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SIEMENS

ICs for Chip Cards

Intelligent 256-Byte EEPROM
SLE 4432/SLE 4442

Data Sheet 07.95

SLE 4432/SLE4442 **Revision History:** **Original Version 07.95**	
Previous Releases: 01.94	
Page	Subjects (changes since last revision)
	Editorial changes

This edition was realized using the software system FrameMaker®

Important:	For further information please contact: Siemens Semiconductor Group in Munich, Germany, Key Account Service Chip Card ICs and Identsystem ICs, Tel.: + 49 89 4144-4362, Fax + 49 89 4144-2360 The supply of this component does not include a licence for its use in smart card applications. This licence is due to: INNOVATRON Patents 137 Boulevard de Sébastopol, 75002 Paris, France, Fax + 33 1 40 13 39 09

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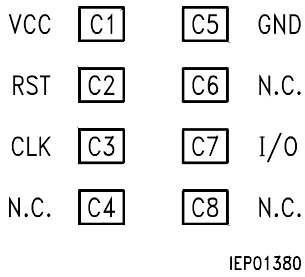
1 Pin Configuration

(top view)



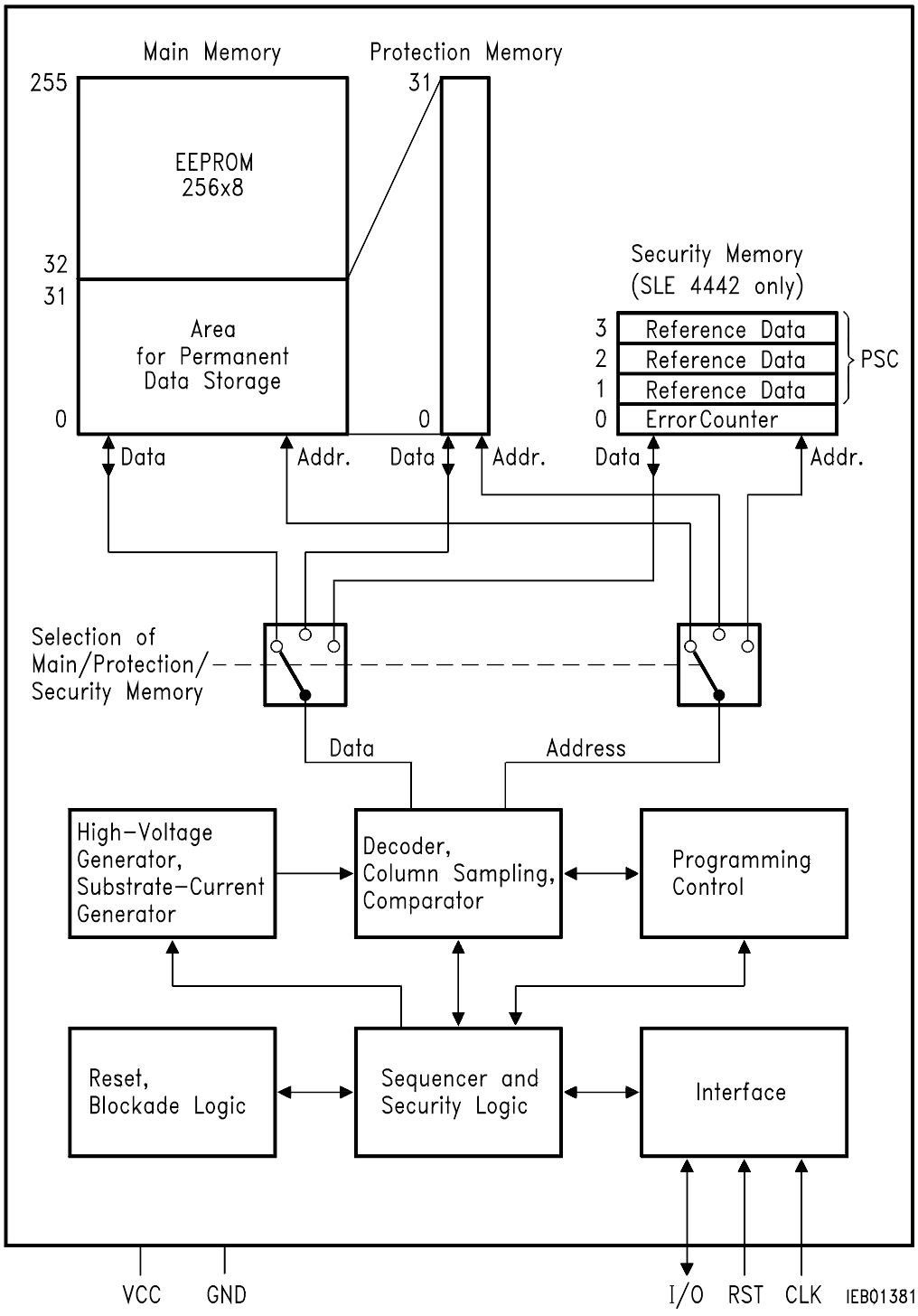
M2.2 (Card Contacts)

Pin Definitions and Functions

Card Contact	Symbol	Function
C1	VCC	Supply voltage
C2	RST	Reset
C3	CLK	Clock input
C4	N.C.	Not connected
C5	GND	Ground
C6	N.C.	Not connected
C7	I/O	Bidirectional data line (open drain)
C8	N.C.	Not connected

SLE 4432/SLE 4442 comes as a M2.2 wire-bonded module for embedding in plastic cards or as a die for customer packaging.

2 Functional Description



Block Diagram

2.1 Memory Overview

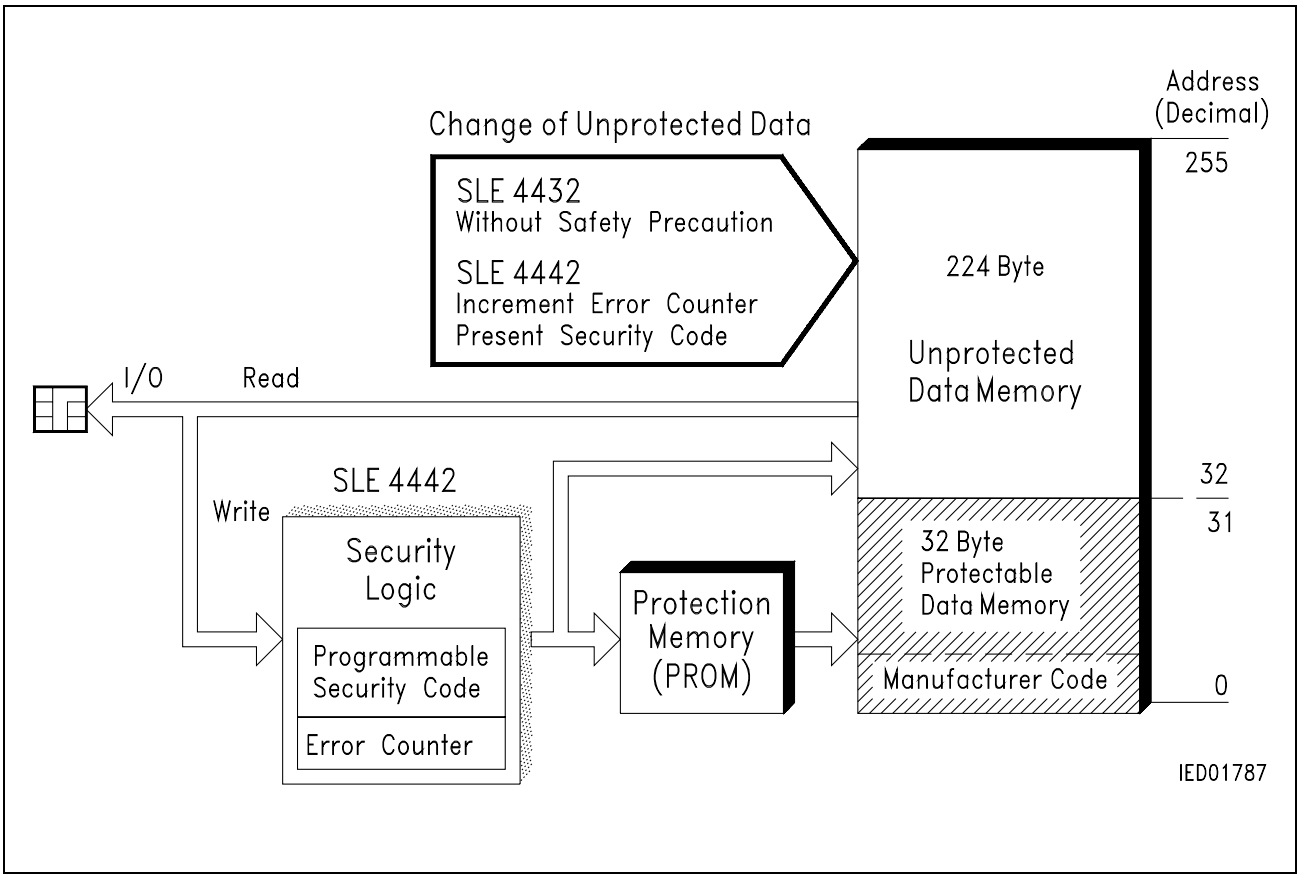


Figure 1
Memory Overwiew

SLE 4432

The SLE 4432 consists of 256 x 8 bit EEPROM main memory and a 32-bit protection memory with PROM functionality. The main memory is erased and written byte by byte. When erased, all 8 bits of a data byte are set to logical one. When written, the information in the individual EEPROM cells is, according to the input data, altered bit by bit to logical zeros (logical AND between the old and the new data in the EEPROM). Normally a data change consists of an erase and write procedure. It depends on the contents of the data byte in the main memory and the new data byte whether the EEPROM is really erased and/or written. If none of the 8 bits in the addressed byte requires a zero-to-one transition the erase access will be suppressed. Vice versa the write access will be suppressed if no one-to-zero transition is necessary. The write and the erase operation takes at least 2.5 ms each.

Each of the first 32 bytes can be irreversibly protected against data change by writing the corresponding bit in the protection memory. Each data byte in this address range is assigned to one bit of the protection memory and has the same address as the data byte in the main memory which it is assigned to. Once written the protection bit cannot be erased (PROM).

SLE 4442

Additionally to the above functions the SLE 4442 provides a security code logic which controls the write/erase access to the memory. For this purpose the SLE 4442 contains a 4-byte security memory with an **E**rror **C**ounter EC (bit 0 to bit 2) and 3 bytes reference data. These 3 bytes as a whole are called **P**rogrammable **S**ecurity **C**ode (PSC). After power on the whole memory, except for the reference data, can only be read. Only after a successful comparison of verification data with the internal reference data the memory has the identical access functionality of the SLE 4432 until the power is switched off. After three successive unsuccessful comparisons the **E**rror **C**ounter blocks any subsequent attempt, and hence any possibility to write and erase.

2.2 Transmission Protocol

The transmission protocol is a two wire link protocol between the interface device IFD and the integrated circuit IC. It is identical to the protocol type “S = A”. All data changes on I/O are initiated by the falling edge on CLK.

The transmission protocol consists of the 4 modes:

- Reset and Answer-to-Reset
- Command Mode
- Outgoing Data Mode
- Processing Mode

} Operational modes

Note: The I/O pin is open drain and therefore requires an external pull up resistor to achieve a high level.

Table 1

Byte 1 Control								Byte 2 Address	Byte 3 Data	Operation	Mode
B7	**B6**	**B5**	**B4**	**B3**	**B2**	**B1**	**B0**	**A7-A0**	**D7-D0**		
0	0	1	1	0	0	0	0	address	no effect	READ MAIN MEMORY	outgoing data
0	0	1	1	1	0	0	0	address	input data	UPDATE MAIN MEMORY	processing
0	0	1	1	0	1	0	0	no effect	no effect	READ PROTECTION MEMORY	outgoing data
0	0	1	1	1	1	0	0	address	input data	WRITE PROTECTION MEMORY	processing

Table 2
SLE 4442 only

0	0	1	1	0	0	0	1	no effect	no effect	READ SECURITY MEMORY	outgoing data
0	0	1	1	1	0	0	1	address	input data	UPDATE SECURITY MEMORY	processing
0	0	1	1	0	0	1	1	address	input data	COMPARE VERIFICATION DATA	processing

2.3.1 Read Main Memory (SLE 4432 and SLE 4442)

The command reads out the contents of the main memory (with LSB first) starting at the given byte address (N = 0…255) up to the end of the memory. After the command entry the IFD has to supply sufficient clock pulses. The number of clocks is m = (256 – N) × 8 + 1. The read access to the main memory is always possible.

Address (decimal)	Main Memory	Protection Memory	Security Memory (only SLE 4442)
255	Data Byte 255 (D7 … D0)	–	–
:	:	–	–
32	Data Byte 32 (D7 … D0)	–	–
31	Data Byte 31 (D7 … D0)	Protection Bit 31 (D31)	–
:	:	:	–
3	Data Byte 3 (D7 … D0)	Protection Bit 3 (D3)	Reference Data Byte 3 (D7 … D0)
2	Data Byte 2 (D7 … D0)	Protection Bit 2 (D2)	Reference Data Byte 2 (D7 … D0)
1	Data Byte 1 (D7 … D0)	Protection Bit 1 (D1)	Reference Data Byte 1 (D7 … D0)
0	Data Byte 0 (D7 … D0)	Protection Bit 0 (D0)	Error Counter

Command: READ MAIN MEMORY

	Control								Address	Data
	B7	B6	B5	B4	B3	B2	B1	B0	A7…A0	D7…D0
Binary	0	0	1	1	0	0	0	0	Address	No effect
Hexadecimal	30_H								00_H…FF_H	No effect

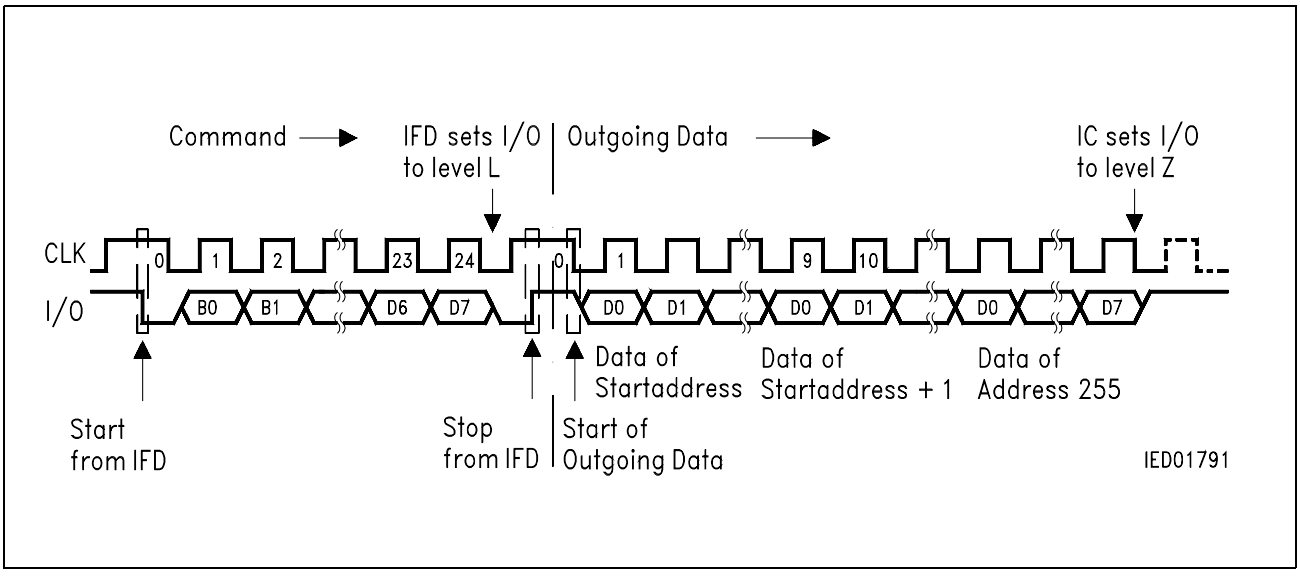


Figure 5
Read Main Memory

2.3.2 Read Protection Memory (SLE 4432 and SLE 4442)

The command transfers the protection bits under a continuous input of 32 clock pulses to the output. I/O is switched to high impedance Z by an additional pulse. The protection memory can always be read, and indicates the data bytes of the main memory protected against changing.

Address (decimal)	Main Memory	Protection Memory	Security Memory (only SLE 4442)
255	Data Byte 255 (D7 … D0)	–	–
:	:	–	–
32	Data Byte 32 (D7 … D0)	–	–
31	Data Byte 31 (D7 … D0)	Protection Bit 31 (D31)	–
:	:	:	–
3	Data Byte 3 (D7 … D0)	Protection Bit 3 (D3)	Reference Data Byte 3 (D7 … D0)
2	Data Byte 2 (D7 … D0)	Protection Bit 2 (D2)	Reference Data Byte 2 (D7 … D0)
1	Data Byte 1 (D7 … D0)	Protection Bit 1 (D1)	Reference Data Byte 1 (D7 … D0)
0	Data Byte 0 (D7 … D0)	Protection Bit 0 (D0)	Error Counter

Command: READ PROTECTION MEMORY

	Control								Address	Data
	B7	B6	B5	B4	B3	B2	B1	B0	A7…A0	D7…D0
Binary	0	0	1	1	0	1	0	0	No effect	No effect
Hexadecimal	34_H								No effect	No effect

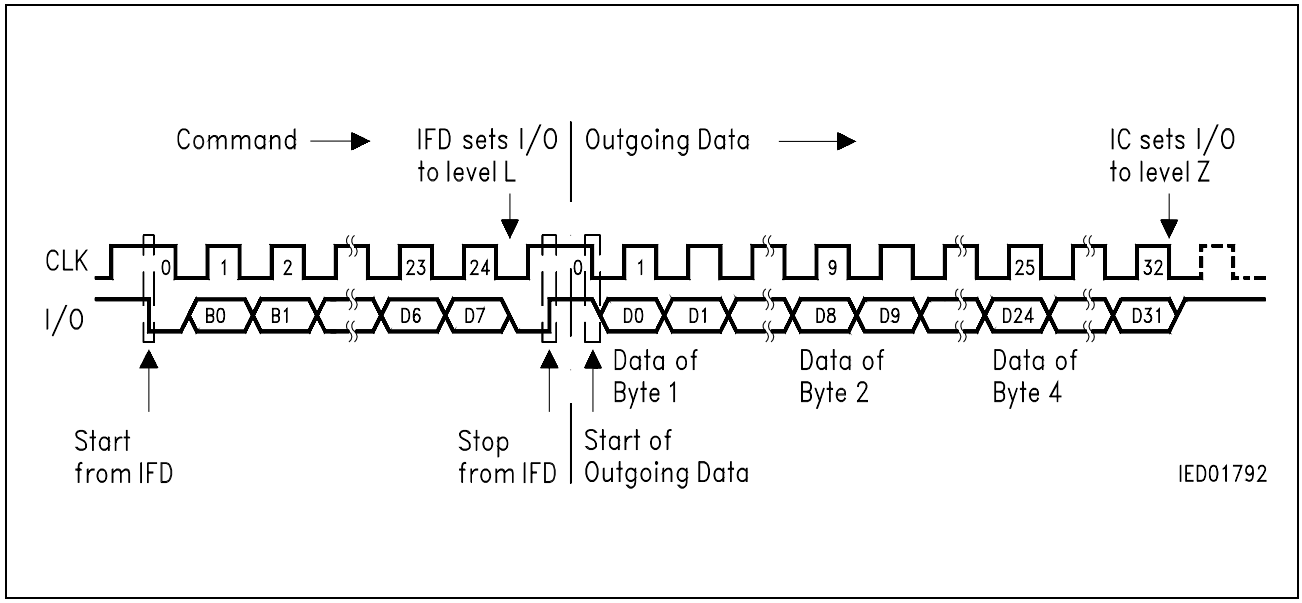


Figure 6
Read Protection Memory

2.3.5 Read Security Memory (SLE 4442 only)

Similar to the read command for the protection memory this command reads out the 4 bytes of the security memory. The number of clock pulses during the outgoing data mode is 32. I/O is switched to high impedance Z by an additional pulse. Without a preceeding successful verification of the PSC the output of the reference bytes is suppressed, that means I/O outputs state L for the reference data bytes.

Address (decimal)	Main Memory	Protection Memory	Security Memory (only SLE 4442)
255	Data Byte 255 (D7 … D0)	–	–
:	:	–	–
32	Data Byte 32 (D7 … D0)	–	–
31	Data Byte 31 (D7 … D0)	Protection Bit 31 (D31)	–
:	:	:	–
3	Data Byte 3 (D7 … D0)	Protection Bit 3 (D3)	Reference Data Byte 3(D7 … D0)
2	Data Byte 2 (D7 … D0)	Protection Bit 2 (D2)	Reference Data Byte 2(D7 … D0)
1	Data Byte 1 (D7 … D0)	Protection Bit 1 (D1)	Reference Data Byte 1(D7 … D0)
0	Data Byte 0 (D7 … D0)	Protection Bit 0 (D0)	Error Counter (0,0,0,0,0,D2,D1,D0)

Command: READ SECURITY MEMORY

	Control								Address	Data
	B7	B6	B5	B4	B3	B2	B1	B0	A7…A0	D7…D0
Binary	0	0	1	1	0	0	0	1	No effect	No effect
Hexadecimal	31_H								No effect	No effect

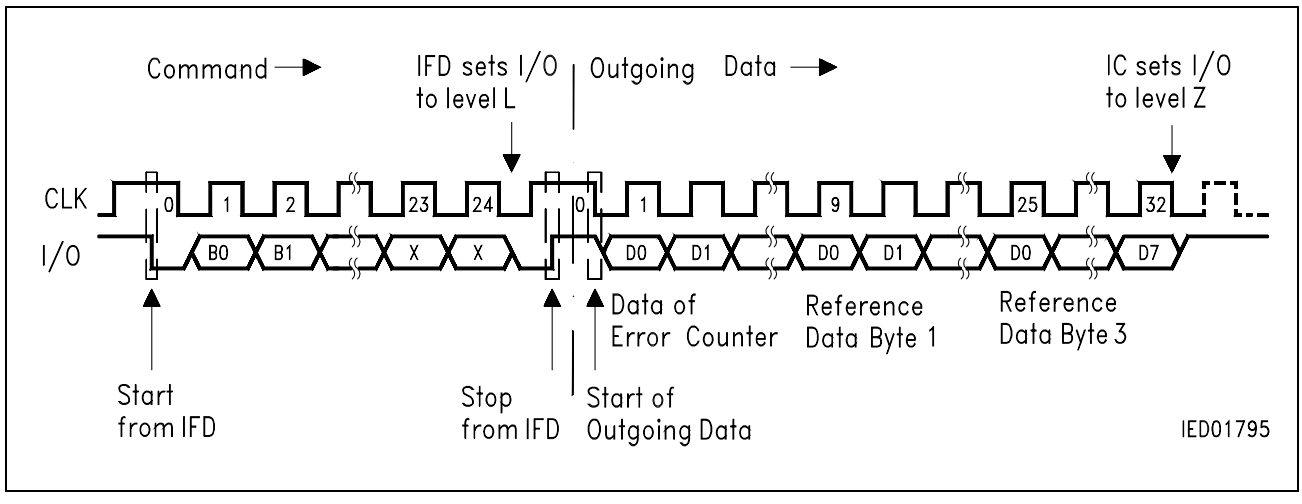


Figure 9
Read Security Memory

2.4 PSC Verification (SLE 4442 only)

The SLE 4442 requires a correct verification of the Programmable Security Code PSC stored in the Security Memory for altering data if desired.

The following procedure has to be carried out exactly as described. Any variation leads to a failure, so that a write/erase access will not be achieved. As long as the procedure has not been successfully concluded the error counter bits can only be changed from “1” to “0” but not erased.

At first an error counter bit has to be written to “0” by an UPDATE command (**see figure 11**) followed by three COMPARE VERIFICATION DATA commands beginning with byte 1 of the reference data. A successful conclusion of the whole procedure can be recognized by being able to erase the error counter which is not automatically erased. Now write/erase access to all memory areas is possible as long as the operating voltage is applied. In case of error the whole procedure can be repeated as long as erased counter bits are available. Having been enabled, the reference data are allowed to be altered like any other information in the EEPROM.

The following table gives an overview of the necessary commands for the PSC verification. The sequence of the shaded commands is mandatory.

Command	**Control**	**Address**	**Data**	**Remark**
	B7…B0	**A7…A0**	**D7…D0**	
Read security Memory	31_H	No effect	No effect	Check Error Counter
Update Security Memory	39_H	00_H	Input data	Write free bit in Error Counter input data: 0000 0ddd binary
Compare Verification Data	33_H	01_H	Input data	Reference Data Byte 1
Compare Verification Data	33_H	02_H	Input data	Reference Data Byte 2
Compare Verification Data	33_H	03_H	Input data	Reference Data Byte 3
Update Security Memory	39_H	00_H	FF_H	Erase Error Counter
Read Security Memory	31_H	No effect	No effect	Check Error Counter

As shipped, the PSC is programmed with a code according to individual agreement with the customer. Thus, knowledge of this code is indispensable to alter data.

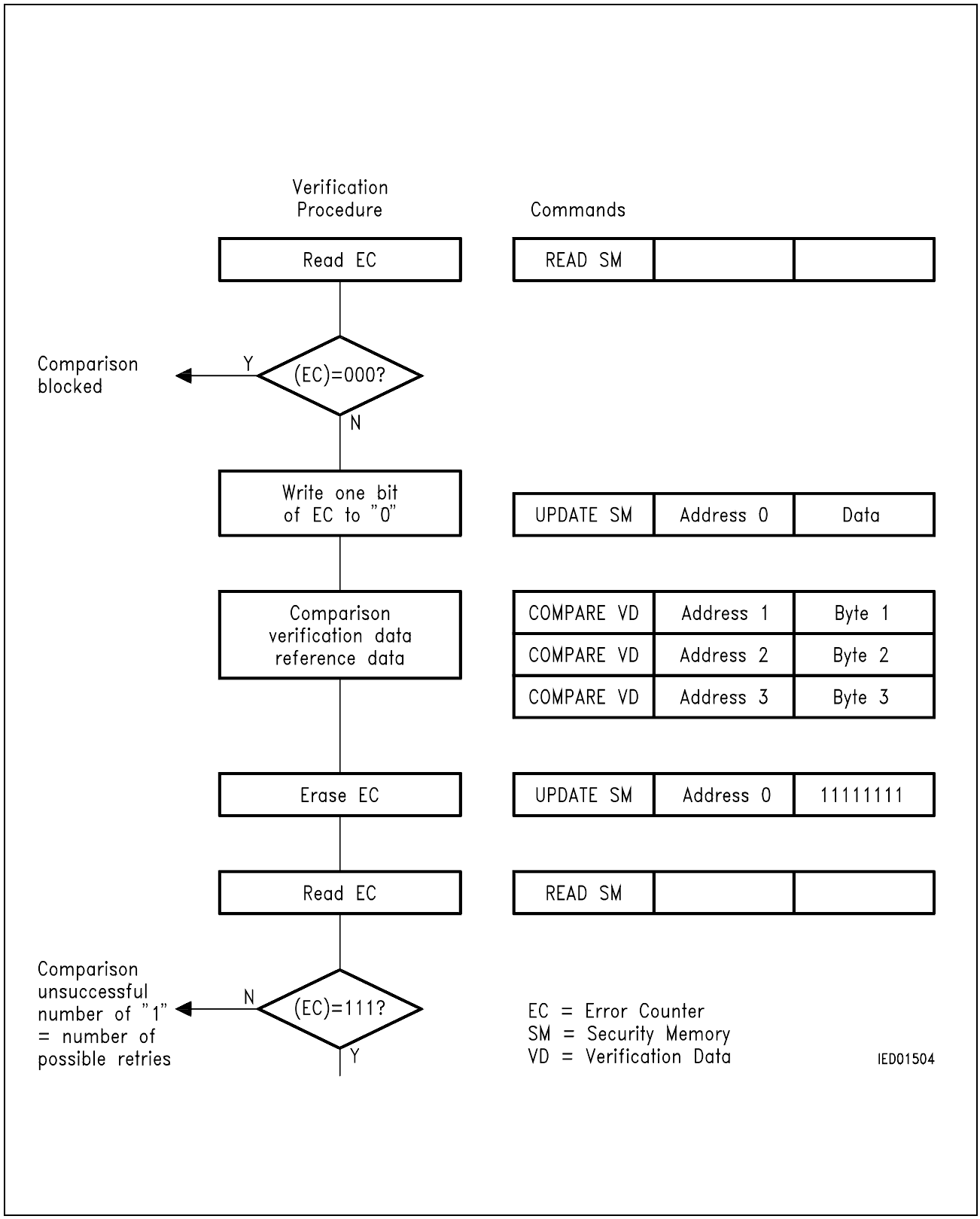


Figure 11
Verification Procedure

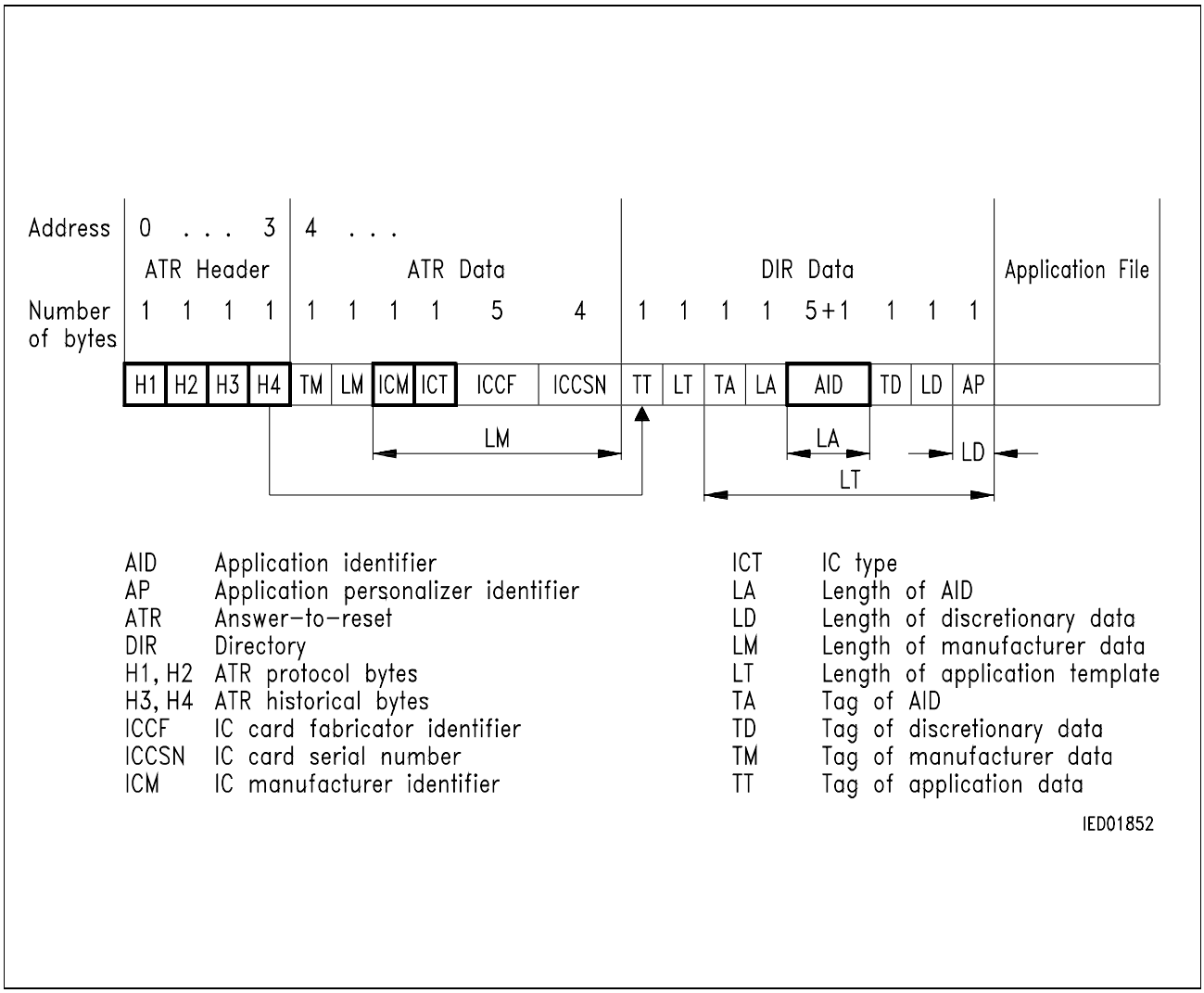


Figure 12
Synchronous Transmission
ATR and Directory Data of Structure 1

3 Operational Information

3.1 Memory Map

Address (decimal)	Main Memory	Protection Memory	Security Memory (only SLE 4442)
255	Data Byte 255 (D7 … D0)		
:	:		
32	Data Byte 32 (D7 … D0)		
31	Data Byte 31 (D7 … D0)	Protection Bit 31 (D31)	
:	:	:	
3	Data Byte 3 (D7 … D0)	Protection Bit 3 (D3)	Reference Data Byte 3 (D7 … D0)
2	Data Byte 2 (D7 … D0)	Protection Bit 2 (D2)	Reference Data Byte 2 (D7 … D0)
1	Data Byte 1 (D7 … D0)	Protection Bit 1 (D1)	Reference Data Byte 1 (D7 … D0)
0	Data Byte 0 (D7 … D0)	Protection Bit 0 (D0)	Error Counter (0,0,0,0,0,D2,D1,D0)

The Data bytes 0 to 31 can be protected against further changes by programming the associated protection bit 0 to 31. The SLE 4442 allows data changing only after correct verification of the Reference Data bytes. Reading of the Data bytes and of the associated protection bits is always possible.

3.2 Electrical Characteristics

3.2.1 Absolute Maximum Ratings

Parameter	Symbol	Limit Values		Unit
		min.	max.	
Supply voltage	V_{CC}	– 0.3	6.0	V
Input voltage (any pin)	V_I	– 0.3	6.0	V
Storage temperature	T_{stg}	– 40	125	°C
Power dissipation	P_{tot}		70	mW

Note: Stresses above those listed under “Absolute Maximum Ratings” may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other conditions above those indicated in the operational sections of this data sheet is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability, including EEPROM data retention and write/erase endurance.

In the operating range the functions given in the circuit description are fulfilled.

3.2.2 Operation Range

Parameter	Symbol	Limit Values			Unit	Test Condition
		min.	typ.	max.		
Supply voltage	V_{CC}	4.75	5.0	5.25	V	–
Supply current	I_{CC}		3	10	mA	V_{CC} = 5 V
Ambient temperature	T_A	0		70	°C	–

3.2.3 DC Characteristics

Parameter	Symbol	Limit Values			Unit	Test Condition
		min.	typ.	max.		
High level input voltage (I/O, CLK, RST)	V_{IH}	3.5		V_{CC}	V	–
Low level input voltage (I/O, CLK, RST)	V_{IL}	0		0.8	V	–
High level input current (I/O, CLK, RST)	I_{IH}			50	µA	V_{IH} = 5 V
Low level output current (I/O)	I_{OL}	1			mA	V_{OL} = 0.4 V, open drain
High level output current (I/O)	I_{OH}			50	µA	V_{OH} = 5 V, open drain
Input capacitance	C_I			10	pF	

3.2.4 AC Characteristics

The AC characteristics refer to the timing diagrams in the following. V_{IHmin} and V_{ILmax} are reference levels for measuring timing of signals.

Parameter	Symbol	Limit Values			Unit	Test Condition
		min.	typ.	max.		
RST High to CLK Setup time	t_{10}	4			µs	
CLK Low to RST Hold time	t_{11}	4			µs	
RST High time (address reset)	t_{12}	20	50		µs	
RST Low to I/O Valid time	t_{13}			2.5	µs	
RST Low to CLK Setup time	t_{14}	4			µs	
CLK Frequency	f_{CLK}	7		50	kHz	
CLK Rise time	t_R			1	µs	
CLK Fall time	t_F			1	µs	
CLK High time	t_{15}	9			µs	
CLK Low time	t_{16}	9			µs	
CLK Low to I/O Valid time	t_{17}			2.5	µs	
Reset time for Break	t_{18}	5			µs	
RST High to I/O Clear time (Break)	t_{19}	2.5			µs	
I/O High time (Start Condition)	t_1	10			µs	
CLK High to I/O Hold time	t_2	4			µs	
I/O Low to CLK Hold time (Start Condition)	t_3	4			µs	
I/O Setup to CLK High time	t_4	1			µs	
CLK Low to I/O Hold time	t_5	1			µs	
CLK High to I/O Clear time (Stop Condition)	t_6	4			µs	
CLK Low to I/O Valid time	t_7			2.5	µs	
CLK Low to I/O Valid time	t_8			2.5	µs	
CLK Low to I/O Clear time	t_9			2.5	µs	
Erase time	t_{ER}	2.5			ms	f_{CLK} = 50 kHz
Write time	t_{WR}	2.5			ms	f_{CLK} = 50 kHz
Power on reset time	t_{POR}			100	µs	

Note: The listed characteristics are ensured over the operating range of the integrated circuit. Typical characteristics specify mean values expected over the production spread. If not otherwise specified, typical characteristics apply at T_A = 25 °C and the given supply voltage.

3.3 Timing Diagrams

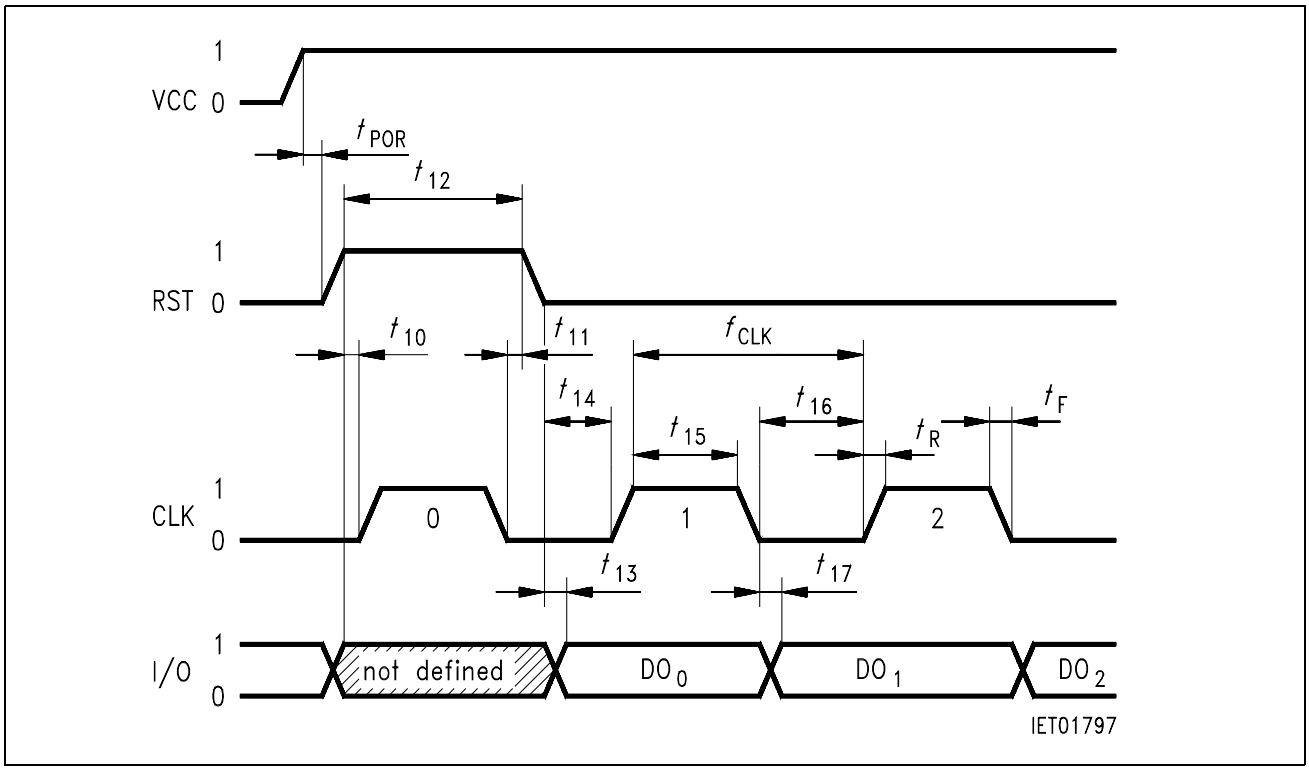


Figure 14
Reset and Answer-to-Reset

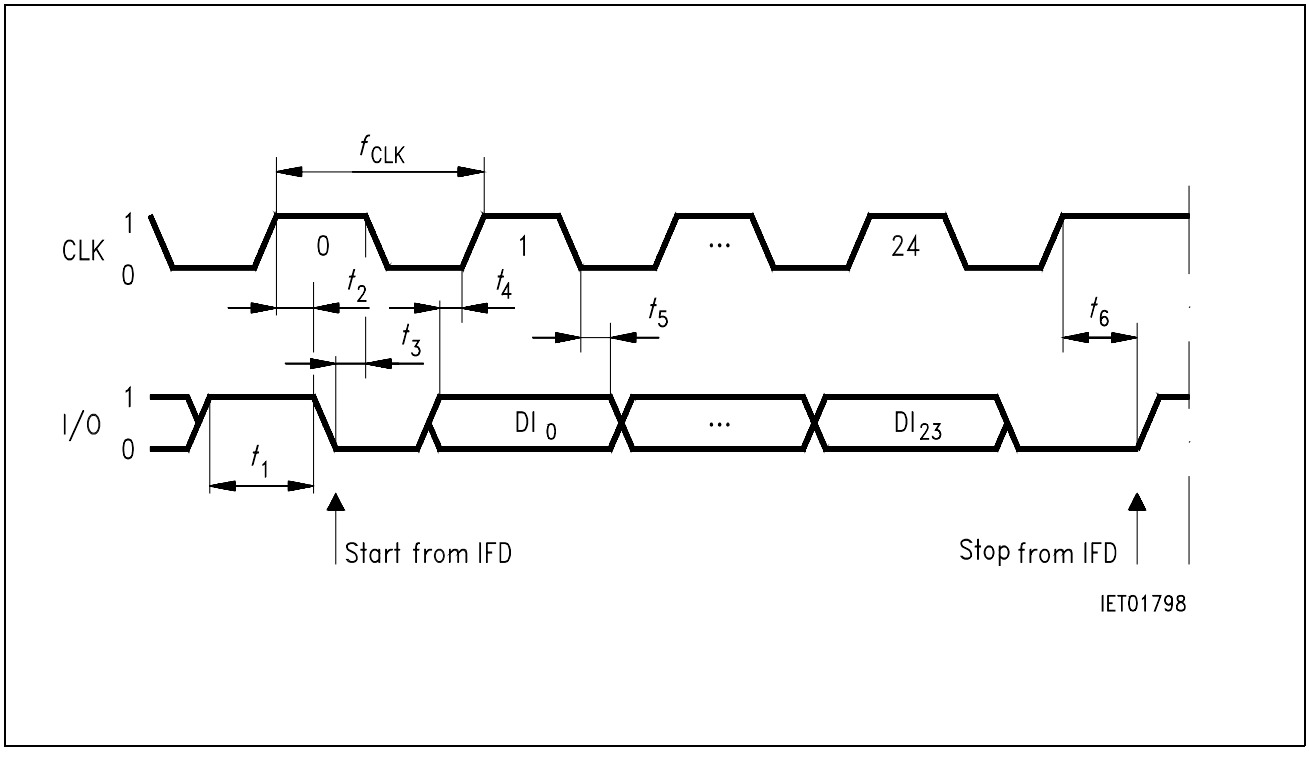


Figure 15
Command Mode

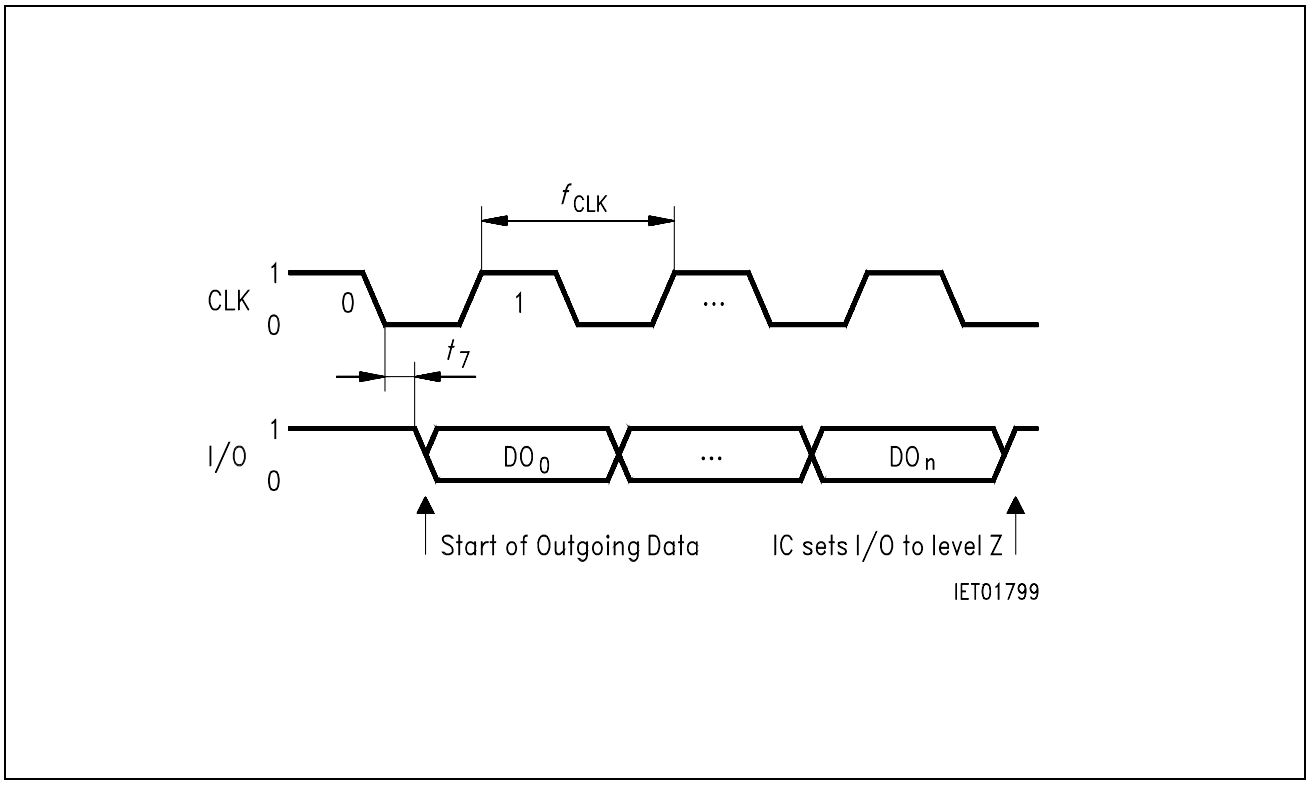


Figure 16
Outgoing Data Mode

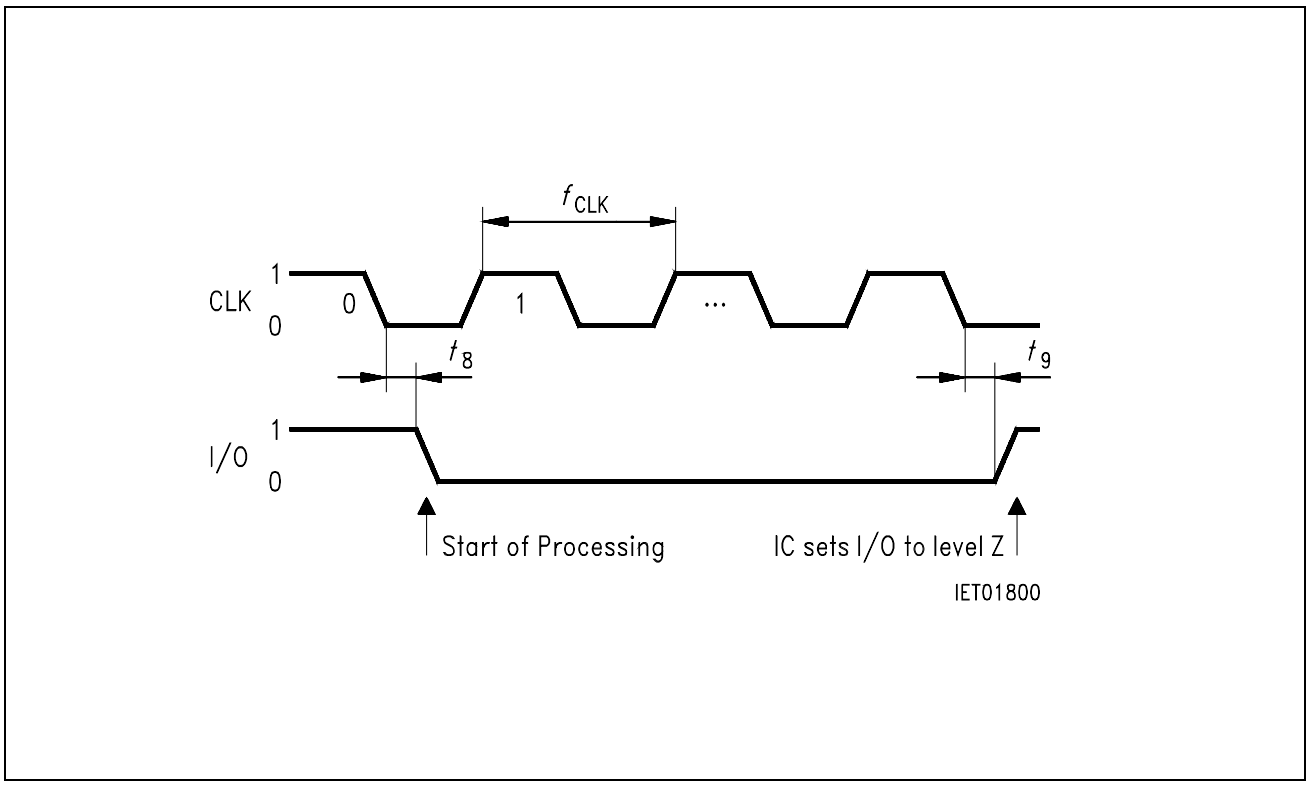


Figure 17
Processing Mode

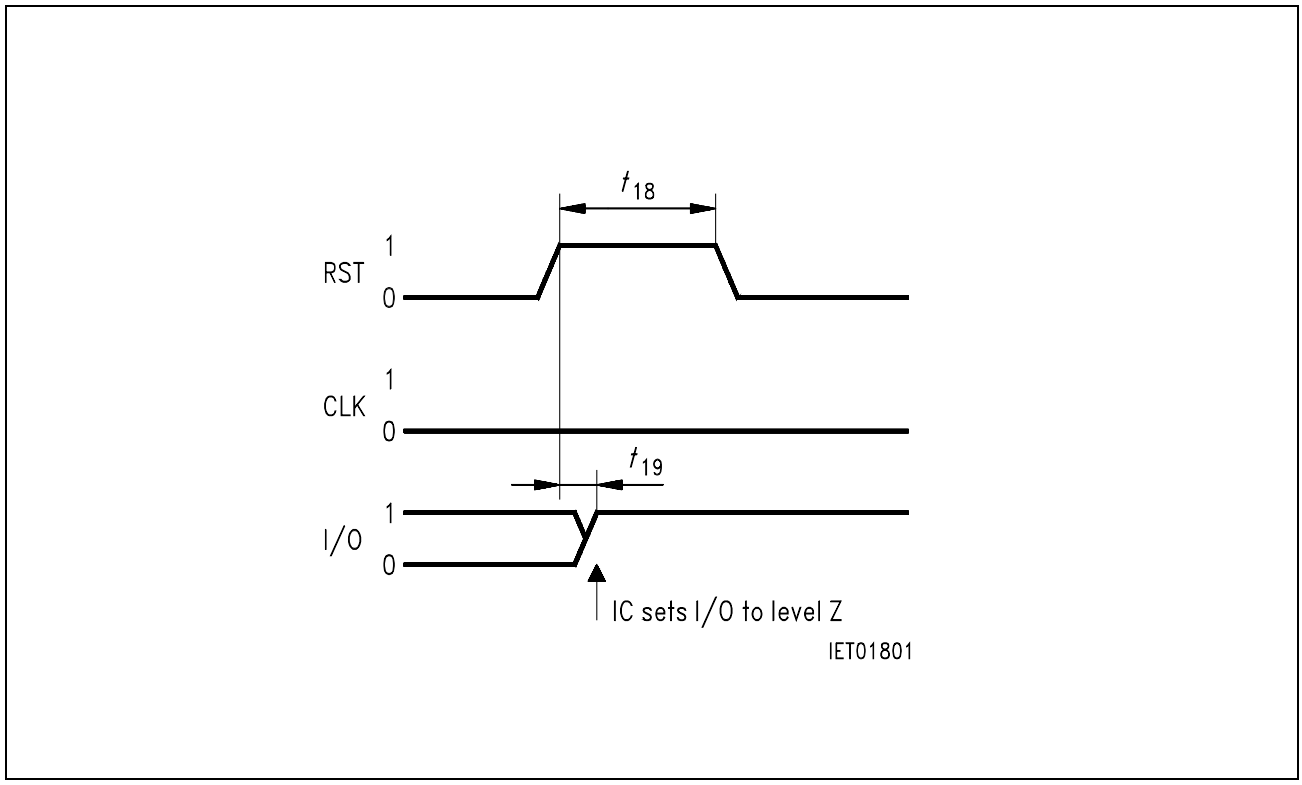


Figure 18
Break