

## 3-wire Serial EEPROMs 16K AF93BC86

### FEATURES:

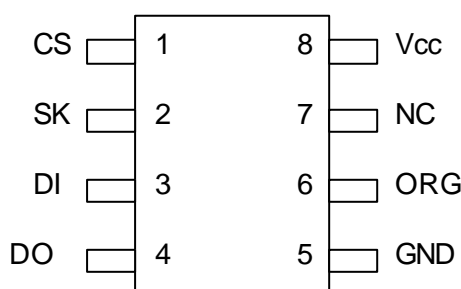
- Internally organized as 2048 x 8 or 1024 x 16
- Wide-voltage range operation
  - 1.8V-5.5 V
- 3-wire serial interface bus
- Data retention: 100 years
- High endurance: 1,000,000 Write Cycles
- 2 MHz (5V) clock rate
- Sequential read operation
- Self-timed write cycle (10ms max)
- Lead free package
- 8-pin PDIP, 8-pin JEDEC SOIC, and 8-pin TSSOP Packages

### DESCRIPTION

Aplus Flash Technology's AF93BC86 family provides 16K of serial electrically erasable and programmable read-only memory (EEPROM). The wide V<sub>dd</sub> range allows for low-voltage operation down to 1.8V. The device, fabricated using traditional CMOS EEPROM technology, is optimized for many industrial and commercial applications where low-voltage and low-power operation is essential. The AF93BC86 is available in 8-pin PDIP, 8-lead JEDEC SOIC, and 8-lead TSSOP packages and is accessed via a 3-wire serial interface.

### Figure 1. Pin Configurations

8-pin PDIP/TSSOP/SOIC



| Pin Name        | Function              |
|-----------------|-----------------------|
| CS              | Chip Select           |
| SK              | Serial Data Clock     |
| DI              | Serial Data Input     |
| DO              | Serial Data Output    |
| GND             | Ground                |
| V <sub>cc</sub> | Power Supply          |
| ORG             | Internal Organization |
| NC              | No Connect            |





## PIN CAPACITANCE

Applicable over recommended operating range from  $T_A = 25^\circ\text{C}$ ,  $f = 1.0\text{ MHz}$ ,  $V_{CC} = +5.0\text{V}$

| Symbol    | Test Condition                 | Max | Units | Condition             |
|-----------|--------------------------------|-----|-------|-----------------------|
| $C_{OUT}$ | Output Capacitance (DO)        | 5   | pF    | $V_{OUT} = 0\text{V}$ |
| $C_{IN}$  | Input Capacitance (CK, SK, DI) | 5   | pF    | $V_{IN} = 0\text{V}$  |

Note: 1. This parameter is characterized and not 100% tested.

## DC CHARACTERISTICS

Applicable over recommended operating range from:

$T_{AMB} = -40^\circ\text{C}$  to  $+85^\circ\text{C}$ ,  $V_{CC} = +1.8\text{V}$  to  $+5.5\text{V}$  (unless otherwise noted)

| Symbol          | Parameter                              | Test Condition  | Min                 | Typ | Max                 | Units         |
|-----------------|--|---|---------------------|-----|---------------------|---------------|
| $V_{CC1}$       | Supply Voltage                         |   | 1.8                 |     | 5.5                 | V             |
| $V_{CC2}$       | Supply Voltage                         |   | 2.7                 |     | 5.5                 | V             |
| $V_{CC3}$       | Supply Voltage                         |   | 4.5                 |     | 5.5                 | V             |
| $I_{CC}$        | Supply Current $V_{CC} = 5.0\text{V}$  | READ at 1 MHz   |                     | 0.5 | 2.0                 | mA            |
| $I_{CC}$        | Supply Current $V_{CC} = 5.0\text{V}$  | WRITE at 1 MHz  |                     | 0.5 | 2.0                 | mA            |
| $I_{SB1}$       | Standby Current $V_{CC} = 1.8\text{V}$ | CS = 0V   |                     | 0   | 0.1                 | $\mu\text{A}$ |
| $I_{SB2}$       | Standby Current $V_{CC} = 2.7\text{V}$ | CS = 0V   |                     | 6.0 | 10.0                | $\mu\text{A}$ |
| $I_{SB3}$       | Standby Current $V_{CC} = 5.0\text{V}$ | CS = 0V   |                     | 17  | 30                  | $\mu\text{A}$ |
| $I_{LI}$        | Input Leakage Current                  | $V_{IN} = 0\text{V}$ to $V_{CC}$                                |                     | 0.1 | 3.0                 | $\mu\text{A}$ |
| $I_{LO}$        | Output Leakage Current                 | $V_{IN} = 0\text{V}$ to $V_{CC}$                                |                     | 0.1 | 3.0                 | $\mu\text{A}$ |
| $V_{IL1}^{(1)}$ | Input Low Level                        | $2.7\text{V} < V_{CC} < 5.5\text{V}$                            | -0.6                |     | 0.8                 | V             |
| $V_{IH1}^{(1)}$ | Input High Level                       |   | 2.0                 |     | $V_{CC} + 1$        |               |
| $V_{IL2}^{(1)}$ | Input Low Level                        | $1.8\text{V} < V_{CC} < 2.7\text{V}$                            | -0.6                |     | $V_{CC} \times 0.3$ | V             |
| $V_{IH2}^{(1)}$ | Input High Level                       |   | $V_{CC} \times 0.7$ |     | $V_{CC} + 1$        |               |
| $V_{OL1}$       | Output Low Level                       | $2.7\text{V} < V_{CC} < 5.5\text{V}$ ; $I_{OL} = 2.1\text{mA}$  |                     |     | 0.4                 | V             |
| $V_{OH1}$       | Output High Level                      | $I_{OH} = -0.4\text{mA}$  | 2.4                 |     |                     |               |
| $V_{OL2}$       | Output Low Level                       | $1.8\text{V} < V_{CC} < 2.7\text{V}$ ; $I_{OL} = 0.15\text{mA}$ |                     |     | 0.2                 | V             |
| $V_{OH2}$       | Output High Level                      | $I_{OH} = -100\mu\text{A}$                                      | $V_{CC} - 0.2$      |     |                     |               |

Note: 1.  $V_{IL}$  and  $V_{IH}$  max are reference only and are not tested.



## AC CHARACTERISTICS

Applicable over recommended operating range from:

$T_{AMB} = -40^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$ ,  $V_{CC} = \text{As specified}$ ,  $CL = 1$  TTL Gate & 100pF (unless otherwise noted).

| Symbol        | Parameter                  | Test Condition   |  | Min                | Typ | Max                | Units        |
|---------------|----------------------------|--|--|--------------------|-----|--------------------|--------------|
| $f_{SK}$      | Clock Frequency, SK        | 4.5V < $V_{CC}$ < 5.5V<br>2.7V < $V_{CC}$ < 5.5V<br>1.8V < $V_{CC}$ < 5.5V |  | 0<br>0<br>0        |     | 2<br>1<br>0.25     | MHz          |
| $t_{SKH}$     | SK High Time               | 4.5V < $V_{CC}$ < 5.5V<br>2.7V < $V_{CC}$ < 5.5V<br>1.8V < $V_{CC}$ < 5.5V |  | 250<br>250<br>1000 |     |                    | ns           |
| $t_{SKL}$     | SK Low Time                | 4.5V < $V_{CC}$ < 5.5V<br>2.7V < $V_{CC}$ < 5.5V<br>1.8V < $V_{CC}$ < 5.5V |  | 250<br>250<br>1000 |     |                    | ns           |
| $t_{CS}$      | Minimum CS Low Time        | 4.5V < $V_{CC}$ < 5.5V<br>2.7V < $V_{CC}$ < 5.5V<br>1.8V < $V_{CC}$ < 5.5V |  | 250<br>250<br>1000 |     |                    | ns           |
| $t_{CSS}$     | CS Setup Time              | Relative to SK   | 4.5V < $V_{CC}$ < 5.5V<br>2.7V < $V_{CC}$ < 5.5V<br>1.8V < $V_{CC}$ < 5.5V | 50<br>50<br>200    |     |                    | ns           |
| $t_{DIS}$     | DI Setup Time              | Relative to SK   | 4.5V < $V_{CC}$ < 5.5V<br>2.7V < $V_{CC}$ < 5.5V<br>1.8V < $V_{CC}$ < 5.5V | 100<br>100<br>400  |     |                    | ns           |
| $t_{CSH}$     | CS Hold Time               | Relative to SK   |  | 0                  |     |                    | ns           |
| $t_{DIH}$     | DI Hold Time               | Relative to SK   | 4.5V < $V_{CC}$ < 5.5V<br>2.7V < $V_{CC}$ < 5.5V<br>1.8V < $V_{CC}$ < 5.5V | 100<br>100<br>400  |     |                    | ns           |
| $t_{PD1}$     | Output Delay to "1"        | AC Test  | 4.5V < $V_{CC}$ < 5.5V<br>2.7V < $V_{CC}$ < 5.5V<br>1.8V < $V_{CC}$ < 5.5V |                    |     | 250<br>250<br>1000 | ns           |
| $t_{PD0}$     | Output Delay to "0"        | AC Test  | 4.5V < $V_{CC}$ < 5.5V<br>2.7V < $V_{CC}$ < 5.5V<br>1.8V < $V_{CC}$ < 5.5V |                    |     | 250<br>250<br>1000 | ns           |
| $t_{SV}$      | CS to Status Valid         | AC Test  | 4.5V < $V_{CC}$ < 5.5V<br>2.7V < $V_{CC}$ < 5.5V<br>1.8V < $V_{CC}$ < 5.5V |                    |     | 250<br>250<br>1000 | ns           |
| $t_{DF}$      | CS to DO in High Impedance | AC Test<br>CS = $V_{IL}$   | 4.5V < $V_{CC}$ < 5.5V<br>2.7V < $V_{CC}$ < 5.5V<br>1.8V < $V_{CC}$ < 5.5V |                    |     | 100<br>100<br>400  | ns           |
| $t_{WP}$      | Write Cycle Time           |  | 1.8V < $V_{CC}$ < 5.5V   |                    | 3   | 10                 | ms           |
| Endurance (1) | 5.0V, 25° C                |  |  | 1M                 |     |                    | Write Cycles |

Note: 1. This parameter is characterized and not 100% tested.



## INSTRUCTION SET FOR THE AF93BC86

| Instruction | SB | Op Code | Address                          |                                 | Data                            |                                  | Comments   |
|-------------|----|---------|----------------------------------|---------------------------------|---------------------------------|----------------------------------|--|
|             |    |         | X8                               | X16                             | X8                              | X16                              |  |
| READ        | 1  | 10      | A <sub>10</sub> – A <sub>0</sub> | A <sub>9</sub> – A <sub>0</sub> |                                 |                                  | Reads data stored at specified memory location.                            |
| EWEN        | 1  | 00      | 11xxxxxxxx                       | 11xxxxxxxx                      |                                 |                                  | Write enable command (must be issued before any erase or write operation). |
| ERASE       | 1  | 11      | A <sub>10</sub> – A <sub>0</sub> | A <sub>9</sub> – A <sub>0</sub> |                                 |                                  | Erase memory location A <sub>n</sub> – A <sub>0</sub>                      |
| WRITE       | 1  | 01      | A <sub>10</sub> – A <sub>0</sub> | A <sub>9</sub> – A <sub>0</sub> | D <sub>7</sub> – D <sub>0</sub> | D <sub>15</sub> – D <sub>0</sub> | Writes memory location A <sub>n</sub> – A <sub>0</sub>                     |
| ERAL        | 1  | 00      | 10xxxxxxxx                       | 10xxxxxxxx                      |                                 |                                  | Erases all memory locations. Valid only at V <sub>cc</sub> = 4.5V to 5.5V  |
| WRAL        | 1  | 00      | 01xxxxxxxx                       | 01xxxxxxxx                      | D <sub>7</sub> – D <sub>0</sub> | D <sub>15</sub> – D <sub>0</sub> | Writes all memory locations. Valid only at V <sub>cc</sub> = 4.5V to 5.5V. |
| EWDS        | 1  | 00      | 00xxxxxxxx                       | 00xxxxxxxx                      |                                 |                                  | Disables all erase or write instructions                                   |

Note: The X's in the address field represent don't care values and must be clocked.

## FUNCTIONAL DESCRIPTION

The AF93BC86 supports 7 different instructions, which must be clocked serially using the CS, SK and DI pins. Before sending each of these instructions, the CS pin must first be pulled high followed by a START bit (logic '1'). The next sequence includes a 2-bit Op Code and usually an 8 or 16-bit address. The next description describes the various functions in the chip.

**READ (READ):** The Read (READ) instruction includes the Op Code ("10") followed by the memory address location to be read. After the instruction and address is sent, the data from the memory location can be clocked out using the serial output pin DO. The data changes on the rising edge of the clock, so the falling edge can be used to strobe the output.



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Note that during shifting the last address bit, the DO pin is a dummy bit (logic “0”).

**ERASE/WRITE (EWEN):** When the chip is first powered-on, no erase or write instructions can be issued. Only when the Erase/Write Enable (EWEN) instruction is sent will the system be allowed to write to the chip. The EWEN command only needs to be issued once after being powered-on. To disable the chip again, the Erase/Write Disable (EWDS) command can be used.

**ERASE (ERASE):** The Erase (ERASE) instruction clears the designated memory location to a logical ‘1’ state. After the Op Code and address location is inputted, the chip will enter into an erase cycle. When the cycle completes, the chip will automatically enter into standby mode.

**WRITE (WRITE):** The Write (WRITE) instruction is used to write to a specific memory location. If word mode (x16) is selected, then 16 bits of data will be written into the location. If byte mode (x8) is chosen, then 8 bits of data will be written into the location. The write cycle will begin automatically after the 8 or 16 bits are shifted into the chip.

**ERASE ALL (ERAL):** The Erase All (ERAL) instruction is primarily used for testing purposes and only functions when  $V_{CC}=4.5\text{ V}$  to  $5.5\text{ V}$ . This instruction will clear the entire memory array to ‘1’.

**WRITE ALL (WRAL):** The Write All (WRAL) instruction will program the entire memory array according to the 8 or 16-bit data pattern provided. The instruction will only be valid when  $V_{CC}=4.5\text{ V}$  to  $5.5\text{ V}$ .

**ERASE/WRITE DISABLE (EWDS):** The Erase/Write Disable (EWDS) instruction blocks any kind of erase or program operations from modifying the contents of the memory array. This instruction should be executed after erasing or programming to prevent accidental data loss.

Note also that the READ instruction will operate regardless of whether the chip is disabled from program and write operations.

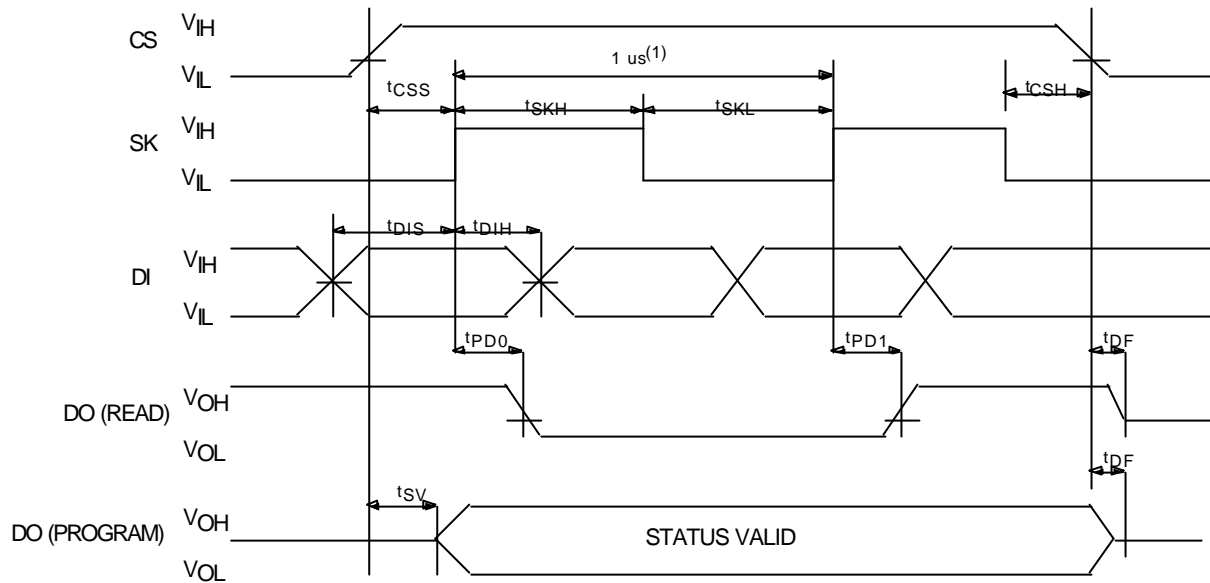
## Ready/Busy

To determine whether the chip has completed an erase or write operation, the CS signal can be pulled LOW for a minimum of 250 ns ( $t_{CS}$ ) and then pulled back HIGH to enter Ready/Busy mode. If the chip is currently in the programming cycle,  $t_{WP}$ , then the DO pin will go low (logical “0”). When the write cycle completes, the DO pin is pulled high (logical “1”) to indicate that the part can receive another instruction. Note that the Ready/Busy polling cannot be done if the chip has already finished and returned back to standby mode.



## TIMING DIAGRAMS

### Synchronous Data Timing



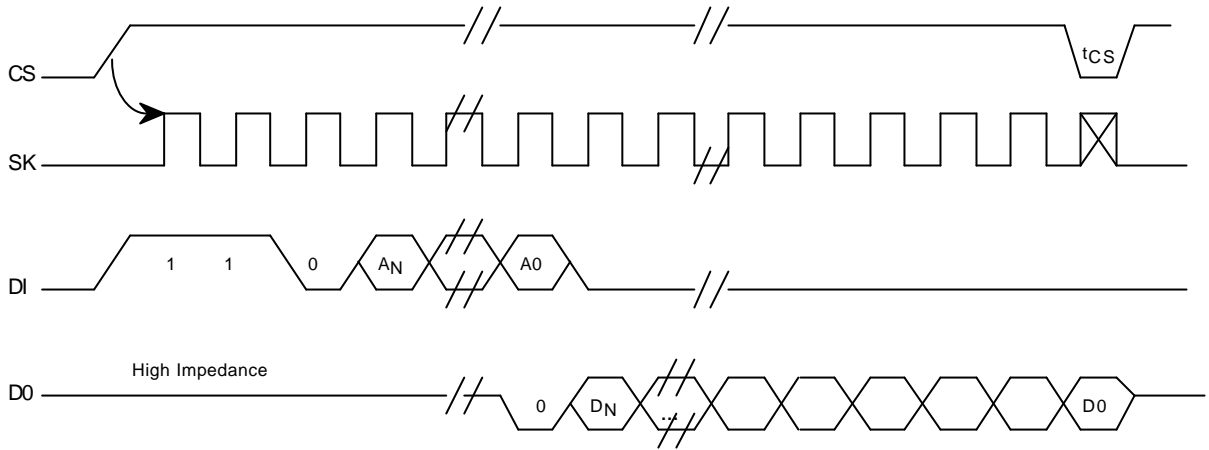
Note (1): This is the minimum SK period.

### Organization Key for Timing Diagrams

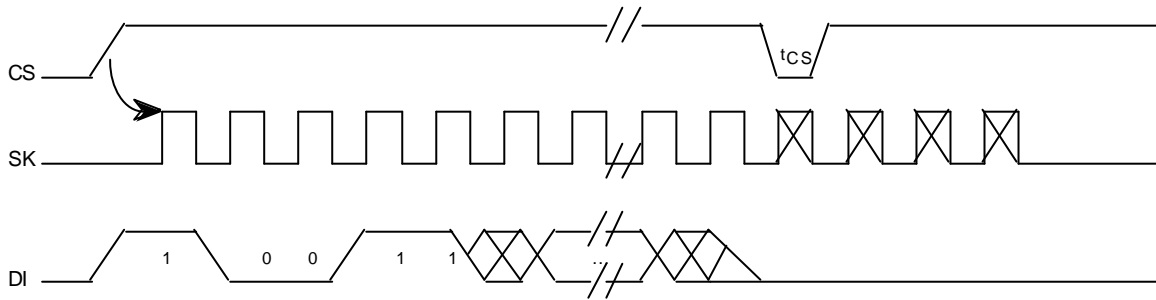
| I/O   | AF93BC86(16K) |          |
|-------|---------------|----------|
|       | X8            | X16      |
| $A_N$ | $A_{10}$      | $A_9$    |
| $D_N$ | $D_7$         | $D_{15}$ |



## READ TIMING

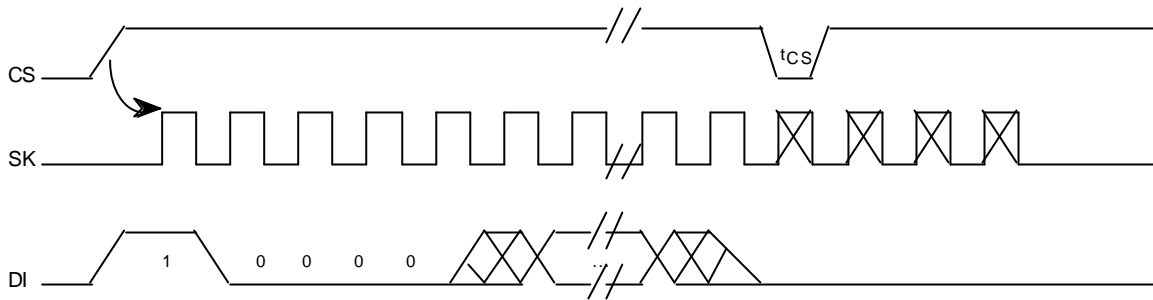


## EWEN TIMING

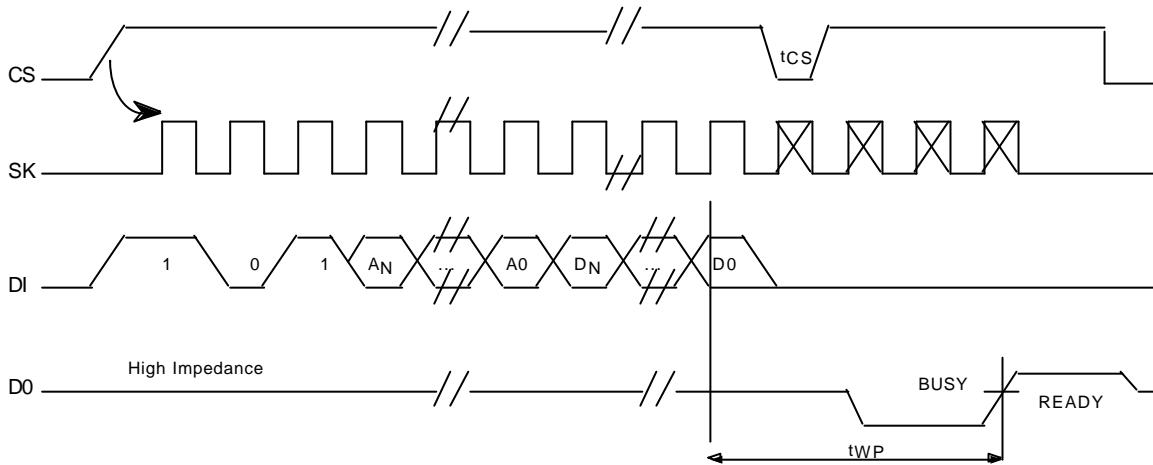




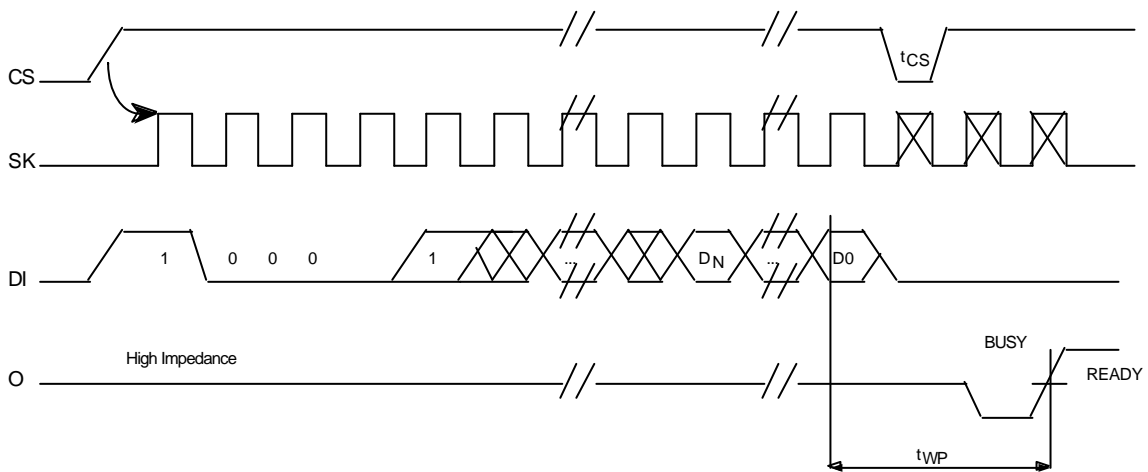
## EWDS TIMING



## WRITE TIMING



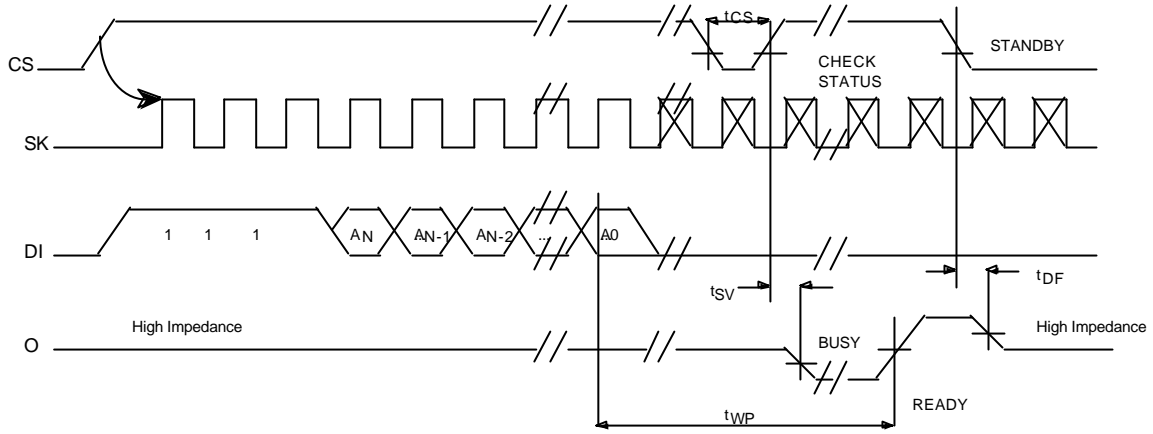
## WRAL TIMING<sup>(1)</sup>



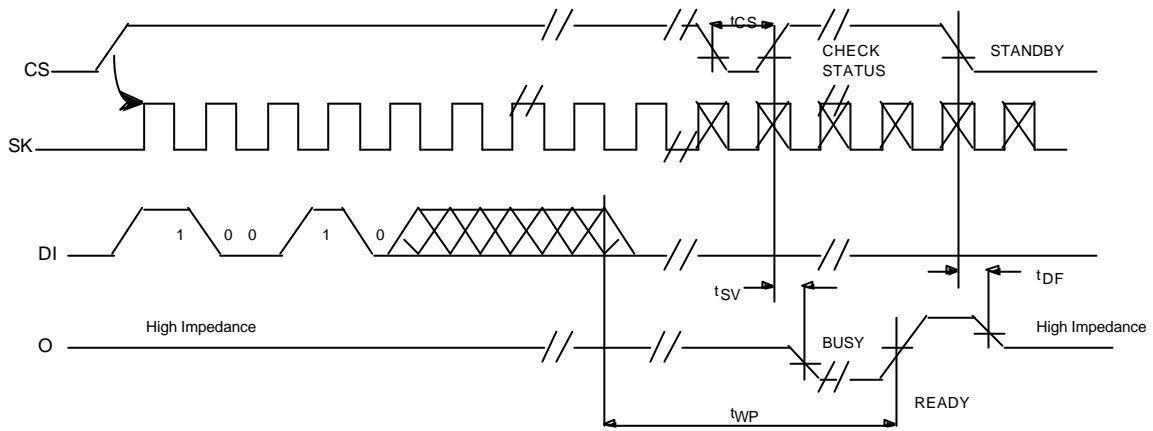
(1) Valid only at  $V_{CC} = 4.5V$  to  $5.5V$



## ERASE TIMING



## ERASE TIMING<sup>1)</sup>



(1) Valid only at  $V_{CC} = 4.5V$  to  $5.5V$



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### AF93BC86 Ordering Information

| Ordering Code | Package | Operating Ranges |
|---------------|---------|------------------|
| AF93BC86 – P1 | P       | Lead free        |
| AF93BC86 – S1 | S       | Industrial       |
| AF93BC86 – T1 | T       | (-40°C to +85°C) |

| Package Type |   |
|--------------|---|
| P            | 8-pin, 0.300" Wide, Plastic Dual Inline Package (PDIP)            |
| S            | 8-lead, 0.150" Wide, Plastic Gull Wing Small Outline (JEDEC SOIC) |
| T            | 8-lead, 0.170" Wide, Thin Shrink Small Outline Package (TSSOP)    |



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## PRODUCT ORDERING INFORMATION

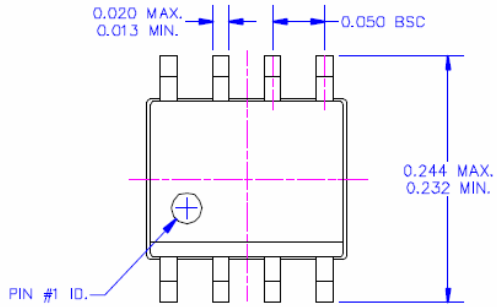
|                                      | AF93 | BC | aa | -Y | Z |
|--------------------------------------|------|----|----|----|---|
| <b>Device Type</b>                   |      |    |    |    |   |
| AF93                                 |      |    |    |    |   |
| <b>Supply Voltage</b>                |      |    |    |    |   |
| BC = 1.8V to 5.5V                    |      |    |    |    |   |
| <b>Device Function</b>               |      |    |    |    |   |
| 86 = 16 Kbit (2048 x 8 or 1024 x 16) |      |    |    |    |   |
| <b>Package</b>                       |      |    |    |    |   |
| P = PDIP<br>S = SOIC<br>T = TSSOP    |      |    |    |    |   |
| <b>Temperature</b>                   |      |    |    |    |   |
| I = Industrial (-40°C ~ 85°C)        |      |    |    |    |   |



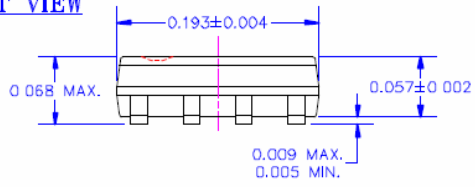
## PACKAGING INFORMATION

### 8-pin SOIC

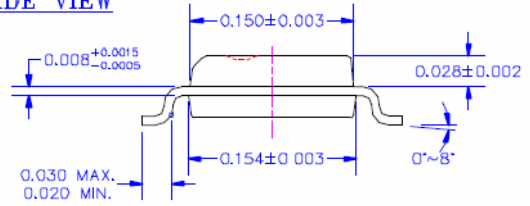
TOP VIEW



FRONT VIEW



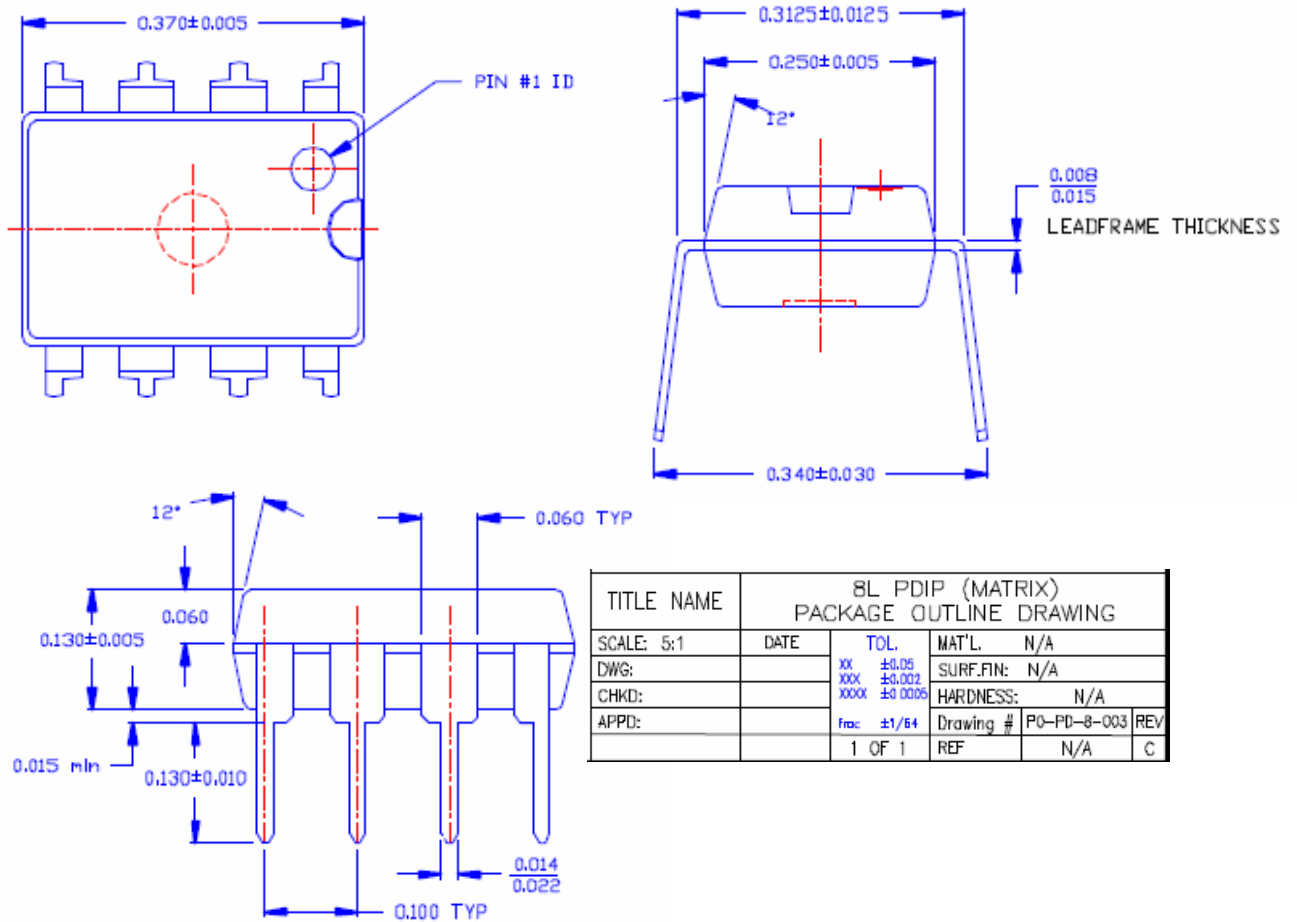
SIDE VIEW



| TITLE NAME |      | 8L SOIC MATRIX PACKAGE OUTLINE DRAWING |                           |      |       |
|------------|------|--|---------------------------|------|-------|
| SCALE: 9:1 | DATE | TOL                                    | MAT'L: N/A                |      |       |
| DWG:       |      | xx N/A                                 | SURF.FIN: N/A             |      |       |
| CHKD:      |      | xxx N/A                                | HARDNESS: N/A             |      |       |
| APPD:      |      | xxxx N/A                               | Drawing # PO-S0-8-001 REV |      |       |
|            |      | arg N/A                                | 1 OF 1                    | REF. | N/A F |
|            |      | fra N/A                                |                           |      |       |



## 8-pin PDIP

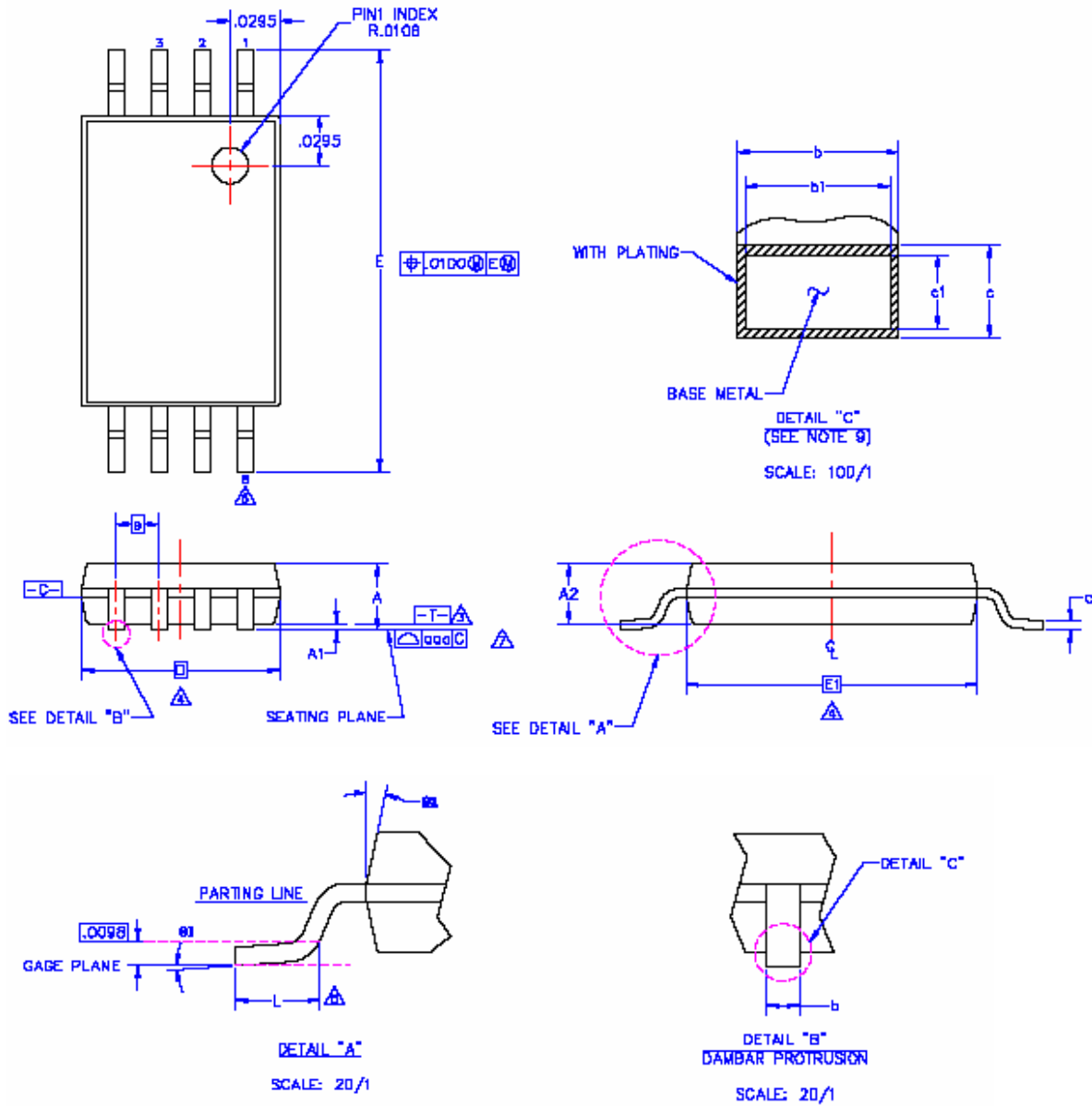


### Note:

1. All package dimensions do not include mold flash. Mold flash shall not exceed 5 mils.
2. Lead dimensions does not include protrusions. Lead protrusions does not exceed 10 mils and lead intrusion is not allowed.
3. All dimensions are in inches.



## 8-pin TSSOP



(continued on next page)



| SYMBOL | DIMENSION      |      |      |            |        |        |
|--------|----------------|------|------|------------|--------|--------|
|        | JEDEC STANDARD |      |      |            |        |        |
|        | IN MM          |      |      | IN INCH    |        |        |
|        | MIN.           | NOM. | MAX. | MIN.       | NOM.   | MAX.   |
| A      | -              | -    | 1.20 | -          | -      | 0.0472 |
| A1     | 0.05           | -    | 0.15 | 0.0020     | -      | 0.0059 |
| A2     | 0.80           | 1.00 | 1.05 | 0.0315     | 0.0394 | 0.0413 |
| b      | 0.19           | -    | 0.30 | 0.0075     | -      | 0.0118 |
| b1     | 0.19           | 0.22 | 0.25 | 0.0075     | 0.0087 | 0.0098 |
| c      | 0.09           | -    | 0.20 | 0.0035     | -      | 0.0079 |
| c1     | 0.09           | -    | 0.16 | 0.0035     | -      | 0.0063 |
| D      | 2.90           | 3.00 | 3.10 | 0.1142     | 0.1181 | 0.1220 |
| e      | 0.85 BSC       |      |      | 0.0256 BSC |        |        |
| F      | 6.4 BSC        |      |      | 0.2520 BSC |        |        |
| E1     | 4.30           | 4.40 | 4.50 | 0.1693     | 0.1732 | 0.1772 |
| L      | 0.45           | 0.60 | 0.75 | 0.0177     | 0.0236 | 0.0295 |
| Ø1     | Ø              | -    | Ø    | Ø          | -      | Ø      |
| Ø2     | 12°REF         |      |      | 12°REF     |        |        |
| Ø3     | 0.10           |      |      | 0.0039     |        |        |

| TITLE NAME  |      | 8L TSSOP<br>PACKAGE OUTLINE DRAWING |               |             |     |
|-------------|------|-------------------------------------|---------------|-------------|-----|
| SCALE: 10:1 | DATE | TOL<br>N/A                          | MAT'L: N/A    |             |     |
| DWG:        |      |                                     | SURF.FIN: N/A |             |     |
| CHKD:       |      |                                     | HARDNESS: N/A |             |     |
| APPD:       |      |                                     | DG NO         | PO-TS-8-001 | REV |
|             |      | 1 OF 1                              | REF.          | N/A         | B   |



## REVISIONS

| Version Number | Description               | Page  | Date       |
|----------------|---------------------------|-------|------------|
| 1.04           | Add lead free description | 1, 11 | 10/15/2007 |

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