

4-digit LED driver with I²C-bus interface

SAA1064

GENERAL DESCRIPTION

The LED-driver is a bipolar integrated circuit made in an I²L compatible 18 volts process. The circuit is especially designed to drive four 7-segment LED displays with decimal point by means of multiplexing between two pairs of digits. It features an I²C-Bus slave transceiver interface with the possibility to program four different SLAVE ADDRESSES, a POWER RESET flag, 16 current sink OUTPUTS, controllable by software up to 21 mA, two multiplex drive outputs for common anode segments, an on-chip multiplex oscillator, control bits to select static, dynamic and blank mode, and one bit for segment test.

QUICK REFERENCE DATA

| parameter | conditions | symbol | min. | typ. | max. | unit |
|--|-----------------------|-------------------|------|------|------|------|
| Supply voltage | V _{EE} = 0 V | V _{CC} | 4.5 | 5 | 15 | V |
| Supply current all outputs OFF | V _{CC} = 5 V | I _{CC} * | 7 | 9.5 | 14 | mA |
| Total power dissipation 24-lead DIL (SOT101B) | | P _{tot} | — | — | 1000 | mW |
| 24-lead DIL SO (SOT137A) | | P _{tot} | — | — | 500 | mW |
| Operating ambient temperature range | | T _{amb} | -40 | — | +85 | °C |

* The positive current is defined as the conventional current flow into a device (sink current).

PACKAGE OUTLINE

SAA1064: 24-lead DIL; plastic with internal heat spreader (SOT101B).

SAA1064T: 24-lead mini-pack; plastic (SO-24; SOT137A).

4-digit LED driver with I²C-bus interface

SAA1064

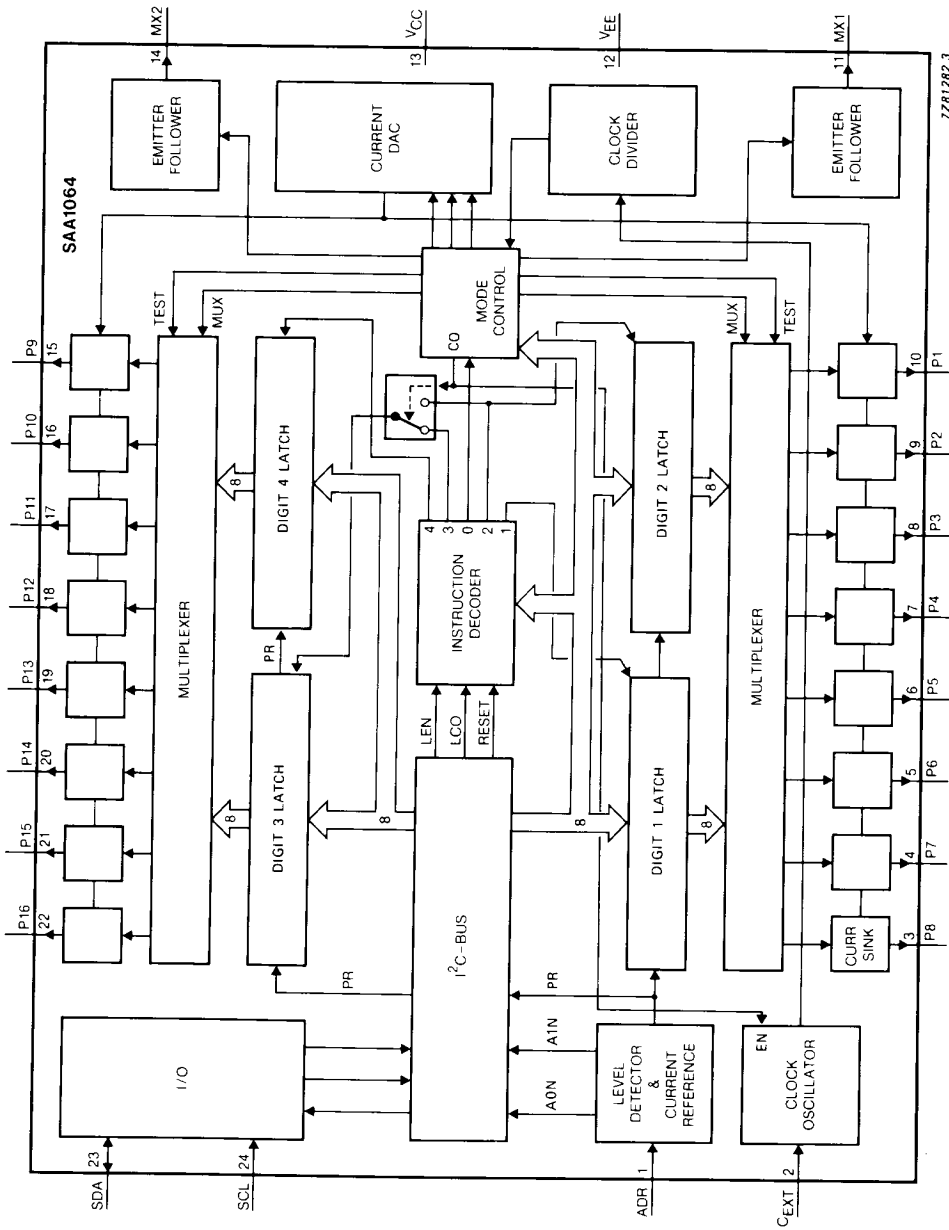


Fig. 1 Block diagram.

4-digit LED driver with I²C-bus interface

SAA1064

PINNING

| SYMBOL | PIN | DESCRIPTION |
|------------------|-------|--|
| ADR | 1 | I ² C-Bus slave address input |
| C _{EXT} | 2 | external control |
| P8 to P1 | 3-10 | segment output |
| MX1 | 11 | multiplex output |
| V _{EE} | 12 | ground |
| V _{CC} | 13 | positive supply |
| MX2 | 14 | multiplex output |
| P9 to P16 | 15-22 | segment output |
| SDA | 23 | I ² C-Bus serial data line |
| SCL | 24 | I ² C-Bus serial clock line |

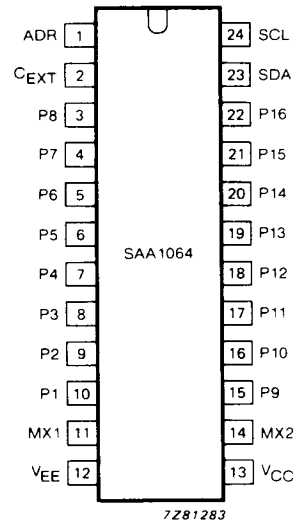


Fig.2 Pinning diagram.

FUNCTIONAL DESCRIPTION

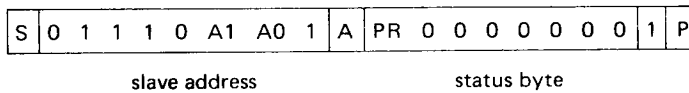


Fig. 3a I²C-Bus format; READ mode.

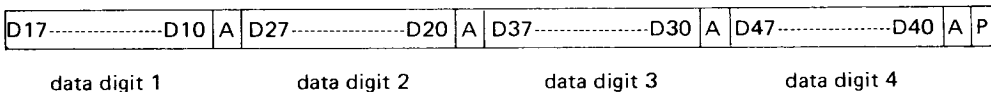
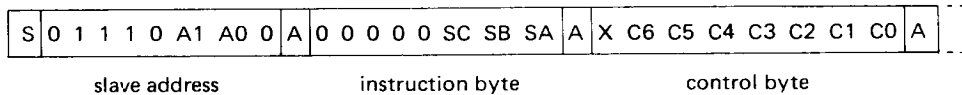


Fig. 3b I²C-Bus format; WRITE mode.

- S = start condition
- P = stop condition
- A = acknowledge
- X = don't care
- A1, A0 = programmable address bits
- SC SB SA = subaddress bits
- C6 to C0 = control bits
- PR = POWER RESET flag

Address pin ADR

Four different slave addresses can be chosen by connecting ADR either to V_{EE}, 3/8 V_{CC}, 5/8 V_{CC} or V_{CC}. This results in the corresponding valid addresses HEX 70, 72, 74 and 76 for writing and 71, 73, 75 and 77 for reading. All other addresses cannot be acknowledged by the circuit.

4-digit LED driver with I²C-bus interface

SAA1064

Status byte

Only one bit is present in the status byte, the POWER RESET flag. A logic 1 indicates the occurrence of a power failure since the last time it was read out. After completion of the READ action this flag will be set to logic 0.

Subaddressing

The bits SC, SB and SA form a pointer and determine to which register the data byte following the instruction byte will be written. All other bytes will then be stored in the registers with consecutive subaddresses. This feature is called Auto-Increment (AI) of the subaddress and enables a quick initialization by the master.

The subaddress pointer will wrap around from 7 to 0.

The subaddresses are given as follows:

| SC | SB | SA | sub-address | function |
|----|----|----|-------------|-------------------------|
| 0 | 0 | 0 | 00 | control register |
| 0 | 0 | 1 | 01 | digit 1 |
| 0 | 1 | 0 | 02 | digit 2 |
| 0 | 1 | 1 | 03 | digit 3 |
| 1 | 0 | 0 | 04 | digit 4 |
| 1 | 0 | 1 | 05 | } reserved, not used |
| 1 | 1 | 0 | 06 | |
| 1 | 1 | 1 | 07 | |

Control bits (see Fig. 4)

The control bits C0 to C6 have the following meaning:

- C0 = 0 static mode, i.e. continuous display of digits 1 and 2
- C0 = 1 dynamic mode, i.e. alternating display of digit 1 + 3 and 2 + 4
- C1 = 0/1 digits 1 + 3 are blanked/not blanked
- C2 = 0/1 digits 2 + 4 are blanked/not blanked
- C3 = 1 all segment outputs are switched-on for segment test*
- C4 = 1 adds 3 mA to segment output current
- C5 = 1 adds 6 mA to segment output current
- C6 = 1 adds 12 mA to segment output current

Data

A segment is switched ON if the corresponding data bit is logic 1. Data bits D17 to D10 correspond with digit 1, D27 to D20 with digit 2, D37 to D30 with digit 3 and D47 to D40 with digit 4.

The MSBs correspond with outputs P8 and P16, the LSBs with P1 and P9. Digit numbers 1 to 4 are equal to their subaddresses (hex) 1 to 4.

* At a current determined by C4, C5 and C6.

4-digit LED driver with I²C-bus interface

SAA1064

SDA, SCL

The SDA and SCL I/O meet the I²C-Bus specification. For protection against positive voltage pulses on these inputs voltage regulator diodes are connected to V_{EE}. This means that normal line voltage should not exceed 5,5 volt. Data will be latched on the positive-going edge of the acknowledge related clock pulse.

Power-on reset

The power-on reset signal is generated internally and sets all bits to zero, resulting in a completely blanked display. Only the POWER RESET flag is set.

External Control (C_{EXT})

With a capacitor connected to pin 2 the multiplex frequency can be set (see Fig. 5). When static this pin can be connected to V_{EE} or V_{CC} or left floating since the oscillator will be switched off.

Segment outputs

The segment outputs P1 to P16 are controllable current-sink sources. They are switched on by the corresponding data bits and their current is adjusted by control bits C4, C5 and C6.

Multiplex outputs

The multiplex outputs MX1 and MX2 are switched alternately in dynamic mode with a frequency derived from the clock-oscillator. In static mode MX1 is switched on. The outputs consist of an emitter-follower, which can be used to drive the common anodes of two displays directly provided that the total power dissipation of the circuit is not exceeded. If this occurs external transistors should be connected to pins 11 and 14 as shown in Fig. 5.

4-digit LED driver with I²C-bus interface

SAA1064

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

| parameter | conditions | symbol | min. | max. | unit |
|-------------------------------------|-----------------------|-----------------------|------|----------------|------|
| Supply voltage (pin 13) | $V_{EE} = 0\text{ V}$ | V_{CC} | -0.5 | 18 | V |
| Supply current (pin 13) | | I_{CC} | -50 | 200 | mA |
| Total power dissipation | | | | | |
| 24-lead DIL (SOT101B) | | P_{tot} | | 1000 | mW |
| 24-lead SO (SO137A) | | P_{tot} | | 500 | mW |
| SDA, SCL voltages | $V_{EE} = 0\text{ V}$ | $V_{23,24}$ | -0.5 | 5.9 | V |
| Voltages ADR-MX1 and MX2-P16 | $V_{EE} = 0\text{ V}$ | V_{1-11}, V_{14-22} | -0.5 | $V_{CC} + 0.5$ | V |
| Input/output current all pins | outputs OFF | $\pm I_{I/O}$ | - | 10 | mA |
| Operating ambient temperature range | | T_{amb} | -40 | + 85 | °C |
| Storage temperature range | | T_{stg} | -55 | + 150 | °C |

THERMAL RESISTANCE

From crystal to ambient

| | | |
|---------------------------------------|---------------|---------|
| 24-lead DIL | $R_{th\ j-a}$ | 35 K/W |
| 24-lead SO (on ceramic substrate) | $R_{th\ j-a}$ | 75 K/W |
| 24-lead SO (on printed circuit board) | $R_{th\ j-a}$ | 105 K/W |

4-digit LED driver with I²C-bus interface

SAA1064

CHARACTERISTICSV_{CC} = 5 V; T_{amb} = 25 °C; voltages are referenced to ground (V_{EE} = 0 V); unless otherwise specified

| parameter | conditions | symbol | min. | typ. | max. | unit |
|---|--|--------------------|----------------------|--------------------|----------------------|------|
| Supply | | | | | | |
| Supply voltage (pin 13) | | V _{CC} | 4,5 | 5,0 | 15 | V |
| Supply current | all outputs OFF V _{CC} = 5 V | I _{CC} | 7,0 | 9,5 | 14,0 | mA |
| Power dissipation | all outputs OFF | P _d | — | 50 | — | mW |
| SDA; SCL (pins 23 and 24) | | | | | | |
| Input voltages | | V _{23,24} | 0 | — | 5,5 | V |
| Logic input voltage LOW | | V _{IL(L)} | — | — | 1,5 | V |
| Logic input voltage HIGH | | V _{IH(L)} | 3,0 | — | — | V |
| Input current LOW | V _{23,24} = V _{EE} | -I _{IL} | — | — | 10 | μA |
| Input current HIGH | V _{23,24} = V _{CC} | I _{IH} | — | — | 10 | μA |
| SDA | | | | | | |
| Logic output voltage LOW | I _O = 3 mA | V _{OL(L)} | — | — | 0,4 | V |
| Output sink current | | I _{SDA} | 3 | — | — | mA |
| Address input (pin 1) | | | | | | |
| Input voltage | | | | | | |
| programmable address bits: | | | | | | |
| A0 = 0; A1 = 0 | | V ₁ | V _{EE} | — | 3/16V _{CC} | V |
| A0 = 1; A1 = 0 | | V ₁ | 5/16V _{CC} | 3/8V _{CC} | 7/16V _{CC} | V |
| A0 = 0; A1 = 1 | | V ₁ | 9/16V _{CC} | 5/8V _{CC} | 11/16V _{CC} | V |
| A0 = 1; A1 = 1 | | V ₁ | 13/16V _{CC} | — | V _{CC} | V |
| Input current LOW | V ₁ = V _{EE} | -I ₁ | — | — | 10 | μA |
| Input current HIGH | V ₁ = V _{CC} | I ₁ | — | — | 10 | μA |
| External control (C_{EXT}) pin 2 | | | | | | |
| Switching level input | | | | | | |
| Input voltage LOW | | V _{IL} | — | — | V _{CC} -3,3 | V |
| Input voltage HIGH | | V _{IH} | V _{CC} -1,5 | — | — | V |
| Input current | V ₂ = 2 V | I ₂ | -140 | -160 | -180 | μA |
| | V ₂ = 4 V | I ₂ | 140 | 160 | 180 | μA |

4-digit LED driver with I²C-bus interface

SAA1064

CHARACTERISTICS (continued)

| parameter | conditions | symbol | min. | typ. | max. | unit |
|---|-------------------------------|--------------|----------------|------|----------|---------------|
| Segment outputs | | | | | | |
| (P8 to P1; pins 3 to 10) P9 to P16; pins 15 to 22) | | | | | | |
| Output voltages | $I_O = 15 \text{ mA}$ | V_O | — | — | 0.5 | V |
| Output leakage current HIGH | $V_O = V_{CC} = 15 \text{ V}$ | I_{LO} | — | — | ± 10 | μA |
| Output current LOW | | | | | | |
| All control bits (C4, C5 and C6) are HIGH | $V_{OL} = 5 \text{ V}$ | I_{OL} | 17.85 | 21 | 25.2 | mA |
| Contribution of: | | | | | | |
| control bit C4 | | I_O | 2.55 | 3.0 | 3.6 | mA |
| control bit C5 | | I_O | 5.1 | 6.0 | 7.2 | mA |
| control bit C6 | | I_O | 10.2 | 12.0 | 14.4 | mA |
| Relative segment output current accuracy | | | | | | |
| with respect to highest value | | ΔI_O | — | — | 7.5 | % |
| Multiplex 1 and 2 (pins 11 and 14) | | | | | | |
| Maximum output voltage (when ON) | $-I_{MPX} = 50 \text{ mA}$ | V_{MPX} | $V_{CC} - 1.5$ | — | — | V |
| Maximum output current HIGH (when ON) | $V_{MPX} = 2 \text{ V}$ | $-I_{MPX}$ | 50 | — | 110 | mA |
| Maximum output current LOW (when OFF) | $V_O = 2 \text{ V}$ | $+I_{MPX}$ | 50 | 70 | 110 | μA |
| Multiplex output period | $C_{EXT} = 2.7 \text{ nF}$ | T_{MPX} | 5 | — | 10 | ms |
| Multiplexed duty factor | | | — | 48.4 | — | % |

* Value to be fixed.

4-digit LED driver with I²C-bus interface

SAA1064

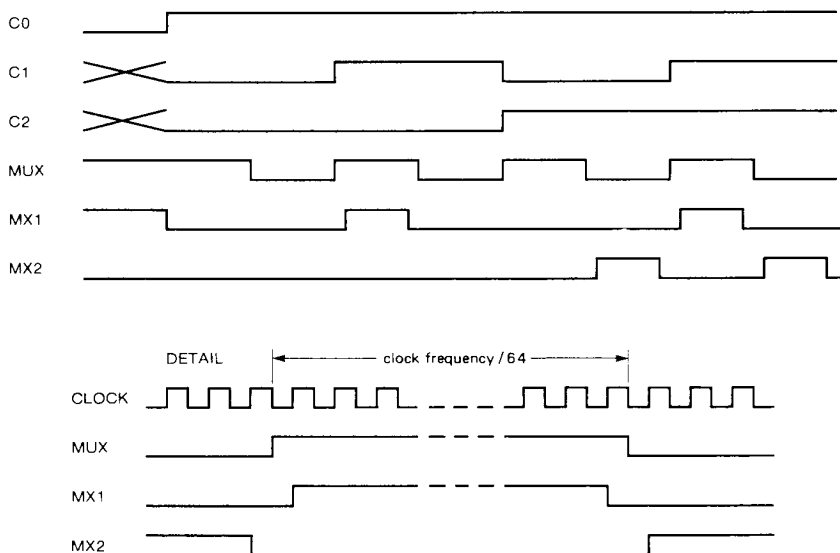


Fig. 4 Timing diagram.

7281284

4-digit LED driver with I²C-bus interface

SAA1064

APPLICATION INFORMATION

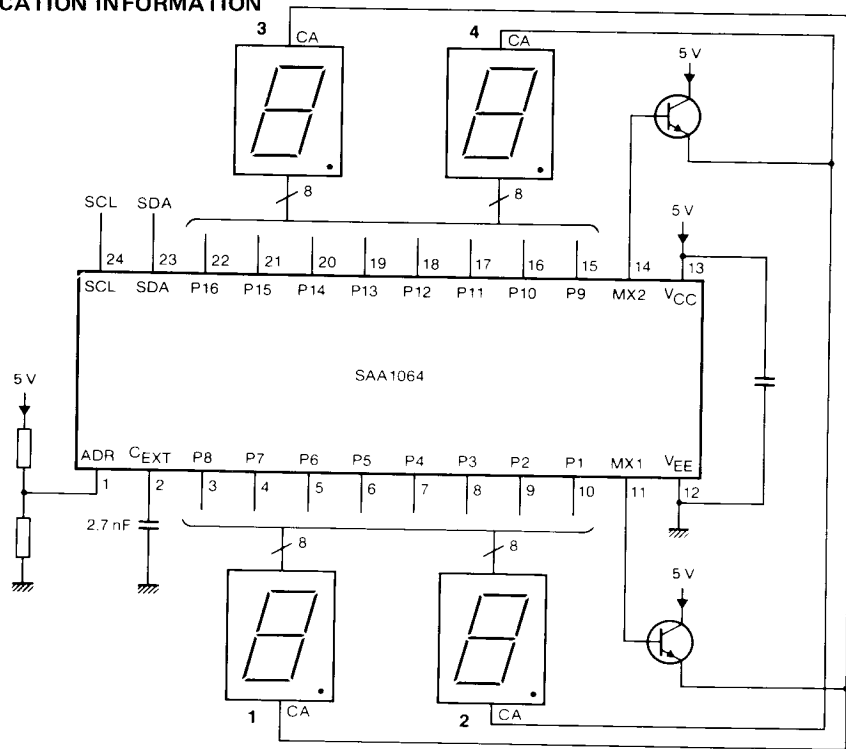


Fig. 5 Dynamic mode application diagram.

7281285

4-digit LED driver with I²C-bus interface

SAA1064

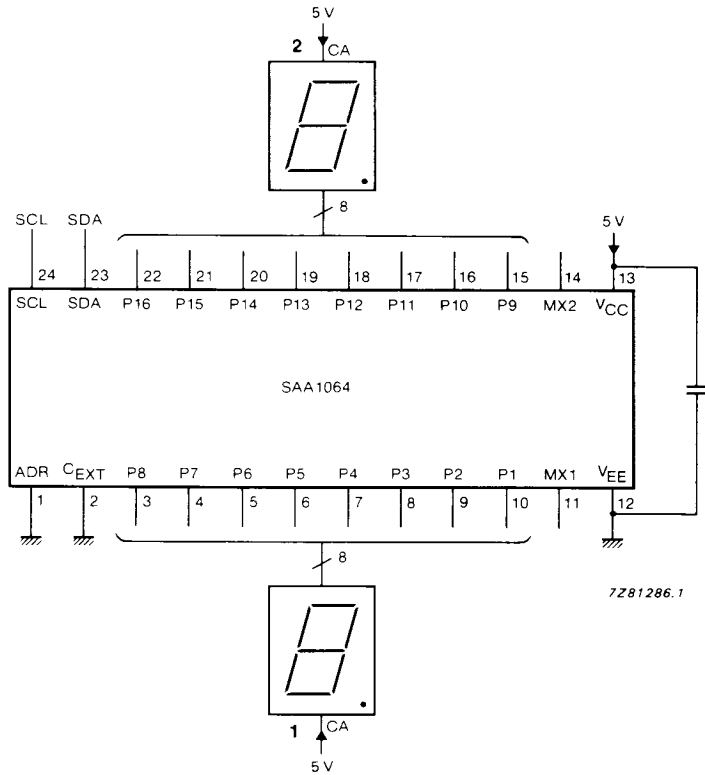


Fig. 6 Static mode application diagram.

4-digit LED driver with I²C-bus interface

SAA1064

POWER DISSIPATION

The total maximum power dissipation of the SAA1064 is made up by the following parts:

1. Maximum dissipation when none of the outputs are programmed (continuous line in Fig.7).
2. Maximum dissipation of each programmed output. The dashed line in Fig.7 visualises the dissipation when all the segments are programmed (max. 16 in the static, and max. 32 in the dynamic mode). When less segments are programmed one should take a proportional part of the maximum value.
3. Maximum dissipation of the programmed segment drivers which can be expressed as:

$$P_{\text{add}} = V_{\text{O}} \times I_{\text{O}} \times N.$$

Where:

- P_{add} = The additional power dissipation of the segment drivers
- V_{O} = The low state segment driver output voltage
- I_{O} = The programmed segment output current
- N = The number of programmed segments in the static mode,
or half the number of programmed segment drivers in the dynamic mode.

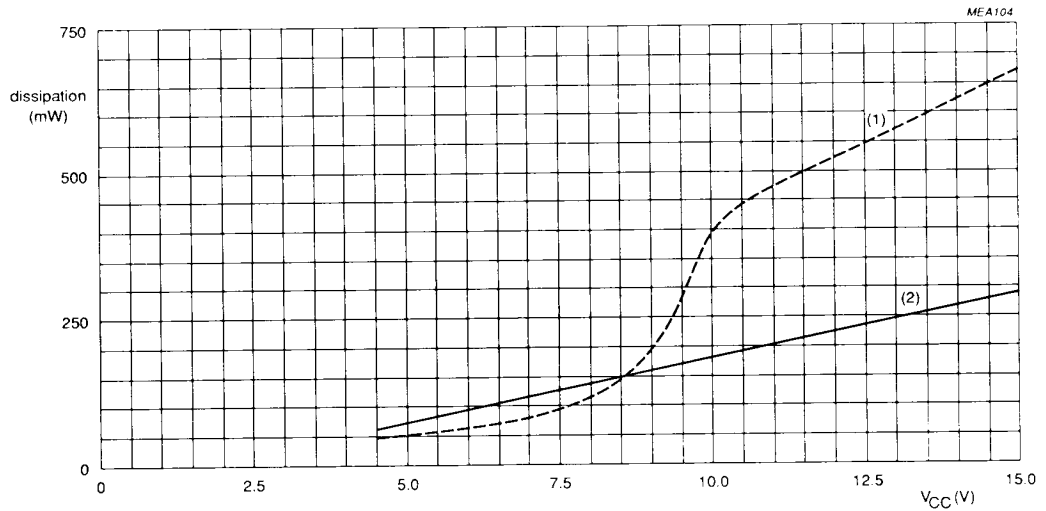
Under no conditions the total maximum dissipation (500 mW for the SO and 1000 mW for the DIL package) should be exceeded.

Example: $V_{\text{CC}} = 5 \text{ V}$
 $V_{\text{O}} = 0.25 \text{ V}$
 $I_{\text{O}} = 12 \text{ mA}$
 24 programmed segments in dynamic mode

$$\begin{aligned} P_{\text{tot}} &= P_1 + P_2 + P_3 \\ &= 75 \text{ mW} + (50 * 24/32) \text{ mW} + (0.25 * 12 \cdot 10^{-3} * 12) \text{ mW} \\ &= 148.5 \text{ mW} \end{aligned}$$

4-digit LED driver with I²C-bus interface

SAA1064



- (1) All outputs programmed (no segment current sink).
 (2) Outputs not programmed.

Fig.7 SAA1064 power dissipation as a function of supply voltage.



Purchase of Philips' I²C components conveys a license under the Philips' I²C patent to use the components in the I²C-system provided the system conforms to the I²C specifications defined by Philips.