

OVERVIEW

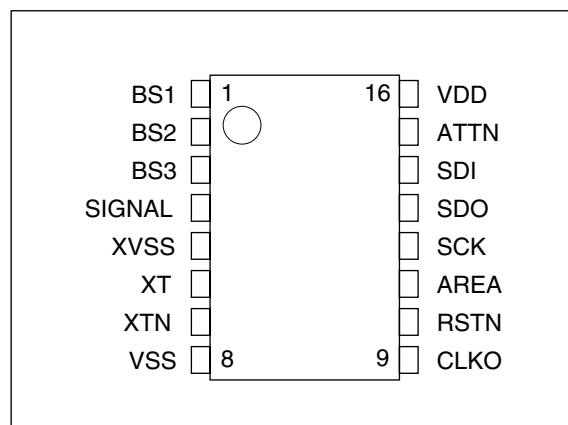
The SM8213AM is a POCSAG-standard (Post Office Code Standardization Advisory Group) signal processor LSI, which conforms to CCIR recommendation 584 concerning standard international wireless calling codes. The SM8213AM supports call messages in either tone, numerical or character outputs at signal speeds of 512, 1200 or 2400bps. The signal input stage features a built-in filter. Each of the addresses (max. 7 + 1 dummy = 8) can be assigned to any frame, which also makes the device configurable for many additional services. Each address can be independently set to ON/OFF. Furthermore, built-in buffer memory means decoded information can be fetched in sync with the microcontroller clock, thereby reducing the microcontroller CPU time required. Intermittent-duty method (battery saving (BS) method) control signals, compatible with PLL operation, and Molybdenum-gate CMOS structure makes possible the construction of low-voltage operation, low power dissipation systems. The SM8213AM is available in 16-pin SSOPs.

FEATURES

- Conforms to POCSAG standard for pagers
- 512, 1200 or 2400bps signal speed
- Multiframe compatible (each address individually controllable)
- 8 addresses × 4 sub-addresses (total of 32 addresses) control
(8 addresses comprise 7 actual addresses + 1 dummy address)
- Built-in buffer memory (1 code word)
- Supports tone, numeric or character call messages
- Built-in input signal filter, with filter ON/OFF and 4 selectable filter characteristics
- PLL-compatible battery saving method (BS1, BS2, BS3 outputs)
- BS1 (RF control main output signal) 61-step setup time setting
- BS3 (PLL setup signal) 61-step setup time setting
- BS2 (RF DC-level adjustment signal) before/during reception selectable adjustment timing
- 1-bit and 2-bit burst error auto-correction function
- 25 to 75% duty factor signal coverage
- 8 rate error detection condition settings
- 76.8kHz system clock (crystal oscillator)
- 76.8 or 38.4kHz clock output pin
- Built-in oscillator capacitor and feedback resistor
- 2.0 to 3.5V operating supply voltage
- Molybdenum-gate CMOS process realizes low power dissipation
- Package: 16-pin SSOP

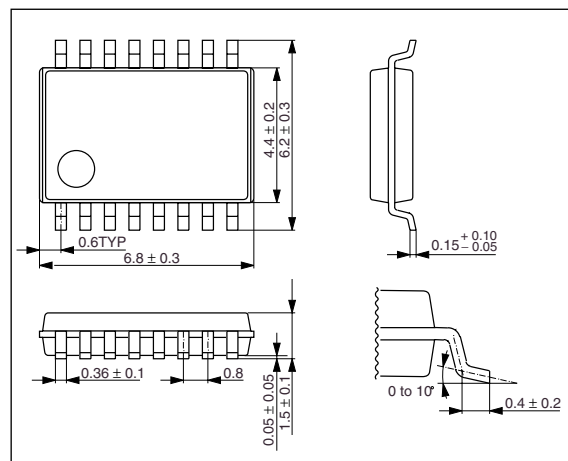
PINOUT

(Top view)

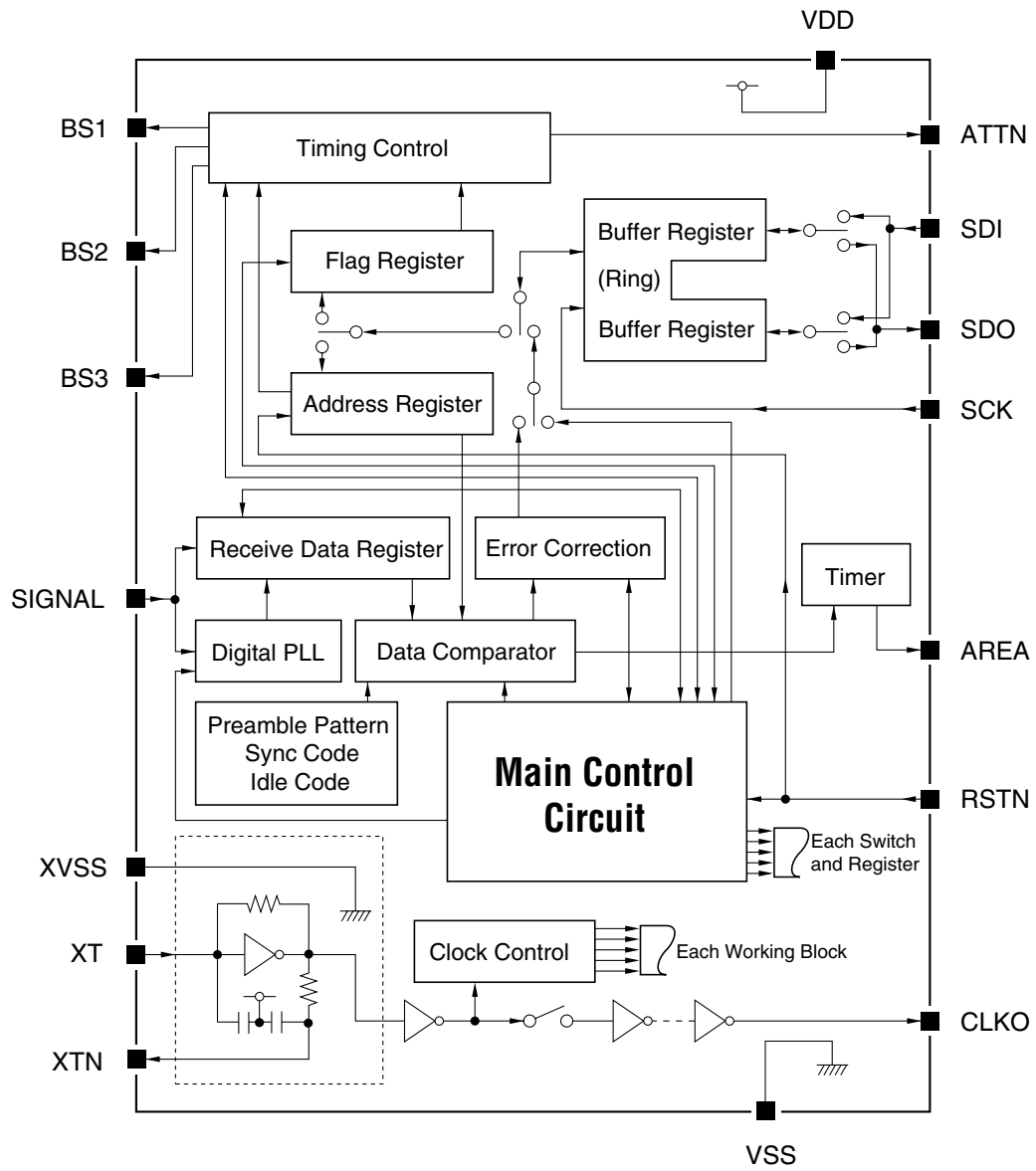


PACKAGE DIMENSIONS

(Unit: mm)



BLOCK DIAGRAM

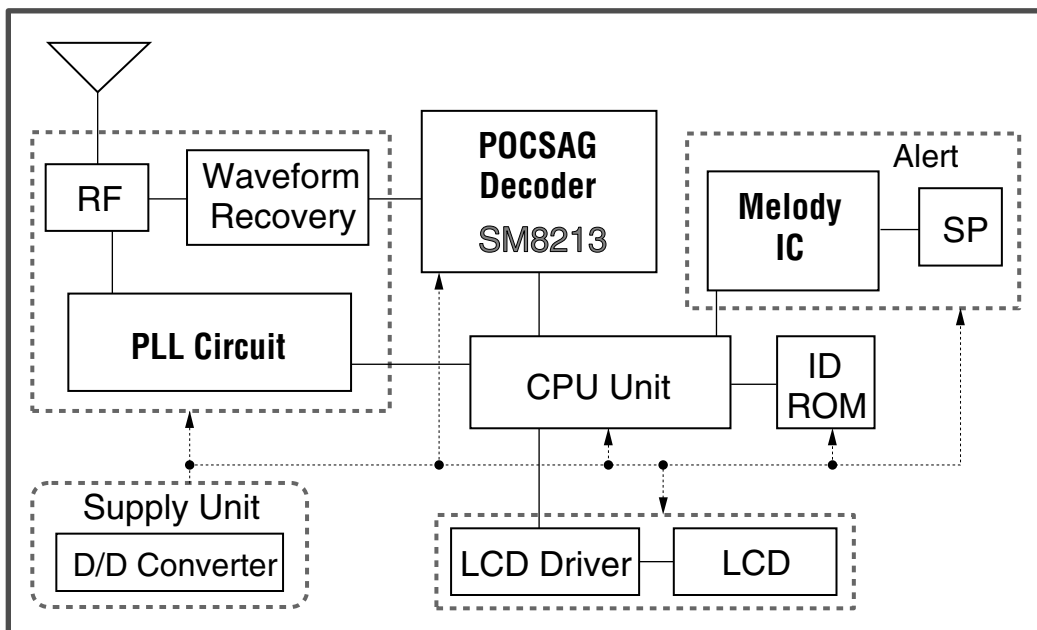


PIN DESCRIPTION

| Number | Name | I/O ¹ | Description |
|--------|--------|------------------|---|
| 1 | BS1 | O | RF control main output signal |
| 2 | BS2 | O | RF DC-level adjustment signal |
| 3 | BS3 | O | PLL setup signal |
| 4 | SIGNAL | I | NRZ signal input pin |
| 5 | XVSS | - | Crystal oscillator ground. Capacitor connected between XVSS and VDD |
| 6 | XT | I | Oscillator input pin |
| 7 | XTN | O | Oscillator output pin |
| 8 | VSS | - | Ground |
| 9 | CLKO | O | 76.8 or 38.4kHz clock output |
| 10 | RSTN | I | Hardware clear (reset) |
| 11 | AREA | O | Sync code detection output (HIGH for minimum 1 sec. on detection) |
| 12 | SCK | I | CPU-to-decoder data transfer sync clock |
| 13 | SDO | O | Status and received data output to CPU |
| 14 | SDI | I | Data input from CPU (including ID data) |
| 15 | ATTN | O | Interrupt detect signal output pin (Ready for data transmission when LOW) |
| 16 | VDD | - | Supply voltage |

1. I = input, O = output

SM8213AM Paging Receiver Block Diagram



SPECIFICATIONS

Absolute Maximum Ratings

$V_{SS} = 0V$

| Parameter | Symbol | Condition | Rating | Unit |
|---------------------------|-----------|-----------|----------------------------------|------|
| Supply voltage range | V_{DD} | | -0.3 to 7.0 | V |
| Input voltage range | V_{IN} | | $V_{SS} - 0.3$ to $V_{DD} + 0.3$ | V |
| Power dissipation | P_D | | 250 | mW |
| Storage temperature range | T_{stg} | | -40 to 125 | °C |
| Soldering temperature | T_{sld} | | 255 | °C |
| Soldering time | t_{sld} | | 10 | s |

Recommended Operating Conditions

$V_{SS} = 0V$

| Parameter | Symbol | Condition | Rating | Unit |
|-----------------------------|-----------|-----------|------------|------|
| Supply voltage range | V_{DD} | | 2.0 to 3.5 | V |
| Operating temperature range | T_{opr} | | -20 to 70 | °C |

DC Characteristics

Recommended operating conditions unless otherwise noted.

| Parameter | Symbol | Condition | Rating | | | Unit |
|--|-----------|--------------------------------|-------------|-----|-------------|---------|
| | | | min | typ | max | |
| Operating current consumption (IDLE mode) ¹ | I_{DD1} | $V_{DD} = 3.0V$ | - | 3.0 | 6.0 | μA |
| | | $V_{DD} = 2.0V$ | - | 2.0 | 4.0 | |
| Standby supply current ² | I_{DD2} | $V_{DD} = 3.0V$ | - | 3.0 | 6.0 | μA |
| | | $V_{DD} = 2.0V$ | - | 2.0 | 4.0 | |
| HIGH-level input voltage (all inputs) | V_{IH} | | $0.8V_{DD}$ | - | - | V |
| LOW-level input voltage (all inputs) | V_{IL} | | - | - | $0.2V_{DD}$ | V |
| HIGH-level output current (all outputs except XTN) | I_{OH} | $V_{OH} = 2.6V, V_{DD} = 3.0V$ | 0.6 | 1.4 | - | mA |
| LOW-level output current (all outputs except XTN) | I_{OL} | $V_{OL} = 0.4V, V_{DD} = 3.0V$ | 1.0 | 2.2 | - | mA |
| HIGH-level output current (all outputs except XTN) | I_{OH} | $V_{OH} = 1.6V, V_{DD} = 2.0V$ | 0.3 | 0.7 | - | mA |
| LOW-level output current (all outputs except XTN) | I_{OL} | $V_{OL} = 0.4V, V_{DD} = 2.0V$ | 0.7 | 1.5 | - | mA |

1. CLK0 output is inactive. The consumption current is slightly higher when RSTN is going LOW.

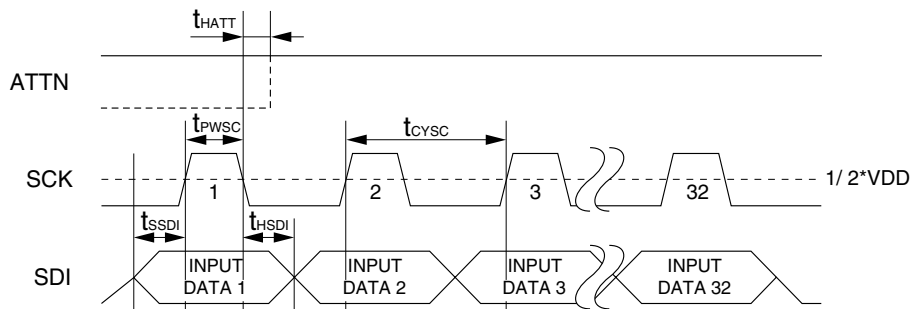
2. Oscillator circuit is working.

AC Characteristics

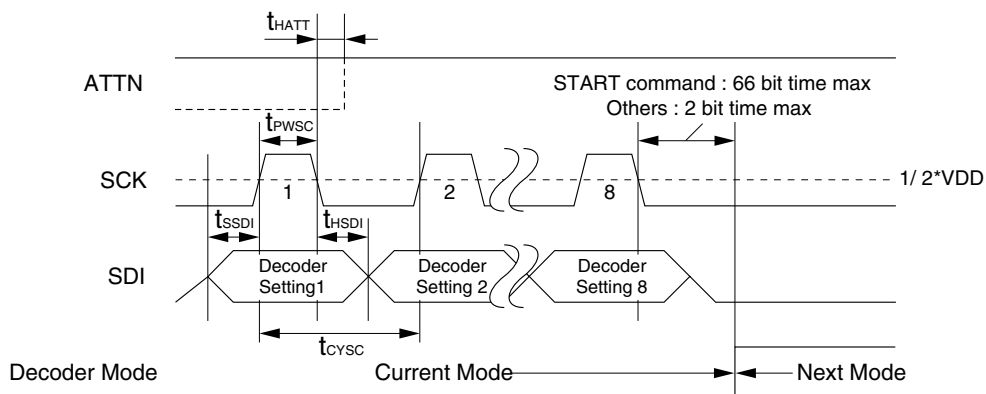
Recommended operating conditions unless otherwise noted.

| Parameter | Symbol | Condition | Rating | | | Unit |
|--|------------|-----------|---------|------|---------|---------|
| | | | min | typ | max | |
| XT clock frequency | f_{CYXT} | | -250ppm | 76.8 | +250ppm | kHz |
| XT clock duty cycle | D_{XT} | | 25 | - | 75 | % |
| SCK clock pulsewidth | t_{PWSC} | | 2 | - | 150 | μ s |
| SCK clock interval (except WRITE mode) | t_{CYSC} | 512bps | 5 | - | 1900 | μ s |
| | | 1200bps | 5 | - | 830 | |
| | | 2400bps | 5 | - | 415 | |
| SCK clock interval (WRITE mode) | t_{CYSC} | | 5 | - | 830 | μ s |
| SDI data setup time | t_{SSDI} | | 1 | - | - | μ s |
| SDI data hold time | t_{HSDI} | | 1 | - | - | μ s |
| SDO data setup time | t_{SSDO} | | 3 | - | - | μ s |
| SDO data hold time | t_{HSDO} | | - | - | 0 | μ s |
| ATTN data setup time | t_{SAT} | | 0 | - | - | μ s |
| ATTN data hold time | t_{HATT} | | 1 | - | - | μ s |
| CLKO clock rise time | t_{RCLK} | No load | - | - | 500 | ns |
| CLKO clock fall time | t_{FCLK} | No load | - | - | 500 | ns |
| CLKO clock delay time | D_{CLKO} | | - | - | 1 | μ s |
| RSTN pulsewidth | t_{PWRS} | | 1 | - | - | ms |

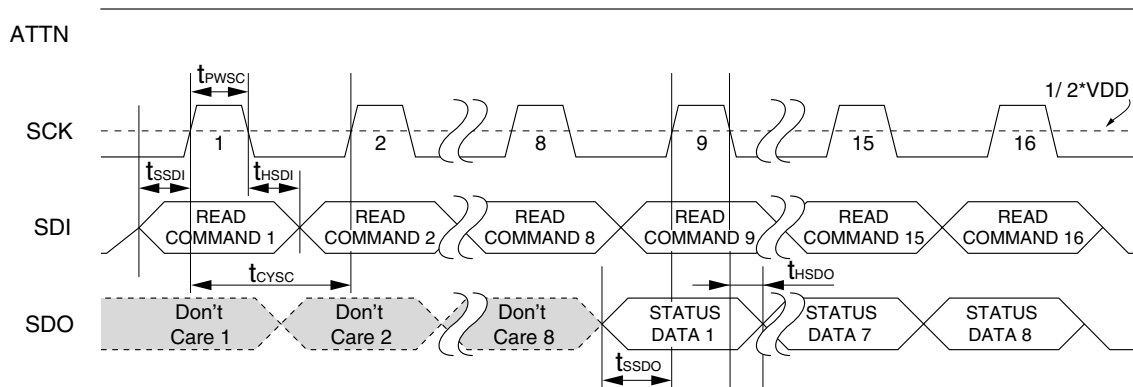
Parameter/address set timing



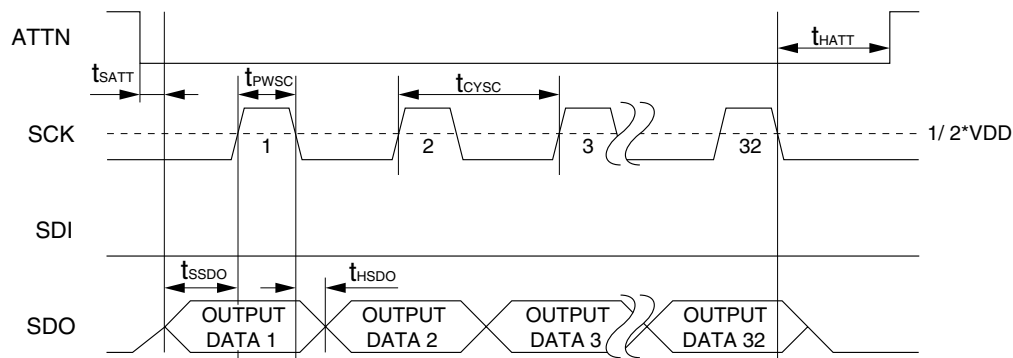
Auxiliary operating mode set timing



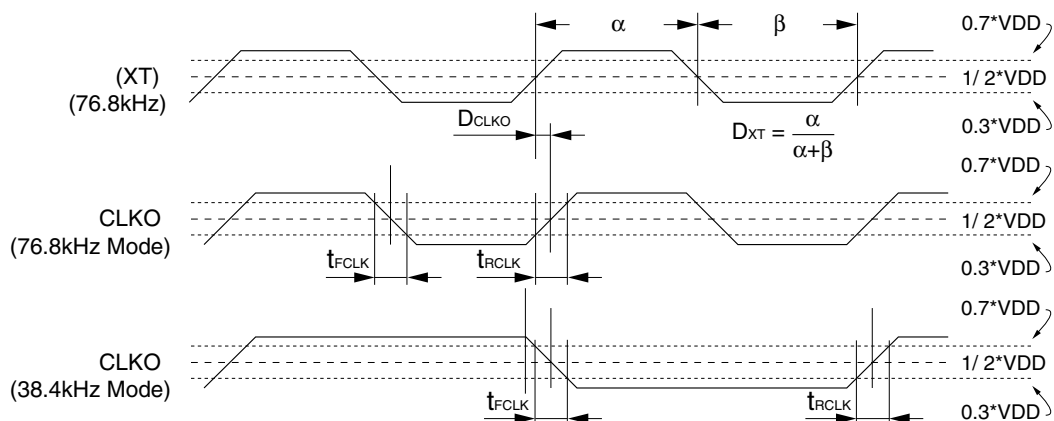
Status data read timing



Received data transfer timing



CLKO clock output timing



FUNCTIONAL DESCRIPTION

Unless otherwise specified, values in diagrams without parentheses are for 512bps, in () are for 1200bps, and in [] are for 2400bps. “M” represents the value of PL5 (MSB) to PL0 (LSB), and “N” represents the value of RF5 (MSB) to RF0 (LSB).

Receive Format

The receive format conforms to CCIR RPC No. 1 (POCSAG).

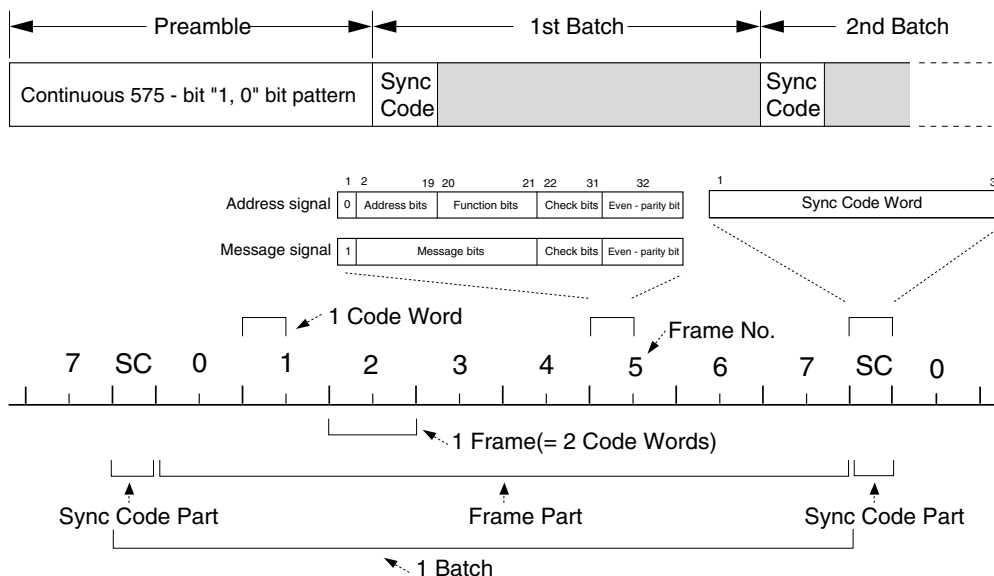


Figure 1. Receive signal format

Sync signal (SC)

The sync signal is a continuous code word in the received signal, used for word synchronization. It comprises 31 bits in an M-series bit pattern plus one even-parity bit, making a 32-bit signal. The sync code word pattern is shown in table 1.

Table 1. Sync code format

| Bit number | Bit value | Bit number | Bit value | Bit number | Bit value | Bit number | Bit value |
|------------|-----------|------------|-----------|------------|-----------|------------|-----------|
| 1 | 0 | 9 | 1 | 17 | 0 | 25 | 1 |
| 2 | 1 | 10 | 1 | 18 | 0 | 26 | 1 |
| 3 | 1 | 11 | 0 | 19 | 0 | 27 | 0 |
| 4 | 1 | 12 | 1 | 20 | 1 | 28 | 1 |
| 5 | 1 | 13 | 0 | 21 | 0 | 29 | 1 |
| 6 | 1 | 14 | 0 | 22 | 1 | 30 | 0 |
| 7 | 0 | 15 | 1 | 23 | 0 | 31 | 0 |
| 8 | 0 | 16 | 0 | 24 | 1 | 32 | 0 |

Code words (address and message signals)

Each code word comprises 32 bits as shown in table 2.

Table 2. Code word format

| Code word | Bit number | | | | | | |
|----------------|----------------------|----------------------|---------------------|----|-----------------------|-----------------------|-----------------|
| | 1 (MSB) ¹ | 2 to 19 ² | 20, 21 ² | | 22 to 31 ³ | 32 (LSB) ⁴ | |
| Address signal | 0 | Address bits | Function bits | | | Check bits | Even-parity bit |
| | | | 20 | 21 | Function | | |
| | | | 0 | 0 | A call | | |
| | | | 0 | 1 | B call | | |
| | | | 1 | 0 | C call | | |
| 1 | 1 | D call | | | | | |
| Message signal | 1 | Message bits | | | Check bits | Even-parity bit | |

1. The MSB is the address/message code word control bit. It is 0 for an address signal, and 1 for a message signal.
2. Bits 2 to 21 contain the address or message information.
3. Bits 22 to 31 are BCH (31, 21) format generated check bits, where BCH (n, k) = BCH (word length, number of information bits).
4. The LSB is an even-parity bit for bits 1 to 31.

Call number to call sign conversion

This conversion expands a 7-digit decimal call number into a 21-bit binary call sign, as shown in figure 2.

After expansion, the high-order 18 bits are assigned to bits 2 to 19 (address signal), and the low-order 3 bits are the user-defined frame identification pattern, which is stored in ID-ROM. The two function bits define which of four call functions is active.

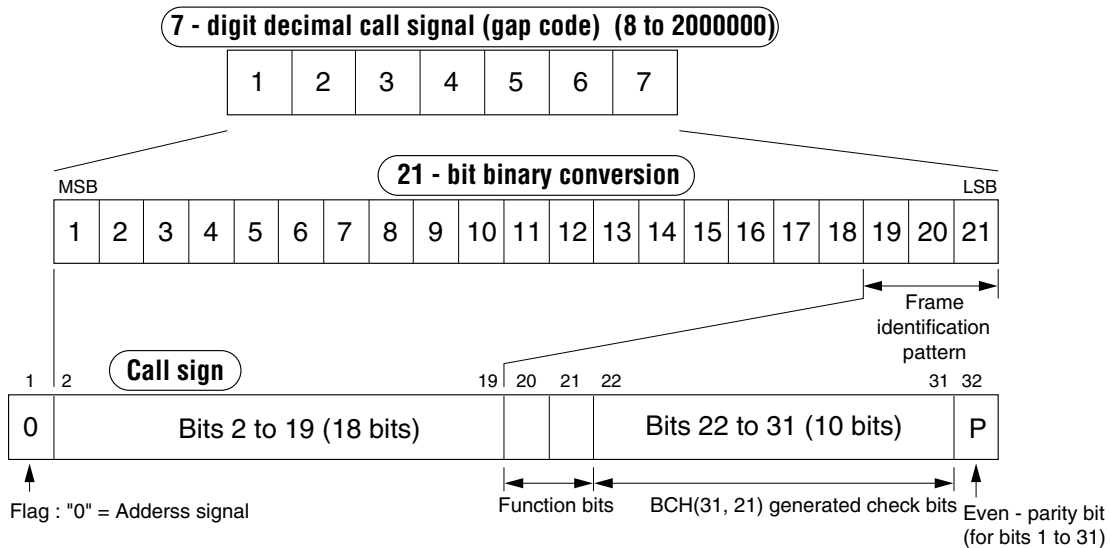


Figure 2. Call number to call sign conversion

Idle signal

In the POCSAG format, for pager systems that send numeric data, the message information content varies and as a result an idle signal or another address signal is inserted after the message to indicate the end of the message.

That is, if no address word or message word exists for a frame within a batch or for a code word within a frame, the idle pattern, shown in table 3, is transmitted in its place. Then during message signal reception, the message ends when the idle signal is detected.

The SM8213AM supports 2 methods of determining the end of message. Namely, a message ends when either an idle signal or another address is received (POCSAG format), or when an interrupt signal from the CPU is received.

Table 3. Idle code format

| Bit number | Bit value | Bit number | Bit value | Bit number | Bit value | Bit number | Bit value |
|------------|-----------|------------|-----------|------------|-----------|------------|-----------|
| 1 | 0 | 9 | 1 | 17 | 1 | 25 | 1 |
| 2 | 1 | 10 | 0 | 18 | 1 | 26 | 0 |
| 3 | 1 | 11 | 0 | 19 | 0 | 27 | 0 |
| 4 | 1 | 12 | 0 | 20 | 0 | 28 | 1 |
| 5 | 1 | 13 | 1 | 21 | 0 | 29 | 0 |
| 6 | 0 | 14 | 0 | 22 | 0 | 30 | 1 |
| 7 | 1 | 15 | 0 | 23 | 0 | 31 | 1 |
| 8 | 0 | 16 | 1 | 24 | 1 | 32 | 1 |

Receive signal duty factor

During preamble detection, the preamble pattern (1, 0) is recognized at duty factors from 25% (min) to 75% (max) of the (1, 0) preamble cycle.

Error correction and detection

The SM8213AM performs error correction (or detection) on each code word as described in table 4. Note that there are 8 selectable error correction conditions for the preamble pattern.

Table 4. Error correction

| Item | Description |
|----------------------------|--|
| Preamble Pattern Detection | Selectable 1 to 8 rate errors in 6 to 544 bits |
| Synchronization Code word | Detection 2 random errors in 32 bits |
| Self Address Code word | Detection 2 random errors in 32 bits |
| Message Code word | 1-bit and 2-bit burst errors in 31 bits |

An error is deemed to have occurred when 2 or more signal edges occur within 1-bit unit time, and a rate error is deemed to have occurred when the number of errors exceeds the counter value. Refer to the “Preamble Mode” section for a discussion of the error counter.

Battery Saving (BS1, BS2, BS3)

The SM8213AM controls the intermittent-duty operation of the RF stage, which reduces battery consumption, and three output control signals (BS1, BS2, BS3). The function each signal controls in each mode is described below.

- BS1 (RF-control main output signal)—The RF stage is active when BS1 is HIGH. The rising-edge setup time for receive timing is set by flags RF0 to RF5 (61 steps). The maximum setup time is 25.417ms at 2400bps, 50.833ms at 1200bps, and 119.141ms at 512bps. Note that 3E_H and 3F_H are invalid settings for BS1.
- BS2 (RF DC-level adjustment signal)—BS2 is used to control the discharge of the receive signal DC-cut capacitor. The function of BS2 is determined by flag BS2, as described below.
 - When flag BS2 is 0, pin BS2 goes HIGH together with BS1 and then goes LOW again after the BS1 setup time (idle mode). In preamble and lock mode (during address/message reception), it stays LOW.
 - When flag BS2 is 1, pin BS2 goes HIGH during lock mode sync code receive timing and idle mode signal receive timing. In preamble mode, it stays LOW.
- BS3 (PLL setup signal)—BS3 is used to control PLL operation when the PLL is used. The rising-edge setup time for receive timing is set by flags PL0 to PL5 (61 steps). The maximum setup time is 25.833ms at 2400bps, 51.667ms at 1200bps, and 121.094ms at 512bps. Note that 3F_H is an invalid setting for BS3.

Note that the setup times should be set up such that (BS3 rising-edge setup time) > (BS1 rising-edge setup time).

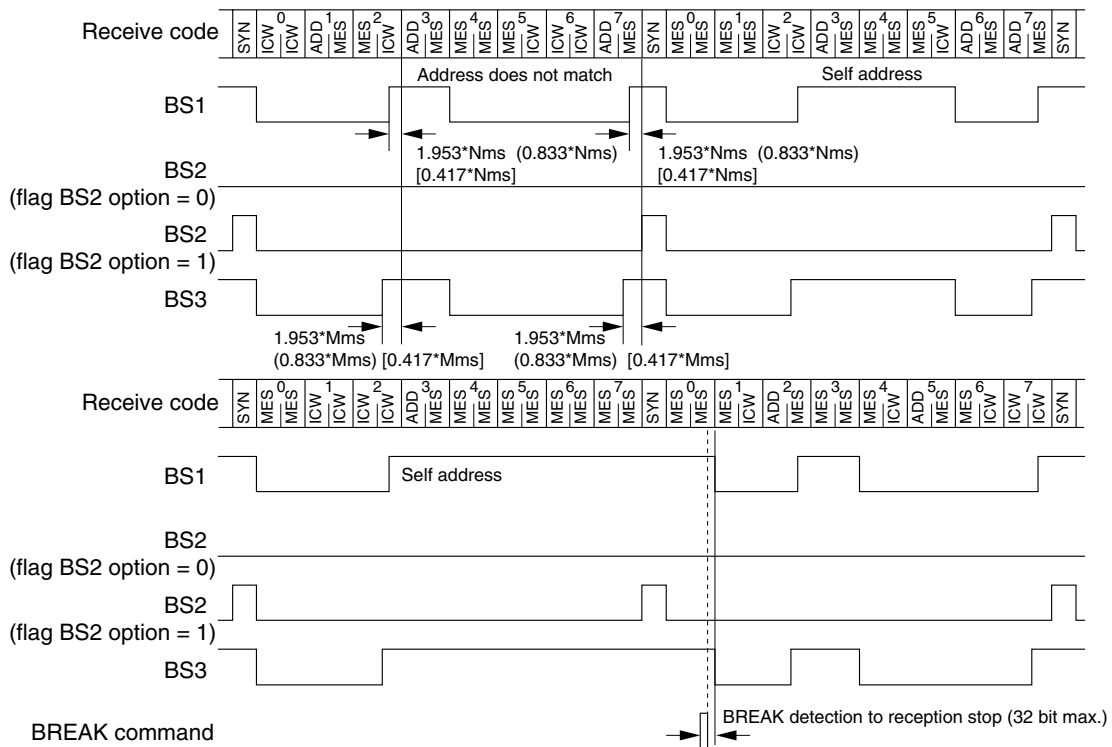


Figure 3. BS1, BS2 and BS3 timing (Lock mode, frame 3)

Operating Modes

The SM8213AM has four operating modes—Power-ON (Write), Preamble, Idle and Lock modes.

Power-ON mode

After power is applied, the internal registers should be reset using RSTN.

When ATTN goes HIGH, the decoder sends a write request for a decoder set read command and then waits for the microcontroller (decoder set write command timing starts approximately 50ms after reset, but you should allow at least 900ms for the oscillator internal to start and stabilize). The internal operation in write mode takes place at the same timing as for 1200bps speed mode.

Write data is prepared in 32-bit batches of 1 parameter batch and 8 address data batches for a total of 9 batches.

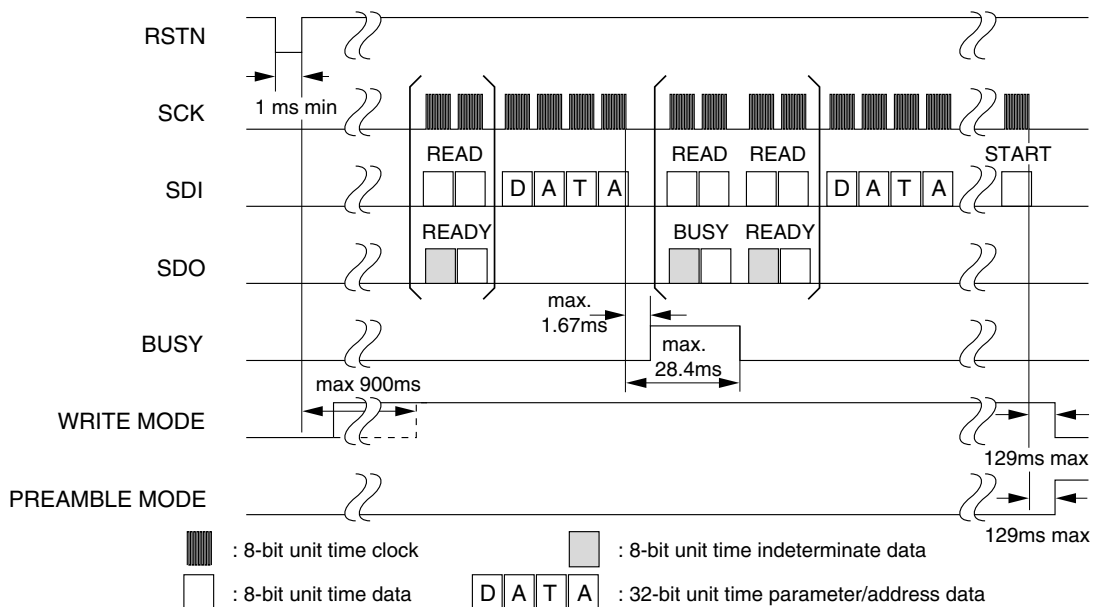
Ensure that there are not multiple writes requests to turn ON the same address. Also, allow a minimum of 1.67ms after transferring each command or data before issuing the next processing command.

The parameter and address set commands are processed in sync with the decoder internal clock (1200Hz). As a consequence, a gap of 28.4ms minimum should be left between batches to provide time for processing. Alternatively, data can be written by first using the decoder set read command to confirm whether or not processing is still in progress (BUSY) before writing each batch. If the time gap is 28.4ms or greater, confirmation (READY) is not required.

After parameters and all addresses have been written and after decoder processing, the decoder set start command transfers operation from write mode and starts preamble mode operation.

When setting parameters and addresses in write mode, the SCK clock frequency should not be less than 1200Hz. If this occurs, the SCK counter is reinitialized. This function, however, does make restoring operation easy even if this or another clock is accidentally input.

In write mode, after power is applied and after reset initialization, all 9 batches (1 parameter and 8 address batches) should be set. If not all batches are set, subsequent operation may become unstable.



Refer to the AC Characteristics section for detailed timing specifications.

Figure 4. Power-ON mode timing

Preamble mode

Preamble mode is a continuous 544-bit long period. If neither a preamble pattern, rate error nor sync code is detected during this period, operation transfers to idle mode.

If a preamble pattern is detected, the preamble mode 544-bit long period is recommenced.

If the sync code is detected, AREA goes HIGH and operation transfers to lock mode. If an error of 2 bits or less occurs, the detected word is recognized as the sync code. During the preamble mode interval, BS1 and BS3 are held HIGH. BS2 stays LOW.

Note that a single error occurs when two active edges occur in the received signal on SIGNAL within 1-bit unit time. A rate error occurs when the number of errors in the error counter equals the error threshold set by flags ER0 to ER2. The error counter is reset when a preamble pattern is detected.

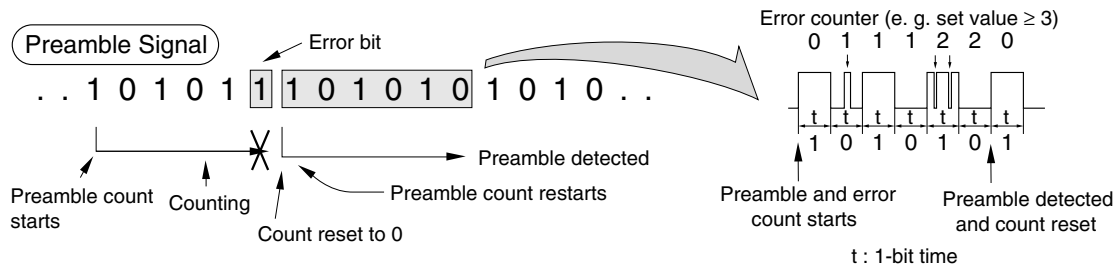


Figure 5. Preamble mode internal operation

Idle mode

In idle mode, a check is made for the presence of a preamble signal when the RF intermittent-duty control signals (BS1, BS2, BS3) for battery saving are active. If a preamble pattern is detected, operation immediately transfers to preamble mode. If a preamble pattern is not detected, intermittent-duty operation continues.

A preamble pattern is detected when either a 101010 or 010101 6-bit pattern is detected. Since there is a reasonable probability that this simple pattern can occur during a valid communicated signal (data, not preamble), this 6-bit pattern makes returning to preamble mode easier. This is useful for cases where weak electric fields, noise or other temporary interference cause device operation to transfer to idle mode.

Furthermore, the idle mode receive timing immediately after transfer from lock mode is the same as the original sync code receive timing. As a result, if a sync code is detected, operation returns to lock mode.

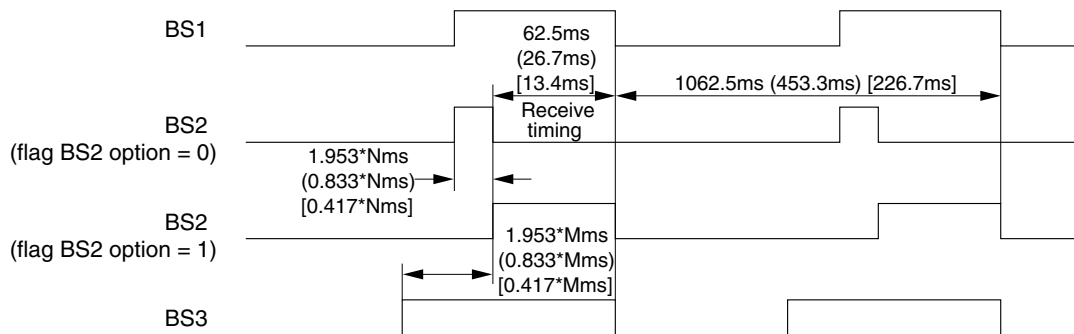


Figure 6. Idle mode timing

Lock mode (dummy address setting is disabled)

If the sync code is detected during the preamble period, device operation transfers to lock mode and BS1 goes LOW. BS1 then goes HIGH again under frame timing, where the frame number is set by flags FF0 to FF2, and the 28 addresses are compared with ID-ROM (If the frame number is 0, BS1 stays HIGH). If errors of 2 bits or less occur, the address is still recognized. Since there are two code words per frame, this check is done twice.

When one of the 28 addresses does not match, BS1 goes LOW and the device waits for the next frame or sync code receive timing. If the sync code is still not detected after two consecutive attempts, device operation transfers to idle mode, except during message reception where operation stays in lock mode. If the sync code is not detected on the second attempt, but instead a pattern forming a preamble is detected, device operation transfers to preamble mode and not idle mode (preamble mode is more advantageous for sync code detection).

When one of the 28 addresses does match, ATTN goes LOW and the 32-address information (see “Data/Flags” section) is transmitted to the CPU on SDO in sync with the SCK clock.

When the address information is confirmed to be a message, BS1 is held HIGH and the message is received. The received message is stored in a buffer as 32-bit error-corrected information (see “Data/Flags” section), then ATTN goes LOW and the data is transmitted to the CPU on SDO in sync with the SCK clock.

When the address and message is received, ATTN should be held LOW while the data is output on SDO.

When an incoming message spans two or more batches, additional sync code detection occurs during sync code receive timing.

Message reception can be selected to end when either an address code or idle code is detected, or when interrupted using the decoder set command BREAK input. This selection is made when setting parameters that will not cause the message to terminate. If the BREAK mode is selected, even if an address other than the self address (MSB = 0) is received during message reception, reception continues without interruption and address data is sent to the microcontroller using the same data handling as for a message. In this case, reception can only be interrupted by a BREAK input signal from the microcontroller.

In either of the above cases, message reception ends if an end-of-message signal is sent. Note that if the device address is received, the end-of-message data is not transmitted.

When message reception ends, BS1 goes LOW and the device waits for either the address detect timing of the next frame or the sync code receive timing.

When sending data from the decoder to the microcontroller, the SCK clock frequency should not be less than 512, (1200), [2400] Hz. If this occurs, the SCK counter is reinitialized. This function, however, does make restoring operation easy even if this or another clock is accidentally input.

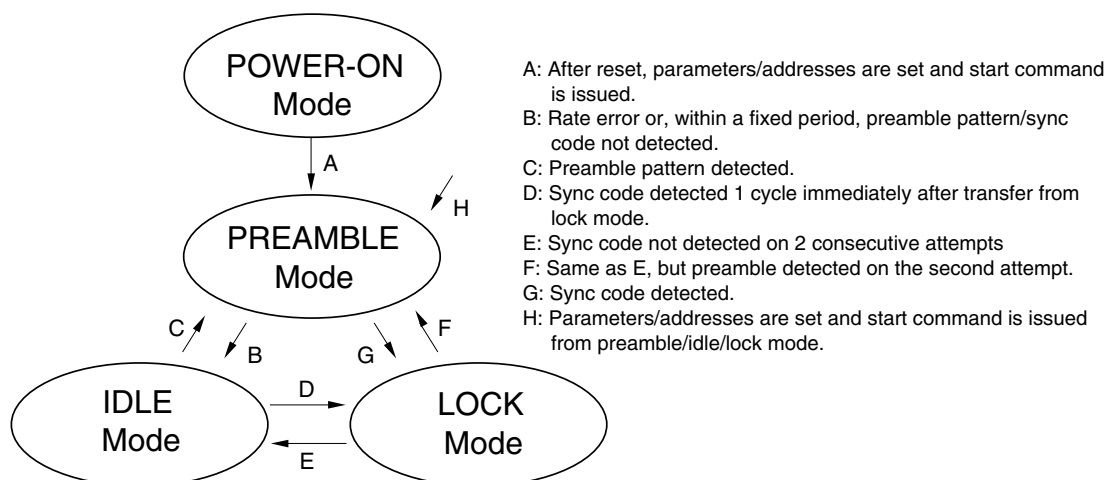


Figure 7. Operating mode transition diagram

Lock mode (dummy address setting is enabled)

If the sync code is detected during the preamble period, device operation transfers to lock mode and BS1 goes LOW. BS1 then goes HIGH again under frame timing, where the frame number is set by flags FF0 to FF2, and the 28 addresses and dummy address are compared with ID-ROM (If the frame number is 0, BS1 stays HIGH). If errors of 2 bits or less occur in the 28 addresses, the address is still recognized. Since there are two code words per frame, this check is done twice.

When all of the 28 addresses do not match, BS1 goes LOW and the device waits for the next frame or sync code receive timing. If the sync code is still not detected after two consecutive attempts, device operation transfers to idle mode, except during message reception where operation stays in lock mode. If the sync code is not detected on the second attempt, but instead a pattern forming a preamble is detected, device operation transfers to preamble mode and not idle mode (preamble mode is more advantageous for sync code detection).

When one of the 28 addresses does match, ATTN goes LOW and the 32-address information (see “Data/Flags” section) is transmitted to the CPU on SDO in sync with the SCK clock.

The dummy address is compared in the same way as normal addresses, but regardless of the comparison result after being compared in the assigned frame, the dummy address is recognized as the device address (even if it occurs within a message). It is always recognized as the device address when it appears in either the first or second code word of the assigned frame. However, if addresses A to G are used at the same time dummy addressing is enabled, frames with dummy addresses should not be specified. If frames with a dummy address are specified, the same frame will receive two addresses, and the data transferred to the microcontroller will always be the data corresponding to the dummy address, even if one of the addresses is not a dummy address.

When the normal address and dummy address information is confirmed to be a message, BS1 is held HIGH and the message is received. The received message is stored in a buffer as 32-bit error-corrected information (see “Data/Flags” section), then ATTN goes LOW and the data is transmitted to the CPU on SDO in sync with the SCK clock.

When the address and message is received, ATTN should be held LOW while the data is output on SDO.

When an incoming message spans two or more batches, additional sync code detection occurs during sync code receive timing.

Message reception can be selected to end when either an address code or idle code is detected, or when interrupted using the decoder set command BREAK input. This selection is made when setting parameters that will not cause the message to terminate. If the BREAK mode is selected, even if an address other than the self address (MSB = 0) is received during message reception, reception continues without interruption and address data is sent to the microcontroller using the same data handling as for a message. In this case, reception can only be interrupted by a BREAK input signal from the microcontroller.

Therefore, when dummy address (in combination with normal addresses) handling is enabled and parameters that will not cause the message to terminate are selected, this means that the device can be used in various radio and test equipment for business applications.

In either of the above cases, message reception ends if an end-of-message signal is sent. Note that if the device address is received, the end-of-message data is not transmitted.

When message reception ends, BS1 goes LOW and the device waits for either the address detect timing of the next frame or the sync code receive timing.

When sending data from the decoder to the microcontroller, the SCK clock frequency should not be less than 512, (1200), [2400] Hz. If this occurs, the SCK counter is reinitialized. This function, however, does make restoring operation easy even if this or another clock is accidentally input.

Refer to figure 7 in the “Lock mode (dummy address setting is disabled)” section.

Address/Parameter Data Transmission (CPU to SM8213AM)

After device reset initialization, the address and parameter data is transmitted from the CPU in 32-bit batches, 1 parameter batch and 8 address batches for a total of 9 batches (288 bits), on SDI in sync with the falling edge of the SCK clock (see “Power-ON Mode” section).

The SM8213AM supports 8 independent addresses (7 normal addresses: A, B, C, D, E, F, G and H + 1 dummy address: H). Also, each address can be assigned a frame number to cover all kinds of group calls or subsidiary services.

Any of the 8 addresses can be individually disabled using the “ADDRESS ENABLE” flag when setting the addresses.

Conversely, if less than 7 addresses are used, then the use of address H is restricted and as a result the device can be used as a normal decoder.

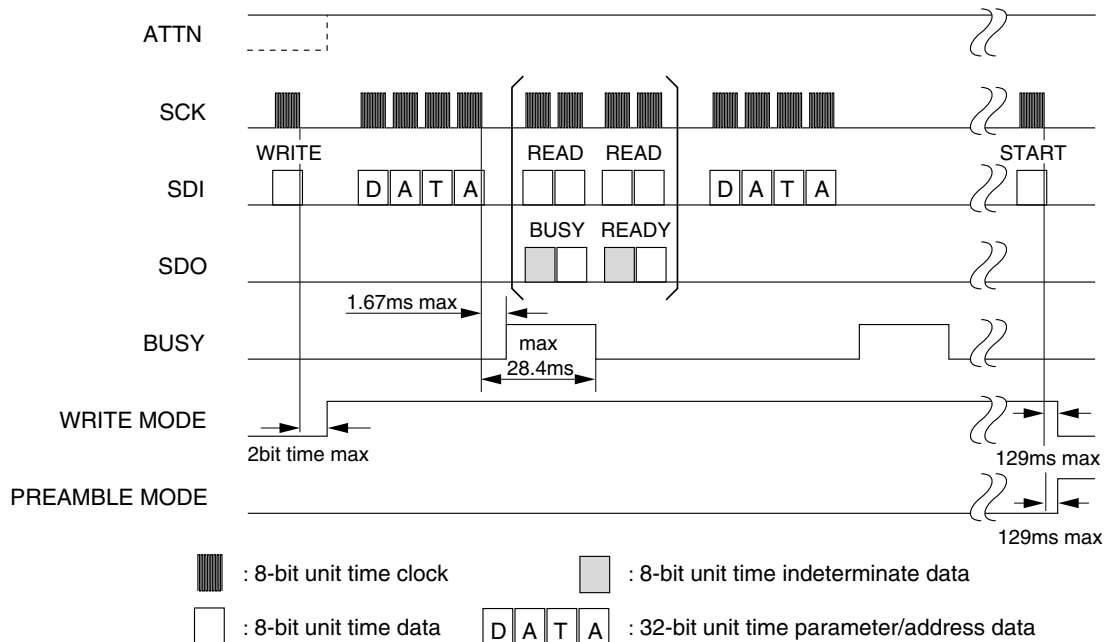
The address data for each of the 8 addresses comprises an 18-bit address plus two function bits used to select one of four sub-addresses. Then, one MSB bit (0 for address signals), ten BCH (31, 21) format generated check bits and an even-parity bit are added to form 32-bit code word representing the address information which is then stored in RAM. This address information is then compared with the received data to determine correct addressing.

Ensure that there are not multiple writes requests to turn ON the same address.

Even if the number of addresses used is less than 8, all addresses should be set immediately after power is applied and immediately after reset. If not all addresses are set, subsequent operation may become unstable.

Each address is 18 bits long and should be input MSB first. Refer to the “AC Characteristics” section for SCK and data specifications, and the “Data/Flags” section for data and flag functions.

When setting parameters and addresses in write mode, the SCK clock frequency should not be less than 1200Hz. If this occurs, the SCK counter is reinitialized. This function, however, does make restoring operation easy even if this or another clock is accidentally input.



Refer to the AC Characteristics section for detailed timing specification:

Figure 8. Address/parameter transmit timing

Received Data Transmission (SM8213AM to CPU)

In lock mode, if the receive data for the frame is recognized as one of the 28 normal addresses or a dummy address with 2 bit errors or less, then the data is temporarily stored in the transmit buffer and then error correction and other processing takes place.

After processing, ATTN goes LOW to inform the CPU that transmit ready data is available.

The SM8213AM switches the data internally and then outputs 32-bit data, shown in table 7, on SDO in sync with the falling edge of the SCK clock. The CPU can then read the data on either the SCK rising edge or the falling edge.

The message bits (1 to 20), which are the 13th to 32nd bits of the detected address data, comprises 18 address information bits and 2 function bits.

When the 32-bit transmission ends, ATTN goes HIGH to indicate that all necessary information has been transmitted.

When an address is detected, the next 32-bit data code word is received. The BCH (31, 21) format error check bits are checked and if a 1-bit or two consecutive bit errors occur, they are corrected. Two random bit errors, or three or more bit errors are not corrected.

If the corrected data MSB is 1, the data is recognized as a message, data reception continues and the corrected message data and error check flags are sent to the CPU as 32-bit data, shown in table 7, with the same data handling as an address. In this case also, ATTN goes LOW after processing to inform the CPU that transmit ready data is available. The time from when ATTN goes LOW until the CPU sends the SCK should be the same as shown in figure 9. Also, when the message continues, the normal SCK clock speed becomes faster than the receive signal bit rate and as a result there is a limit to the transmitted information capacity. As ATTN is used as the transmit ready data available signal output, it can be used as the CPU interrupt signal to receive data with the timing shown in figure 9.

Conversely, when the decoder takes ATTN LOW to indicate transmit ready data is available, the microcontroller operates under normal starting conditions (high-speed clock operation), and 32-bit clock is input on SCK. After data is read in and until ATTN goes LOW for the next transmit ready data signal, the series processing should be such that it takes less than $\{32 \times (\text{bit rate})\}$ time. If it takes longer than this amount of time, the succeeding data may not be output correctly.

When the MSB is 0 and data is recognized as an idle signal or idle code, data reception and data transfer to the CPU stops after the end-of-message is output for addresses not matching the self address.

However, when CPU BREAK input interrupt end-of-message method is selected (see “Flag Setting” section), data is treated as a message and reception continues even if the MSB is 0.

When sending data from the decoder to the microcontroller, the SCK clock frequency should not be less than 512, (1200), [2400] Hz. If this occurs, the SCK counter is reinitialized. This function, however, does make restoring operation easy even if this or another clock is accidentally input.

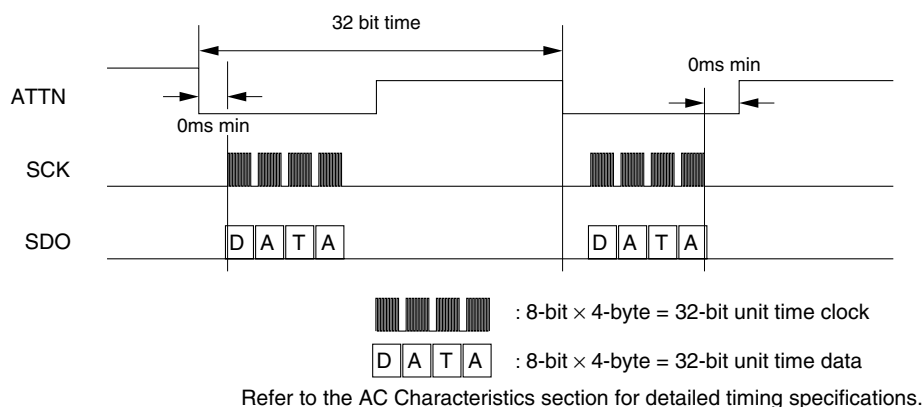


Figure 9. Received data transmit timing

Decoder Set Command Transfer (CPU to SM8213AM)

In the SM8213AM, the Break, Back-up, Write, BS-test, Start and End auxiliary modes are control signals from the CPU. These modes are set by data written on SDI in sync with the SCK clock (see “Data/Flags” section).

Allow a minimum of 1.67ms after transferring each command or data before issuing the next processing command in write mode. In other modes, allow a minimum of 4.0 (1.67) [0.9] ms.

When sending data from the decoder to the microcontroller, the SCK clock frequency should not be less than 1200Hz when in write mode. In other modes, the frequency should not be less than 512 (1200) [2400] Hz. If this occurs, the SCK counter is reinitialized. This function, however, does make restoring operation easy even if this or another clock is accidentally input. Note that read mode function is described in the “Decoder Internal Status Transfer” section.

Break

This is the interrupt command to stop reception and data transfer. When the Break command is detected, the received code word ends and reception stops, then the device waits for self frame address detection or sync code detection timing. Reception may continue for up to 32-bit units of time after the Break command is received (or 34-bit time after the Break command is sent).

Even though message reception may continue for a short time when the Break command is sent, sync code detection does not take place and accordingly the received data may be deemed to have many errors.

Also, when CPU BREAK input interrupt end-of-message method only is selected, message reception continues even if an address code or an idle code is present, as long as the Break command is not issued.

The time required from when the Break command is issued until received data is output can be approximately 2 to 3 code words at internal sync speed. During this interval, 32 clock cycles are sent to the decoder while ATTN is LOW, and processing should be performed just as for normal operation. If no processing is performed, subsequent operation may become unstable.

Back-up (Power save control)

This is the decoder OFF mode command. This command stops all internal operation except the oscillator, and thus is used to control current consumption. (the decoder internal status is write mode).

Note that in back-up mode, the input/output pins do not become high impedance.

Back-up mode is released and operation restarts when the decoder set start command is issued. All parameter and address information is retained during back-up, so operation starts directly from preamble mode.

Write

This is the parameter and address write command. This operation mode can also be used to modify parameters and addresses. Write mode can be activated from BS-test mode, and also approximately 50ms after reset, but you should allow at least 900ms for the oscillator internal to start and stabilize.

Parameters and addresses can be changed by first issuing a decoder set command to enter write mode and then writing new parameters and addresses. Note that in write mode, all internal operation takes place with the same timing as for 1200bps speed mode. BS1, BS2 and BS3 are held LOW.

Each of the addresses can be turned ON/OFF, according to flag settings in the data written. Using this feature for a specific address in a pager allows the service provider, by prior agreement, to prohibit improper use of the pager delivery service (excluding delivery testing, stopping subsidiary services and similar functions).

In the SM8213AM, data writes from the microcontroller have priority, even if a received information transmit ready signal (ATTN = LOW) is present (forced write).

When reception from the decoder RF stage has priority, operation switches to write mode after the end-of-message is confirmed by monitoring the internal operation using the read command. Then the parameter set commands and address set commands are written.

After writing, write mode is released using the decoder set start command, and operation starts from preamble mode.

BS-test

This mode is used to test the RF stage operation, and is only available from write mode. BS1 and BS3 are held HIGH for RF stage testing.

After testing, BS-test mode is released using the decoder set start command, and operation starts from preamble mode.

Note that issuing the BACK-UP command is prohibited in BS-test mode.

Start

This command is used to return to normal operation from back-up, write and BS-test modes. Operation always restarts from preamble mode.

Note the following points when setting commands:

- Immediately after ATTN goes LOW
 Commands send 8 SCK clock cycles to the decoder and the received data is sent using 32 clock cycles immediately after ATTN goes LOW. However, apart from the 8 clock cycles needed for the command, 32 clock cycles are needed to release ATTN. Note that during this time, there is no guarantee of data.
- When ATTN is HIGH
 After command is transferred and until ATTN goes LOW for the next transmit ready data signal, the series processing should be such that it takes less than $\{32 \times (\text{bit rate})\}$ time. If it takes longer than this amount of time, the command setting may be delayed (relative to normal operation) when ATTN goes LOW. Note that during this time, there is no guarantee of data.

When ATTN goes HIGH (excluding write mode), SCK is examined to determine if the signal is a break, back-up, write or read command. During message reception, ATTN is temporarily held HIGH if a command is issued to set ATTN LOW. This delay ensures that the data from the decoder is not misinterpreted. And in this case, even if ATTN keeps LOW, transmitted receiving data is unstable.

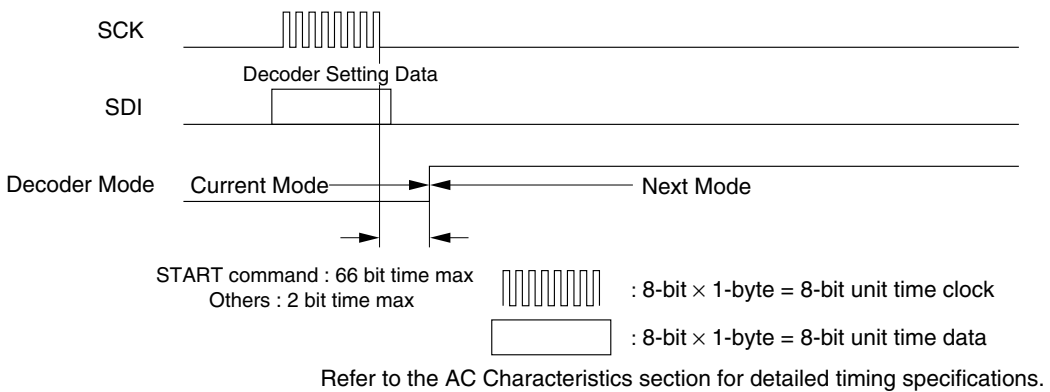


Figure 10. Auxiliary operating mode timing

Decoder Internal Status Transfer (SM8213AM to CPU)

In the SM8213AM, the internal decoder status and parameter/address end-of-processing confirmation, is transmitted to the CPU. The microcontroller uses this status information only when needed.

This is a 2-byte (16 bits) command where the first byte is a decoder set read command and the second byte is the decoder internal status that is sent to the microcontroller in sync with the SCK clock.

The microcontroller can use this function when not receiving data from the decoder (when ATTN is HIGH only).

Note the following points when setting the read command:

- When ATTN is HIGH
After data is transferred and until ATTN goes LOW for the next transmit ready data signal, the series processing should be such that it takes less than $\{32 \times (\text{bit rate})\}$ time. If it takes longer than this amount of time, the command setting may be delayed (relative to normal operation) when ATTN goes LOW. Note that during this time, there is no guarantee of data.

When ATTN goes HIGH (excluding write mode), SCK is examined to determine if the signal is a break, back-up, write or read command. During message reception, ATTN is temporarily held HIGH if a command is issued to set ATTN LOW. This delay ensures that the data from the decoder is not misinterpreted. And in this case, even if ATTN keeps LOW, transmitted receiving data is unstable.

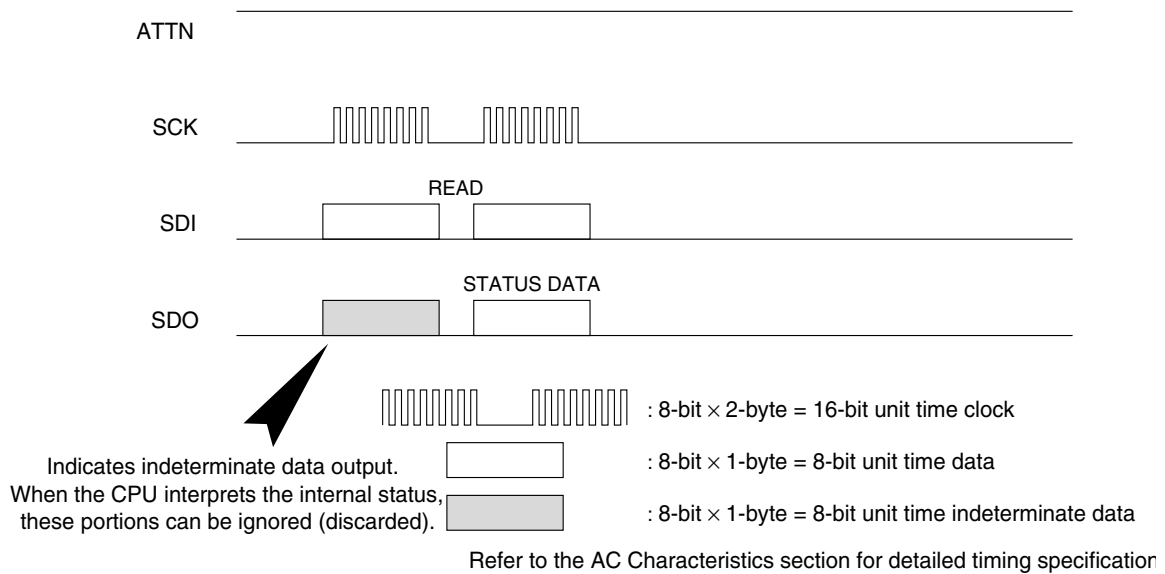


Figure 11. Internal status transfer timing

Miscellaneous Interface Pins

SIGNAL

NRZ-format signal input pin, with built-in noise canceller filter.

Current pager systems operate at 3 baud rates (512, 1200 and 2400bps). In conventional systems, the RF stage LPF time constants are changed in response to the baud rate in order to get the best possible reception. However, this requires switching the external components which results in increased product operating costs.

The SM8213AM, however, performs digital processing on the input signal which allows the 3 baud rates to be covered without the need to substitute RF stage LPF components. The side effect of this digital filter processing is a small probability of rate errors occurring.

Digital processing can be turned ON/OFF using flags. When turned ON, there are 4 filter constant settings that can be selected to obtain the best possible reception conditions in a flexible manner (see “Parameter Flags” section).

XT, XTN

Crystal oscillator element connection pins.

The SM8213AM operates at 76.8kHz system clock speed, and this clock can be provided simply by connecting a crystal element between XT and XTN. The oscillator amplifier, feedback resistance and oscillator capacitance are all built-in.

In this case, XTN should not be used as a clock to drive an external device.

Also, a 1000pF to 0.1μF capacitor should be connected between XVSS and VDD.

CLKO

Clock output pin. The clock output can be used as a CPU sleep clock or melody IC (SM1124 series) clock.

The output clock frequency, 76.8 or 38.4kHz, is selected using the decoder parameter set command.

RSTN

Decoder IC internal initialization reset pin. It also functions as an oscillator start-up booster (current source) immediately after power is applied to speed up oscillator stabilization.

AREA

This pin goes HIGH for ≥ 1 second when a sync code is detected with 2 or less random bit errors in preamble, lock or idle mode sync code detection timing.

During intermittent-duty CPU operation, monitoring this pin is useful for out-of-range signal strength.

However, even if a sync code is detected, this pin is not held HIGH for ≥ 1 second if 2 consecutive sync codes could not be detected, or under the following situations in 1200 and 2400bps modes.

- When the second of 2 consecutive sync codes could not be detected but a 6-bit preamble is detected and preamble continues.
- When operation transfers from lock mode to idle mode and then to preamble mode. Note that if operation stays in idle mode after transfer from lock mode, this pin goes HIGH for ≥ 1 second.

Data/Flags

Parameter Set Flags

Table 5. Parameter set flags

| Bit | Parameter setting flag |
|-----|--------------------------|
| 1 | 0 |
| 2 | 1 |
| 3 | 0 |
| 4 | 0 |
| 5 | 0 |
| 6 | 0 |
| 7 | 0 |
| 8 | BS2 OPTION (BS2 option) |
| 9 | END OF MESSAGE DETECTION |
| 10 | SELECT CLKO FREQUENCY |
| 11 | KILL CLKO |
| 12 | BIT RATE SET 1 (BRS1) |
| 13 | BIT RATE SET 0 (BRS0) |
| 14 | SIGNAL POLARITY |
| 15 | PL5 |
| 16 | PL4 |
| 17 | PL3 |
| 18 | PL2 |
| 19 | PL1 |
| 20 | PL0 |
| 21 | RF5 |
| 22 | RF4 |
| 23 | RF3 |
| 24 | RF2 |
| 25 | RF1 |
| 26 | RF0 |
| 27 | FILTER ENABLE/ DISABLE |
| 28 | FILTER 1 |
| 29 | FILTER 0 |
| 30 | ERROR 2 (ER 2) |
| 31 | ERROR 1 (ER 1) |
| 32 | ERROR 0 (ER 0) |

Bits 1 to 7

These bits form the parameter set command.

Bit 8

This bit selects the output format of the RF DC-level adjustment signal output on BS2.

When the “BS2 option” flag is 0, pre-receive adjustment mode is selected, and BS2 goes HIGH for a period of 1.953Nms (0.833Nms) [0.417Nms] immediately before receive timing during intermittent-duty operation in idle mode. BS2 is held LOW in preamble and lock mode. Note that values without parentheses are for 512bps, in () are for 1200bps, and in [] are for 2400bps. “N” represents the value set by RF5 (MSB) to RF0 (LSB).

When the “BS2 option” flag is 1, mid-receive adjustment mode is selected, with different timing depending on the mode.

In idle mode, BS2 is held HIGH only during intermittent-duty operation receive timing which is a period of 62.5ms (26.7ms) [13.4ms].

In preamble mode, BS2 is held LOW.

In lock mode, BS2 is held HIGH during sync code receive timing. The sync code is a POCSAG-format conforming signal comprising 32 bits of 16 “0” and 16 “1” bits to maintain energy balance so that, even for long message reception and fast-changing reception conditions, it can still be detected.

Bit 9

End-of-message method select flag.

When 0, end of message occurs when either an idle code word or another address is received during message reception, or when a break command is issued from the CPU.

When 1, end of message occurs only when a break command is issued from the CPU. So even if another address is received, the data is sent continuously to the CPU with message data handling. Therefore, the signal is considered to be valid even if the service provider sends a message and not enough information is received due to signal noise.

Bit 10

CLKO output clock frequency select flag.

When 0, 76.8kHz is selected.

When 1, 38.4kHz is selected.

Bit 11

CLKO clock output enable flag.

When 0, output is enabled.

When 1, output is disabled.

If CLKO clock output is not used, it can be useful in preventing unwanted noise generation.

Bits 12 to 13

Receive bit rate set flags.

| BRS1 | BRS0 | Reception bit rate |
|------|------|--------------------|
| 0 | 0 | 512bps |
| 0 | 1 | 1200bps |
| 1 | 0 | 2400bps |
| 1 | 1 | Can't accept |

Bit 14

NRZ input signal polarity select flag.

When 0, normal logic is selected.

When 1, inverse logic is selected.

Bits 15 to 20

BS3 (PLL setup signal) setup time set flags.

“M” represents the value of PL5 (MSB) to PL0 (LSB) and is used to control the receive timing setup time before BS3 rising edge. The setup time is 1.953Mms (0.833Mms) [0.417Mms]. The valid values are from 2 to 62 (61 steps). Note that 3F_H is an invalid setting.

Bits 21 to 26

BS1 (RF control main output signal) setup time set flags.

“N” represents the value of RF5 (MSB) to RF0 (LSB) and is used to control the receive timing setup time before BS3 rising edge. The setup time is 1.953Nms (0.833Nms) [0.417Nms]. The valid values are from 2 to 62 (61 steps). Note that 3E_H and 3F_H are invalid settings.

Note also that the setup times should be set such that (BS3 rising-edge setup time) > (BS1 rising-edge setup time).

Bit 27

NRZ signal input noise canceller filter ON/OFF flag.

When 0, filter is OFF.

When 1, filter is ON.

Bits 28 to 29

These bits set the noise canceller filter on-state (strength) when the filter is turned ON using bit 27.

| FILTER 1 | FILTER 0 | Filter strength ¹ |
|----------|----------|------------------------------|
| 0 | 0 | Filter strength 1 |
| 0 | 1 | Filter strength 2 |
| 1 | 0 | Filter strength 3 |
| 1 | 1 | Filter strength 4 |

1. Filter ON-state strength: 1 < 2 < 3 < 4

Bits 30 to 32

Preamble mode rate error detection condition set flags.

In preamble mode, under worst-case reception conditions, a single standard is used when distinguishing between noise and preamble to detect rate errors. These flags determine the rate error detection standard. The error counter value (number of permissible rate errors) can be selected from the range 1 to 8.

| ER 2 | ER 1 | ER 0 | Threshold |
|------|------|------|-----------|
| 0 | 0 | 0 | Count = 1 |
| 0 | 0 | 1 | Count = 2 |
| 0 | 1 | 0 | Count = 3 |
| 0 | 1 | 1 | Count = 4 |
| 1 | 0 | 0 | Count = 5 |
| 1 | 0 | 1 | Count = 6 |
| 1 | 1 | 0 | Count = 7 |
| 1 | 1 | 1 | Count = 8 |

Address Set Flags

In the SM8213AM, each of the 8 independent addresses can be assigned a frame.

Address settings are made in 8 batches in write mode immediately after power is applied and immediately after reset (9 batches total, including the parameter batch). All batches should be set. If not all batches are set, subsequent operation may become unstable.

Also, an address setting can be modified during normal operation, 1 address at a time, with no adverse effects.

Ensure that there are not multiple writes requests to turn ON the same address.

Table 6. Address set flags

| Bit | Address setting flag |
|-----|----------------------|
| 1 | 0 |
| 2 | 1 |
| 3 | 1 |
| 4 | 0 |
| 5 | 0 |
| 6 | 0 |
| 7 | 0 |
| 8 | ADDRESS ENABLE |
| 9 | ADDRESS 2 (ADDR 2) |
| 10 | ADDRESS 1 (ADDR 1) |
| 11 | ADDRESS 0 (ADDR 0) |
| 12 | FRAME 2 (FR 2) |
| 13 | FRAME 1 (FR 1) |
| 14 | FRAME 0 (FR 0) |
| 15 | A1 |
| 16 | A2 |
| 17 | A3 |
| 18 | A4 |
| 19 | A5 |
| 20 | A6 |
| 21 | A7 |
| 22 | A8 |
| 23 | A9 |
| 24 | A9 |
| 25 | A11 |
| 26 | A12 |
| 27 | A13 |
| 28 | A14 |
| 29 | A15 |
| 30 | A16 |
| 31 | A17 |
| 32 | A18 |

Bits 1 to 7

These bits form the address set command.

Bit 8

These bits are the address (bits 9 to 32) enable flags.

When 1, the address set by bits 9 to 32 are valid.

When 0, the address set by bits 9 to 32 are invalid.

Bits 9 to 11

These bits are the address (bits 15 to 32) call sign set flags.

Using 8-address control, the call signs are A, B, C, D, E, F, G and H.

| ADDR 2 | ADDR 1 | ADDR 0 | Name |
|--------|--------|--------|------|
| 0 | 0 | 0 | A |
| 0 | 0 | 1 | B |
| 0 | 1 | 0 | C |
| 0 | 1 | 1 | D |
| 1 | 0 | 0 | E |
| 1 | 0 | 1 | F |
| 1 | 1 | 0 | G |
| 1 | 1 | 1 | H |

Bits 12 to 14

These bits are the address (bits 15 to 32) frame assign flags.

Any frame can be assigned individually to any of the 8 controllable addresses. Up to 8 frames can be assigned.

| FR 2 | FR 1 | FR 0 | Frame |
|------|------|------|---------|
| 0 | 0 | 0 | Frame 0 |
| 0 | 0 | 1 | Frame 1 |
| 0 | 1 | 0 | Frame 2 |
| 0 | 1 | 1 | Frame 3 |
| 1 | 0 | 0 | Frame 4 |
| 1 | 0 | 1 | Frame 5 |
| 1 | 1 | 0 | Frame 6 |
| 1 | 1 | 1 | Frame 7 |

Bits 15 to 32

Address bits.

The 18-bit address should be written with MSB first.

Received Data

Table 7. Receive data format

| Bit | Reception data |
|-----|-----------------------|
| 1 | 1 |
| 2 | MESSAGE/ ADDRESS |
| 3 | SELF ADDRESS |
| 4 | ADDRESS 2 (ADDR 2) |
| 5 | ADDRESS 1 (ADDR 1) |
| 6 | ADDRESS 0 (ADDR 0) |
| 7 | FUNCTION 1 (FUNC 1) |
| 8 | FUNCTION 0 (FUNC 0) |
| 9 | SYN - VAL |
| 10 | ERROR 1 (ERR 1) |
| 11 | ERROR 0 (ERR 0) |
| 12 | PARITY ERROR |
| 13 | MESSAGE 1/ADDRESS 1 |
| 14 | MESSAGE 2/ADDRESS 2 |
| 15 | MESSAGE 3/ADDRESS 3 |
| 16 | MESSAGE 4/ADDRESS 4 |
| 17 | MESSAGE 5/ADDRESS 5 |
| 18 | MESSAGE 6/ADDRESS 6 |
| 19 | MESSAGE 7/ADDRESS 7 |
| 20 | MESSAGE 8/ADDRESS 8 |
| 21 | MESSAGE 9/ADDRESS 9 |
| 22 | MESSAGE 10/ADDRESS 10 |
| 23 | MESSAGE 11/ADDRESS 11 |
| 24 | MESSAGE 12/ADDRESS 12 |
| 25 | MESSAGE 13/ADDRESS 13 |
| 26 | MESSAGE 14/ADDRESS 14 |
| 27 | MESSAGE 15/ADDRESS 15 |
| 28 | MESSAGE 16/ADDRESS 16 |
| 29 | MESSAGE 17/ADDRESS 17 |
| 30 | MESSAGE 18/ADDRESS 18 |
| 31 | MESSAGE 19/FUNCTION 1 |
| 32 | MESSAGE 20/FUNCTION 0 |

Bit 1

The receive data leading bit is always 1.

Bit 2

Message/address indicator flag.

When 0, the data is an address.

When 1, the data is a message.

Bit 3

Self address indicator flag.

When 1, the data is treated as a self address (device address).

When 0, the data is a message.

When this bit is set to 1, the self address corresponds to one of the addresses indicated by bits 4 to 6.

Bits 4 to 6

Address call sign flags.

When bit 3 of data is 1, indicating a self address, these bits indicate the call sign.

When the data is a message, all 3 bits are set to 0.

| ADDR 2 | ADDR 1 | ADDR 0 | Name |
|--------|--------|--------|------|
| 0 | 0 | 0 | A |
| 0 | 0 | 1 | B |
| 0 | 1 | 0 | C |
| 0 | 1 | 1 | D |
| 1 | 0 | 0 | E |
| 1 | 0 | 1 | F |
| 1 | 1 | 0 | G |
| 1 | 1 | 1 | H |

Bits 7 to 8

Function bit flags.

When bit 3 of data is 1, indicating a self address, these bits set the call function for the address indicated by bits 4 to 6.

However, when a dummy address is received (address H), bits 7 and 8 are both set to 0.

When the data is a message, both bits are set to 0.

| FUNC 1 | FUNC 0 | Function |
|--------|--------|----------|
| 0 | 0 | A Call |
| 0 | 1 | B Call |
| 1 | 0 | C Call |
| 1 | 1 | D Call |

Bit 9

Sync code preceding data reception receive status flag.

When 1, indicates that there are 2 or less random bit errors.

This flag is useful in determining data reliability.

Bits 10 to 11

Received message (or address) error correction indicator flags.

Note that 2-bit random errors and 3-bit (or more) errors are not corrected.

When the transmitted data is an address, a 2-bit random error condition is indicated when bits 10 and 11 are both 1.

| ERR 1 | ERR 0 | Condition |
|-------|-------|---------------------------------------|
| 0 | 0 | No errors |
| 0 | 1 | 1-bit error |
| 1 | 0 | 2-bit continuous (burst) error |
| 1 | 1 | 2-bit random or 3-bit (or more) error |

Bit 12

Parity error indicator flag.

When 1, indicates a parity error.

When 0, indicates no parity error.

Bits 13 to 32

Message (or address) bits.

These bits represent the message (or address) content, output with MSB first.

End-of-message Data

These bits represent data at the end of a message (including when using the break command). The end-of-message data is as follows:

Bits 1 to 3

All 3 bits are set to 1.

Bits 4 to 8

All 5 bits are set to 0.

Bit 9

Sync code preceding data reception receive status flag.

When 1, indicates that there are 2 or less random bit errors.

Bits 10 to 12

These bits are unknown data to be ignored.

Bits 13 to 32

All bits are set to 0.

Summary

The following table show the address, message and end-of-message data formats, respectively. Note that in table 7-1, bits 7 and 8 are both 0 if a dummy address (address H) is used.

Table 7-1. Address data format

| Bit | Reception data |
|-----|---------------------|
| 1 | 1 |
| 2 | 0 |
| 3 | 1 |
| 4 | ADDRESS 2 (ADDR 2) |
| 5 | ADDRESS 1 (ADDR 1) |
| 6 | ADDRESS 0 (ADDR 0) |
| 7 | FUNCTION 1 (FUNC 1) |
| 8 | FUNCTION 0 (FUNC 0) |
| 9 | SYN - VAL |
| 10 | ERROR 1 (ERR1) |
| 11 | ERROR 0 (ERR) |
| 12 | PARITY ERROR |
| 13 | ADDRESS 1 |
| 14 | ADDRESS 2 |
| 15 | ADDRESS 3 |
| 16 | ADDRESS 4 |
| 17 | ADDRESS 5 |
| 18 | ADDRESS 6 |
| 19 | ADDRESS 7 |
| 20 | ADDRESS 8 |
| 21 | ADDRESS 9 |
| 22 | ADDRESS 10 |
| 23 | ADDRESS 11 |
| 24 | ADDRESS 12 |
| 25 | ADDRESS 13 |
| 26 | ADDRESS 14 |
| 27 | ADDRESS 15 |
| 28 | ADDRESS 16 |
| 29 | ADDRESS 17 |
| 30 | ADDRESS 18 |
| 31 | FUNCTION 1 |
| 32 | FUNCTION 0 |

Table 7-2. Message data format

| Bit | Reception data |
|-----|-----------------|
| 1 | 1 |
| 2 | 1 |
| 3 | 0 |
| 4 | 0 |
| 5 | 0 |
| 6 | 0 |
| 7 | 0 |
| 8 | 0 |
| 9 | SYN - VAL |
| 10 | ERROR 1 (ERR 1) |
| 11 | ERROR 0 (ERR 0) |
| 12 | PARITY ERROR |
| 13 | MESSAGE 1 |
| 14 | MESSAGE 2 |
| 15 | MESSAGE 3 |
| 16 | MESSAGE 4 |
| 17 | MESSAGE 5 |
| 18 | MESSAGE 6 |
| 19 | MESSAGE 7 |
| 20 | MESSAGE 8 |
| 21 | MESSAGE 9 |
| 22 | MESSAGE 10 |
| 23 | MESSAGE 11 |
| 24 | MESSAGE 12 |
| 25 | MESSAGE 13 |
| 26 | MESSAGE 14 |
| 27 | MESSAGE 15 |
| 28 | MESSAGE 16 |
| 29 | MESSAGE 17 |
| 30 | MESSAGE 18 |
| 31 | MESSAGE 19 |
| 32 | MESSAGE 20 |

Table 7-3. End-of-message format

| Bit | Reception data |
|-----|----------------|
| 1 | 1 |
| 2 | 1 |
| 3 | 1 |
| 4 | 0 |
| 5 | 0 |
| 6 | 0 |
| 7 | 0 |
| 8 | 0 |
| 9 | SYN - VAL |
| 10 | UNKNOWN |
| 11 | UNKNOWN |
| 12 | UNKNOWN |
| 13 | 0 |
| 14 | 0 |
| 15 | 0 |
| 16 | 0 |
| 17 | 0 |
| 18 | 0 |
| 19 | 0 |
| 20 | 0 |
| 21 | 0 |
| 22 | 0 |
| 23 | 0 |
| 24 | 0 |
| 25 | 0 |
| 26 | 0 |
| 27 | 0 |
| 28 | 0 |
| 29 | 0 |
| 30 | 0 |
| 31 | 0 |
| 32 | 0 |

Decoder Set Flags

These flags set the auxiliary operating modes. See “Decoder Set Command Transfer” for a description of each auxiliary operating mode.

Note that the start command is accepted when in back-up, write, or BS-test mode. The start command is not accepted in modes other than these three. Also note that the write command is invalid in write mode.

Table 8. Decoder set flags

| Bit | Decoder setting flag |
|-----|----------------------|
| 1 | 1 |
| 2 | 0 |
| 3 | BREAK |
| 4 | BACK - UP |
| 5 | WRITE |
| 6 | BS - TEST |
| 7 | START |
| 8 | 0 |

Bits 1 to 2 and bit 8

These bits form the decoder set command.

Only one of bits 3 to 7 can be logic 1 at any given time to select the corresponding auxiliary operating mode. If more than one bit is 1 at any time, operation may become unstable.

Bit 3

Break mode (command) flag.

When 1, break mode operation is invoked.

Bit 4

Back-up mode (command) flag.

When 1, back-up mode operation is invoked.

Bit 5

Write mode (command) flag.

When 1, write mode operation is invoked.

Bit 6

BS-test mode (command) flag.

When 1, BS-test mode operation is invoked.

Bit 7

Start mode (command) flag.

When 1, start mode operation is invoked.

Read Command Set Flags/Data

Table 9. Read command format/internal status data

| Bit | READ command | Bit | Internal status ¹ |
|-----|--------------|-----|------------------------------|
| 1 | 1 | 1 | 0 |
| 2 | 0 | 2 | AREA |
| 3 | 0 | 3 | IDLE MODE |
| 4 | 0 | 4 | PREAMBLE MODE |
| 5 | 0 | 5 | LOCK MODE |
| 6 | 0 | 6 | WRITE MODE |
| 7 | 0 | 7 | ADET+MDET (Receiving) |
| 8 | 1 | 8 | BUSY/ READY |
| 9 | 0 | 9 | 0 |
| 10 | 0 | 10 | AREA |
| 11 | 0 | 11 | IDLE MODE |
| 12 | 0 | 12 | PREAMBLE MODE |
| 13 | 0 | 13 | LOCK MODE |
| 14 | 0 | 14 | WRITE MODE |
| 15 | 0 | 15 | ADET+MDET (Receiving) |
| 16 | 0 | 16 | BUSY/ READY |

1. = indeterminate data, = determinate data

Read command bits 1 to 16

These bits form the decoder read command.

Bits 1 to 8 form the actual command, and bits 9 to 16 are dummy data. While command bits 1 to 8 are being set, data may be output on SDO and can be treated as indeterminate data and ignored. While bits 9 to 16 are being set, however, data output on SDO is valid data.

Internal status bit 1 (read command bit 9)

Internal status output data leading bit.

This bit is always 0.

Internal status bit 2 (read command bit 10)

AREA pin condition flag (when reading internal status data).

When 0, AREA is LOW.

When 1, AREA is HIGH.

Internal status bit 3 (read command bit 11)

Decoder status flag.

When 1, decoder is operating in idle mode.

Internal status bit 4 (read command bit 12)

Decoder status flag.

When 1, decoder is operating in preamble mode.

Internal status bit 5 (read command bit 13)

Decoder status flag.

When 1, decoder is operating in lock mode.

Internal status bit 6 (read command bit 14)

Decoder status flag.

When 1, decoder is operating in write mode.

Internal status bit 7 (read command bit 15)

Decoder status flag.

When 1, decoder is receiving self address or message.

Internal status bit 8 (read command bit 16)

Decoder status flag.

When 1, indicates data write operation to the decoder internal RAM (BUSY in write mode).

Do not write data when this flag is set to 1.

After each 32-bit data is written, READY confirmation is not required before writing subsequent data if a space of 28.4ms maximum is provided.

Lock Mode Timing Examples

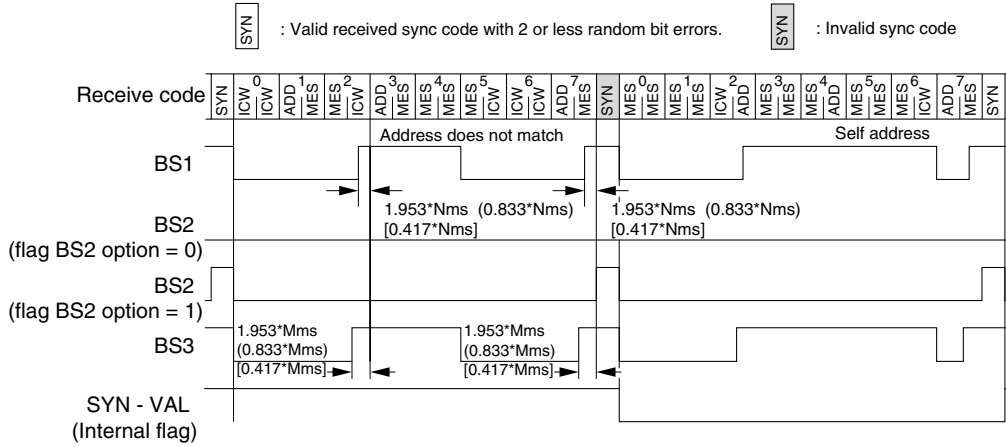


Figure 12. Self frame 3 and 4

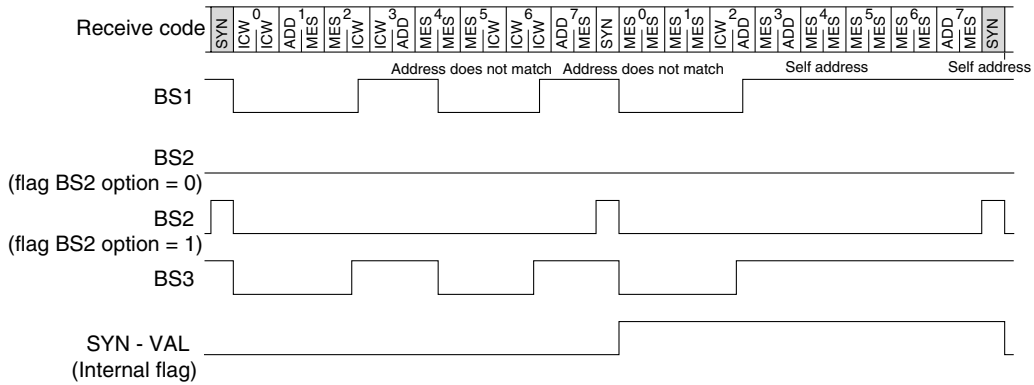


Figure 13. Self frame 3 and 7 (1)

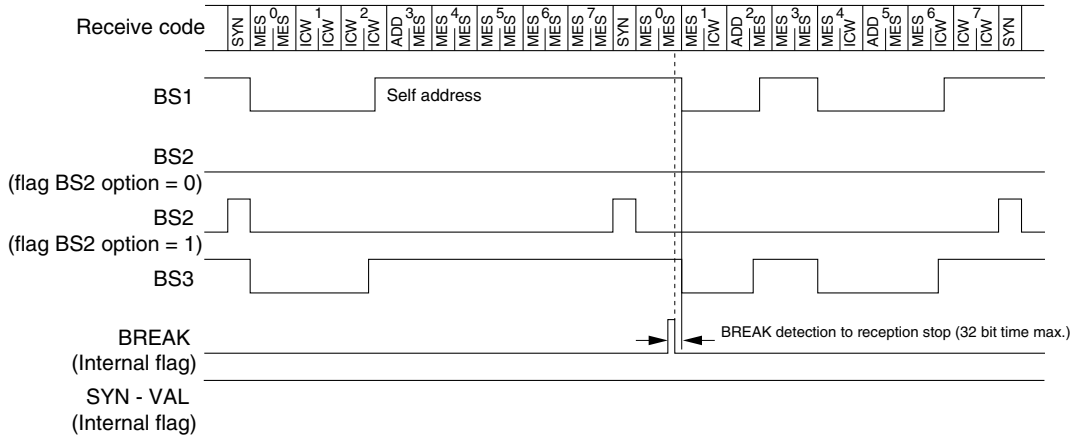
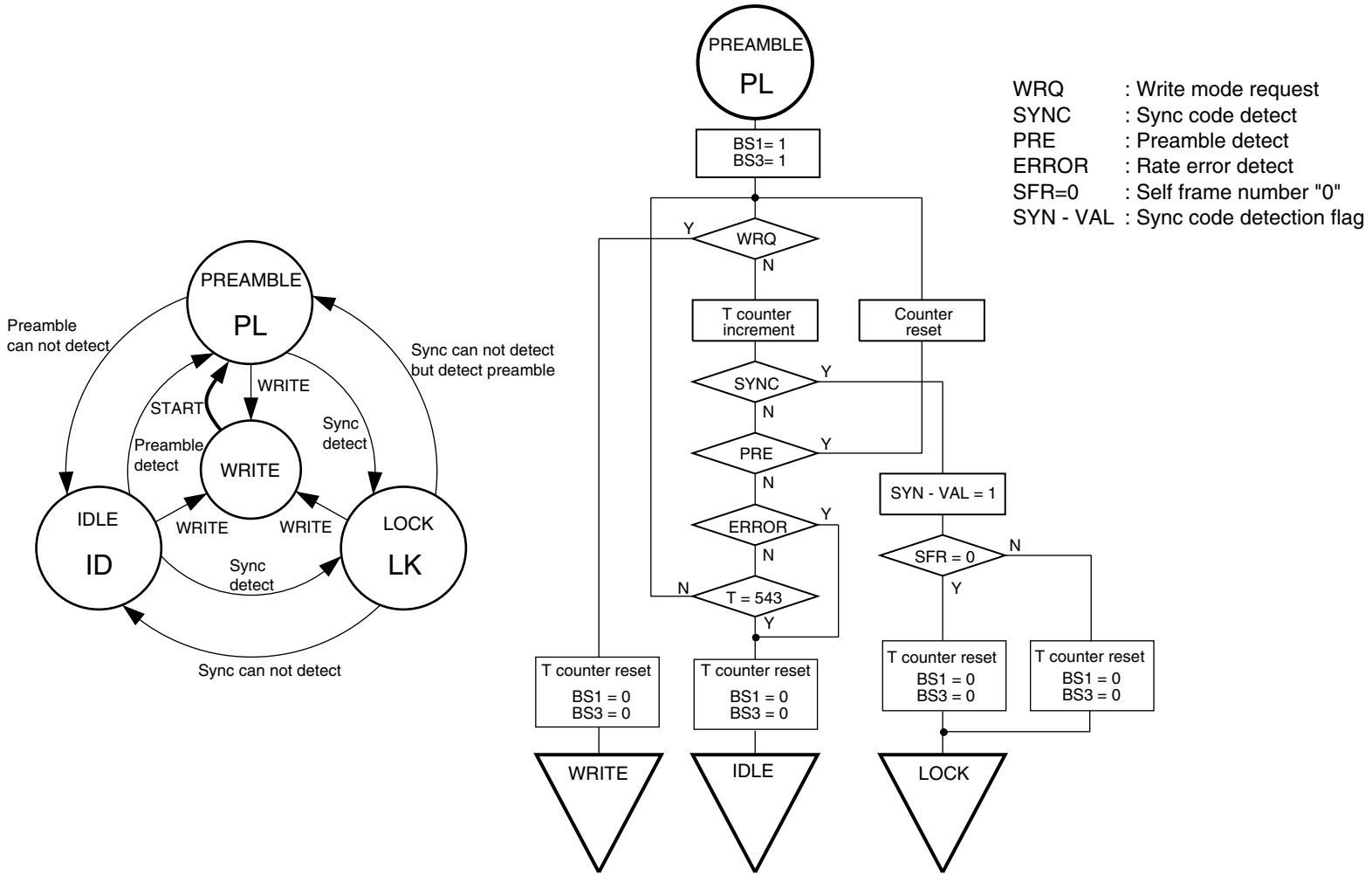
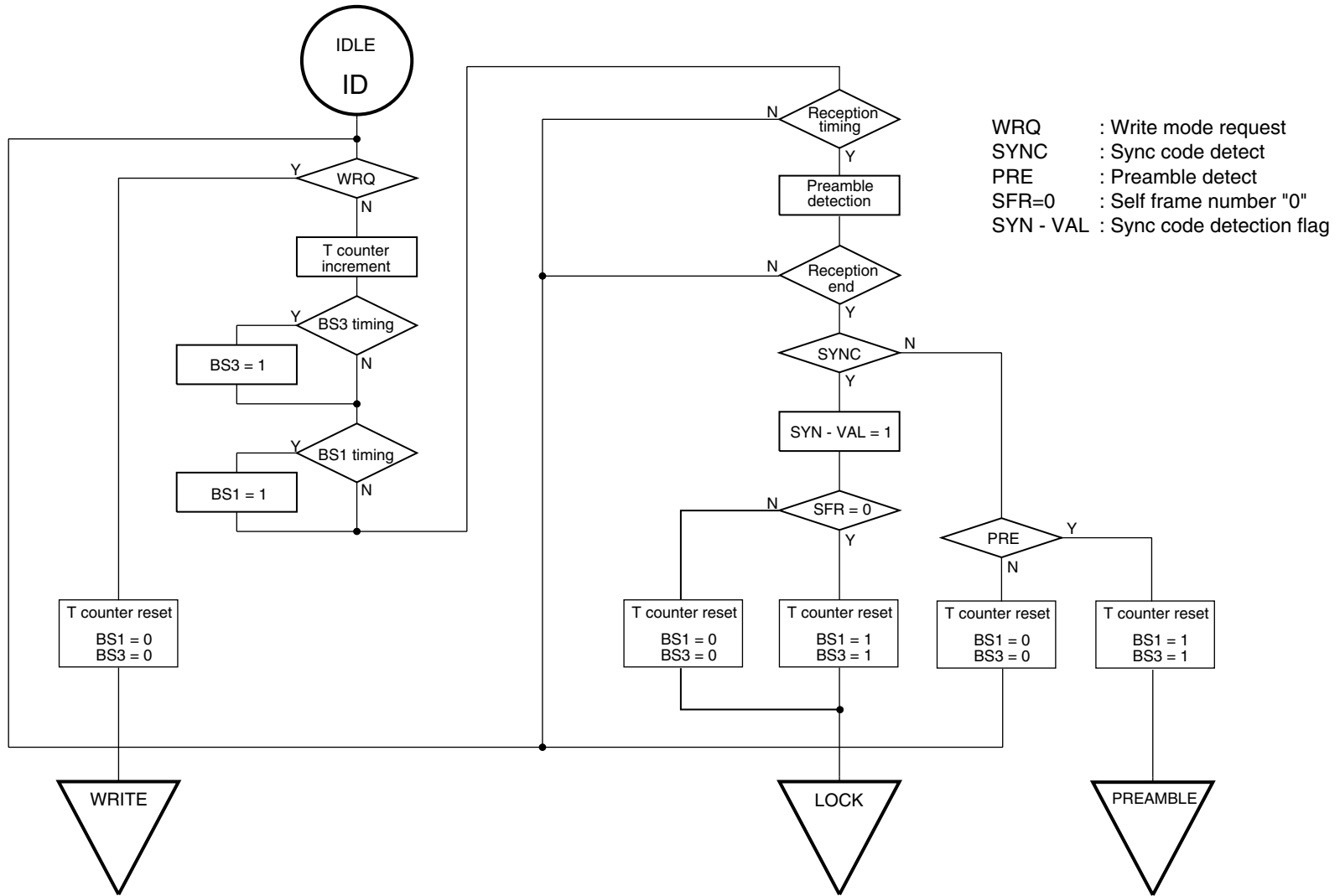


Figure 14. Self frame 3 and 7 (2)



Preamble, Idle, and Lock Mode Signal Flow



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