

## UNIVERSAL INDUSTRIAL LOGIC AND INTERFACE CIRCUIT

### GENERAL DESCRIPTION

The SAA1029 is a universal bipolar logic and interface IC with high noise immunity and operational stability for industrial control applications. The most fundamental industrial control functions can be accomplished with only one SAA1029 IC. Figure 1 shows the logic configuration.

The IC comprises,

- (1) Gate 1: 4-input AND gate with 1 inverted input,
- (2) Gate 2: 3-input AND gate with 1 inverted input and adjustable propagation delay,
- (3) Gate 3: 2-input AND gate with 1 inverted input.

The SAA1029 can be used as direct interface with LOC MOS (CMOS) ICs for realizing more complex functions. Therefore, the output signal can be limited to the voltage level of the common output clamping pin Z.

The propagation delay of NAND gate 2 is adjustable from microseconds to seconds by using an external capacitor at pin C. This makes it possible to adapt the control frequency limits to the system, so the optimum dynamic noise immunity can be achieved.

All the static and dynamic circuit values (including the output voltage) are independent of the supply voltage over a wide operating range. This allows the use of a simple unstabilized power supply.

The output is held to the LOW state automatically during switching on the power supply, so a special reset pulse can be omitted.

### Features

- Simple realization of the basic industrial control functions (logic functions, timing functions, memory functions).
- High dynamic and static noise immunity.
- High operation stability.
- Short-circuit protection of inputs and outputs to both  $V_{EE}$  and  $V_{CC}$ .
- Wide supply voltage range, so a simple power supply can be used.
- Wire interruption results in a safe input LOW state.
- LOC MOS (CMOS) compatible.

### QUICK REFERENCE DATA

|                                              |           |                             |
|----------------------------------------------|-----------|-----------------------------|
| Supply voltage range                         | $V_{CC}$  | 14 to 31,2 V                |
| Operating ambient temperature range          | $T_{amb}$ | -30 to + 85 °C              |
| Input voltage HIGH                           | $V_{IH}$  | 6,5 to 44 V                 |
| Output voltage HIGH (without clamping)       | $V_{OH}$  | 13 to 30 V                  |
| Output voltage HIGH (with clamping at pin Z) | $V_{OH}$  | 2,0 to ( $V_{CC} - 0,7$ ) V |
| Input current                                | $I_I$     | max. 10 mA                  |
| Quiescent supply current                     | $I_{CC}$  | typ. 7,8 mA                 |

### PACKAGE OUTLINE

16-lead DIL; plastic (SOT38).

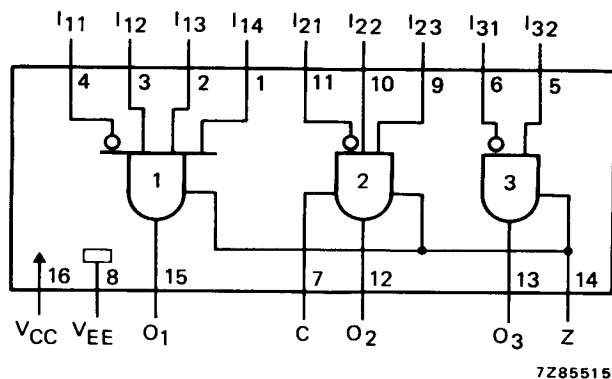


Fig. 1 Logic diagram.

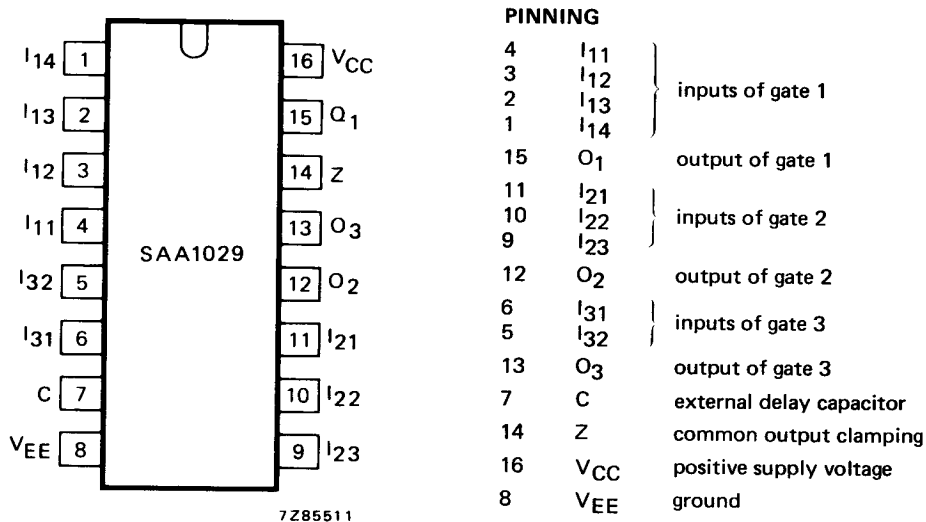


Fig. 2 Pinning diagram.

Logic equations:

$$O_1 = \overline{I_{11}} \cdot I_{12} \cdot I_{13} \cdot I_{14}$$

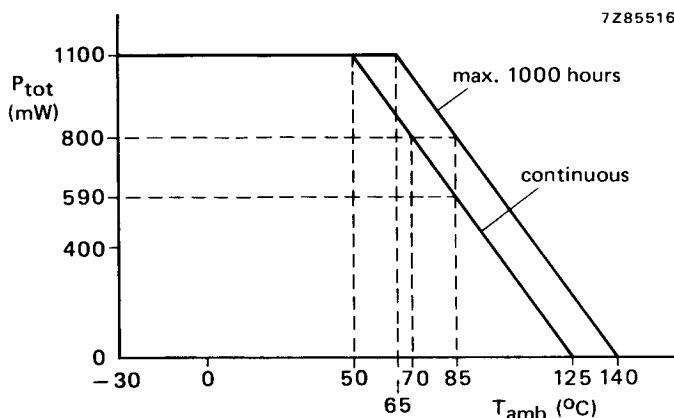
$$O_2 = \overline{I_{21}} \cdot I_{22} \cdot I_{23}$$

$$O_3 = \overline{I_{31}} \cdot I_{32}$$

## RATINGS

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

|                                                             |                 |                                               |
|-------------------------------------------------------------|-----------------|-----------------------------------------------|
| Supply voltage range                                        | $V_{CC}$        | 0 to +35 V                                    |
| Input voltage (independent of $V_{CC}$ )                    | $V_I$           | -0,15 to +44 V                                |
| Output clamping voltage (pin 14)                            | $V_Z$           | 0 to +35 V                                    |
| Voltage at any output (pins 12, 13 and 15)                  |                 |                                               |
| pin 14 (Z) open                                             | $V_O$           | -0,15 to $V_{CC}$ V                           |
| pin 14 (Z) at $V_Z$                                         | $V_O$           | max. $V_Z$ V<br>or $V_{CC}$ if $V_{CC} < V_Z$ |
| Current into any input                                      |                 |                                               |
| d.c.                                                        | $\pm I_I$       | max. 10 mA                                    |
| $t_p = 0,5 \mu s$ ; $\delta = 0,1\%$ (peak value)           | $\pm I_{IM}$    | max. 100 mA                                   |
| Sum of input currents                                       |                 |                                               |
| d.c.                                                        | $\Sigma I_I$    | -90 to +10 mA                                 |
| $t_p = 0,5 \mu s$ ; $\delta = 0,1\%$ (peak value)           | $\Sigma I_{IM}$ | -900 to +300 mA                               |
| External applied current at any output (pins 12, 13 and 15) |                 |                                               |
| pin 14 (Z) open                                             |                 |                                               |
| d.c.                                                        | $\pm I_O$       | max. 30 mA                                    |
| $t_p = 0,5 \mu s$ ; $\delta = 0,1\%$ (peak value)           | $\pm I_{OM}$    | max. 500 mA                                   |
| External applied current at any output (pins 12, 13 and 15) |                 |                                               |
| pin 14 (Z) at $V_Z$                                         |                 |                                               |
| d.c.                                                        | $I_O$           | -30 to +10 mA                                 |
| $t_p = 0,5 \mu s$ ; $\delta = 0,1\%$ (peak value)           | $I_O$           | -500 to +100 mA                               |
| Voltage at pin 7 (C)                                        | $V_C$           | -0,15 to +6 V                                 |
| External capacitor at pin 7 (C)                             | any value       |                                               |
| Short-circuit of outputs (pins 12, 13 and 15)               |                 |                                               |
| pin 14 (Z) open                                             |                 | allowed to $V_{CC}$ and $V_{EE}$ (0 V)        |
| at $V_Z < V_{CC}$                                           |                 | allowed only to $V_{EE}$ (0 V)                |
| Total power dissipation (see also Fig. 3)                   |                 |                                               |
| at $T_{amb} = 50^\circ C$ ; continuous                      | $P_{tot}$       | max. 1100 mW                                  |
| at $T_{amb} = 65^\circ C$ ; max. 1000 hours                 | $P_{tot}$       | max. 1100 mW                                  |
| Storage temperature range                                   | $T_{stg}$       | -40 to +150 $^\circ C$                        |

Fig. 3 Power derating curves;  $R_{th j-a} = 70 \text{ K/W}$ .

## CHARACTERISTICS

At  $T_{amb} = -30$  to  $+85$  °C;  $T_j \leq 125$  °C;  $V_{CC} = 14$  to  $31,2$  V; unless otherwise specified

| parameter                                        | conditions                           | symbol                    | min.           | typ. | max. | unit    |
|--------------------------------------------------|--------------------------------------|---------------------------|----------------|------|------|---------|
| Supply voltage                                   |                                      | $V_{CC}$                  | 14             | 24   | 31,2 | V       |
| Quiescent supply current                         |                                      | $I_{CC}$                  | —              | 7,8  | —    | mA      |
|                                                  |                                      | $I_{CC}$                  | —              | —    | 12,2 | mA      |
| Quiescent current ratio                          |                                      | $\frac{I_{CC1}}{I_{CC2}}$ | —              | 0,67 | —    | —       |
| Input voltage LOW                                | $V_{CC} = 31$ V; $T_{amb} = 25$ °C   | $V_{IL}$                  | —              | —    | 5    | V       |
| Input voltage HIGH                               | $I_{CC1} = I_{CC}$ at $T_j = 125$ °C | $V_{IH}$                  | 6,5            | —    | —    | V       |
|                                                  | $I_{CC2} = I_{CC}$ at $T_j = 25$ °C  | $V_{IH}$                  | 6,55           | —    | —    | V       |
| Input current LOW                                |                                      | $-I_{IL}$                 | —              | —    | 100  | $\mu$ A |
| Input current HIGH                               |                                      | $-I_{IL}$                 | —              | —    | 95   | $\mu$ A |
| Rate of change of input signal                   |                                      | $I_{IH}$                  | 300            | —    | —    | $\mu$ A |
| Input current*                                   |                                      | $dV/dt$                   | 3              | —    | —    | V/ms    |
|                                                  | $V_I = 1$ V                          | $-I_I$                    | —              | —    | 120  | $\mu$ A |
|                                                  | $V_I = 35$ V                         | $I_I$                     | —              | —    | 280  | $\mu$ A |
| Output clamping voltage*                         | $V_Z = V_{CC} - 1$ V                 | $V_Z$                     | —              | —    | 30   | V       |
| Output voltage without clamping (pin 14 open)*   | $V_{CC} = 14$ V                      |                           |                |      |      |         |
| non-inverting input: $V_I = 5,1$ V               |                                      |                           |                |      |      |         |
| inverting input: $V_I = 6,3$ V                   |                                      |                           |                |      |      |         |
| LOW                                              |                                      |                           |                |      |      |         |
| HIGH                                             |                                      |                           |                |      |      |         |
| Output voltage with clamping (pin 14 at $V_Z$ )* |                                      |                           |                |      |      |         |
| LOW                                              |                                      |                           |                |      |      |         |
|                                                  | $I_O = 1,32$ mA                      | $V_{OL}$                  | —              | —    | 1    | V       |
|                                                  | $I_O = 2,91$ mA                      | $V_{OL}$                  | —              | —    | 1,5  | V       |
|                                                  | $-I_O = 5$ mA                        | $V_{OH}$                  | $V_{CC} - 1,4$ | —    | —    | V       |
|                                                  | $V_{CC} = 31,2$ V                    |                           |                |      |      |         |
|                                                  | $V_Z < V_{CC} - 1$ V                 |                           |                |      |      |         |
|                                                  | $I_O = 1,32$ mA                      | $V_{OL}$                  | —              | —    | 1    | V       |
|                                                  | $I_O = 1,91$ mA                      | $V_{OL}$                  | —              | —    | 1,5  | V       |

\* At  $T_{amb} = 25$  °C;  $V_{CC} = 24$  V; unless otherwise specified.

| parameter                     | conditions                                                             | symbol                           | min.                                                 | typ.        | max.                                                 | unit          |
|-------------------------------|------------------------------------------------------------------------|----------------------------------|------------------------------------------------------|-------------|------------------------------------------------------|---------------|
| HIGH                          | $I_O = 0 \text{ mA}$<br>$-I_O = 1 \text{ mA}$<br>$-I_O = 3 \text{ mA}$ | $V_{OH}$<br>$V_{OH}$<br>$V_{OH}$ | $(V_Z - 0,475)$<br>$(V_Z - 0,455)$<br>$(V_Z - 0,41)$ | —<br>—<br>— | $(V_Z + 0,225)$<br>$(V_Z + 0,12)$<br>$(V_Z + 0,055)$ | V<br>V<br>V   |
| Output short-circuit current* | output at $V_{CC}$                                                     | $I_{scL}$                        | 2,95                                                 | —           | 9,6                                                  | mA            |
| LOW-signal                    | output at $V_{EE} (0 \text{ V})$                                       | $-I_{scH}$                       | 10,1                                                 | —           | 21,9                                                 | mA            |
| Capacitor charging current*   |                                                                        | $I_C$                            | —                                                    | 30          | —                                                    | $\mu\text{A}$ |
| Propagation delays*           |                                                                        |                                  |                                                      |             |                                                      |               |
| gates 1, 2 and 3              |                                                                        |                                  |                                                      |             |                                                      |               |
| HIGH to LOW                   | $C = 0$ (at gate 2)                                                    | $t_{PHL}$                        | —                                                    | 3,5         | —                                                    | $\mu\text{s}$ |
| LOW to HIGH                   |                                                                        | $t_{PLH}$                        | —                                                    | 3,5         | —                                                    | $\mu\text{s}$ |
| gate 2                        |                                                                        |                                  |                                                      |             |                                                      |               |
| HIGH to LOW                   | $C = 47 \text{ nF} \pm 1\%$                                            | $t_{PHL}$                        | 1,85                                                 | —           | 5,2                                                  | ms            |
| LOW to HIGH                   | $R_{insulation} > 100 \text{ M}\Omega$                                 | $t_{PLH}$                        | 7,5                                                  | —           | 14                                                   | ms            |

\* At  $T_{amb} = 25^\circ\text{C}$ ;  $V_{CC} = 24 \text{ V}$ ; unless otherwise specified.

## CHARACTERISTICS (worst case conditions)

At  $T_j = +125$  to  $+140$  °C; maximum 1000 hours

| parameter                                                                      | conditions                                                                                                             | symbol                                       | min.                                                 | typ.             | max.                                               | unit               |
|--------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------|----------------------------------------------|------------------------------------------------------|------------------|----------------------------------------------------|--------------------|
| Input voltage LOW                                                              |                                                                                                                        | $V_{IL}$                                     | —                                                    | —                | 5                                                  | V                  |
| Input voltage HIGH                                                             |                                                                                                                        | $V_{IH}$                                     | 6,55                                                 | —                | —                                                  | V                  |
| Input current                                                                  | $V_I = 1$ to $44$ V                                                                                                    | $I_I$                                        | 95                                                   | —                | 300                                                | $\mu$ A            |
| Change of input current<br>overdrive of other<br>inputs $\Sigma(-I_I) < 10$ mA | $V_I < V_{CC} - 1$ V<br>$V_I > V_{CC} - 1$ V                                                                           | $\Delta I_I$<br>$\Delta I_I$                 | —<br>—                                               | —<br>—           | 120<br>158                                         | $\mu$ A<br>$\mu$ A |
| overdrive of other<br>inputs $\Sigma(-I_I) < 90$ mA                            | $V_I < V_{CC} - 1$ V<br>$V_I > V_{CC} - 1$ V                                                                           | $\Delta I_I$<br>$\Delta I_I$                 | —<br>—                                               | —<br>—           | 280<br>320                                         | $\mu$ A<br>$\mu$ A |
| Input voltage by<br>current overdrive                                          | $\Sigma(-I_I) = 10$ mA                                                                                                 | $V_I$                                        | 46                                                   | —                | 65                                                 | V                  |
| Output voltage without<br>clamping (pin 14 open)                               |                                                                                                                        |                                              |                                                      |                  |                                                    |                    |
| LOW                                                                            | $I_{OL} \leq 0,095$ mA<br>$I_{OL} = 0,095$ to $1$ mA<br>$I_{OL} = 1$ to $2,5$ V<br>$-I_{OH} \leq 5$ mA                 | $V_{OL}$<br>$V_{OL}$<br>$V_{OL}$<br>$V_{OH}$ | —<br>—<br>—<br>$V_{CC} - 1,5$                        | —<br>—<br>—<br>— | 0,35<br>1<br>1,5<br>—                              | V<br>V<br>V<br>V   |
| HIGH                                                                           |                                                                                                                        |                                              |                                                      |                  |                                                    |                    |
| Output voltage with<br>clamping (pin 14 at $V_Z$ )                             | $V_Z = 2,5$ to $V_{CC} - 1$ V<br>$I_{OH} = 0$ mA<br>$I_{OH} = 1$ mA<br>$I_{OH} = 3$ mA<br>$I_{OH} = 0$ mA; $V_Z = 0$ V | $V_{OH}$<br>$V_{OH}$<br>$V_{OH}$<br>$V_{OH}$ | $(V_Z - 0,5)$<br>$(V_Z - 0,5)$<br>$(V_Z - 0,5)$<br>— | —<br>—<br>—<br>— | $(V_Z + 0,245)$<br>$(V_Z + 0,15)$<br>$V_Z$<br>0,75 | V<br>V<br>V<br>V   |
| Output short-circuit current                                                   |                                                                                                                        |                                              |                                                      |                  |                                                    |                    |
| LOW-signal                                                                     | output at $V_{CC}$                                                                                                     | $I_{OscL}$                                   | —                                                    | —                | 11                                                 | mA                 |
| HIGH-signal                                                                    | output at $V_{EE}$ (0 V)                                                                                               | $-I_{OscH}$                                  | 5                                                    | —                | 28,5                                               | mA                 |
| HIGH-signal                                                                    | output at $V_{EE}$ (0 V)<br>$T_j = 140$ °C                                                                             | $-I_{OscH}$                                  | —                                                    | —                | 10                                                 | mA                 |

| parameter                                                              | conditions                                                                                                            | symbol                    | min.                                         | typ. | max.    | unit          |
|------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------|---------------------------|----------------------------------------------|------|---------|---------------|
| Current out of pin 14 (Z)<br>when currents are<br>forced into outputs  | $-I_O \leq 3 \text{ mA}$                                                                                              | $-I_Z$                    | —                                            | —    | 2,2     | mA            |
| Current into pin 14 (Z)<br>when inputs are set<br>for output to be LOW | $\Sigma I_O = (I_{O1} + I_{O2} + I_{O3})$                                                                             | $-I_Z$                    | $\Sigma I_O$                                 | —    | —       | mA            |
| Supply current change                                                  | $-I_O = 30 \text{ mA}; V_O \leq V_{EE}$<br>{ input and/or output voltages<br>are negative with respect<br>to $V_{EE}$ | $I_Z$                     | —                                            | —    | 300     | $\mu\text{A}$ |
| Propagation delays<br>gates 1 and 3<br>HIGH to LOW<br>LOW to HIGH      | { without capacitor<br>with capacitor; C in $\mu\text{F}$                                                             | $\Delta I_{CC\text{max}}$ | $(0,3 \times I_{I1}) + (0,55 \times I_{I0})$ |      | —       | mA            |
| gate 2<br>HIGH to LOW                                                  |                                                                                                                       | t <sub>PHL</sub>          | 1                                            | —    |         | $\mu\text{s}$ |
| LOW to HIGH                                                            |                                                                                                                       | t <sub>PLH</sub>          | 1                                            | —    |         | $\mu\text{s}$ |
| gate 2<br>HIGH to LOW                                                  |                                                                                                                       | t <sub>PHL</sub>          | 0,1                                          | —    |         | $\mu\text{s}$ |
| LOW to HIGH                                                            | { without capacitor<br>with capacitor; C in $\mu\text{F}$                                                             | t <sub>PLH</sub>          | 0,3                                          | —    | 4       | $\mu\text{s}$ |
| HIGH to LOW                                                            |                                                                                                                       | t <sub>PHL</sub>          | 38 x C                                       | —    | 6       | $\mu\text{s}$ |
| LOW to HIGH                                                            |                                                                                                                       | t <sub>PLH</sub>          | 142 x C                                      | —    | 113 x C | $\mu\text{s}$ |
| Voltage spikes output<br>LOW                                           | see note 1                                                                                                            | V <sub>OL</sub>           | —                                            | —    | 2       | V             |

**Note to the characteristics**

1. V<sub>CC</sub> rising from 0 to 14 V; all inputs open; internally it is guaranteed that the input threshold voltage  $V_{IL} > V_{OL}$ .

## APPLICATION INFORMATION

The following figures (Figs 4 to 11) give some examples of the basic industrial control functions.

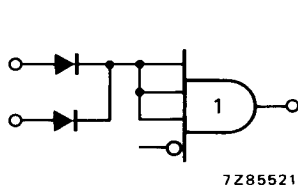


Fig. 4 OR function.

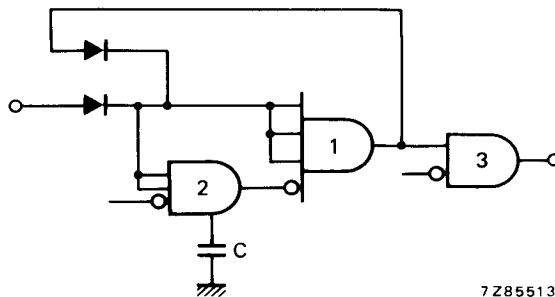


Fig. 8 Monostable flip-flop; for  $C = 4,7 \mu F$ , 1 s no reaction.

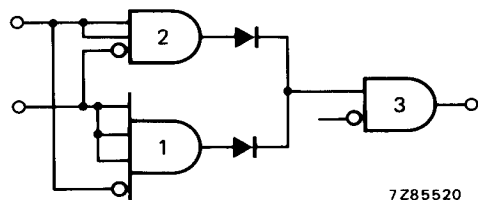


Fig. 5 EXCLUSIVE-OR function.

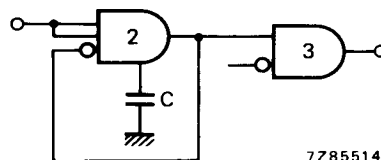


Fig. 9 Start delay function.

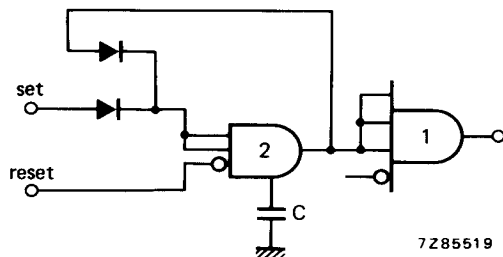


Fig. 6 Delayed memory; reset is dominating.

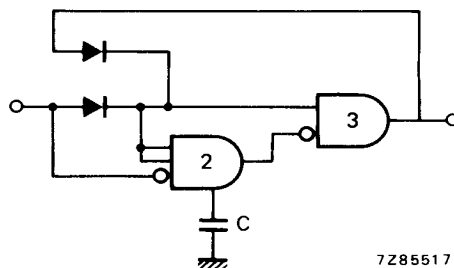


Fig. 10 Decay delay function.

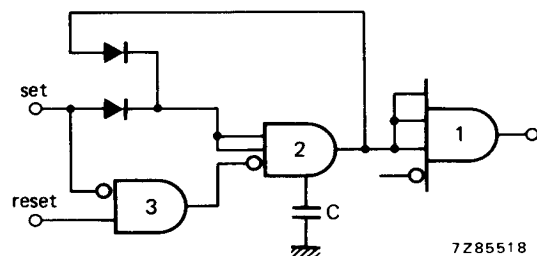


Fig. 7 Delayed memory; set is dominating.

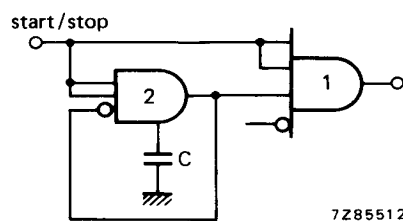


Fig. 11 Square-wave oscillator.