

# DATA SHEET

**SA5777A**

Dual air-core gauge driver

Product specification  
Supersedes data of 1997 Feb 24

1999 Sep 20

# Dual air-core gauge driver

# SA5777A

## DESCRIPTION

The SA5777A is a monolithic driver for controlling air-core (or differential) meters typically used in automotive instrument cluster applications. The circuit interfaces with a microprocessor through a serial bus and directly drives the air-core meter. The SA5777A has 10-bit resolution (0.35 degree) and is guaranteed to be monotonic. Data can be shifted through the part, allowing several SA5777As to be cascaded with only one chip-select line. On-chip current shut down logic protects the circuit from external faults.

## FEATURES

- 10-Bit resolution (0.35 degrees)
- Exceptional accuracy (0.5 degrees, typical)
- High-torque capability
- Active differential drivers eliminate back-EMF issues
- No RFI/EMI generation issues
- Simple serial interface
- Simple cascading capability for multiple meters
- Internal fault protection
- Only one external component required (bypass capacitor)

## APPLICATION

- Instrumentation utilizing air-core meters

## PIN CONFIGURATION

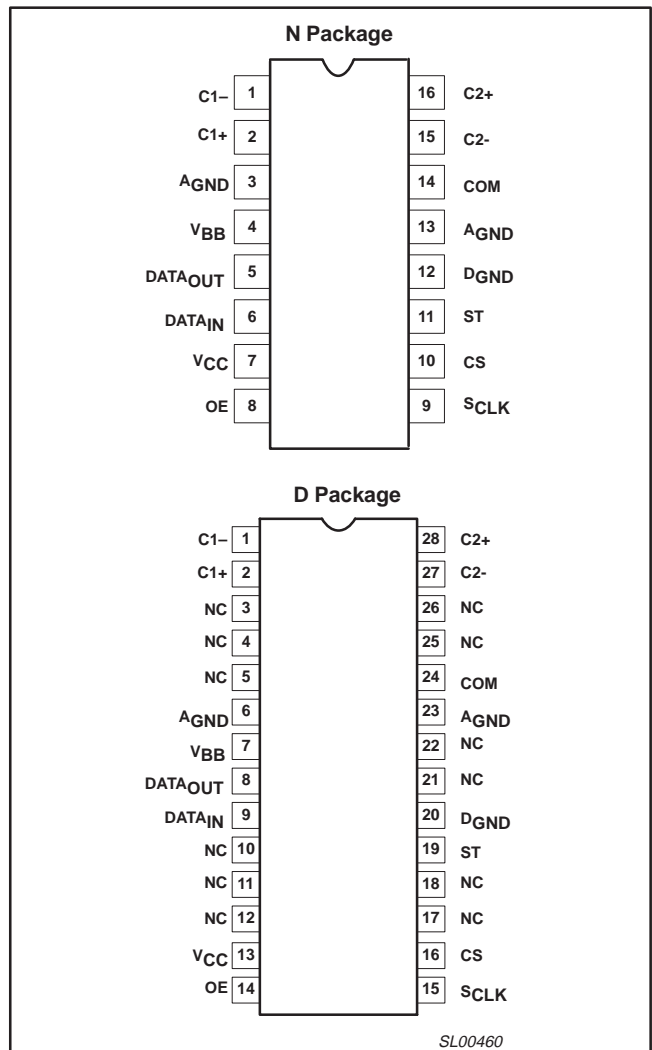


Figure 1. Pin configuration

## ORDERING INFORMATION

DESCRIPTION	TEMPERATURE RANGE	ORDER CODE	DWG #
16-Pin Plastic Dual In-Line Package (DIP)	-40 to +85°C	SA5777AN	SOT38-4
28-Pin Plastic Small Outline Package (SO)	-40 to +85°C	SA5777AD	SOT136-1

# Dual air-core gauge driver

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## BLOCK DIAGRAM

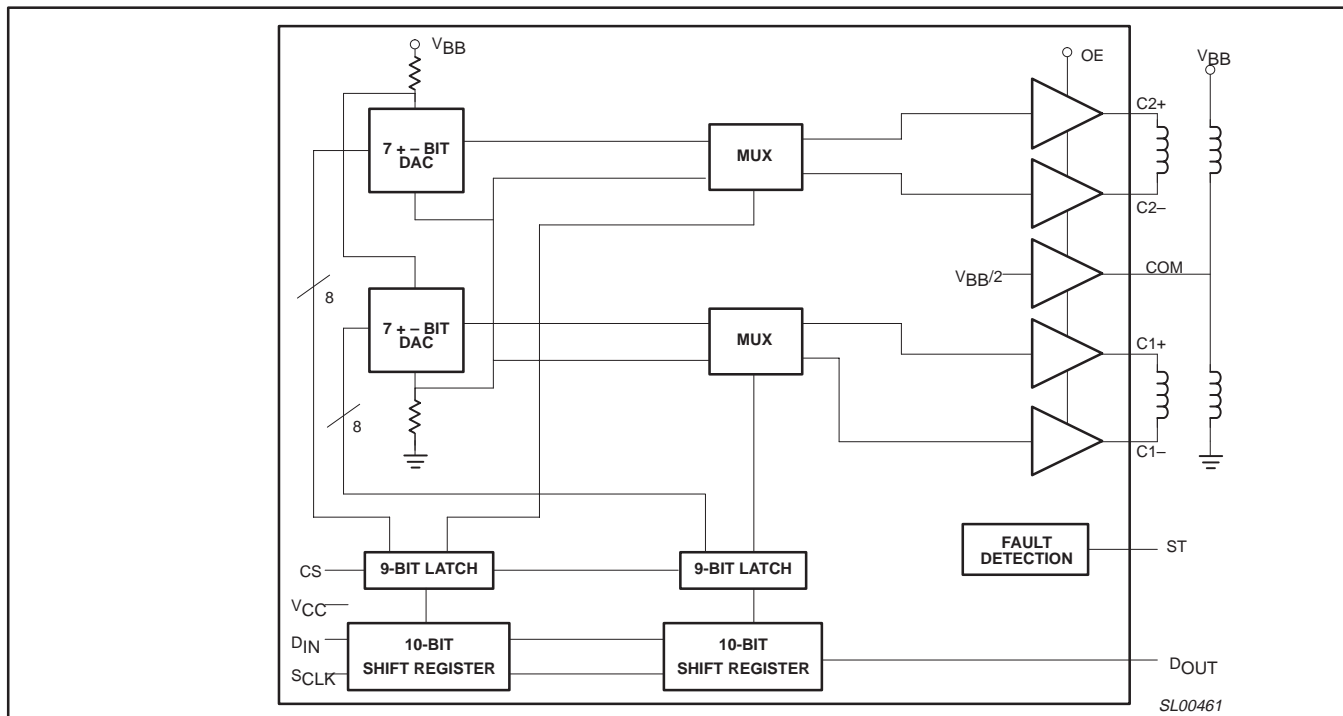


Figure 2. Block diagram

Table 1. SA5777A Pin Descriptions for the N Package (Dual In-Line)

Pin #	Name	Function
1.	C1-	Negative output connection to the TAN coil of meter #1.
2.	C1+	Positive output connection to the TAN coil of meter #1.
3.	AGND	Ground for V <sub>BB</sub> supply. Pins 3, 12 and 13 should be connected on the circuit board.
4.	V <sub>BB</sub>	Analog supply. Nominally 13.5 V.
5.	DATA <sub>OUT</sub>	Serial data output. Output of the internal shift register. When a new data word is shifted in, the old word is shifted out the DATA <sub>OUT</sub> pin. DATA <sub>OUT</sub> output is always active.
6.	DATA <sub>IN</sub>	Serial data input. A new data word is serially shifted into the part on the rising edge of S <sub>CLK</sub> . The data is shifted in MSB first, gauge 1 first.
7.	V <sub>CC</sub>	5 V logic supply. The internal latches and registers are set to zero on the rising edge of this signal.
8.	OE	Output drivers are turned off when this input is low.
9.	S <sub>CLK</sub>	Serial clock input. Data is loaded into the part on the rising edge of S <sub>CLK</sub> . Data is shifted out of DATA <sub>OUT</sub> on the falling edge of S <sub>CLK</sub> .
10.	CS	Active high chip select input. When CS is high, the part is enabled to receive a new serial input word. The high-to-low transition of CS loads the new 20-bit word into the DAC registers and updates the output.
11.	ST	Status output. This is an open drain output and goes low when the coil output buffers (C1+, C1-, C2+, C2-, COM) have been disabled. The coil outputs may be disabled due to shorted outputs, over-temperature conditions, power-on reset, or by the output enable (OE) pin. Multiple status outputs, ST, may be wire OR'ed together.
12.	DGND	Ground for V <sub>CC</sub> supply. Connect to Pins 3 and 13.
13.	AGND	Ground for V <sub>BB</sub> supply. Connect to Pins 3 and 12.
14.	COM	Output drive for biased coils. This output will be 1/2 of V <sub>BB</sub> .
15.	C2-	Negative output connection to the TAN coil of meter #2.
16.	C2+	Positive output connection to the TAN coil of meter #2.

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Table 2. SA5777A Pin Descriptions for the D Package (Small Outline)

Pin #	Name	Function
1.	C1-	Negative output connection to the TAN coil of meter #1.
2.	C1+	Positive output connection to the TAN coil of meter #1.
3.	NC	No connect
4.	NC	No connect
5.	NC	No connect
6.	A <sub>GND</sub>	Ground for V <sub>BB</sub> supply. Pins 6, 20 and 23 should be connected on the circuit board.
7.	V <sub>BB</sub>	Analog supply. Nominally 13.5 V.
8.	DATA <sub>OUT</sub>	Serial data output. Output of the internal shift register. When a new data word is shifted in, the old word is shifted out the DATA <sub>OUT</sub> pin. DATA <sub>OUT</sub> output is always active.
9.	DATA <sub>IN</sub>	Serial data input. A new data word is serially shifted into the part on the rising edge of S <sub>CLK</sub> . The data is shifted in MSB first, gauge 1 first.
10.	NC	No connect
11.	NC	No connect
12.	NC	No connect
13.	V <sub>CC</sub>	5 V logic supply. The internal latches and registers are set to zero on the rising edge of this signal.
14.	OE	Output drivers are turned off when this input is low.
15.	S <sub>CLK</sub>	Serial clock input. Data is loaded into the part on the rising edge of S <sub>CLK</sub> . Data is shifted out of DATA <sub>OUT</sub> on the falling edge of S <sub>CLK</sub> .
16.	CS	Active high chip select input. When CS is high, the part is enabled to receive a new serial input word. The high-to-low transition of CS loads the new 20-bit word into the DAC registers and updates the output.
17.	NC	No connect
18.	NC	No connect
19.	ST	Status output. This is an open drain output and goes low when the coil output buffers (C1+, C1-, C2+, C2-, COM) have been disabled. The coil outputs may be disabled due to shorted outputs, over-temperature conditions, power-on reset, or by the output enable (OE) pin. Multiple status outputs, ST, may be wire OR'ed together.
20.	D <sub>GND</sub>	Ground for V <sub>CC</sub> supply. Connect to Pins 6 and 23.
21.	NC	No connect
22.	NC	No connect
23.	A <sub>GND</sub>	Ground for V <sub>BB</sub> supply. Connect to Pins 6 and 20.
24.	COM	Output drive for biased coils. This output will be 1/2 of V <sub>BB</sub> .
25.	NC	No connect
26.	NC	No connect
27.	C2-	Negative output connection to the TAN coil of meter #2.
28.	C2+	Positive output connection to the TAN coil of meter #2.

## ABSOLUTE MAXIMUM RATINGS

SYMBOL	PARAMETER	RATING	UNIT
V <sub>BB</sub>	Analog supply	-1 to +23	V
V <sub>CC</sub>	Digital supply	-1 to +6	V
V <sub>IN</sub>	Digital input voltage, Data In, OE, CS, S <sub>CLK</sub>	-1 to +6	V
D <sub>GND</sub> to A <sub>GND</sub>	Ground difference	±0.5	V
T <sub>A</sub>	Ambient operating temperature	-40 to +85	°C
T <sub>J</sub>	Junction temperature	150	°C
T <sub>STG</sub>	Storage temperature	-65 to +150	°C
P <sub>D</sub>	Power dissipation (T <sub>A</sub> = 25°C) <sup>1</sup> N, D packages	1500	mW
θ <sub>JA</sub>	DIP and SO packages	90	°C/W

## NOTE:

- For power dissipation ratings in still air, derate above 25°C at the following rates:  
N and D packages at 12mW/°C

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## DC ELECTRICAL CHARACTERISTICS

 $V_{BB} = 7.5$  to  $18$  V;  $V_{CC} = 4.5$  to  $5.5$  V;  $T_A = -40$  to  $+85^\circ\text{C}$ .

SYMBOL	PARAMETER	TEST CONDITIONS	LIMITS			UNIT
			MIN	TYP	MAX	
$V_{BB}$	Analog supply voltage		7.5		18	V
$I_{IGN}$	Analog supply current	$V_{IGN} = 18$ V no load $V_{BB} = 18$ V with load $R_{C1} = R_{C2} = R_{LMIN}$			30 235	mA
$I_{CC}$	Logic supply current	$V_{CC} = 5.5$ V			1.0	mA
$V_{OH}$	Output high voltage	Data out $I_{OH} = 800$ $\mu\text{A}$	$V_{CC} - 0.8$			
$V_{OL}$	Output low voltage	Data out $I_{OL} = 1.5$ mA			0.4	V
$V_{OL}$ Status		ST, $I_{OL} = 2.5$ mA			0.8	V
$I_{OH}$ Status		ST, $V_O$ (ST) = $V_{CC}$			25	$\mu\text{A}$
$V_{IH}$	Input high voltage	CS, $S_{CLK}$ , $DATA_{IN}$ , OE	$0.7 \times V_{CC}$			V
$V_{IL}$	Input low voltage	CS, $S_{CLK}$ , $DATA_{IN}$ , OE			$0.3 \times V_{CC}$	V
$I_{IH}$	Input high current	CS, $S_{CLK}$ , $DATA_{IN}$ , $V_{IN} = 0.7 \times V_{CC}$			1	$\mu\text{A}$
$I_{IL}$	Input low current	CS, $S_{CLK}$ , $DATA_{IN}$ , $V_{IN} = 0.3 \times V_{CC}$			1	$\mu\text{A}$
ACC	Output function accuracy <sup>2</sup>	$R_{C1} = R_{C2} = R_{LMIN}$			$\pm 1$	Degree
$I_{SD}$	Output shut-down current	C1+, C1-, C2+, C2-, COM				
		$I_{SINK}$ $V_{BB} = V_{BB} (MAX)$	85		500	mA
		$V_{BB} = V_{BB} (MIN)$	43		300	mA
		$I_{SOURCE}$ $V_{BB} = V_{BB} (MAX)$	85		500	mA
$V_{BB} = V_{BB} (MIN)$	43		300	mA		
$V_{DRIVE}$	Differential coil drive voltage <sup>1</sup>	$V_{BB} = V_{BB} (MAX)$ $R_L = R_L (MIN)$	$0.7 \times V_{BB}$		$0.8 \times V_{BB}$	V
$R_{LMIN}$	Minimum load resistance	$T_A = 85^\circ\text{C}$	215			$\Omega$
		$T_A = 25^\circ\text{C}$	171			$\Omega$
		$T_A = -40^\circ\text{C}$	138			$\Omega$
$V_{BIAS}$	Bias voltage <sup>3</sup>	IOB (Source or Sink) $R_L = R_L (MIN)$	$0.475 \times V_{BB}$		$0.525 \times V_{BB}$	V

## NOTE:

- $V_{DRIVE}$  is the maximum voltage that is applied across the coil, it is equal to (C1+) – (C1-) or (C2+) – (C2-).
- In reference to nominal values in Figure 4. (Based on 7+ bit DAC).

$$3. \text{ Output Angle } (\theta) = \tan^{-1} \left[ \frac{(C+) - (C-)}{V_{BB} - V_{BIAS}} \right]$$

## AC ELECTRICAL CHARACTERISTICS

 $V_{DD} = 7.5$  to  $18$  V;  $V_{CC} = 4.5$  to  $5.5$  V;  $T_A = -40$  to  $+85^\circ\text{C}$ .

SYMBOL	PARAMETER	TEST CONDITIONS	LIMITS			UNIT
			MIN	TYP	MAX	
$f_{SCLK}$	Input frequency				1.60	MHz
$T_{SCLKH}$	$S_{CLK}$ high time		175			ns
$T_{SCLKL}$	$S_{CLK}$ low time	$V_{CC} = 5.5$ V	175			ns
TRO	Output rise time DO	$0.75$ to $V_{CC} - 1.2$ V, $C_L = 90$ pF			75	ns
TFO	Output fall time DO	$V_{CC} - 1.2$ V to $0.75$ , $C_L = 90$ pF			75	ns
TSU	DI set-up time		75			ns
THI	DI hold time		75			ns
$T_{CSH}$	Time before first $S_{CLK}$ rising edge		75			ns
$T_{CSL}$	Time after last $S_{CLK}$ falling edge		75			ns

# Dual air-core gauge driver

# SA5777A

## FUNCTIONAL DESCRIPTION

The SA5777A dual air-core gauge driver logic Block Diagram shows the two 10-bit input shift registers and two 9-bit parallel latches, and two 7+ bit DACs. The MSB is a dummy bit required for compatibility with the SA5775A. The DACs generate output voltages that are offset within the supply rails to give the output buffers enough headroom to operate. With a 14 V supply, the typical output swing is from 1 V to 11.5 V. The MUX generates the two required quadrants by switching the 56° data from the DAC to the appropriate output buffer. The output buffers provide the necessary current to drive the air-core gauge. The output buffers are always connected to the coils and can sink and source sufficient current so that inductive kickback is eliminated during normal operation.

The primary function of the SA5777A IC is to generate the transfer function that maps an input code into the correct voltages for linearly controlling the coils of an air-core gauge display (Figure 3). The SA5777A has been implemented using the tangent drive algorithm. Therefore, one coil on each meter will be driven with an output approximating the tangent function, the other coils will be biased at 1/2  $V_{BB}$ . The internal DAC is designed to operate over a 7+ bit (56°) data range. An extended range can be achieved by changing the relationship between the bias coil and the driver coil. As the current through the bias coil is reduced, the full scale deflection is increased. Theoretically, this deflection could approach 180°, but practical limitations of accuracy, resolution, and torque restrict the full scale range to approximately 112° (Figure 4). This full scale range corresponds to a bias coil voltage of 0.5 x  $V_{BB}$  and a full scale tangent voltage of 0.744 x  $V_{BB}$ . The DAC has been tailored to

maintain the meter accuracy at this maximum deflection. The 0.5 x  $V_{BB}$  bias coil voltage is obtained by connecting the bias coils of the two meters in series across  $V_{BB}$ . This gives bias stability over temperature. The internal bias generator is used to offset any inaccuracies due to meter mismatches. This circuit receives commands via an internal serial data interface port which is SPI compatible. These parts can be serially cascaded with other SA5777A ICs and/or SA5775A ICs to interface signals in multi-chip systems. The SA5777A has a typical resolution of 0.35° over a full scale deflection of approximately 112° and is guaranteed to be monotonic. The input data is directly proportional to the displayed angle in degrees (Figure NO TAG). Input code 0 gives an output angle of 0°, code 319 (decimal) will generate a full scale output of 112.15°. Codes higher than decimal 319 will not be loaded into the DAC latches and will leave the coil output buffers unchanged. However, codes greater than 319 can be shifted through the SA5777A intact if other parts are cascaded. The SA5777A is capable of sourcing and sinking up to 100mA per differential driver to control either one or two air-core gauge displays directly.

On-chip overcurrent and thermal shut-down logic prevents the chip from overheating due to high current fault conditions. When a shut-down condition is detected, the protection circuit disables the coil output buffers (i.e., C1+, C1-, C2+, C2-, COM). The coil output buffers remain in this condition until the first falling edge of CS that occurs after the die temperature has decreased to about 140°C or the overcurrent condition has been removed. During shut-down, the digital portion of this IC continues to operate normally.

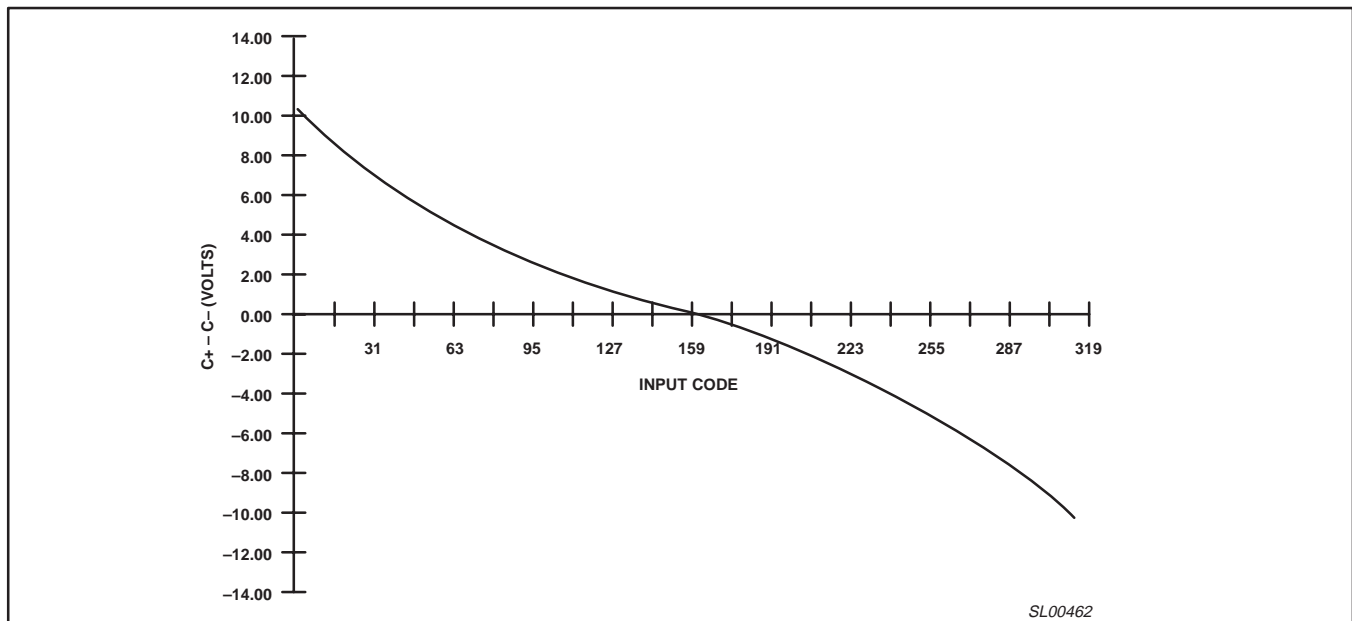


Figure 3. Typical output voltage vs input code ( $V_{BB} = 14\text{ V}$ )

Dual air-core gauge driver

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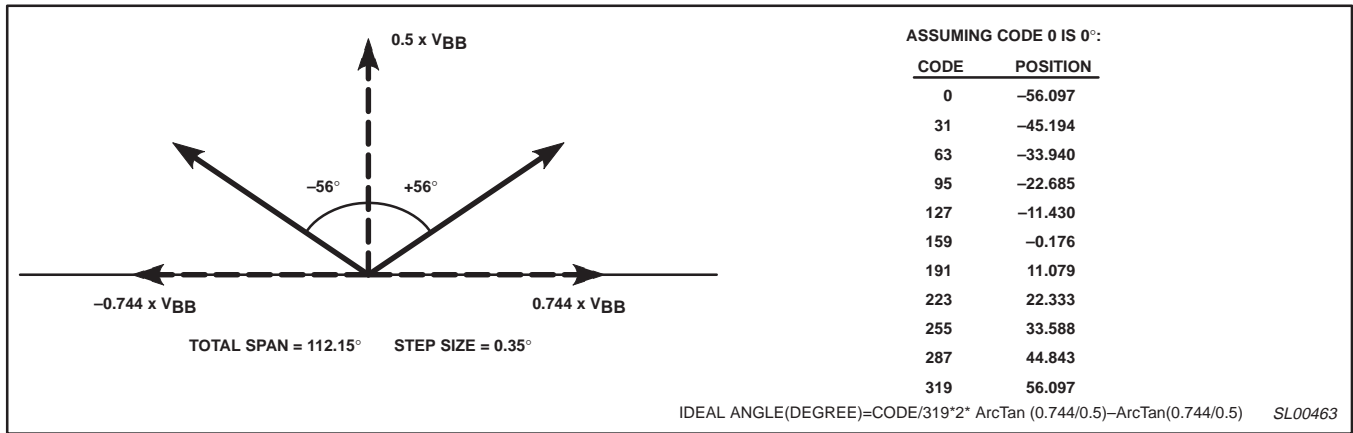


Figure 4. Total span

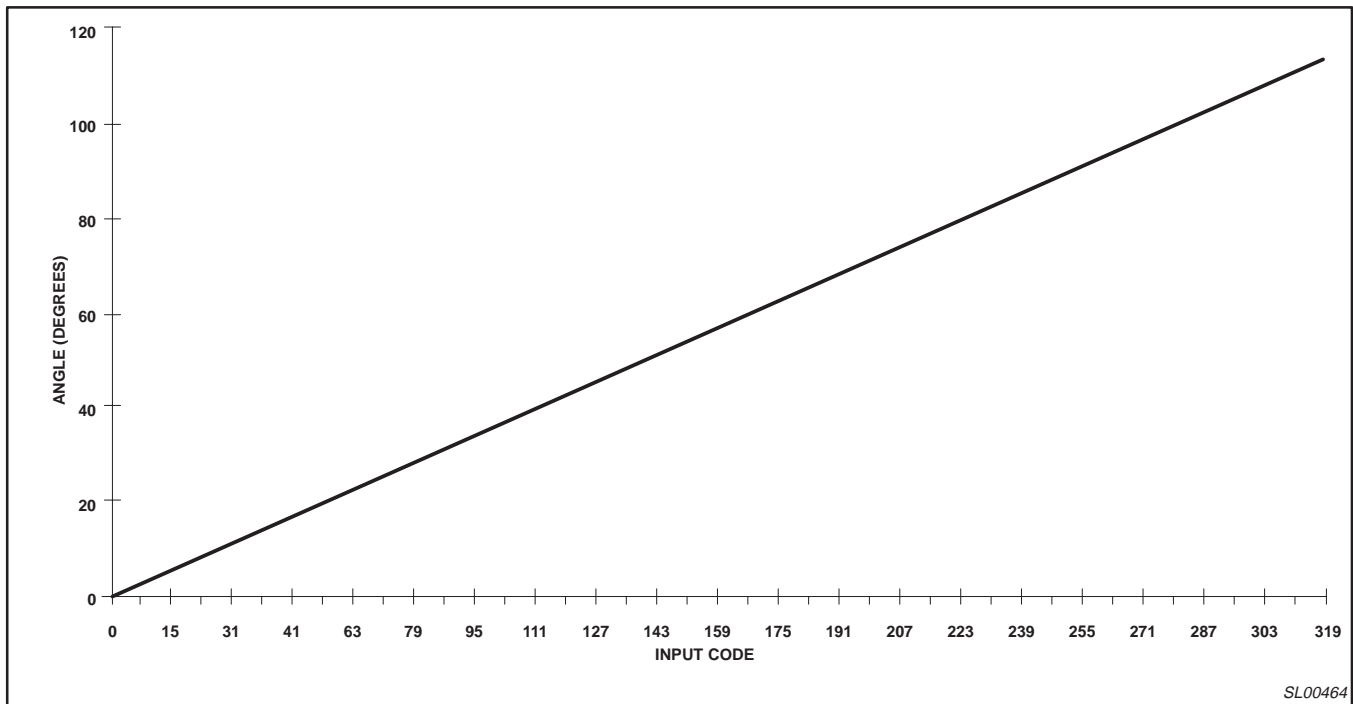


Figure 5. Meter position (degrees) vs input code

# Dual air-core gauge driver

# SA5777A

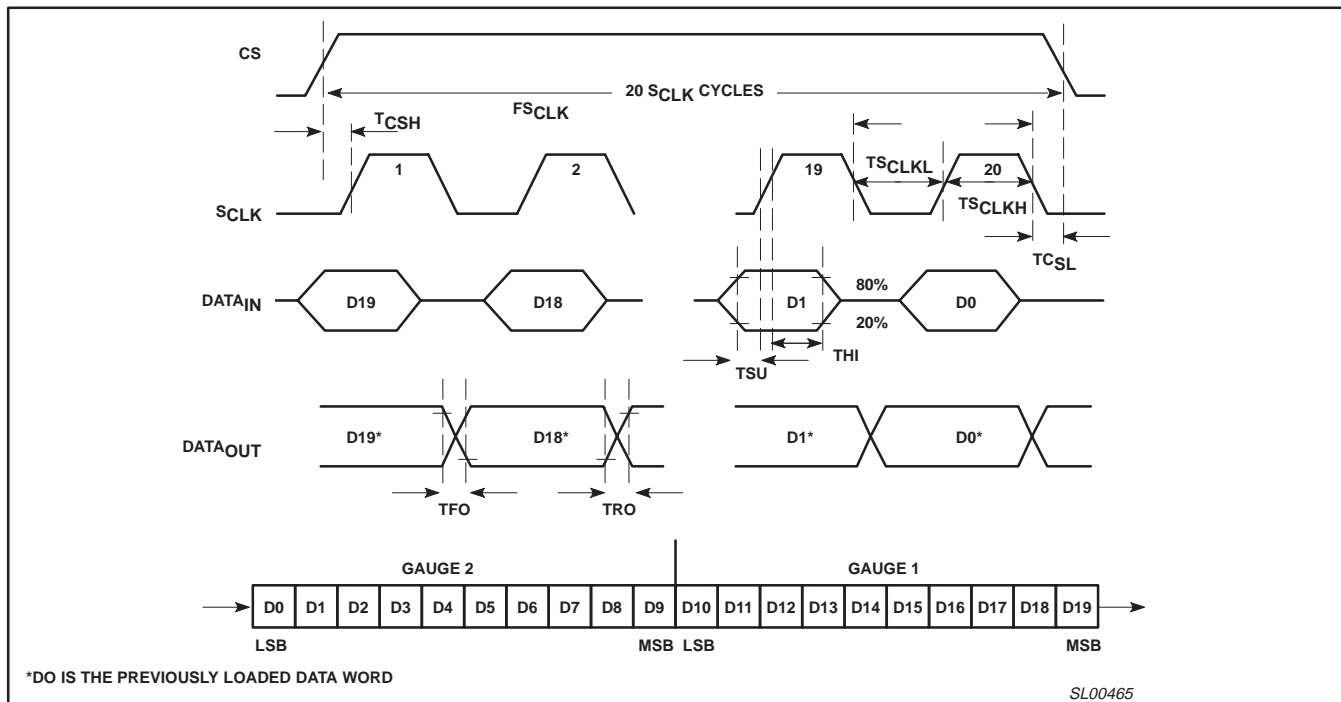


Figure 6. Serial interface timing

## Serial Interface

The SA5777A is controlled through a serial interface with the following control functions (reference Figure 6):

SCLK	Serial input clock. When CS is high, the rising edge of SCLK shifts a new data bit into the SA5777A and the falling edge shifts the data out of DATA_OUT.
CS	Active high chip select. Enables the SA5777A to receive serial input data. The falling edge of CS loads a new 20-bit data word into the internal DAC registers which updates the tangent coil output buffers (C1+, C1-, C2+, C2-).
DATA_IN	Serial data input. The data at this pin is shifted into the internal shift register on the rising edge of SCLK. Data is shifted in MSB first, gauge 1 first.
DATA_OUT	Serial data output. This pin is the output of the internal shift register. The data output on this pin is the input data from DATA_IN pin delayed by 20 clock cycles. This pin can be used to cascade several SA5777As with one CS line to load all of the SA5777As concurrently.

## Power Moding

The SA5777A has a power-on reset capability. On the rising edge of V<sub>CC</sub>, the internal latches and registers are set to zero and the coil output buffers (C1+, C1-, C2+, C2-, COM) are disabled.

## Coil Output Buffer Control

The coil buffers (C1+, C1-, C2+, C2-, COM) are disabled:

1. With the rising edge of V<sub>CC</sub> (power-on reset).
2. When OE is taken low or held low. The data registers for the outputs can still be updated while OE is low. When OE is taken high, the current output data value is displayed. A falling edge on CS will be required to activate the outputs if a fault condition has occurred prior to the OE going high.
3. Due to an overcurrent condition on either of the coil output buffers. The coil output buffers will be enabled after the next CS high-to-low transition; assuming OE is high. If the overcurrent condition has not been removed, the outputs will immediately return to their disabled condition. The ST pin will indicate status of the coil outputs.

4. Due to excessive power dissipation (i.e., thermal shut-down). The die temperature must go below 140°C before a falling edge on the CS pin will clear this fault condition and allow the coil outputs to go active.

## Application Notes

The air-core gauge is constructed of two coils wound on a cavity at 90° to each other. Inside the cavity there is a disk which is magnetized on its diameter. The currents through the coils generate a resultant magnetic vector that causes the magnetic disc to move until the magnetic fields are aligned. If the ratio of the currents in the two coils follows the tangent function, then the transfer characteristic relating the input data to output angle is linear.

Maximum current is when output is at zero and full scale degrees, T<sub>A</sub> = -40°C, and R<sub>L</sub> = 180.

Copper wire has a typical temperature coefficient of 0.4%/C

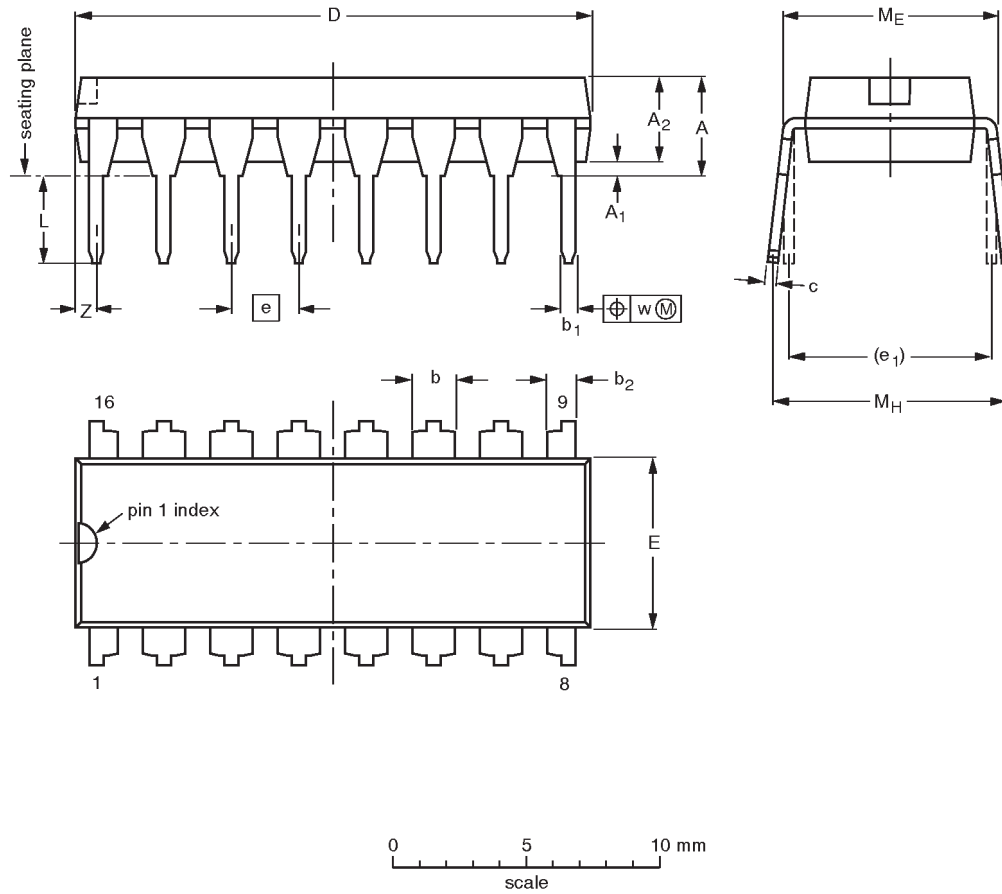


# Dual air-core gauge driver

## SA5777A

DIP16: plastic dual in-line package; 16 leads (300 mil)

SOT38-4



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

UNIT	A max.	A <sub>1</sub> min.	A <sub>2</sub> max.	b	b <sub>1</sub>	b <sub>2</sub>	c	D <sup>(1)</sup>	E <sup>(1)</sup>	e	e <sub>1</sub>	L	M <sub>E</sub>	M <sub>H</sub>	w	Z <sup>(1)</sup> max.
mm	4.2	0.51	3.2	1.73 1.30	0.53 0.38	1.25 0.85	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	0.76
inches	0.17	0.020	0.13	0.068 0.051	0.021 0.015	0.049 0.033	0.014 0.009	0.77 0.73	0.26 0.24	0.10	0.30	0.14 0.12	0.32 0.31	0.39 0.33	0.01	0.030

**Note**

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

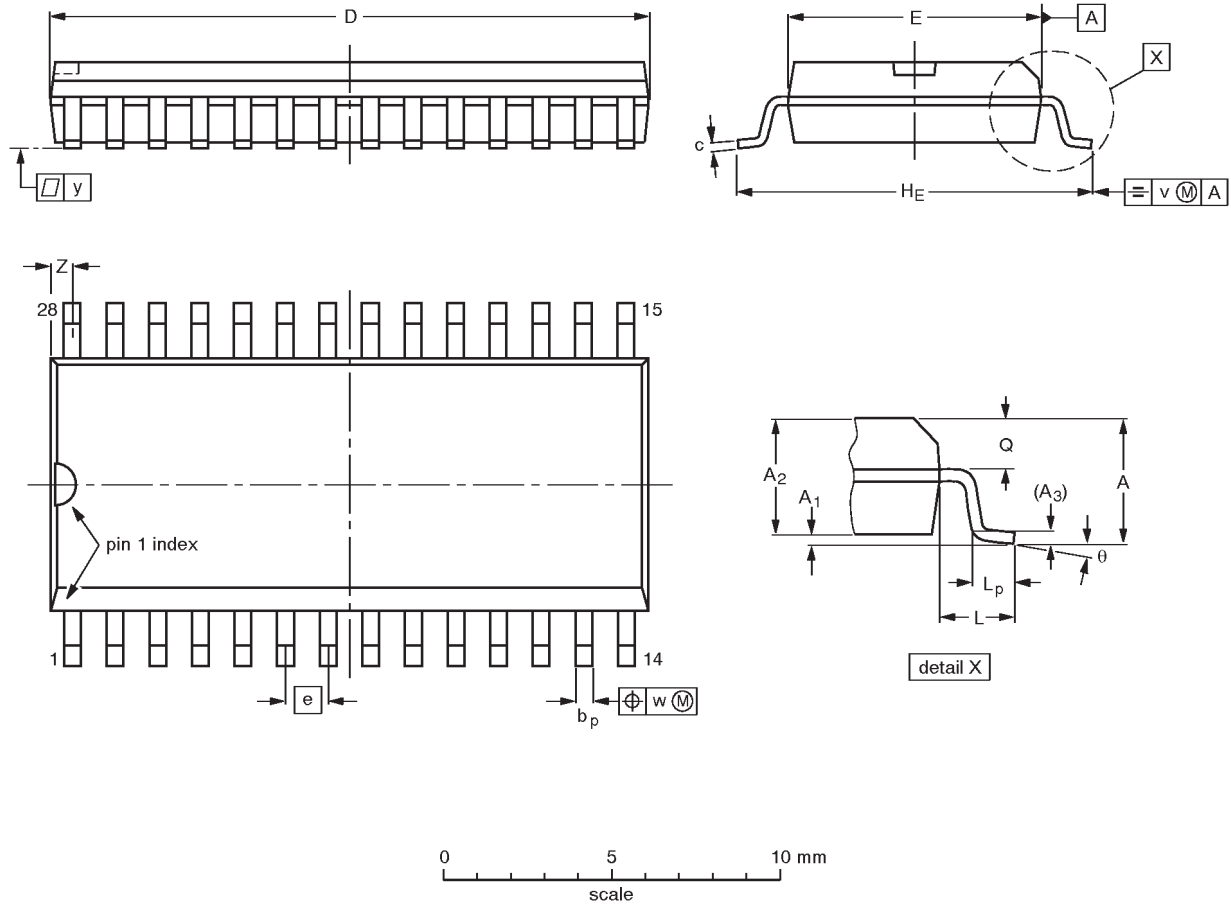
OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	EIAJ			
SOT38-4						-92-11-17 95-01-14

# Dual air-core gauge driver

# SA5777A

**SO28: plastic small outline package; 28 leads; body width 7.5mm**

**SOT136-1**



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

UNIT	A max.	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	b <sub>p</sub>	c	D <sup>(1)</sup>	E <sup>(1)</sup>	e	H <sub>E</sub>	L	L <sub>p</sub>	Q	v	w	y	Z <sup>(1)</sup>	$\theta$
mm	2.65	0.30 0.10	2.45 2.25	0.25	0.49 0.36	0.32 0.23	18.1 17.7	7.6 7.4	1.27	10.65 10.00	1.4	1.1 0.4	1.1 1.0	0.25	0.25	0.1	0.9 0.4	8° 0°
inches	0.10	0.012 0.004	0.096 0.089	0.01	0.019 0.014	0.013 0.009	0.71 0.69	0.30 0.29	0.050	0.42 0.39	0.055	0.043 0.016	0.043 0.039	0.01	0.01	0.004	0.035 0.016	

**Note**

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

OUTLINE VERSION	REFERENCES			EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	EIAJ		
SOT136-1	075E06	MS-013AE			91-08-13 95-01-24

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**NOTES**

## Dual air-core gauge driver

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## Data sheet status

Data sheet status	Product status	Definition [1]
Objective specification	Development	This data sheet contains the design target or goal specifications for product development. Specification may change in any manner without notice.
Preliminary specification	Qualification	This data sheet contains preliminary data, and supplementary data will be published at a later date. Philips Semiconductors reserves the right to make changes at any time without notice in order to improve design and supply the best possible product.
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[1] Please consult the most recently issued datasheet before initiating or completing a design.

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**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 134). 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.

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Philips Semiconductors  
811 East Arques Avenue  
P.O. Box 3409  
Sunnyvale, California 94088-3409  
Telephone 800-234-7381

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