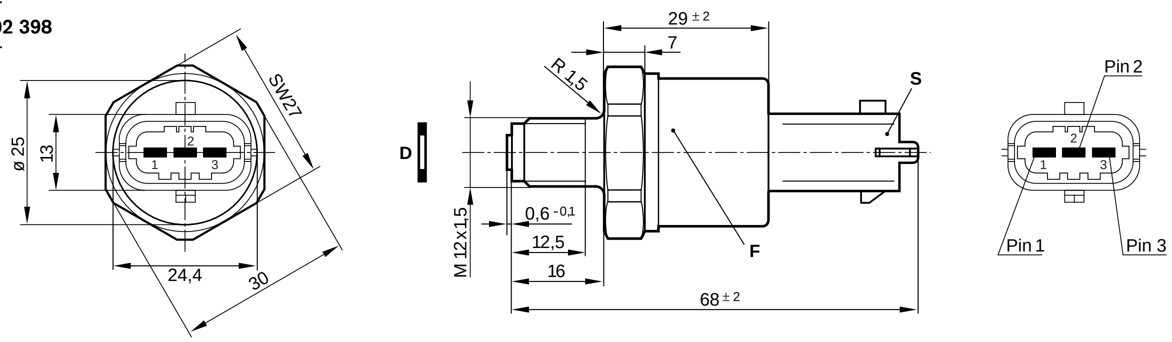
0 265 005 303 ②
250 bar



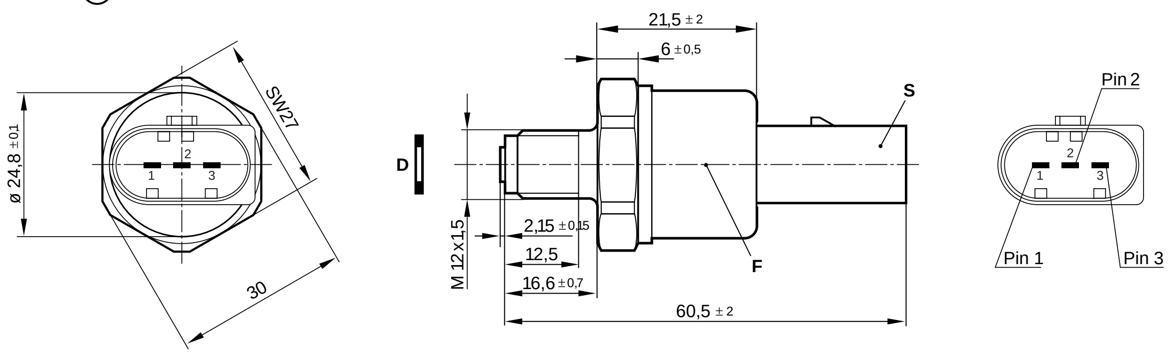
0 281 002 238 ③
1500 bar



0 281 002 405 ④
1500 bar
0 281 002 398
1800 bar



0 281 002 498 ⑤
1500 bar

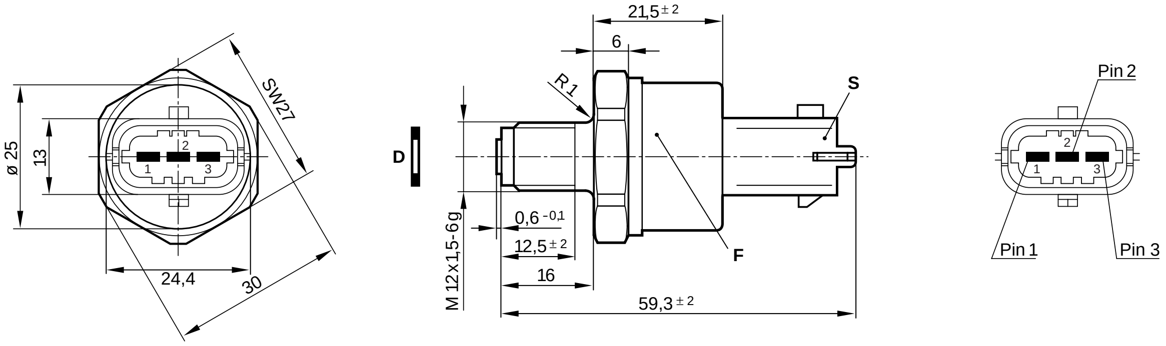


Dimension drawings
Space required by plug, approx. 25 mm
Space required when plugging/unplugging, approx. 50 mm
SW = A/F size

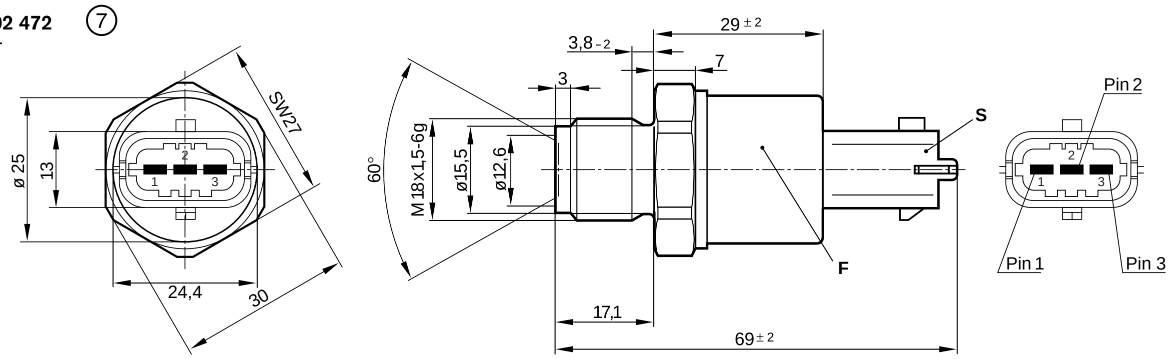
D Gasket
F Date of manufacture
S 3-pin plug

Connector-pin assignment
Pin 1 Ground
Pin 2 Output voltage U_A
Pin 3 Supply voltage U_V

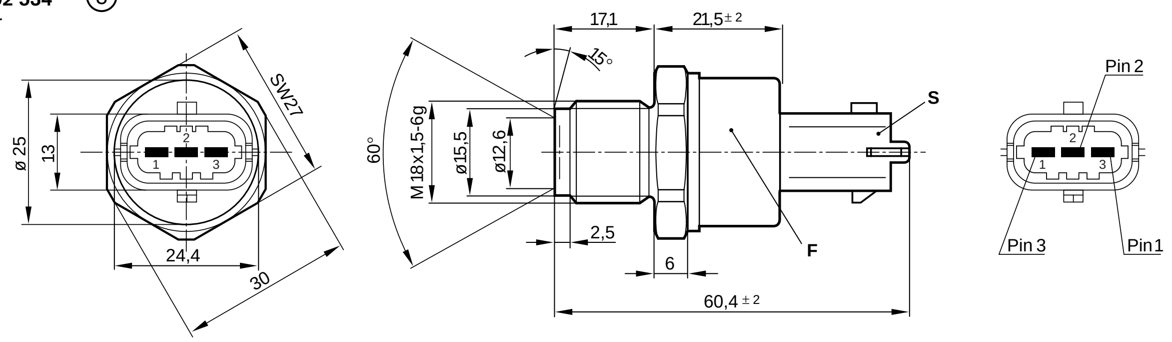
0 281 002 522 ⑥
1500 bar



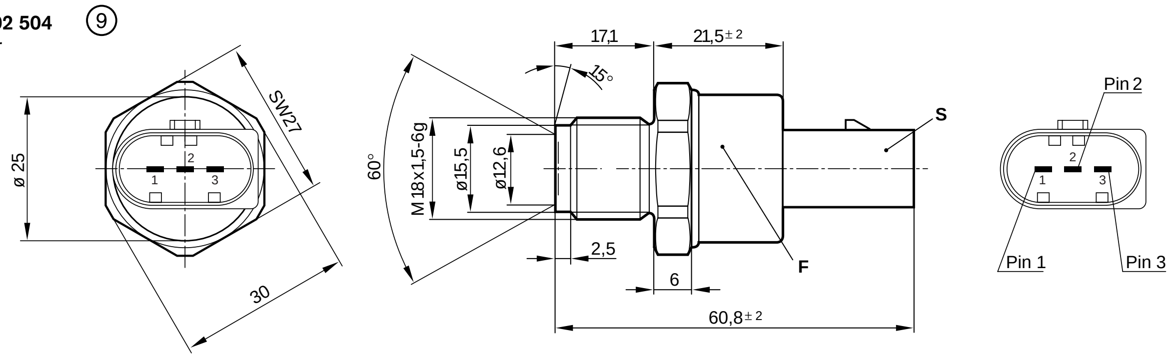
0 281 002 472 ⑦
1800 bar



0 281 002 534 ⑧
1800 bar

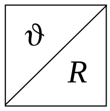


0 281 002 504 ⑨
1800 bar

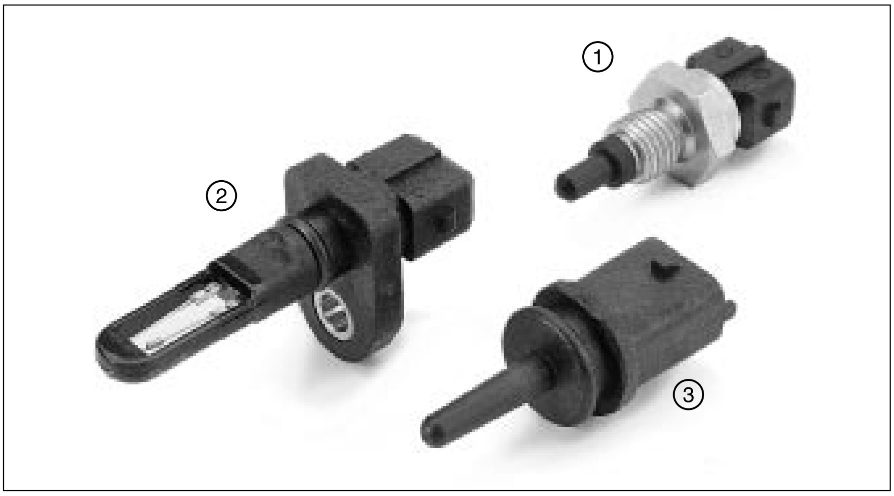


NTC temperature sensors

Measurement of air temperatures between –40 °C and +130 °C



- Measurement with temperature-dependent resistors.
- Broad temperature range.



Range

NTC temperature sensor
NTC resistor in plastic sheath

Steel housing	
Screw fastening	**0 280 130 039**

Polyamide housing	
Plug-in mounting	**0 280 130 092**
Plug-in mounting	**0 280 130 085**

Accessories

For 0 280 130 039; .. 085	
Connector	**1 237 000 036**

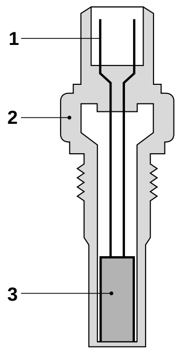
For 0 280 130 092

Designation	For cable cross-section	Part number
Plug housing	–	**1 928 403 137**
Contact pins	0.5...1.0 mm²	**1 987 280 103**
	1.5...2.5 mm²	**1 987 280 105**
Individual gaskets	0.5...1.0 mm²	**1 987 280 106**
	1.5...2.5 mm²	**1 987 280 107**

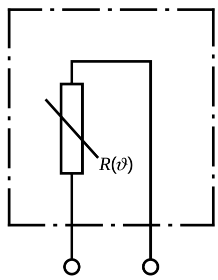
Note
Each 2-pole plug requires 1 plug housing, 2 contact pins, and 2 individual gaskets. For automotive applications, original AMP crimping tools must be used.

Explanation of symbols:
R Resistance
ϑ Temperature

Temperature sensor (principle).
1 Electrical connection
2 Housing
3 NTC resistor



Block diagram.

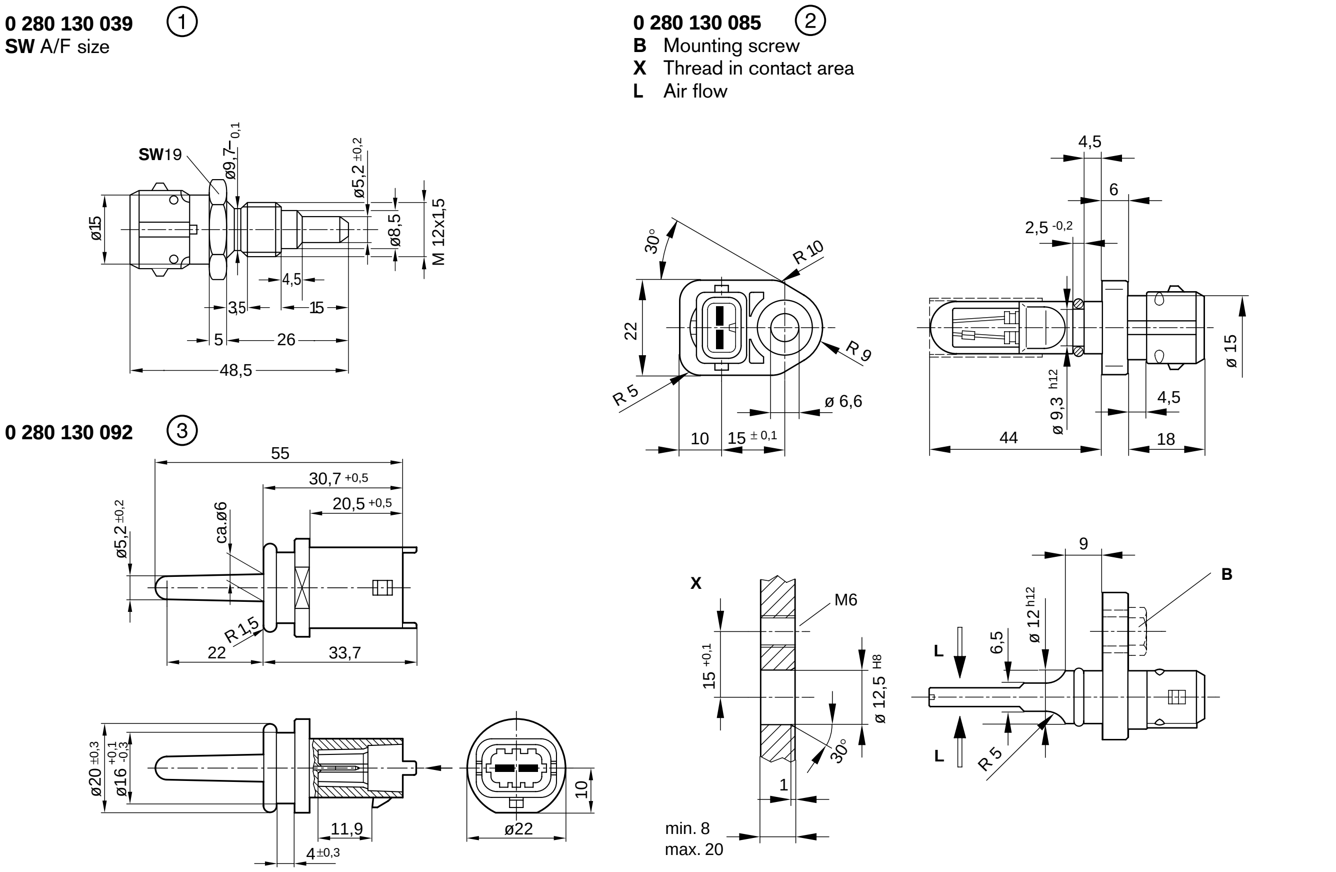


Technical data

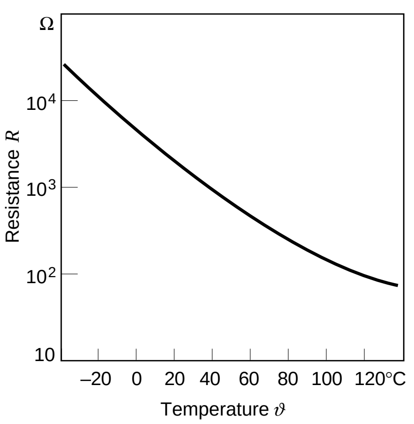
Part number		**0 280 130 039**	**0 280 130 085**	**0 280 130 092**
Illustration		1	2	3
Characteristic curve		1	2	1
Measuring range	°C	–40...+130	–40...+130	–40...+130
Permissible temp., max.	°C	+130	+140	+130
Electrical resistance at 20 °C	kΩ	2.5 ±5 %	2.4 ±5.4 %	2.5 ±5 %
Electrical resistance at –10 °C	kΩ	8.26...10.56	–	8.727...10.067
+20 °C	kΩ	2.28...2.72	2.290...2.551	2.375...2.625
+80 °C	kΩ	0.290...0.364	–	–
Nominal voltage	V	≤ 5	≤ 5	≤ 5
Measured current, max.	mA	1	1	1
Self-heating at max. permissible power loss P = 2 mW and stationary air (23 °C)	K	≤ 2	–	≤ 2
Thermal time constant [1]	s	ca. 20	≤ 5 [2]	44
Guide value for permissible vibration acceleration (sinusoidal vibration)	$m \cdot s^{-2}$	100	100	≤ 300
Corrosion-tested as per		DIN 50 018	DIN 50 018	DIN 50 018

[1]) At 20 °C. Time required to reach 63% of final value for difference in resistance, given an abrupt increase in air temperature; air pressure 1000 mbar; air-flow rate 6 $m \cdot s^{-1}$.
[3]) Time constant τ_{63} in air for a temperature jump of –80 °C to +20 °C at an air-flow rate of ≥ 6 $m \cdot s^{-1}$.

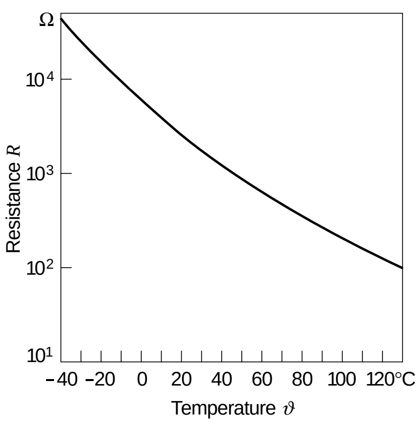
Dimension drawings.



Characteristic curve 1.



Characteristic curve 2.



Design and function

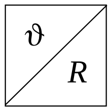
NTC sensor:
The sensing element of an NTC temperature sensor (NTC = **N**egative **T**emperature **C**oefficient), is a resistor comprised of metal oxides and oxidized mixed crystals. This mixture is produced by sintering and pressing with the addition of binding agents. For automotive applications, NTC resistors are enclosed in a protective sheath.
If NTC resistors are exposed to external heat, their resistance drops drastically and, provided the supply voltage remains constant, their input current climbs rapidly. This property can be utilised for temperature measurement. NTC resistors are suitable for an extremely wide range of ambient conditions, and with them it is possible to measure a wide range of temperatures.

Installation instructions

Installation is to be such that the front part of the sensing element is directly exposed to the air flow.

NTC temperature sensors

Measurement of liquid temperatures from –40 °C to +130 °C



● For a wide variety of liquid-temperature measurements using temperature-dependent resistors.

NTC temperature sensor
Plastic-sheathed NTC resistor in a brass housing

Design and function
NTC sensor:
The sensing element of the NTC temperature sensor (NTC = **N**egative **T**emperature **C**oefficient) is a resistor comprised of metal oxides and oxidized mixed crystals. This mixture is produced by sintering and pressing with the addition of binding agents.
For automotive applications, NTC resistors are enclosed in a protective housing.
If NTC resistors are exposed to external heat, their resistance drops drastically and, provided the supply voltage remains constant, their input current climbs rapidly. This property can be utilised for temperature measurement. NTC resistors are suitable for use in the most varied ambient conditions, and with them it is possible to measure a wide range of liquid temperatures.

Note
Each 2-pole plug requires 1 plug housing, 2 contact pins, and 2 individual gaskets. For automotive applications, original AMP crimping tools must be used.

Explanation of symbols
R Resistance
ϑ Temperature

Temperature sensor (principle)
1 Electrical connection
2 Housing
3 NTC resistor

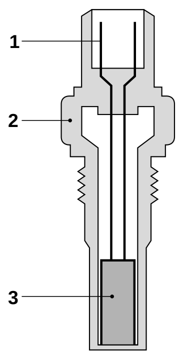
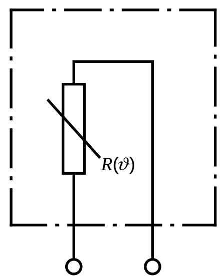
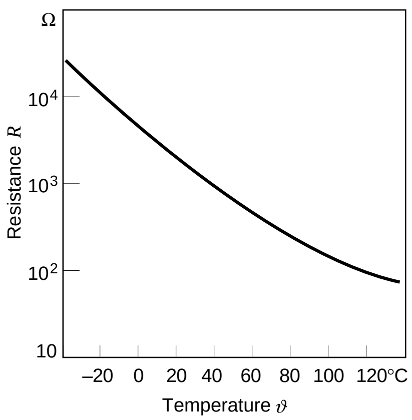


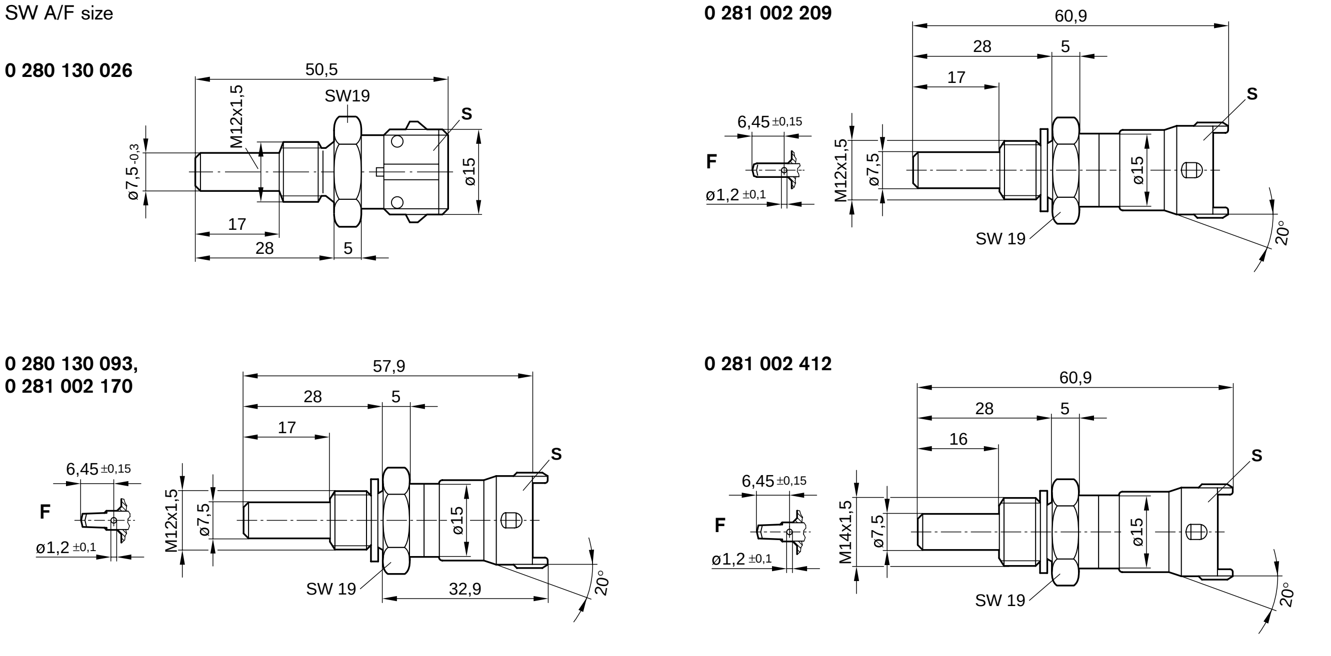
Diagram.



Characteristic curve.



Dimension drawing.
S Plug
F Blade terminal
SW A/F size



Technical data

Part number			0 280 130 026	0 280 130 093	0 281 002 170	0 281 002 209	0 281 002 412
Application/medium			Water	Water	Oil/Water	Water	Water
Measuring range		°C	–40...+130	–40...+130	–40...+150	–40...+130	–40...+130
Tolerance at	+20 °C	°C	1.2	1.2	±1.5	±1.5	±1.5
	+100 °C	°C	3.4	3.4	±0.8	±0.8	±0.8
Nominal resistance at 20 °C		kΩ	2.5 ±5 %	2.5 ±5 %	2.5 ±6 %	2.5 ±6 %	2.5 ±6 %
Electrical resistance at	–10 °C	kΩ	8.26…10.56	8.727...10.067	8.244...10.661	8.244...10.661	8.244...10.661
	+20 °C	kΩ	2.28…2.72	2.375...2.625	2.262...2.760	2.262...2.760	2.262...2.760
	+80 °C	kΩ	0.290…0.364	–	0.304…0.342	0.304…0.342	0.304…0.342
Nominal voltage		V	≤ 5	≤ 5	≤ 5	≤ 5	≤ 5
Measured current, max.		mA	1	1	1	1	1
Thermal time constant		s	44	44	15	15	15
Max. power loss at ΔT ≈ 1K and stationary air 23 °C		$m \cdot s^{-2}$	100	≤ 300	≤ 300	≤ 300	≤ 300
Degree of protection [1]				IP 54A	IP 64K	IP 64K	IP 64K IP 64K
Thread			M 12 x 1.5	M 12 x 1.5	M 12 x 1.5	M 12 x 1.5	M 14 x 1.5
Corrosion-tested as per			DIN 50 018	DIN 50 018	DIN 50 021 [2]	DIN 50 021 [2]	DIN 50 021 [2]
Plugs			Jetronic, Tin-plated pins	Compact 1, Tin-plated pins	Compact 1, Gold-plated pins	Compact 1.1, Tin-plated pins	Compact 1.1, Tin-plated pins
Tightening torque		Nm	25	18	18	25	20

[1]) With single-conductor sealing
[2]) Saline fog 384 h

Accessories

For 0 280 130 026

Designation	Part number
Connector	**1 237 000 036**

For 0 280 130 093, 0 281 002 170

Designation	For cable cross-section	Part number
Plug housing	–	**1 928 403 137**
Contact pins	0.5 ... 1.0 mm²	**1 987 280 103**
	1.5 ... 2.5 mm²	**1 987 280 105**
Individual gaskets	0.5 ... 1.0 mm²	**1 987 280 106**
	1.5 ... 2.5 mm²	**1 987 280 107**

For 0 281 002 209, 0 281 002 412

Designation	For cable cross-section	Part number
Plug housing	–	**1 928 403 874**
Contact pins	0.5 ... 1.0 mm²	**1 928 498 060**
	1.5 ... 2.5 mm²	**1 928 498 061**
Individual gaskets	0.5 ... 1.0 mm²	**1 928 300 599**
	1.5 ... 2.5 mm²	**1 928 300 600**

Hot-film air-mass meter, type HFM 2

Measurement of air-mass throughflow up to 1080 kg / h

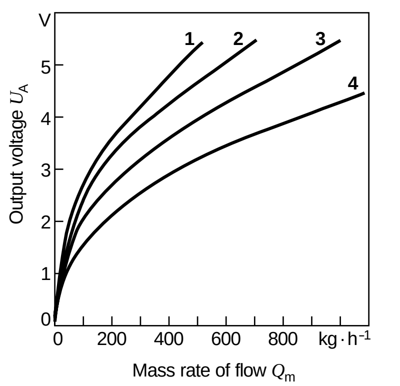
Q_m / U

- Measurement of air mass (gas mass) throughflow per unit of time, independent of density and temperature.
- Extensive measuring range.
- Highly sensitive, particularly for small changes in flow rate.
- Wear-free since there are no moving parts.
- Insensitive to dirt and contamination.

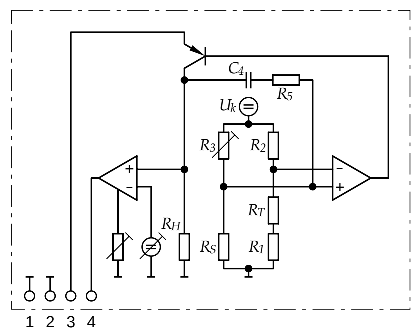
Application
Measurement of air-mass flow rate to provide data needed for clean combustion. Air-mass meters are suitable for use with other gaseous mediums.

Design and function
The sensor element comprises a ceramic substrate containing the following thick-film resistors which have been applied using silk-screen printing techniques: Air-temperature-sensor resistor R_ϑ, heater resistor R_H, sensor resistor R_S, and trimmer resistor R_1.
The heater resistor R_H maintains the platinum metallic-film resistor R_S at a constant temperature above that of the incoming air. The two resistors are in close thermal contact.
The temperature of the incoming air influences the resistor R_ϑ with which the trimmer resistor R_1 is connected in series. Throughout the complete operating-temperature range it compensates for the bridge circuit's temperature sensitivity. Together with R_2 and R_ϑ, R_1 forms one arm of the bridge circuit, while the auxiliary resistor R_3 and sensor resistor R_S form the other arm. The difference in voltage between the two arms is tapped off at the bridge diagonal and used as the measurement signal.
The evaluation circuit is contained on a second thick-film substrate. Both hybrids are integrated in the plastic housing of the plug-in sensor.
The hot-film air-mass meter is a thermal flowmeter. The film resistors on the ceramic substrate are exposed to the air mass under measurement. For reasons associated with flow, this sensor is far less sensitive to contamination than, for example, a hot-wire air-mass meter, and there is no need for the ECU to incorporate a self-cleaning burn-off function.

Characteristic curves.



Operating principle.

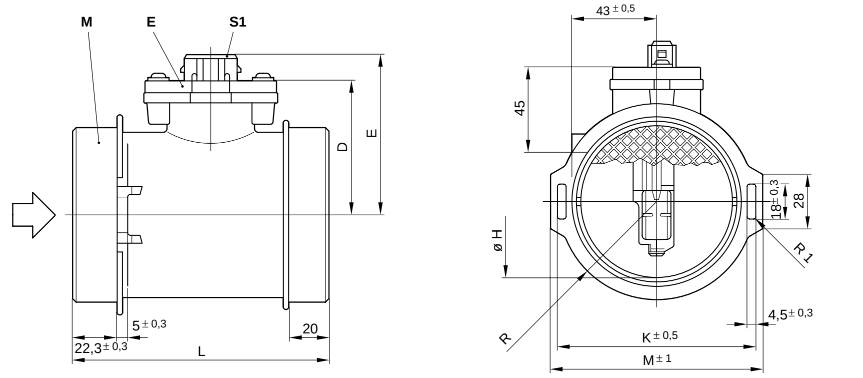


Technical data / Range

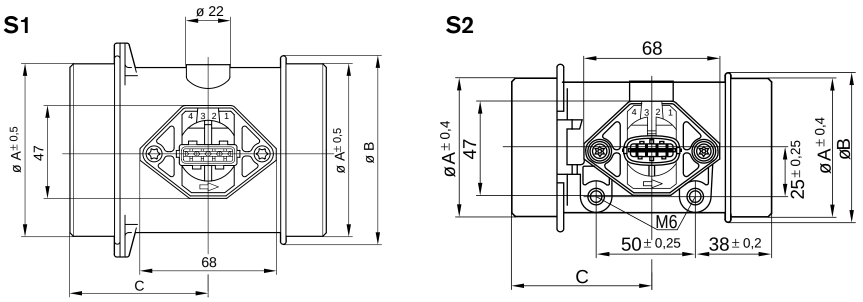
Part number		**0 280 217 102**	**0 280 217 120** **0 280 217 107**	**0 280 217 519**	**0 280 217 801**
Characteristic curve		1	2	3	4
Installation length L	mm	130	130 96	130	130
Air-flow measuring range	kg · h⁻¹	10...350	10...480	12...640	20...1080
Accuracy referred to measured value	%	±4	±4	±4	±4
Supply voltage	V	14	14	14	14
Input current					
at 0 kg · h⁻¹	A	≤ 0,25	≤ 0,25	≤ 0,25	≤ 0,25
at $Q_{m\ nom.}$	A	≤ 0,8	≤ 0,8	≤ 0,8	≤ 0,8
Time constant [1])	ms	≤20	≤20	≤20	≤20
Temperature range					
Sustained	°C	–30...+110	–30...+110	–30...+110	–30...+110
Short-term	°C	–40...+125	–40...+125	–40...+125	–40...+125
Pressure drop at nominal air mass hPa	mbar	<15	<15	<15	<15
Vibration acceleration max.	m · s⁻²	150	150	150	150

[1]) In case of sudden increase of the air-mass flow from 10 kg · h⁻¹ auf 0.7 $Q_{m\ nominal}$, time required to reach 63% of the final value of the air-mass signal.

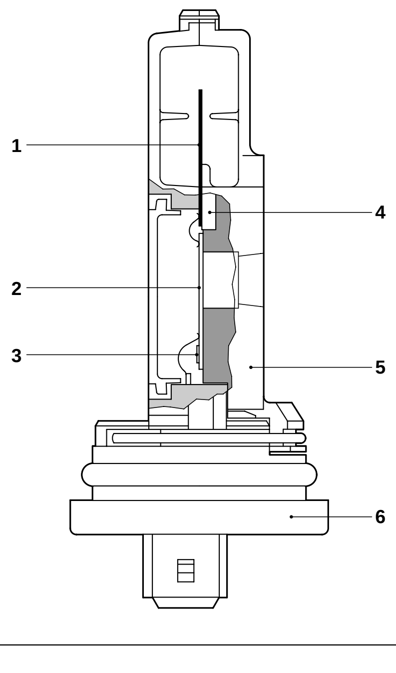
Dimension drawings.
E Plug-in sensor, **M** Measurement venturi, S1/S2 Plug connection



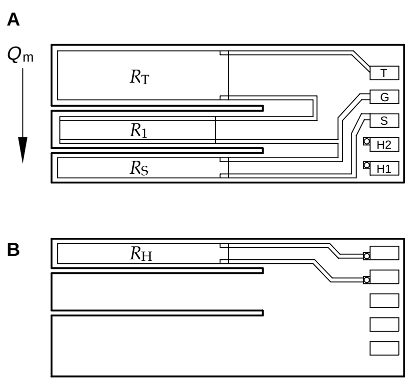
Ø A	Ø B	C	D	E	H	K	L	M	R	Measure-ment venturi	Plug-in connection	Part number
60	66	70	73	86	33	75	130	82	37	KS	S1	**0 280 217 102**
70	76	50	69	82	34.8	–	96	–	42	KS	S1	**0 280 217 107**
70	76	70	69	82	33.5	85	130	92	42	KS	S2	**0 280 217 120**
80	86	70	73	86	39	–	130	–	–	KS	S2	**0 280 217 519**
95.6	102	70	76.2	91.2	45	110	130	117	54	Alu	S1	**0 280 217 801**



Plug-in sensor.
1 Sensor, **2** Hybrid, **3** Power module,
4 Mounting plate, **5** Heat sink, **6** Plug housing



Sensor element with thick-film resistors.
Q_M Mass rate of flow, R_1 Trimmer resistor,
R_H Heater resistor, R_S Sensor resistor,
R_T Air-temperature measuring resistor,
A Front, **B** Rear



Installation instructions

Water and other liquids must not collect in the measurement venturi. The measurement venturi must therefore be inclined by at least 5° relative to the horizontal. Since care must be taken that the intake air is free of dust, it is imperative that an air filter is fitted.

Explanation of symbols:

R_1 Trimmer resistor
R_2, R_3 Auxiliary resistors
R_5, C_4 RC element
R_H Heater resistor
R_S Platinum metal-film resistor
R_T Resistance of the air-temperature-sensor resistor
U_K Bridge supply voltage
U_A Output voltage
U_V Supply voltage

Connector-pin assignment

Pin 1 Ground
Pin 2 U_A (–)
Pin 3 U_V
Pin 4 U_A (+)

Accessories

For 0 280 217 102, .. 107, .. 801

Plug housing	**1 284 485 118**
Receptacle	**1 284 477 121** [1])
Protective cap	**1 280 703 023** [1])

Each 4-pole plug requires 1 plug housing, 4 receptacles, and 1 protective cap.
[1]) Quantity 5 per package

For 0 280 217 120, .. 519

Desig-nation	For conductor cross-section	Part number
Plug housing	–	**1 928 403 112**
Contact pin	0.5...1.0 mm²	**1 987 280 103**
	1.5...2.5 mm²	**1 987 280 105**
Individual gasket	0.5...1.0 mm²	**1 987 280 106**
	1.5...2.5 mm²	**1 987 280 107**

Each 4-pole plug requires 1 plug housing, 4 contact pins, and 4 individual gaskets.

Note

For automotive applications, original AMP crimping tools must be used.

“Lambda” oxygen sensors, Type LSM 11

For measuring the oxygen content

λ / U

● Principle of the galvanic oxygen concentration cell with solid electrolyte permits measurement of oxygen concentration, for instance in exhaust gases.
● Sensors with output signal which is both stable and insensitive to interference, as well as being suitable for extreme operating conditions.

Application

Combustion processes
– Oil burners
– Gas burners
– Coal-fired systems
– Wood-fired systems
– Bio refuse and waste
– Industrial furnaces

Engine-management systems
– Lean-burn engines
– Gas engines
– Block-type thermal power stations

Industrial processes
– Packaging machinery and installations
– Process engineering
– Drying plants
– Hardening furnaces
– Metallurgy (steel melting)
– Chemical industry (glass melting)

Measuring and analysis processes
– Smoke measurement
– Gas analysis
– Determining the Wobb index

Range

Sensor	
Total length = 2500 mm	**0 258 104 002***
Total length = 650 mm	**0 258 104 004**

* Standard version

Accessories

Connector for heater element	
Plug housing	**1 284 485 110**
Receptacles [1]	**1 284 477 121**
Protective cap	**1 250 703 001**

Connector for the sensor	
Coupler plug	**1 224 485 018**
Blade terminal [1]	**1 234 477 014**
Protective cap	**1 250 703 001**

Special grease for the screw-in thread	
Tin 120 g	**5 964 080 112**

[1]) 5 per pack
2 needed in each case

Special accessories

Please enquire regarding analysing unit LA2. This unit processes the output signals from the Lambda oxygen sensors listed here, and displays the Lambda values in digital form. At the same time, these values are also made available at an analog output, and via a multislave V24 interface.

Installation instructions

The Lambda sensor should be installed at a point which permits the measurement of a representative exhaust-gas mixture, and which does not exceed the maximum permissible temperature. The sensor is screwed into a mating thread and tightened with 50…60 N · m.

– Install at a point where the gas is as hot as possible.
– Observe the maximum permissible temperatures.
– As far as possible install the sensor vertically, whereby the electrical connections should point upwards.
– The sensor is not to be fitted near to the exhaust outlet so that the influence of the outside air can be ruled out. The exhaust-gas passage opposite the sensor must be free of leaks in order to avoid the effects of leak-air.
– Protect the sensor against condensation water.
– The sensor body must be ventilated from the outside in order to avoid overheating.
– The sensor is not to be painted, nor is wax to be applied or any other forms of treatment. Only the recommended grease is to be used for lubricating the threads.
– The sensor receives the reference air through the connection cable. This means that the connector must be clean and dry. Contact spray, and anti-corrosion agents etc. are forbidden.
– The connection cable must not be soldered. It must only be crimped, clamped, or secured by screws.

Technical data

Application conditions	
Temperature range, passive (storage-temperature range)	–40…+100 °C
Sustained exhaust-gas temperature with heating switched on	+150…+600 °C
Permissible max. exhaust-gas temperature with heating switched on (200 h cumulative)	+800 °C
Operating temperature	
of the sensor-housing hexagon	≤ +500 °C
At the cable gland	≤ +200 °C
At the connection cable	≤ +150 °C
At the connector	≤ +120 °C
Temperature gradient at the sensor-ceramic front end	≤ +100 K/s
Temperature gradient at the sensor-housing hexagon	≤ +150 K/s
Permissible oscillations at the hexagon	
Stochastic oscillations – acceleration, max.	≤ 800 m · s^{-2}
Sinusoidal oscillations – amplitude	≤ 0.3 mm
Sinusoidal oscillations – acceleration	≤ 300 m · s^{-2}
Load current, max.	±1 µA

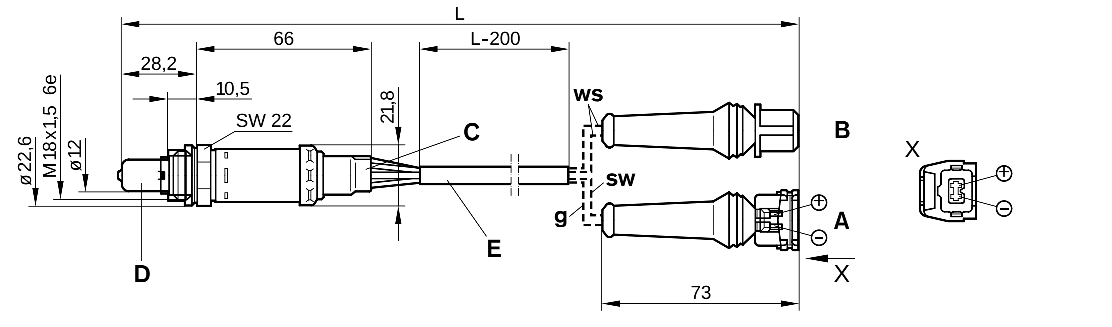
Heater element	
Nominal supply voltage (preferably AC)	12 V_{eff}
Operating voltage	12…13 V
Nominal heating power for ϑ_{Gas} = 350 °C and exhaust-gas flow speed of ≈ 0.7 m · s^{-1} at 12 V heater voltage in steady state	≈ 16 W
Heater current at 12 V steady state	≈ 1.25 A
Insulation resistance between heater and sensor connection	> 30 MΩ

Data for heater applications	
Lambda control range λ	1.00…2.00
Sensor output voltage for λ = 1.025…2.00 at ϑ_{Gas} = 220 °C and a flow rate of 0.4…0.9 m · s^{-1}	68…3.5 mV 2)
Sensor internal resistance R_i~ in air at 20 °C and at 12 V heater voltage	≤ 250 Ω
Sensor voltage in air at 20 °C in as-new state and at 13 V heater voltage	–9...–15 mV 3)
Manufacturing tolerance $\Delta\lambda$ in as-new state (standard deviation 1 s) at ϑ_{Gas} = 220 °C and a flow rate of approx. 0.7 m · s^{-1}	
at λ = 1.30	≤ ±0.013
at λ = 1.80	≤ ±0.050
Relative sensitivity $\Delta U_S/\Delta\lambda$ at λ = 1.30	0.65 mV/0.01
Influence of the exhaust-gas temperature on sensor signal for a temperature increase from 130 °C to 230 °C, at a flow rate ≤ 0.7 m · s^{-1} at λ = 1.30; $\Delta\lambda$	≤ ±0.01
Influence of heater-voltage change ±10 % of 12 V at ϑ_{Gas} = 220 °C	
at λ = 1.30; $\Delta\lambda$	≤ ±0.009
at λ = 1.80; $\Delta\lambda$	≤ ±0.035
Response time at ϑ_{Gas} = 220 °C and approx. 0.7 m · s^{-1} flow rate As-new values for the 66% switching point; λ jump = 1.10 ↔ 1.30	
for jump in the “lean” direction	2.0 s
for jump in the “rich” direction	1.5 s
Guideline value for sensor’s “readines for control” point to be reached after switching on oil burner and sensor heater; ϑ_{Gas} ≈ 220 °C; flow rate approx. 1.8 m · s^{-1}; λ = 1.45; sensor in exhaust pipe dia. 170 mm	70 s
Sensor ageing $\Delta\lambda$ in heating-oil exhaust gas after 1,000 h continuous burner operation with EL heating oil; measured at ϑ_{Gas} = 220 °C	
at λ = 1.30	≤ ±0.012
at λ = 1.80	≤ ±0.052
Useful life for ϑ_{Ga} < 300 °C	In individual cases to be checked by customer; guideline value > 10,000 h

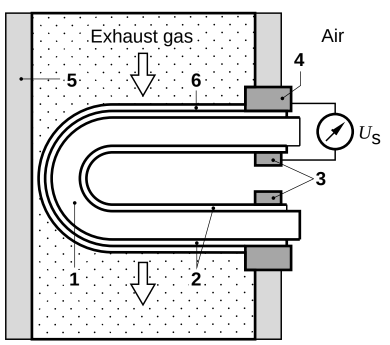
2) See characteristic curves. 3) Upon request –8.5...–12 mV.

Warranty claims
In accordance with the general Terms of Delivery A17, warranty claims can only be accepted under the conditions that permissible fuels were used. That is, residue-free, gaseous hydrocarbons and light heating oil in accordance with DIN 51 603.

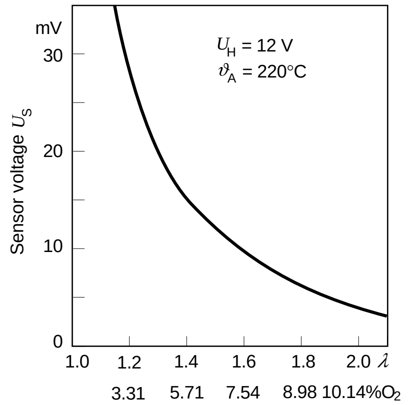
Dimension drawing.
A Signal voltage, **B** Heater voltage, **C** Cable sleeve and seals, **D** Protective tube, **E** Protective sleeve, **L** Overall length. **ws** White, **sw** Black, **g** Grey.



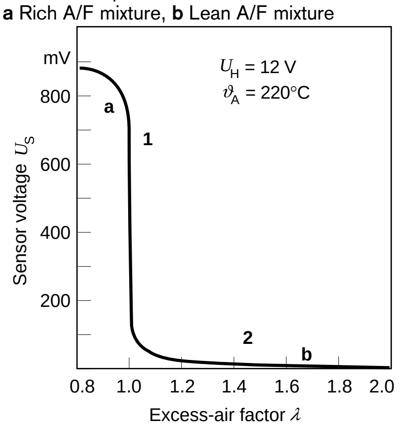
Lambda sensor in exhaust pipe (principle).
1 Sensor ceramic, **2** Electrodes, **3** Contact, **4** Housing contact, **5** Exhaust pipe, **6** Ceramic protective coating (porous).



Characteristic curve: Propane gas (lean range).



Characteristic curve: Complete range.
1 Closed-loop control λ = 1; **2** Lean control
a Rich A/F mixture, **b** Lean A/F mixture



Design and function

The ceramic part of the Lambda sensor (solid electrolyte) is in the form of a tube closed at one end. The inside and outside surfaces of the sensor ceramic have a microporous platinum layer (electrode) which, on the one hand, has a decisive influence on the sensor characteristic, and on the other, is used for contacting purposes. The platinum layer on that part of the sensor ceramic which is in contact with the exhaust gas is covered with a firmly bonded, highly porous protective ceramic layer which prevents the residues in the exhaust gas from eroding the catalytic platinum layer. The sensor thus features good long-term stability.
The sensor protrudes into the flow of exhaust gas and is designed such that the exhaust gas flows around one electrode, whilst the other electrode is in contact with the outside air (atmosphere). Measurements are taken of the residual oxygen content in the exhaust gas.
The catalytic effect of the electrode surface at the sensor's exhaust-gas end produces a step-type sensor-voltage profile in the area around λ = 1. [1])

The active sensor ceramic (ZrO_2) is heated from inside by means of a ceramic Wolfram heater so that the temperature of the sensor ceramic remains above the 350 °C function limit irrespective of the exhaust-gas temperature. The ceramic heater features a PTC characteristic, which results in rapid warm-up and restricts the power requirements when the exhaust gas is hot. The heater-element connections are completely decoupled from the sensor signal voltage (R ≥ 30 MΩ). Additional design measures serve to stabilize the lean characteristic-curve profile of the Type LSM11 Lambda sensor at λ > 1.0...1.5 (for special applications up to λ = 2.0):
– Use of powerful heater (16 W)
– Special design of the protective tube
– Modified electrode/protective-layer system.

[1]) The excess-air factor (λ) is the ratio between the actual and the ideal air/fuel ratio.

The special design permits:
– Reliable control even with low exhaust-gas temperatues (e.g. with engine at idle),
– Flexible installation unaffected by external heating,
– Function parameters practically independent of exhaust-gas temperature,
– Low exhaust-gas values due to the sensor's rapid dynamic response,
– Little danger of contamination and thus long service life,
– Waterproof sensor housing.

Explanation of symbols

U_S Sensor voltage
U_H Heater voltage
ϑ_A Exhaust-gas temperature
λ Excess-air factor [1])
O_2 Oxygen concentration in %

F. Actuadores

F.1 Inyector

Injection Valve EV 6

The development of the EV 6 took into account all the essential functional requirements which originate from injector operation in multipoint electronic fuel injection systems (EFI).

This resulted in: low weight, “dry” solenoid winding, plastic encapsulation, finely matched flow-rate classes, good valve-seat sealing, excellent hot-start capabilities, close tolerances of the specified functional values, high level of corrosion resistance and long service life.

Mechanical data	
System pressure	max. 8 bar
Weight	45, 8 g

Electrical data	
Solenoid resistance	e.g. 12 Ω
Max. power supply	16 V

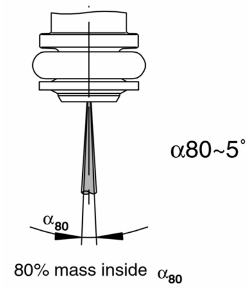
Conditions for use	
Fuel input	axial (top-feed)
Operating temperature	-40 ... 110°C
Permissible fuel temperatures	≤ 70°C
Climate proofness corresponds to saline DIN 53 167	fog test

Technical data

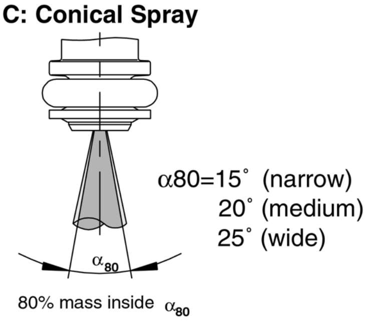
Order numbers	Design	Fuel type	Spray type	Flow rate at 3 bar (N-Heptan)	Spray angle α	Impedance
B 280 431 126	Standard	Gasoline	C	261,2 g/min	25°	12 Ω
B 280 431 127	Standard	Gasoline	C	261,2 g/min	70°	12 Ω
0 280 155 737	Long	Gasoline	C	261,2 g/min	15°	12 Ω
B 280 431 128	Standard	Gasoline	C	364,3 g/min	25°	12 Ω
B 280 431 129	Standard	Gasoline	C	364,3 g/min	70°	12 Ω
B 280 431 130	Standard	Gasoline	C	493,1 g/min	25°	1,2 Ω
B 280 431 131	Standard	Gasoline	C	493,1 g/min	70°	1,2 Ω
0 280 156 012	Standard	Gasoline	C	310,1 g/min	20°	12 Ω
B 280 434 499_01	Standard	Methanol	C	658 g/min	25°	12 Ω
B 280 434 499_02	Standard	Gasoline	C	658 g/min	25°	12 Ω

Further injection valves on request.

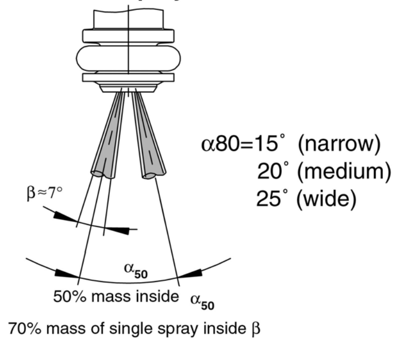
B: Pencil Beam



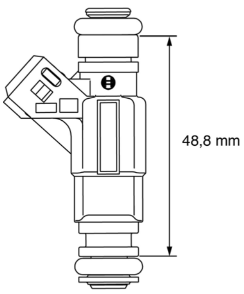
C: Conical Spray



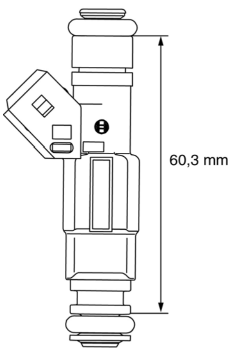
E: 2-Spray



standard

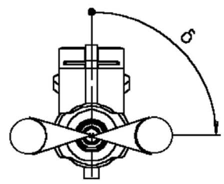


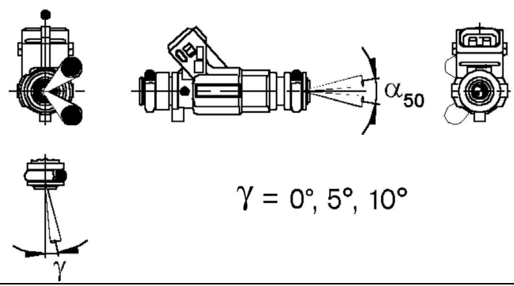
long



Angel between connection and spray level (δ = delta):
(only 2-spray preparation)

δ = 0°- 360° possible





F.2 Bobina independiente

Distributorless & Direct Ignition Systems Overview

Essentially, a Distributorless Ignition System is an ignition system without a distributor. Eliminating the distributor improved reliability by reducing the number of mechanical components. Other advantages are:

- Greater control over ignition spark generation - There is more time for the coil to build a sufficient magnetic field necessary to produce a spark that will ignite the air/fuel mixture. This reduces the number of cylinder misfires.
- Electrical interference from the distributor is eliminated - Ignition coils can be placed on or near the spark plugs. This helps eliminate electrical interference and improve reliability.
- Ignition timing can be controlled over a wider range - In a distributor, if too much advance is applied the secondary voltage would be directed to the wrong cylinder.

All of the above reduces the chances of cylinder misfires and consequently, exhaust emissions.

Distributorless Ignition System

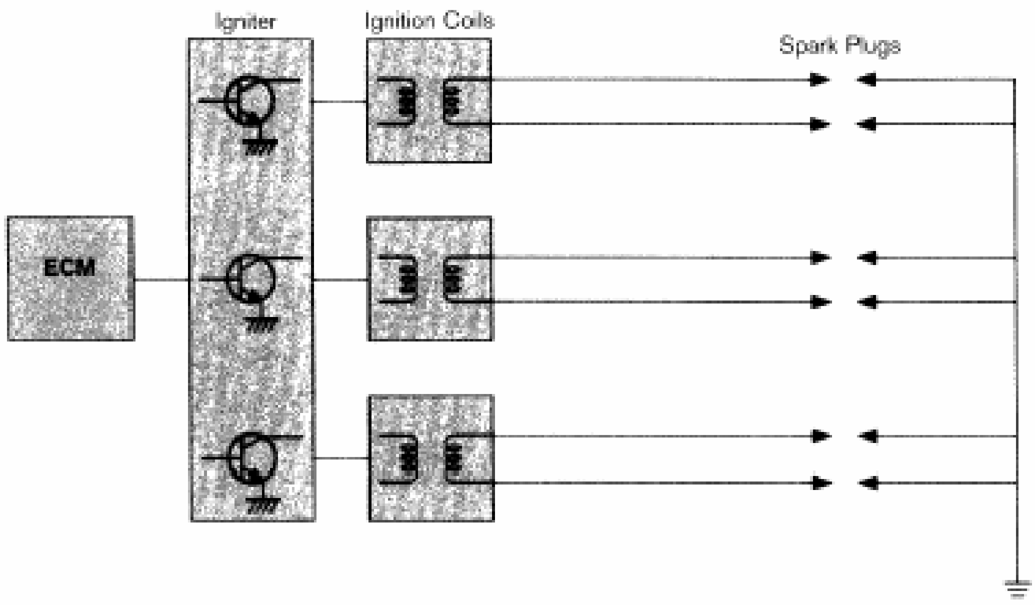


Fig. 3-31

Distributorless Ignition systems are usually defined as having one ignition coil with two spark plug wires for two cylinders. Distributorless Ignition Systems use a method called simultaneous ignition (also called waste spark) where an ignition spark is generated from one ignition coil for two cylinders simultaneously.

Direct Ignition System Independent Ignition

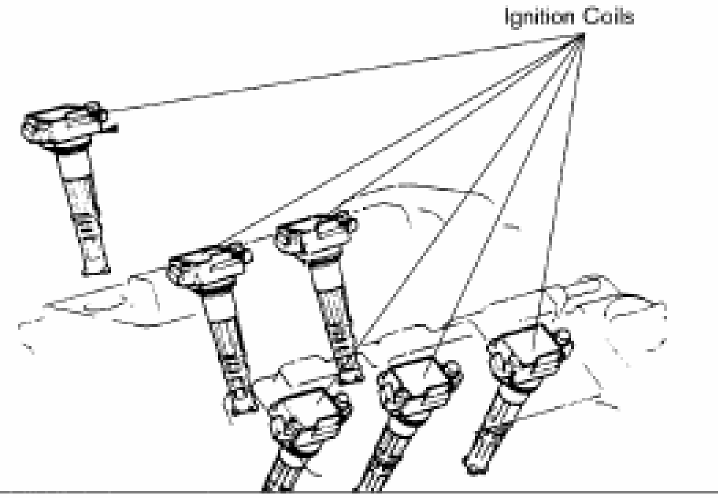


Fig. 3-32

Direct Ignition System Circuit

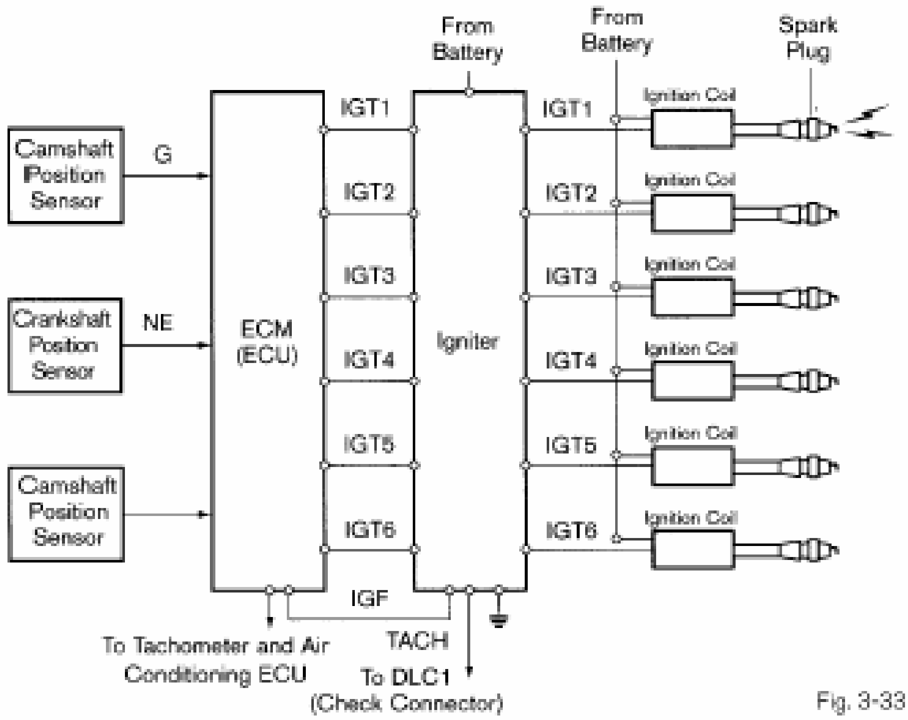


Fig. 3-33

Direct Ignition Systems (DIS) have the ignition coil mounted on the spark plug. DIS can come in two forms:

- **Independent ignition** - one coil per cylinder.
- **Simultaneous ignition** - one coil for two cylinders. In this system an ignition coil is mounted directly to one spark plug and a high tension cord is connected to the other spark plug. A spark is generated in both cylinders simultaneously.

Direct Ignition System (DIS) Simultaneous Ignition

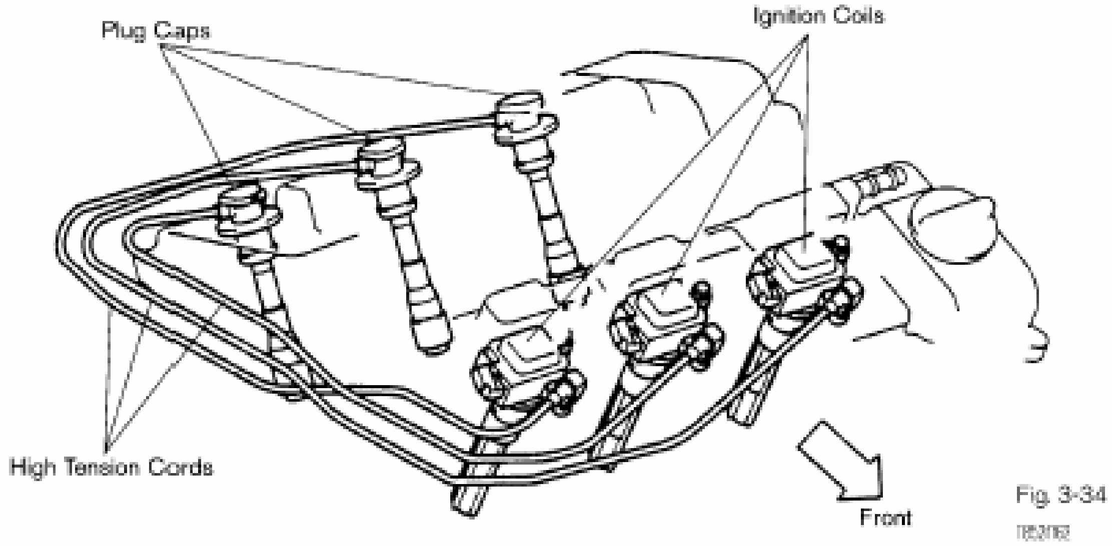


Fig. 3-34

Distributorless Ignition System Circuit

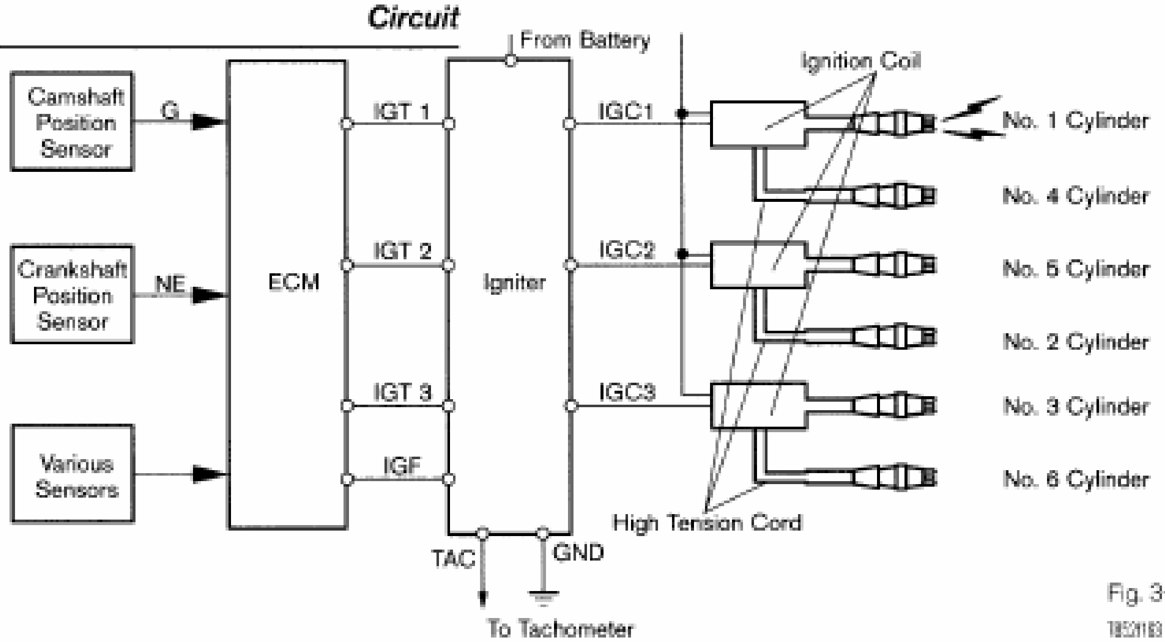


Fig. 3-35

Distributorless (Simultaneous Ignition) Operation

Distributorless Ignition Systems and Direct Ignition Systems that use one coil for two cylinders use a method known as simultaneous ignition. With simultaneous ignition systems, two cylinders are paired according to piston position. This has the effect simplifying ignition timing and reducing the secondary voltage requirement.

For example, on a V-6 engine, on cylinders one and four, the pistons occupy the same cylinder position (both are at TDC and BDC at the same time), and move in unison, but they are on different strokes. When cylinder one is on the compression stroke, cylinder four is on the exhaust stroke, and vice versa on the next revolution.

Simultaneous Ignition Sequence

Two cylinders simultaneously will have spark, though only one cylinder will be on the compression stroke. Note that cylinders 2 and 5 both have spark, but cylinder No. 5 is compression. One crankshaft revolution later cylinder No. 3 is on compression.

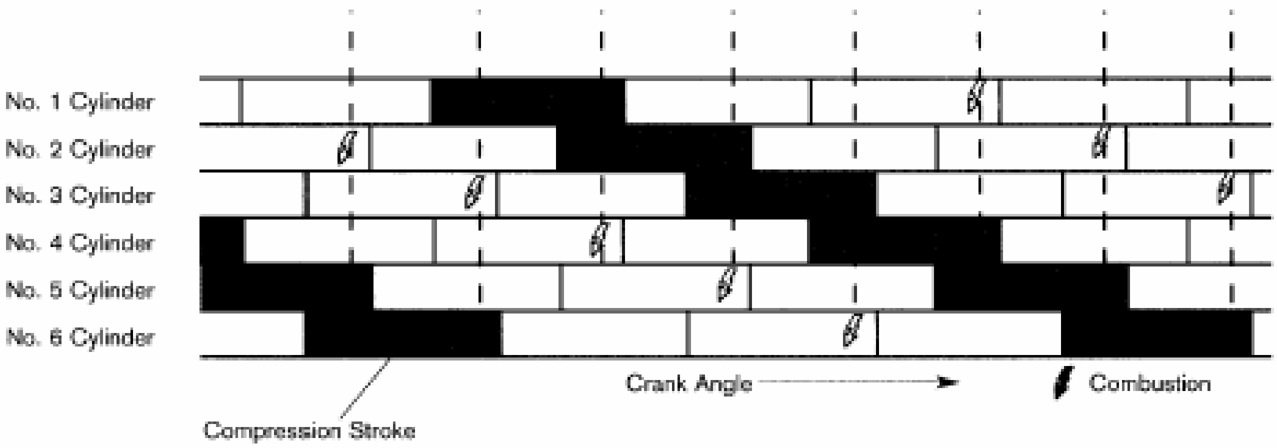


Fig. 3-36

The high voltage generated in the secondary winding is applied directly to each spark plug. In one of the spark plugs, the spark passes from the center electrode to the side electrode, and at the other spark plug the spark is from the side to the center electrode.

Simultaneous Ignition Current Flow

One spark plug will always have the spark going from the center to side electrode, the other spark plug from the side to center electrode.

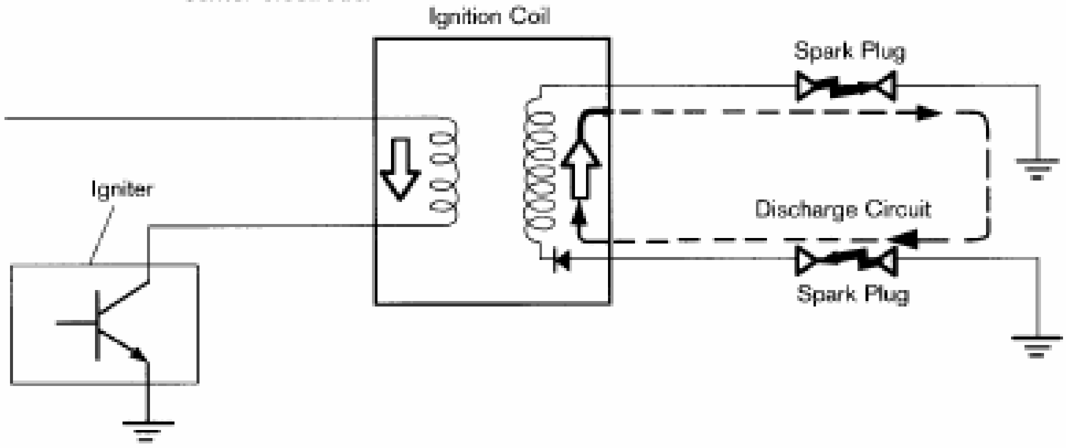


Fig. 3-37

Typically, the spark plugs with this style of ignition system are platinum tipped for stable ignition characteristics.

The voltage necessary for a spark discharge to occur is determined by the spark plug gap and compression pressure. If the spark plug gap between both cylinders is equal, then a voltage proportional to the cylinder pressure is required for discharge. The high voltage generated is divided according to the relative pressure of the cylinders. The cylinder on compression will require and use more of the voltage discharge than the cylinder on exhaust. This is because the cylinder on the exhaust stroke is nearly at atmospheric pressure, so the voltage requirement is much lower.

When compared to a distributor ignition system, the total voltage requirement for distributorless ignition is practically the same. The voltage loss from the spark gap between the distributor rotor and cap terminal, is replaced by the voltage loss in the cylinder on the exhaust stroke in the Distributorless Ignition System.

Direct Ignition System (DIS)

As DIS has evolved, there have been changes to the function and location of the igniter. With independent ignition DIS, there may be one igniter for all cylinders or one igniter per cylinder. On simultaneous ignition DIS there is one igniter for all coils. The following gives an overview of the different types used on various engines.

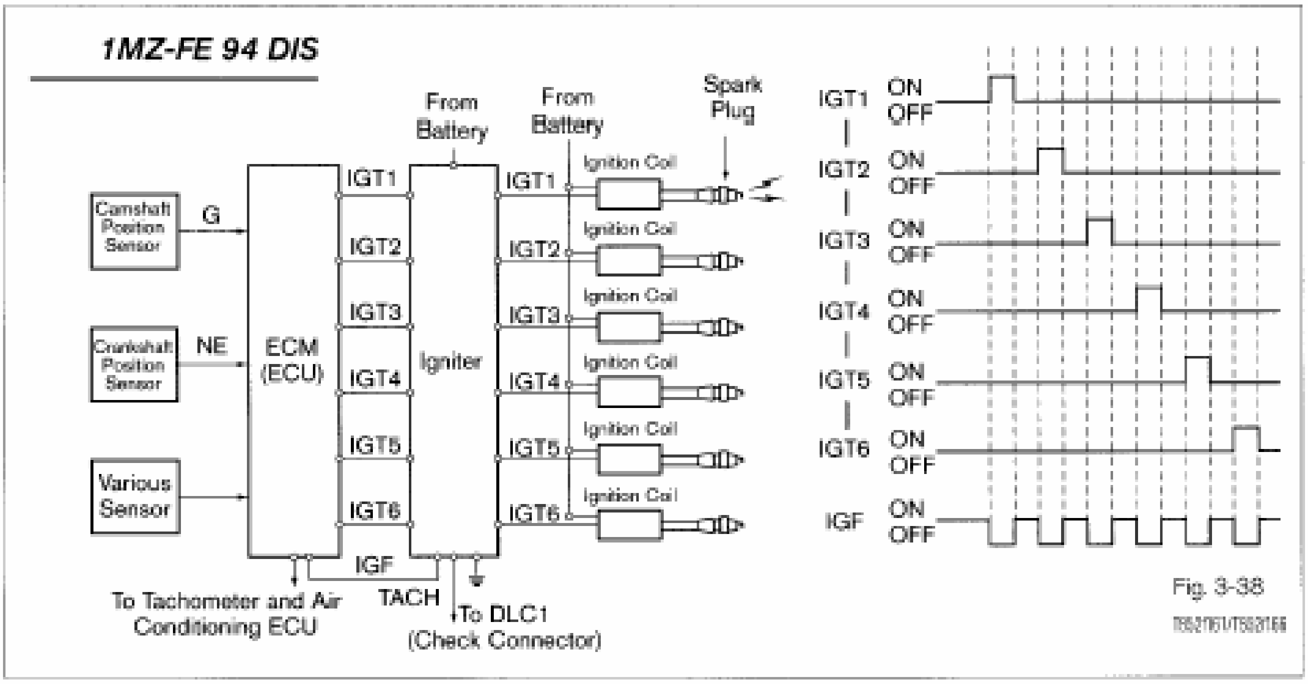


Fig. 3-38

1 MZ-FE 94 DIS

This DIS uses one igniter for all coils. The IGF signal goes low when IGT is turned on. The coils in this system use a high voltage diode for rapid cutoff of secondary ignition. If a coil is suspected of being faulty, swap with another coil.

1MZ-FE 94 DIS Igniter

With one igniter for all coils, there are 6 IGT signal wires used to signal the igniter. Primary current flows through the IGC wires.

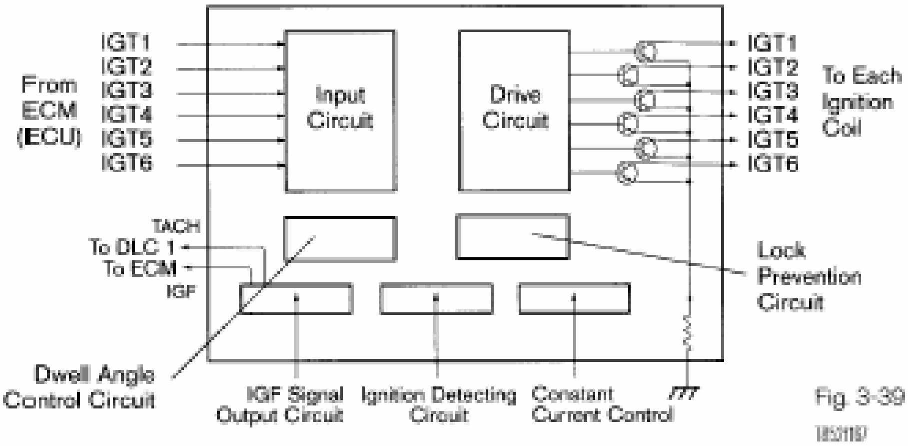


Fig. 3-39

Ignition Coil with Diode

With the diode in the circuit, it is recommended to swap coils to test for a faulty coil.

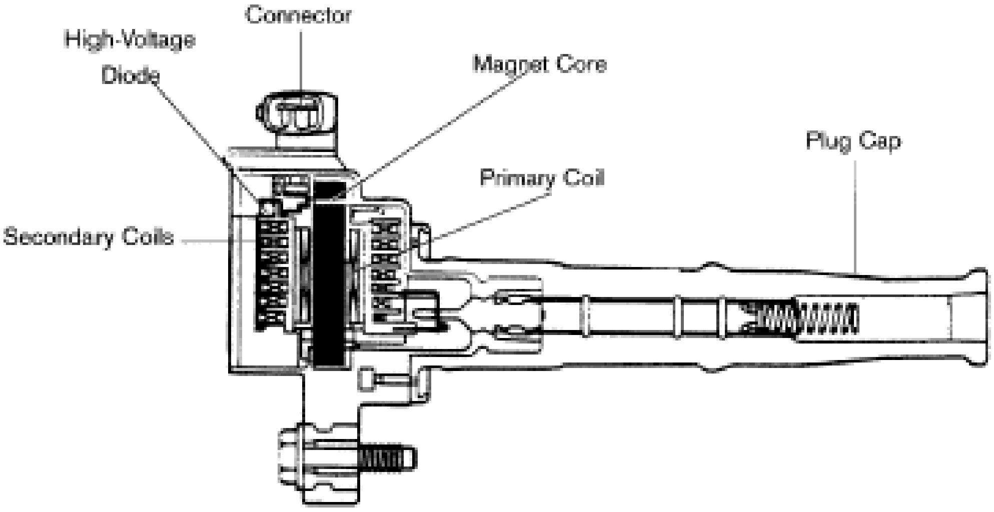


Fig. 3-40

T852f108

High Voltage Diode

The diode is in the secondary circuit.

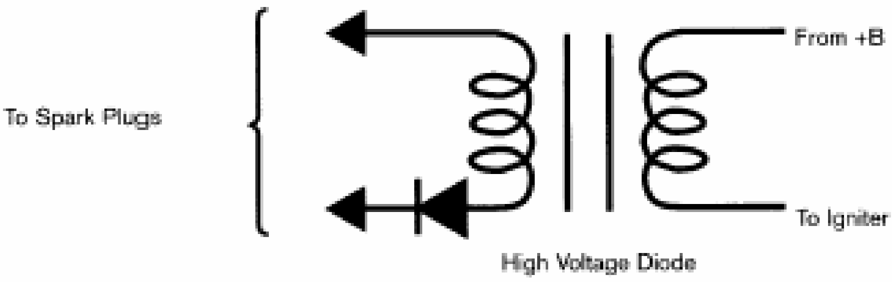


Fig. 3-41

T852f109

1 MZ-FE with DIS Simultaneous Ignition
This system uses three IGT signals to trigger the ignition coils in the proper sequence. When a coil is turned on, IGF goes low.

1MZ-FE with DIS
Simultaneous Ignition

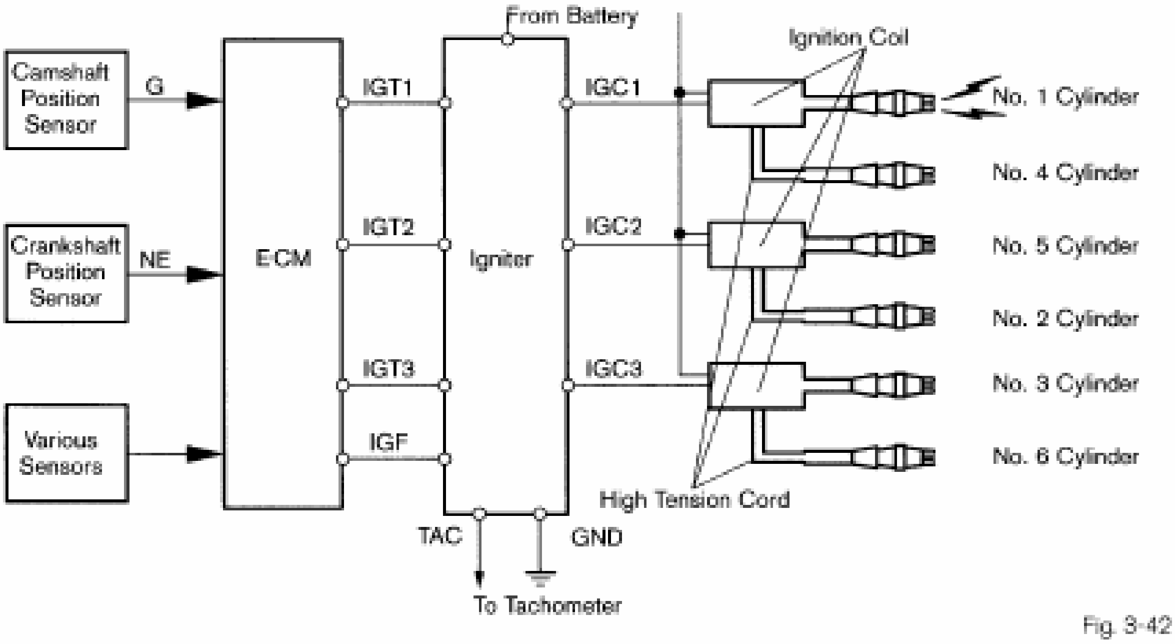


Fig. 3-42

Igniter

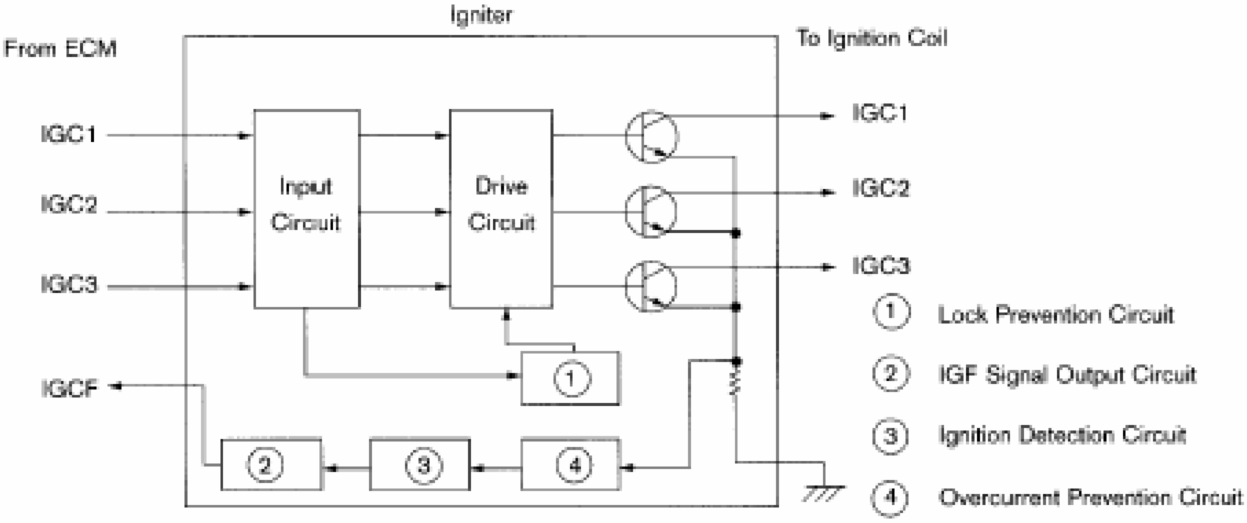


Fig. 3-43

V-6 Igniter Sequence

When a coil is turned on, IGF goes low.

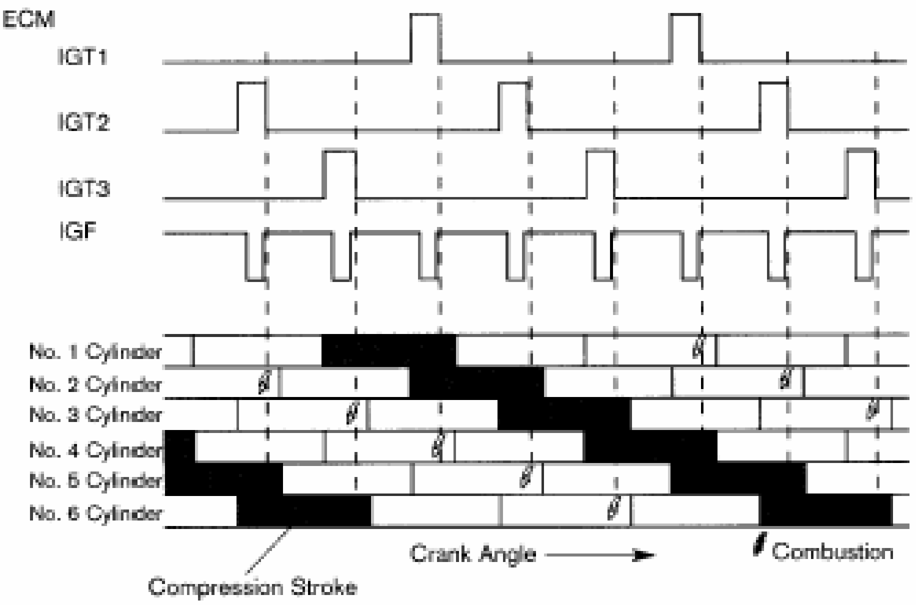


Fig. 3-44

T852f164

In-Line 6 Cylinder

The in-line 6 has a different firing order and cylinders are paired differently.

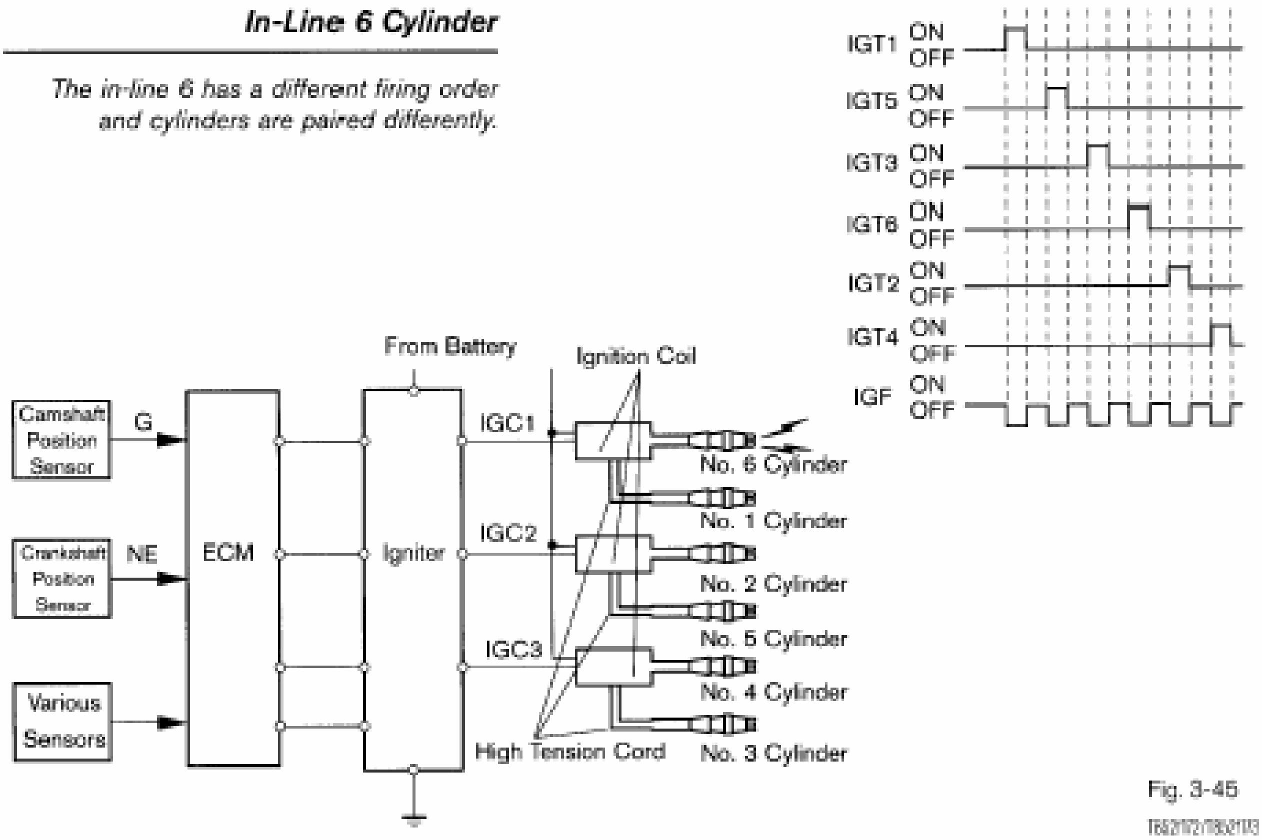


Fig. 3-45

T852f172/T852f173

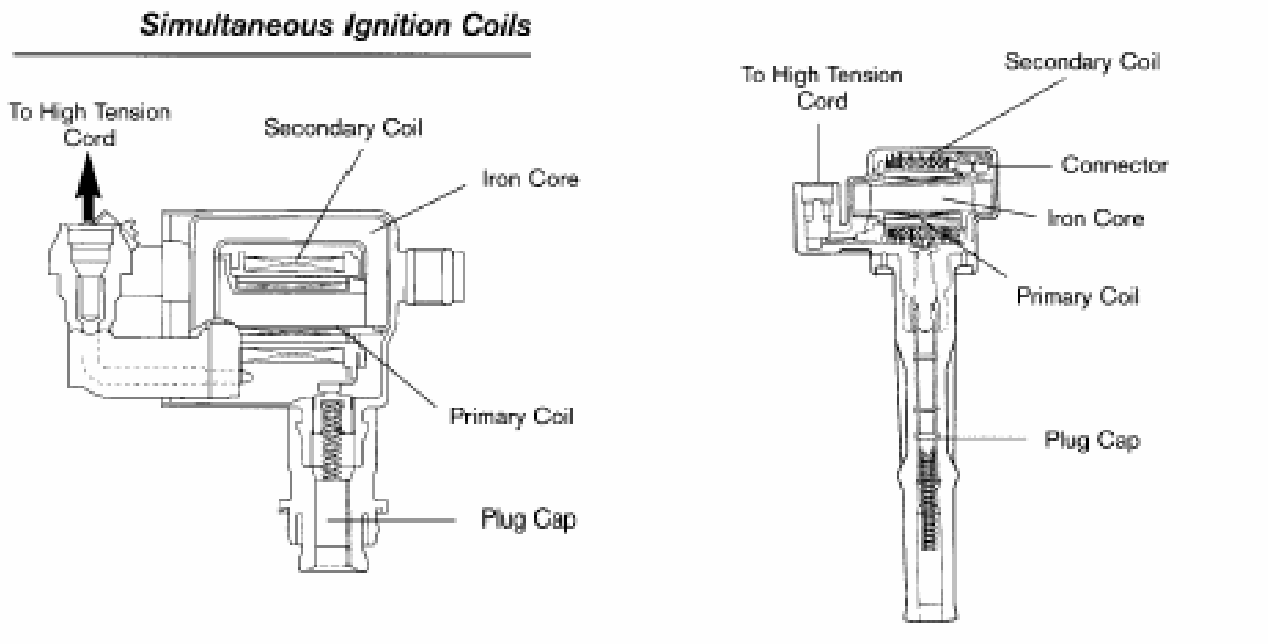


Fig. 3-46

TL652f104/TL652f105

DIS with Independent Ignition

The DIS with independent ignition has the igniter built into the coil. Typically, there are four wires that make up the primary side of the coil:

- +13.
- IGT signal.
- IGF signal.
- Ground.

The ECM is able to distinguish which coil is not operating based on when the IGF signal is received. Since the ECM knows when each cylinder needs to be ignited, it knows from which coil to expect the IGF signal.

The major advantages of DIS with independent ignition are greater reliability and less chance of cylinder misfire.

