

## OVERVIEW

The SM6105 and SM6106 are multi-channel, 8-bit A/D converters fabricated in Molybdenum-gate CMOS. They feature fast conversion times for four or eight channels, respectively, using a half-flash conversion method. They do not require an external sample-and-hold circuit, and can operate with or without an external microprocessor.

The SM6105 is available in 24-pin plastic skinny DIPs and 24-pin SOPs, and the SM6106, in 28-pin plastic DIPs and 28-pin SOPs.

## FEATURES

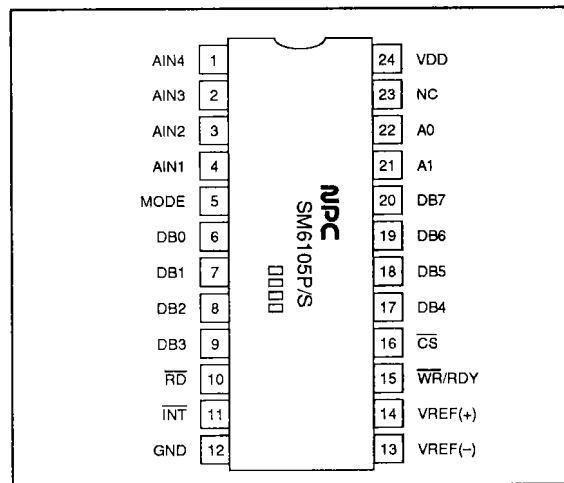
- 8-bit resolution
- Four (SM6105) or eight (SM6106) multiplexed input channels
- 1.3  $\mu$ s (max) conversion time in RD mode and 0.7  $\mu$ s (max) in WR-RD mode
- External sample-and-hold circuit not required for input signals with less than 200 mV/s slew rate
- 7 mA (typ) current consumption (excluding VREF current)
- $\pm 0.7$  LSB (max) non-linearity
- $\pm 0.7$  LSB (max) differential non-linearity
- No external clock required
- Direct microprocessor interface
- TTL- and CMOS-compatible input/outputs
- Single 5 V supply
- 24-pin plastic skinny DIP and 24-pin SOP (SM6105)
- 28-pin plastic DIP and 28-pin SOP (SM6106)
- Molybdenum-gate CMOS process

## APPLICATIONS

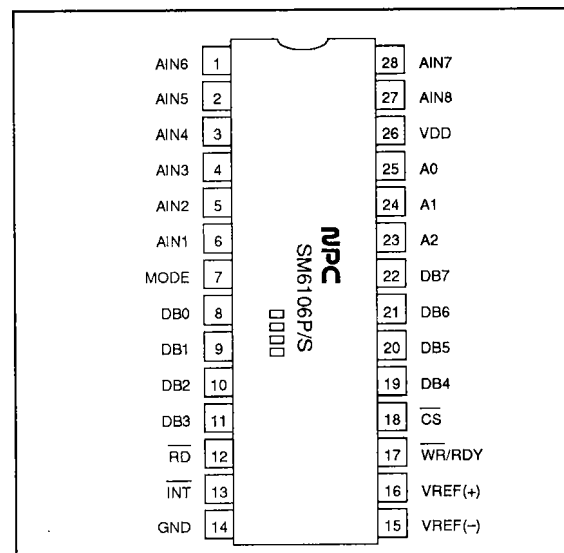
- Data acquisition systems
- Measuring instruments
- Process control

## PINOUT

### SM6105



### SM6106

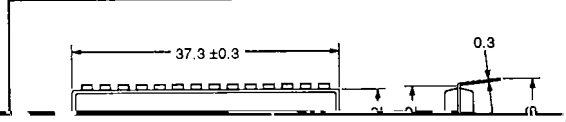
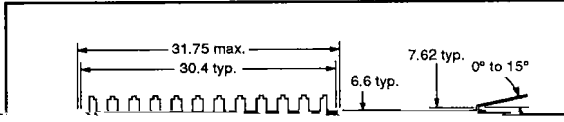


**PACKAGE DIMENSIONS**

Unit: mm

**24-pin plastic skinny DIP (SM6105)**

**28-pin plastic DIP (SM6106)**



## PIN DESCRIPTION

Number		Name	Description
SM6105	SM6106		
–	1	AIN6	Analog input channel 6
–	2	AIN5	Analog input channel 5
1	3	AIN4	Analog input channel 4
2	4	AIN3	Analog input channel 3
3	5	AIN2	Analog input channel 2
4	6	AIN1	Analog input channel 1
5	7	MODE	Mode select input with internal pull-down resistance. RD mode when LOW or open, and WR-RD mode when HIGH
6	8	DB0	Tristate data output bit 0 (LSB)
7	9	DB1	Tristate data output bit 1
8	10	DB2	Tristate data output bit 2
9	11	DB3	Tristate data output bit 3
10	12	$\overline{RD}$	WR-RD mode: The results of the last conversion are output on DB0 to DB7 when $\overline{CS}$ and $\overline{INT}$ are LOW and $\overline{RD}$ is pulled LOW. If $\overline{RD}$ is pulled LOW before the internal conversion time has elapsed (approx. 400 ns), the conversion results are latched and output. For stand-alone operation, $\overline{RD}$ should be held LOW. RD mode: Conversion begins when $\overline{CS}$ is LOW and $\overline{RD}$ is pulled LOW. Mode A or B is selected depending on whether $\overline{RD}$ is held LOW until conversion is completed or $\overline{RD}$ is returned HIGH before conversion is completed.
11	13	$\overline{INT}$	$\overline{INT}$ goes LOW when conversion is completed and the data is latched. $\overline{INT}$ returns HIGH on the rising edge of $\overline{RD}$ or $\overline{CS}$ .
12	14	GND	Ground
13	15	VREF–	Reference voltage input (low end)
14	16	VREF+	Reference voltage input (high end)
15	17	$\overline{WR}/RDY$	WR-RD mode ( $\overline{WR}$ input): Conversion is started on the falling edge of $\overline{WR}$ . If $\overline{RD}$ is HIGH, the conversion is completed approx. 400 ns after the rising edge of $\overline{WR}$ . $\overline{INT}$ then goes LOW and the data is latched. RD mode (RDY output): This is an N-channel open-drain output. RDY goes LOW on the falling edge of $\overline{CS}$ or $\overline{RD}$ . It enters a high-impedance state when conversion is completed (mode A) or on the falling edge of $\overline{CS}$ or $\overline{RD}$ (mode B).
16	18	$\overline{CS}$	Chip select input. $\overline{RD}$ and $\overline{WR}$ propagate through the internal circuits only when $\overline{CS}$ is LOW.
17	19	DB4	Tristate data output bit 4
18	20	DB5	Tristate data output bit 5
19	21	DB6	Tristate data output bit 6
20	22	DB7	Tristate data output bit 7 (MSB)
–	23	A2	Analog channel select inputs with internal pull-down resistances
21	24	A1	
22	25	A0	
23	–	NC	No connection
24	26	VDD	Supply voltage

**SM6105/SM6106**

Number		Name	Description
SM6105	SM6106		
-	27	AIN8	Analog input channel 8
-	28	AIN7	Analog input channel 7

**SPECIFICATIONS**

**Absolute Maximum Ratings**

$V_{SS} = 0 \text{ V}$

Parameter	Symbol	Rating	Unit
Supply voltage range	$V_{DD}$	-0.3 to 7.0	V
Input voltage range	$V_{IN}$	-0.3 to $V_{DD} + 0.3$	V
Output voltage range	$V_{OUT}$	-0.3 to $V_{DD} + 0.3$	V
Power dissipation	$P_D$	250	mW
Operating temperature range	$T_{opr}$	-20 to 80	deg. C
Storage temperature range	$T_{stg}$	-40 to 125	deg. C
Soldering temperature	$T_{sld}$	260	deg. C
Soldering time	$t_{sld}$	10	s

**Recommended Operating Conditions**

Parameter	Symbol	Rating			Unit
		min	typ	max	
Supply voltage	$V_{DD}$	4.75	5.0	5.25	V
Operating temperature	$T_{opr}$	-20	-	70	deg. C

**DC Electrical Characteristics**

$V_{DD} = 5 \text{ V} \pm 5\%$ ,  $T_a = -20 \text{ to } 70 \text{ deg. C}$ , unless otherwise noted

Parameter	Symbol	Condition	Rating			Unit
			min	typ	max	
$V_{REF+}$ to $V_{REF-}$ reference resistance	$R_{REF}$		0.5	0.85	1.3	k $\Omega$
Analog input voltage	$V_{IN}$		-0.1		$V_{DD} + 0.1$	V
Analog input leakage current	$I_{LEAK1}$	$V_{IN} = 0 \text{ V to } V_{DD}$ , $V_{\overline{CS}} = V_{\overline{WR}} = 0 \text{ V}$ , $V_{MODE} = V_{DD}$	-	$\pm 0.1$	$\pm 3$	$\mu\text{A}$
$\overline{CS}$ , $\overline{WR}$ , $\overline{RD}$ and A0 to A2 HIGH-level input voltage	$V_{IH1}$		2.4	-	-	V
MODE HIGH-level input voltage	$V_{IH2}$		3.5	-	-	V
$\overline{CS}$ , $\overline{WR}$ , $\overline{RD}$ and A0 to A2 LOW-level input voltage	$V_{IL1}$		-	-	0.8	V
MODE LOW-level input voltage	$V_{IL2}$		-	-	1.5	V

SM6105/SM6106

Parameter	Symbol	Condition	Rating			Unit
			min	typ	max	
$\overline{CS}$ and $\overline{RD}$ HIGH-level input current	$I_{IH1}$	$V_{IH} = V_{DD}$	-	-	1	$\mu A$
$\overline{WR}$ HIGH-level input current	$I_{IH2}$	$V_{IH} = V_{DD}$	-	-	3	$\mu A$
MODE and A0 to A2 HIGH-level input current	$I_{IH3}$	$V_{IH} = V_{DD}$	-	60	-	$\mu A$
$\overline{CS}$ , $\overline{WR}$ , $\overline{RD}$ , MODE and A0 to A2 LOW-level input current	$I_{IL}$	$V_{iL} = 0 V$	-1	-	-	$\mu A$
DB0 to DB7 and $\overline{INT}$ HIGH-level output voltage	$V_{OH}$	$I_{source} = 360 \mu A$	4	-	-	V
DB0 to DB7, $\overline{INT}$ and RDY LOW-level output voltage	$V_{OL}$	$I_{sink} = 1.6 mA$	-	-	0.4	V
DB0 to DB7 high-impedance leakage current	$I_{LEAK2}$	$V_{OUT} = V_{DD}$	-	-	3	$\mu A$
		$V_{OUT} = 0 V$	-3	-	-	
Current consumption	$I_{DD}$	Not operating, $V_{\overline{CS}} = V_{\overline{RD}} = V_{MODE} = 0 V$	-	5	-	mA
		Operating $t_{WR} = 250 ns$ , $t_{RD} = 300 ns$ , $RD_{PW} = 150 ns$ , $t_P = 100 ns$ , $V_{MODE} = V_{DD}$	-	7	-	
AIN1 to AIN8 analog input pin capacitance	$C_{VIN}$		-	30	-	pF
Logic output pin capacitance	$C_{OUT}$		-	5	-	pF
Logic input pin capacitance	$C_{IN}$		-	5	-	pF

AC Electrical Characteristics

$V_{DD} = 5 V \pm 5\%$ ,  $t_r = t_f = 20 ns$ ,  $T_a = -20$  to  $70$  deg. C

Parameter	Symbol	Condition	Rating			Unit
			min	typ	max	
RD mode conversion time	$t_{CRD}$		-	0.8	1.3	$\mu s$
WR-RD mode B conversion time	$t_{WR} + t_{RD} + t_{ACC1}$	$t_{WR} = 250 ns$ , $t_{RD} = 300 ns$	-	-	0.7	$\mu s$
Input signal slew rate	SR		-	-	0.2	V/ $\mu s$
A0 to A2 setup time	$t_{AS}$		0	-	-	ns
A0 to A2 hold time	$t_{AH}$		35	-	-	ns
$\overline{CS}$ to RDY delay time	$t_{RDY}$	RD mode	-	30	60	ns
$\overline{RD}$ to $\overline{INT}$ delay time	$t_{INTH}$		-	50	100	ns
Data access time	$t_{ACC}$	RD mode A. See note 2.	-	$t_{CRD} + 20$	$t_{CRD} + 40$	ns
Data hold time	$t_{DH}$	See note 3.	-	50	100	ns
$\overline{RD}$ pulsewidth	$\overline{RD}_{PW1}$	RD mode B	70	-	300	ns
Data access time	$t_{ACC2}$	RD mode B, WR-RD modes A and B. See note 2.	-	50	100	ns

SM6105/SM6106

Parameter	Symbol	Condition	Rating			Unit
			min	typ	max	
$\overline{WR}$ pulsewidth	$t_{WR}$	WR-RD mode	0.25	–	50	$\mu$ s
$\overline{WR}$ to $\overline{RD}$ setup time	$t_{RD}$	WR-RD modes A and B	300	–	–	ns
$\overline{WR}$ to $\overline{RD}$ setup time	$t_{INTL}$	WR-RD mode A	–	–	$t_i$	ns
		WR-RD mode B	–	$t_{RD} + 50$	$t_{RD} + 100$	
Data access time	$t_{ACC1}$	WR-RD mode B. See note 2.	–	80	150	ns
$\overline{RD}$ pulsewidth	$\overline{RD}_{PW2}$	WR-RD modes A and B	150	–	–	ns
Internal comparison time	$t_i$	WR-RD mode	–	400	650	ns
$\overline{INT}$ to data delay time	$t_{ID}$	WR-RD mode C. See note 2.	–	20	40	ns
Succeeding conversion wait time	$t_p$		100	–	–	ns

Notes

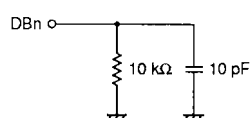
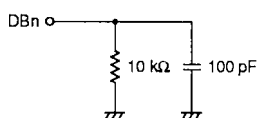
1. All timing is measured at a signal control level of 1.6 V.
2. Measured using the data access test circuits at output levels of 1.6 V.
3. Measured using the data hold test circuits at output levels of 1.6 V.

Data access test circuits

Data hold test circuits

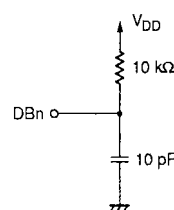
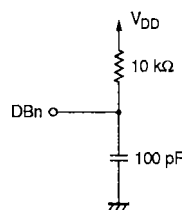
$V_{OH}$  from high impedance

High impedance from  $V_{OH}$



$V_{OL}$  from high impedance

High impedance from  $V_{OL}$



Converter Characteristics

$V_{DD} = 5 \text{ V} \pm 5\%$ ,  $V_{REF+} = 5 \pm 0.5 \text{ V}$ ,  $V_{REF-} = 0 \text{ V}$ ,  $T_a = -20 \text{ to } 70 \text{ deg. C}$

Parameter	Rating			Unit
	min	typ	max	
Resolution	8	–	–	bit
Non-linearity	–	–	$\pm 0.7$	LSB
Differential non-linearity	–	–	$\pm 0.7$	LSB
Offset error	–	–	$\pm 0.7$	LSB
Gain error	–	–	$\pm 0.7$	LSB

**FUNCTIONAL DESCRIPTION**

The SM6105 and SM6106 comprise two parallel A/D converters, one each for the upper and lower four bits of the 8-bit output.

When both  $\overline{RD}$  and  $\overline{CS}$  go LOW (RD mode) or both  $\overline{WR}$  and  $\overline{CS}$  go LOW (WR-RD mode), analog data on the selected input channel is latched and conversion begins. The fifteen comparators in the upper converter (upper four bits) set the threshold levels for the fifteen comparators in the lower converter (lower four bits). The data is then latched and buffered for output.

The SM6105 and SM6106 have two basic modes of operation, set by the level on MODE. If MODE is LOW or open, RD mode is selected, and if MODE is HIGH, WR-RD mode is selected. These two basic modes also have sub-modes of operation, according to the timing of  $\overline{CS}$ ,  $\overline{RD}$  and  $\overline{WR}$ .

**Input Channel Selection**

A2	A1	A0	Channel
0	0	0	AIN1
0	0	1	AIN2
0	1	0	AIN3
0	1	1	AIN4
1	0	0	AIN5
1	0	1	AIN6
1	1	0	AIN7
1	1	1	AIN8

The thick line indicates the data that applies to the SM6105.

**RD Mode (MODE = LOW or open)**

**Mode A**

This mode is provided for microprocessors that support wait cycles. When  $\overline{CS}$  is LOW, the CPU can strobe  $\overline{RD}$  LOW. The data on the selected input channel is latched on the falling edge of  $\overline{CS}$ , then  $\overline{RDY}$  goes LOW and conversion begins.  $\overline{INT}$  goes LOW to signal the CPU that the conversion has completed approximately 800 ns later, and the data is output.

If  $\overline{RDY}$  is connected to a pull-up resistor,  $\overline{RDY}$  goes HIGH on the falling edge of  $\overline{INT}$ , thus acting as the bus wait signal for the CPU.  $\overline{INT}$  returns HIGH and the outputs go high impedance on the rising edge of  $\overline{RD}$  or  $\overline{CS}$ .

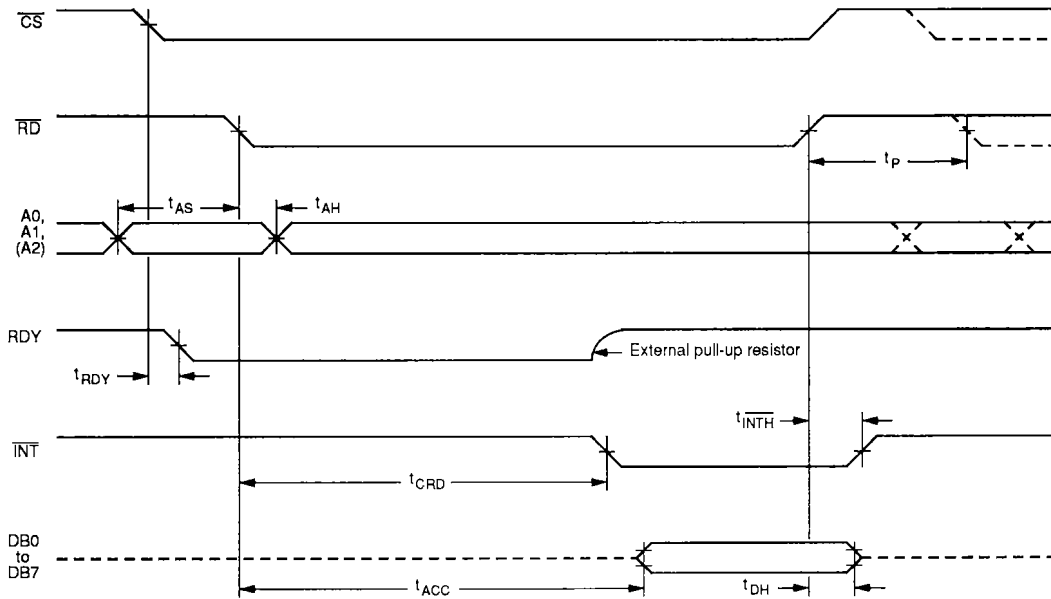


Figure 1. RD mode A

**Mode B**

This mode is provided for microprocessors that do not support wait cycles. When  $\overline{CS}$  is LOW, the CPU can strobe  $\overline{RD}$  LOW. The data on the selected input channel is latched on the falling edge of  $\overline{CS}$ , then RDY goes LOW and conversion begins.  $\overline{INT}$

goes HIGH on the rising edge of  $\overline{RD}$  or  $\overline{CS}$ , and then LOW again when conversion completes. The output data is read by strobing  $\overline{RD}$  LOW again; this also starts the succeeding conversion cycle.

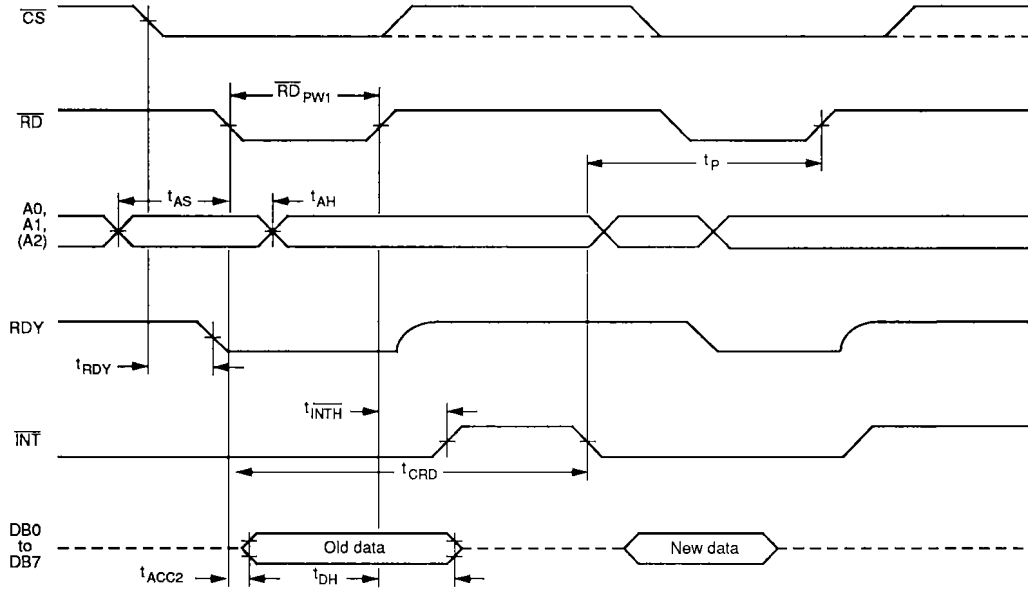


Figure 2. RD mode B



**WR-RD Mode (MODE = HIGH)**

**Mode A**

When  $\overline{CS}$  is LOW, either  $\overline{RD}$  or  $\overline{WR}$  can be pulled LOW. The data on the selected input channel is latched on the falling edge of  $\overline{WR}$ , and conversion begins. If  $\overline{RD}$  is held HIGH,  $\overline{INT}$  goes LOW approximately 400 ns after the rising edge of  $\overline{WR}$ ,

to inform the CPU that conversion is complete, and the output data is latched. When  $\overline{RD}$  goes LOW, the output data is output on DB0 to DB7 to be read by the CPU. In this mode, the CPU is effectively performing interrupt processing.

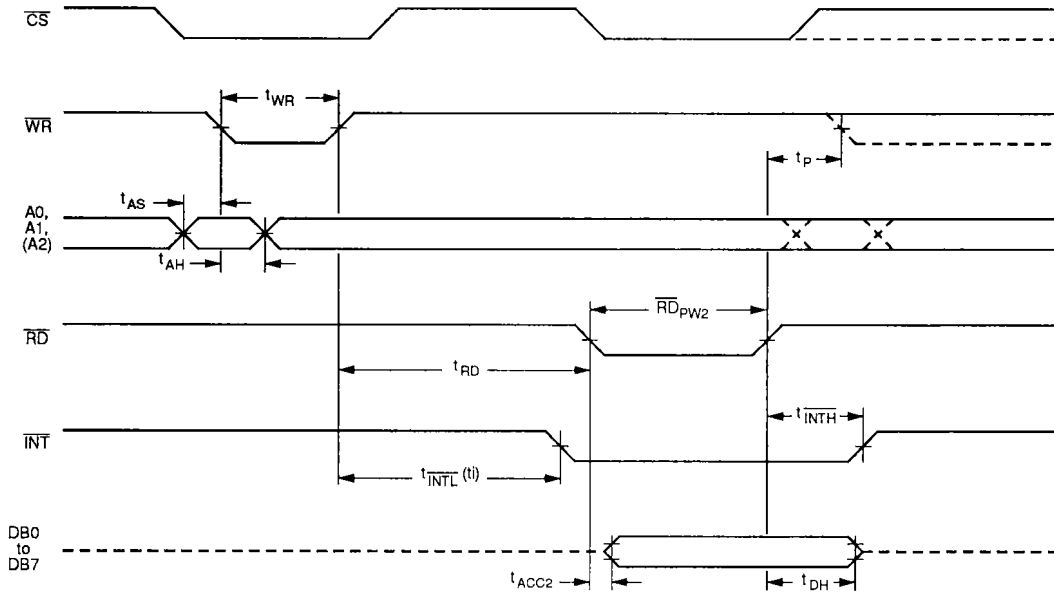


Figure 3. WR-RD mode A ( $t_{RD} > t_i$ )

**Mode B**

In mode A,  $\overline{RD}$  is not pulled LOW until after  $\overline{INT}$  goes LOW, indicating conversion completion. In mode B, however,  $\overline{RD}$  is pulled LOW earlier to shorten the conversion cycle. Provided that the WR-RD setup time ( $t_{RD}$ ) is satisfied, approximately

300 ns,  $\overline{RD}$  can be pulled LOW to complete the conversion without error.  $\overline{INT}$  then goes LOW and the output data is latched and output on DB0 to DB7. In this mode, the CPU is effectively polling the A/D converter.

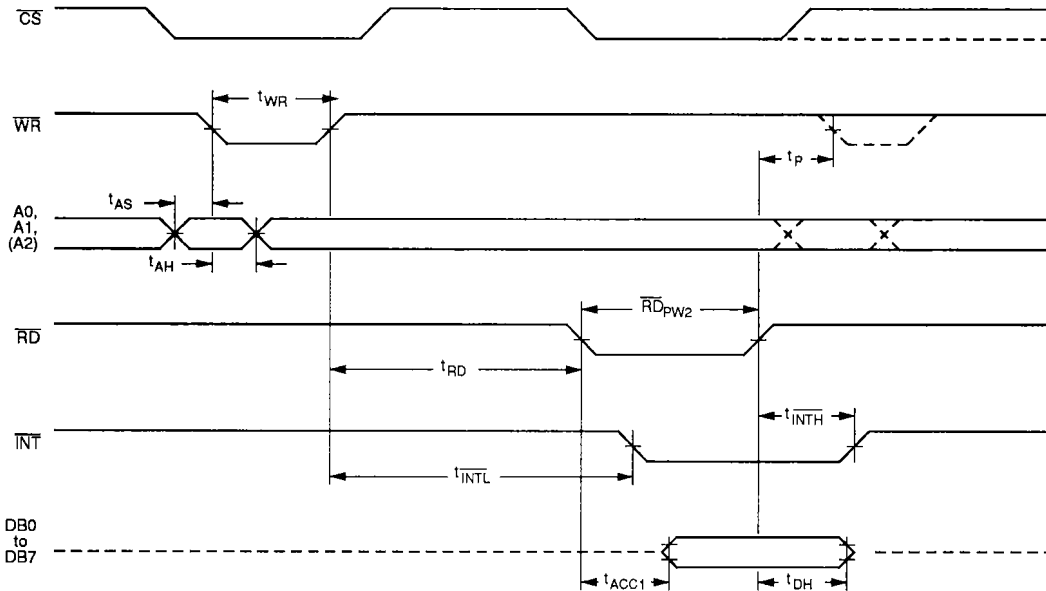


Figure 4. WR-RD mode B ( $t_{RD} < t_i$ )

**Mode C**

In mode C,  $\overline{CS}$  and  $\overline{RD}$  are both tied LOW to allow stand-alone operation (without an external microprocessor). The data on the selected input channel is latched on the falling edge of  $\overline{WR}$ , and conversion begins.  $\overline{INT}$  then goes HIGH on the

rising edge of  $\overline{WR}$ , and the DB0 to DB7 outputs go high impedance.  $\overline{INT}$  then goes LOW again approximately 400 ns after the rising edge of  $\overline{WR}$ , and the output data is output on DB0 to DB7.

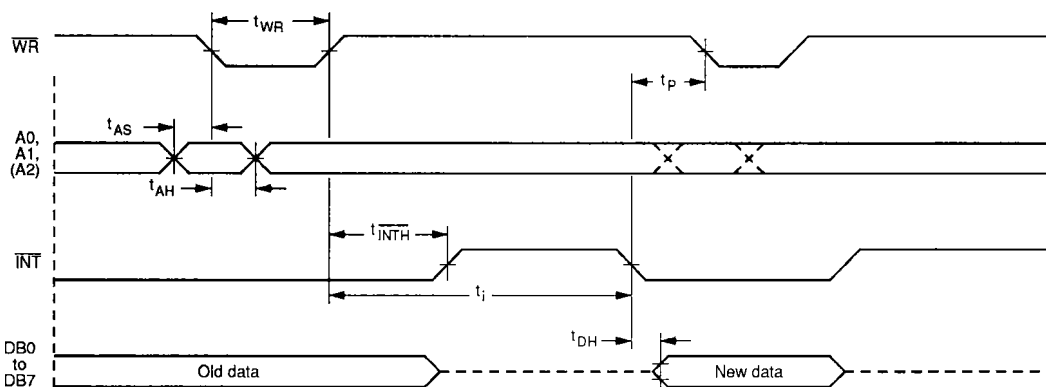
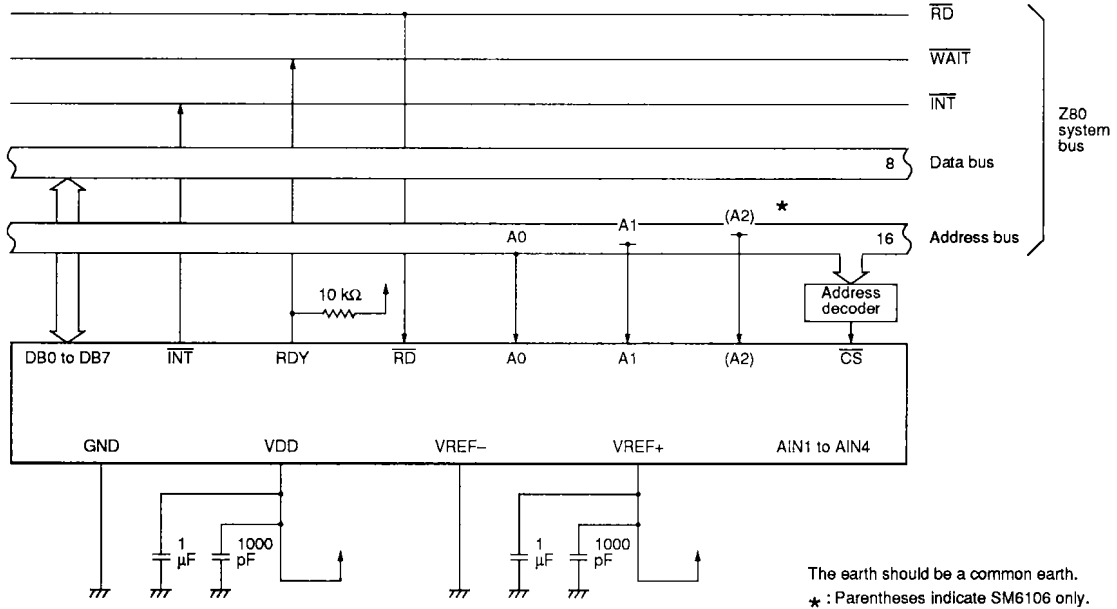


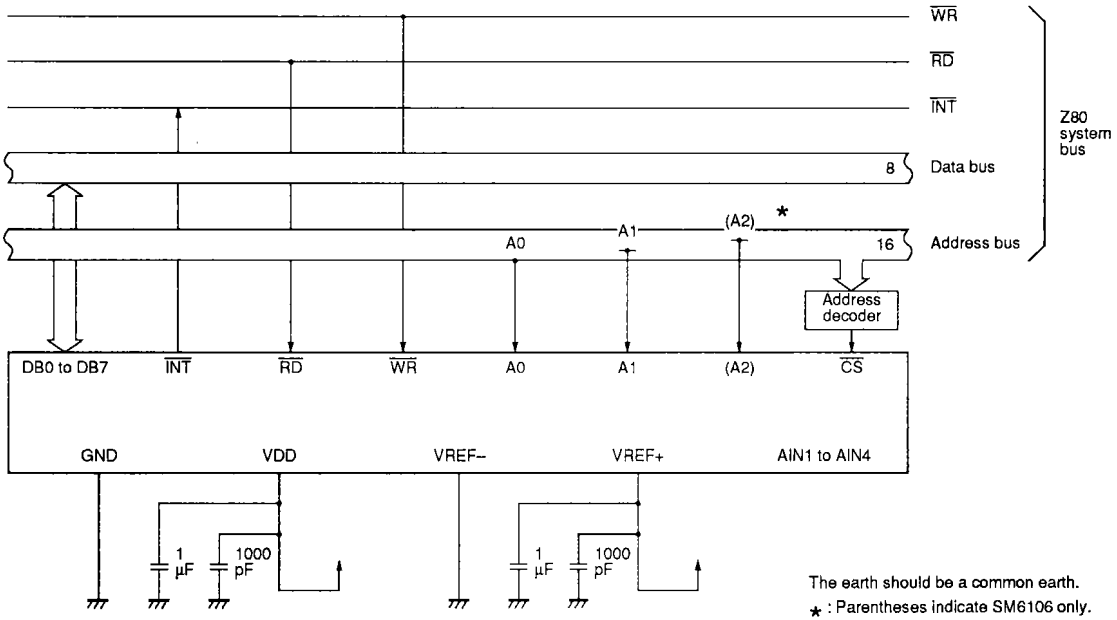
Figure 5. WR-RD mode C ( $\overline{CS} = \overline{RD} = \text{LOW}$ )

Standard Configuration

RD mode



WR-RD mode



## DESIGN NOTE

The SM6105 and SM6106 use CMOS chopper comparators where the analog input is alternately connected and disconnected from the input circuits.

The analog inputs should, therefore, have a low impedance. Also, input buffering is recommended.

NIPPON PRECISION CIRCUITS LTD. reserves the right to make changes to the products contained in this data sheet in order to improve the design or performance and to supply the best possible products. Nippon Precision Circuits Ltd. assumes no responsibility for the use of any circuits shown in this data sheet, conveys no license under any patent or other rights, and makes no claim that the circuits are free from patent infringement. Applications for any devices shown in this data sheet are for illustration only and Nippon Precision Circuits Ltd. makes no claim or warranty that such applications will be suitable for the use specified without further testing or modification.

**NPC**  
NIPPON PRECISION CIRCUITS LTD.

**NIPPON PRECISION CIRCUITS LTD.**

Shuwa Sakurabashi Building  
5-4, Hachobori 4-chome  
Chuo-ku, Tokyo 104 Japan  
Telephone: 03-3555-7521  
Facsimile: 03-3555-7528

NC8930AE 1993.07