coolteq.h Version 3 Control and Monitoring Interface

PD002239

1 Introduction

The document is a logical specification of the coolteq.h™ Modulator's Control and Monitoring interface implemented via an I^2C bus, Interface Version AA.03.

For physical aspects of the coolteq.h™ Modulator's interface, please refer to ref [1].

2 Specification

The I^2C Control and Monitoring interface is used to manage the coolteq.h™ Modulator through register reads and writes. These registers make the following functions available to the host system:

- Modulator start-up.
- Modulator shut-down.
- Report product ID and serial number.
- Report Modulator status – temperature, warning & alarm states.
- Reset Modulator warning & alarm states
- Configure Modulator for TDD Power Saving operation
- Test LVDS data path

These functions are utilised using a protocol over I^2C bus base on request & response scheme. Details of the protocol are given in the following sections.

2.1 Protocol

The Modulator is controlled by the host using an I^2C interface with additional signals for selecting the bus address and for signalling exception conditions to the host. The I^2C interface complies with ref [2] and implements 7-bit addressing and clock stretching.

The modulator uses a request-response protocol over the I^2C bus. A request packet is sent to request specific information or action from the modulator, then a response packet is read to confirm the request and to receive any requested information. Error information is contained within the response packet if the request has been unsuccessful. This protocol provides a robust and efficient communication mechanism with the modulator.

2.1.1 Host Request and Response Protocol

Communication with the modulator is performed using a combined request-response protocol. All data is sent most-significant-bit first in line with ref [2]. Any multi-byte values that are used in the Request parameters or Result data are sent most-significant byte first.

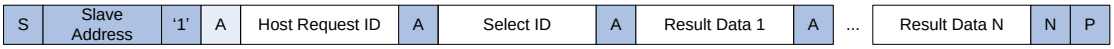
2.1.1.1 Standard Protocol

The general format starts with a request where two or more bytes are written using an I²C write transaction. All Host requests have a RequestID and SelectID, with zero or more bytes of parameter data

S = Start Condition, A = Acknowledgement, P = Stop Condition

Figure 2-1 Standard Host Request I²C write transaction

The request is followed by a response where two or more response bytes are read back using an I²C read transaction. With the exception of the Error response, all responses mirror the RequestID and SelectID used in the request, with zero or more bytes of result data.



S = Start Condition, A = Acknowledgement, N = Negative Acknowledgement, P = Stop Condition

Figure 2-2 Standard Host Response I²C Read transaction

Note: the modulator will normally respond with ack(A) to all data bytes in a I²C write transaction. However, the modulator will respond with not-ack(N) to terminate a write transaction early if it detects a communication error during that transaction.

2.1.1.2 Combined Transactions

The modulator supports I²C combined transactions as defined in ref [2], where consecutive I²C write/read transactions to the modulator are separated by restart conditions.
It is possible to modify the standard protocol so that request write transaction does not include a stop condition, but continues immediately in to the restart condition of the response read transaction.

S = Start Condition, A = Acknowledgement, N = Negative Acknowledgement, P = Stop Condition

Figure 2-3 Combined Host Request-Response I²C transaction

2.1.1.3 Legacy Protocol

Some systems are designed to operate on a 'read with pointer' protocol. In these systems the standard request write transaction can be performed unmodified. However the response read transaction must be modified to include a dummy write transaction as follows

S = Start Condition, A = Acknowledgement, N = Negative Acknowledgement, P = Stop Condition

Figure 2-4 Legacy Host Response I²C transaction

Examples utilising the legacy protocol for RD_STATUS_INFO and WR_STATUS_INFO Host Request & Response transactions are given in Figure 2-4. Here, a dummy write transaction (Dummy ID = 0) is included in to the response read transaction. Stop condition is optional after the dummy write; indicated as greyed out [P].
To communicate with the coolteq.h™ Modulator, the legacy protocol is not mandatory.

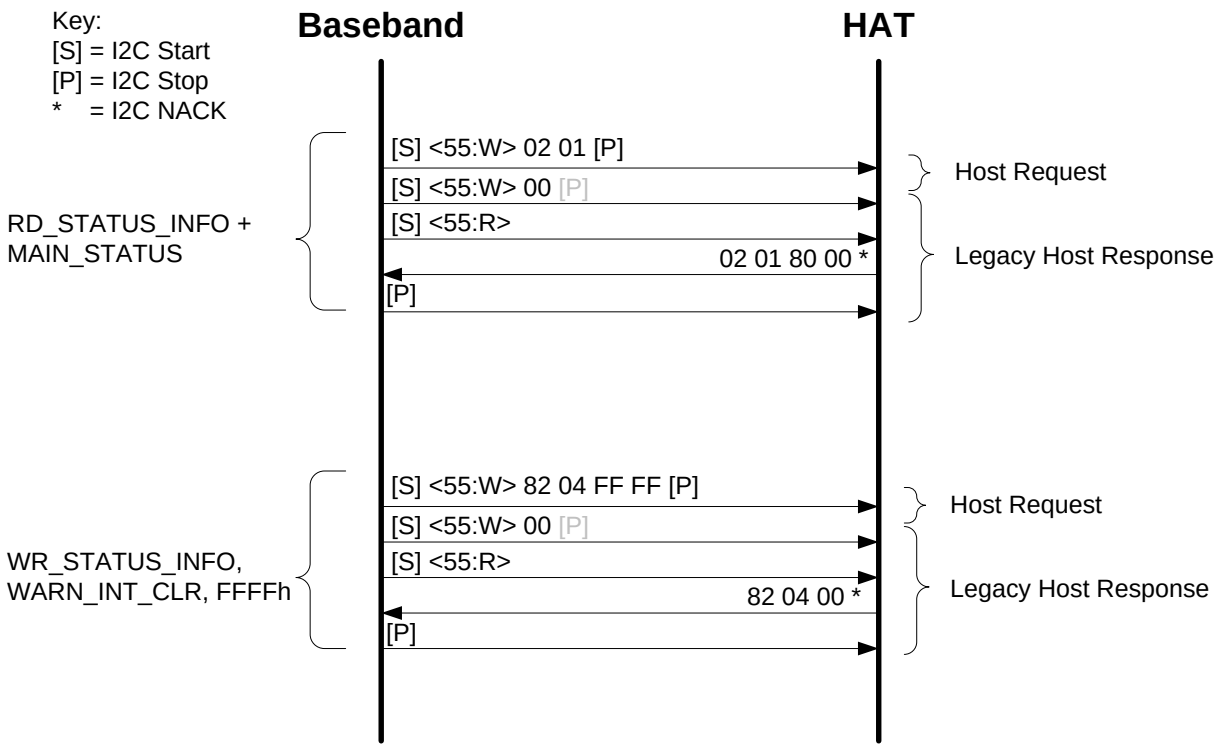


Figure 2-5 I²C transaction with legacy response

2.2 I²C Interface Signals

2.2.1 Host I²C bus

The modulator is managed through the Host I²C bus. It acts as a slave device and conforms to the Fast mode transfers as defined in ref [1].

2.2.2 HOST_SLA_SEL input lines

The modulator has 2 HOST_SLA_SELect lines that select one-of-four predefined 7-bit SLAs for the modulator. SLA_0 is always address 55h. The other 3 SLA values are user configurable (see section 3.9.3.5).

The state of the HOST_SLA_SEL lines are read and the modulator's SLA updated from the appropriate value after a power cycle.

The state of these lines is ignored at all other times.

2.2.3 HOST_INT output line

The modulator has a single HOST_INT line that can be configured to alert the I²C master of various conditions. It generates alerts for both alarm and warning conditions if configured to do so. There are separate output enable configuration registers for alarms and warnings, (see sections 3.9.3.2-3.9.3.3).

3 Host Requests & Responses

This section describes the high level Requests that can be made by the system controller to obtain information from the modulator or get it to perform a particular action.

All Host Requests fit in to a two-level structure. There are a set of main requests, each with their own RequestID. Each main request requires a secondary SelectID that further refines the request. Some requests may require further data, and this data is referred to as Request Parameters.

All requests generate a response from the modulator. The response may be a single value or collection of values. These values are referred to as Results Data.

Any request can also generate an Error response instead of the expected response, if the modulator is unable to process the request for any reason. (See section 3.1).

The main requests are summarised in the table below. Full details are given in further sections.

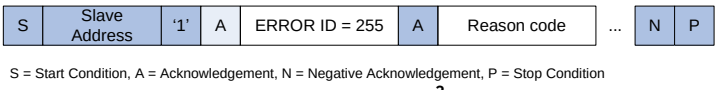
Req ID	Request with parameters	Results data
00h	RD_NO_DATA	See **Note 1**
02h	RD_STATUS_INFO, statusID	Status_info_value
03h	RD_DEVICE_INFO, infoID	Device_info_value
04h	RD_CONFIG_INFO, configID	Config_info_value
05h	RD_DIAGNS_INFO, diagTypeID	Diag_info_value
08h	RD_BLOCK_DATA, blockID, offset, length	Block_data
80h	COMMAND, commandID, …	Status_code
82h	WR_STATUS_INFO, statusID, value	Status_code
84h	WR_CONFIG_INFO, configID, value	Status_code
FFh	See **Note 2**	ERROR, reason

Note 1: The RD_NO_DATA id is only used in the Legacy Host Response Read transaction. All Host Request Write transactions using this id are disregarded.

Note 2: The ERROR id is only used in Host Response transactions, indicating that there has been a problem with the Host Request. (See later in this section for details of the Error Packet.)

3.1 The Error Response

If the Modulator is unable to carry out a particular host request, the Response Packet is filled with an Error Response, instead of the expected response.



S = Start Condition, A = Acknowledgement, N = Negative Acknowledgement, P = Stop Condition

Figure 3-1 The Error Response I²C Read transaction

The Error Response consists of 2 bytes: the RequestID field contains the ERROR id = 255, and the SelectID field contains one of the following reason codes.

Reason Code	Reason	Notes
00h	HAT_OK	Request successfully completed
01h	HAT_ID_ERROR_UNKNOWN	RequestID or SelectID with invalid value
02h	HAT_ID_ERROR_NOT_ALLOWED	Recognised request not allowed at this time
03h	HAT_ID_ERROR_BAD_FORMAT	Wrong number of request parameters
04h	HAT_ID_ERROR_BAD_PARAM	Parameter with invalid value
10h	HAT_ID_ERROR_SYS_ERROR	Error occurred performing request
FFh	HAT_ID_ERROR_COMMS	I²C Bus error transferring the request

3.2 RD_STATUS_INFO (02h) Requests

3.2.1 RD_STATUS_INFO (02h) Host Requests Overview

RD_STATUS_INFO requests are used to access information on the Modulator's status.

There are three main status registers: MAIN_STATUS, ALARM_STATUS and WARN_STATUS. These show the current state of the modulator. The MAIN_STATUS provides a summary of the modulator's state, showing if it is busy and active and showing if ALARM or WARN conditions are present. The ALARM_STATUS shows details of current ALARM conditions. The WARM_STATUS shows details of current WARN conditions.

ALARM conditions are serious and force the modulator to become and remain inactive. WARN conditions are indicators that the modulator is close to an ALARM condition.

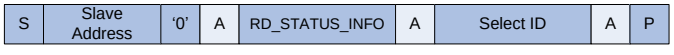
There are also shadow registers to the ALARM_STATUS and WARN_STATUS registers: ALARM_INT_STATUS and WARN_INT_STATUS. These shadow the contents of the respective status registers but have memory. Once a bit is set in the shadow register it remains set until cleared by the system controller. (See WR_STATUS_INFO request.) This ensures that the occurrence of ALARM and WARN conditions are not lost if the condition disappears.

The ALARM_INT_STATUS and WARN_INT_STATUS registers can be used to generate a hardware interrupt to the system controller, via the HOST_INT signal. Individual bits in these registers can be selected to cause an interrupt via the ALARM_OUTPUT_ENABLE and WARN_OUTPUT_ENABLE registers. (See WR_CONFIG_INFO request.)

There are four other ancillary status requests: ALARM_SYSTEM_INFO, ALARM_EVENT_INFO, WARN_SYSTEM_INFO and WARN_EVENT_INFO. These provide additional information about ALARM and WARN events signalled in the other status registers.

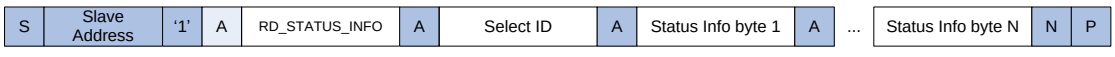
Events differ from conditions by existing only at an instance in time compared to conditions that can exist over a period of time. For example, an over-temperature alarm is a condition because it exists for as long as the temperature is too high. A modulator start failure generates an event as the failure occurs only at a specific instance in the power start sequence and does not have meaning outside of that context.

All RD_STATUS_INFO requests have no parameter data in the Host request packet. The Select ID is used to identify the particular status information to return in the response. The Host Response transaction contains requested status information as either 2 or 16 bytes of result data.



S = Start Condition, A = Acknowledgement, P = Stop Condition

Figure 3-2 Read Status Information Request I^2C write transaction



S = Start Condition, A = Acknowledgement, N = Negative Acknowledgement, P = Stop Condition

Figure 3-3 Read Status Information Response I^2C read transaction

3.2.2 RD_STATUS_INFO (02h) Host Requests Summary

The following table summarises the RD_STATUS_INFO requests.

Rd	Status Info Select IDs	Status Info value	Stats Info byte size
01h	MAIN_STATUS	<Main_status>	2
02h	ALARM_STATUS	<Alarm_status>	2
03h	WARN_STATUS	<Warning_status>	2
04h	ALARM_INT_STATUS	<Alarm_int_status>	2
05h	WARN_INT_STATUS	<Warn_int_status>	2
08h	ALARM_SYSTEM_INFO	<Alarm_system_info>	16
09h	ALARM_EVENT_INFO	<Alarm_event_info>	16
0Ah	WARN_SYSTEM_INFO	<Warn_system_info>	16
0Bh	WARN_EVENT_INFO	<Warning_event_info>	16
10h	TEMPERATURE	<Temperature>	2

3.2.3 RD_STATUS_INFO (02h) Host Request Details

3.2.3.1 MAIN_STATUS (01h), SelectID = 01h, Rsp Data = 2, Uint16

The Main Status register presents an overview of the modulator's current status.

15	14	13	12	11	10	9	8
Alarm Int	Warn Int			Fatal Error			

7	6	5	4	3	2	1	0
Alarm	Warn		Test			Active	Busy

Busy– set to 1 when the modulator is processing a command, e.g. START, STOP and LVDS_TEST.

Active – set to 1 when the modulator has started and its output voltage is active. Set to 0 when the modulator is inactive.

Test– set to 0 in normal operation. Used during internal testing.

Warn – set to 1 when any bit in the Warning Status register is set.

Alarm – set to 1 when any bit in the Alarm Status register is set.

Fatal Error – set to 1 when an error is encountered during the power-on-reset sequence (see below). Additional information may be available via the ALARM_SYSTEM_INFO Request.

Warn Int – set to 1 when any bit in the Warning Interrupt Status register is set.

Alarm Int – set to 1 when any bit in the Alarm Interrupt Status register is set.

If the **Fatal Error** bit is set, a serious error condition is present and the modulator will not be functional. The only Host Requests that function are;
RD_STATUS_INFO->MAIN_STATUS
RD_STATUS_INFO->ALARM_SYSTEM_INFO

All others will generate HOST_ERROR_NOT_ALLOWED error response.

3.2.3.2 ALARM_STATUS (02h), SelectID = 02h, Rsp Data = 2, Uint16

The Alarm Signal Status register shows the current state of alarm conditions. Alarm conditions are serious enough to stop the modulator working safely. Any one of these conditions becoming active (set) will result in the modulator stopping and returning to the Inactive state. The modulator can not be restarted while the alarm condition is still present.

15	14	13	12	11	10	9	8
	System Alarm	Alarm Event				Vsh High	Vsh Low

7	6	5	4	3	2	1	0
	No LVDS clk	Base plate Temp High	Base plate Temp Low		Va Low	Vsl High	Vsl Low

Vsl Low – The modulator's primary input supply voltage Vsl is below the minimum allowable voltage. The minimum voltage is defined in the modulator's Data Sheet.

Vsl High – The modulator's primary input supply voltage Vsl is above the maximum allowable voltage. The maximum voltage is defined in the modulator's Data Sheet.

Vsh Low – The modulator's secondary input supply voltage Vsh (for HV modulators only) is below the minimum allowable voltage. The minimum voltage is defined in the modulator's Data Sheet.

Vsh High – The modulator's secondary input supply voltage Vsh (for HV modulators only) is above the maximum allowable voltage. The maximum voltage is defined in the modulator's Data Sheet.

Va Low – The modulator's input supply voltage Va is below the minimum allowable voltage. The minimum voltage is defined in the modulator's Data Sheet.

Temp Low – The modulator's base-plate temperature is below the minimum allowable temperature. The minimum temperature is defined in the modulator's Data Sheet.

Temp High – The modulator's base-plate temperature is above the maximum allowable temperature. The maximum temperature is defined in the modulator's Data Sheet.

No LVDS clk – The modulator is detecting that there is no LVDS clock signal present, and therefore no LVDS data available. The modulator cannot become or be active in this condition.

Alarm Event – A new alarm event has occurred and the Alarm Event Information has been updated.

System Alarm – A new system alarm has occurred and the System Alarm Information has been updated.

Note: The modulator will not start if this register is not all zeros.

3.2.3.3 WARN_STATUS (03h), SelectID = 03h, Rsp Data = 2, Uint16

The Warn Signal Status register shows the current state of warning conditions. Warning conditions give notice that the modulator is close to generating an alarm condition. The system controller should use these warnings to take actions so that alarm conditions are avoided.

Warning conditions do not signify unsafe conditions. The modulator will continue to operate if active. The modulator can be started if warning conditions are present. Compare this behaviour with alarm conditions in the Alarm Signal Status register.

15	14	13	12	11	10	9	8
	System Warn	Warn Event				Vsh High	Vsh Low

7	6	5	4	3	2	1	0
		Base plate Temp High	Base plate Temp Low			Vsl High	Vsl Low

Vsl Low – The modulator's primary input supply voltage Vsl is close to the minimum allowable voltage. The minimum voltage is defined in the modulator's Data Sheet.

Vsl High – The modulator's primary input supply voltage Vsl is close to the maximum allowable voltage. The maximum voltage is defined in the modulator's Data Sheet.

Vsh Low – The modulator's secondary input supply voltage Vsh (for HV modulators only) is close to the minimum allowable voltage. The minimum voltage is defined in the modulator's Data Sheet.

Vsh High – The modulator's secondary input supply voltage Vsh (for HV modulators only) is close to the maximum allowable voltage. The maximum voltage is defined in the modulator's Data Sheet.

Temp Low – The modulator's base-plate temperature is close to the minimum allowable temperature. The minimum temperature is defined in the modulator's Data Sheet.

Temp High – The modulator's base-plate temperature is close to the maximum allowable temperature. The maximum temperature is defined in the modulator's Product Specification.

Warning Event – A new warning event has occurred and the Warn Event Information has been updated.

System Warning – A new system warning has occurred and the System Warn Information has been updated.

3.2.3.4 ALARM_INT_STATUS (04h), SelectID = 04h, Rsp Data = 2, Uint16

The Interrupt Alarm Status register indicates that one or more new alarm conditions or events have occurred. An alarm will result in the modulator stopping and returning to the Inactive state. The System Controller can use this register or the MAIN_STATUS, Alarm Int bit to see if a new alarm has occurred. It should use this register to identify the source of the alarm.

15	14	13	12	11	10	9	8
	System Alarm	Alarm Event				Vsh High	Vsh Low

7	6	5	4	3	2	1	0
	No LVDS clk	Base plate Temp High	Base plate Temp Low		Va Low	Vsl High	Vsl Low

Vsl Low – The associated bit in the Alarm Signal Status register has gone high.

Vsl High – The associated bit in the Alarm Signal Status register has gone high.

Vsh Low – The associated bit in the Alarm Signal Status register has gone high.

Vsh High – The associated bit in the Alarm Signal Status register has gone high.

Va Low – The associated bit in the Alarm Signal Status register has gone high.

Temp Low – The associated bit in the Alarm Signal Status register has gone high.

Temp High – The associated bit in the Alarm Signal Status register has gone high.

No LVDS clk – The associated bit in the Alarm Signal Status register has gone high.

Alarm Event – A new alarm event has occurred and the Alarm Event Information has been updated.

System Alarm – A new system error has occurred and the System Alarm Information has been updated.

The signals in this register remain active (set) until manually cleared, (see WR_STATUS_INFO, ALARM_SYSTEM_INFO, ALARM_INT_CLR and ALARM_EVENT_INFO requests).

This register does not inhibit the modulator's operation, i.e. this register does not need to be zero to start/re-start the modulator (c.f. ALARM_STATUS register).

The signals in this register respond to transitions on alarm conditions and events, not states. They can be cleared even when alarm conditions are still present. They will remain active (set) even when alarm conditions disappear. For example if the modulator's temperature goes above the maximum allowable value but then returns to below this value, the ALARM_STATUS register will read this signal as a zero, but this ALARM_INT_STATUS signal will still be set. Similarly, this ALARM_INT_STATUS signal can be manually cleared even though the modulator's temperature is above the maximum allowable value and the ALARM_STATUS signal is still set.

3.2.3.5 WARN_INT_STATUS (05h), SelectID = 05h, Rsp Data = 2, Uint16

The Interrupt Warn Status register indicates that one or more new warning conditions or events have occurred. The System Controller can use this register or the MAIN_STATUS, Warn Int bit to see if a new warning has occurred. It should use this register to identify the source of the warning.

15	14	13	12	11	10	9	8
	System Warning	Warning Event				Vsh High	Vsh Low

7	6	5	4	3	2	1	0
		Base plate Temp High	Base plate Temp Low			Vsl High	Vsl Low

Vsl Low – The associated bit in the Alarm Signal Status register has gone high.

Vsl High – The associated bit in the Alarm Signal Status register has gone high.

Vsh Low – The associated bit in the Alarm Signal Status register has gone high.

Vsh High – The associated bit in the Alarm Signal Status register has gone high.

Temp Low – The associated bit in the Alarm Signal Status register has gone high.

Temp High – The associated bit in the Alarm Signal Status register has gone high.

Warning Event – A new warning event has occurred and the Warn Event Information has been updated.

System Warning – A new system warning has occurred and the System Warn Information has been updated.

The signals in this register remain active (set) until manually cleared, (see WR_STATUS_INFO, WARN_SYSTEM_INFO, WARN_INT_CLR and WARN_EVENT_INFO requests).

The signals in this register respond to transitions on conditions and events, not states. They can be cleared even when conditions are still present. They will remain active (set) even when conditions disappear. For example if the modulator's temperature gets close to the maximum allowable value but then returns to below this value, the WARN_STATUS signal will read as a zero, but this WARN_INT_STATUS signal will read as set.

Similarly, this WARN_INT_STATUS signal can be manually cleared even though the modulator's temperature is above the maximum allowable value and the WARN_STATUS signal is still set.

3.2.3.6 ALARM_SYSTEM_INFO (08h), SelectID = 08h, Rsp Data = 16, Data Block

The ALARM_SYSTEM_INFO request gives information about system errors that occur during operation. System errors are serious enough to stop the modulator working safely. They always result in the modulator stopping and returning to the Inactive state. Information about the error is automatically cleared by reading the information with this request. The occurrence of a system error is flagged in the ALARM_STATUS register.

Byte 1	Bytes 2 - 16
System code	Auxiliary information

The ALARM_SYSTEM_INFO is a block of 16 bytes of data. The first byte always contains a system code. The subsequent bytes may contain auxiliary data, dependant on system code. System codes and associated data are defined in section 4.

Reading this information automatically clears this information block and the System Alarm signal in the ALARM_STATUS register and in the ALARM_INT_STATUS register.

3.2.3.7 ALARM_EVENT_INFO (09h), SelectID = 09h, Rsp Data = 16, Data Block

The ALARM_EVENT_INFO request gives information about alarm events that occur during operation. Alarm Events are serious enough to stop the modulator working safely. They always result in the modulator stopping and returning to the Inactive state. Information about the event is automatically cleared by reading the information with this request. The occurrence of an alarm event is flagged in the ALARM_STATUS register.

Byte 1	Bytes 2 - 16
Event code	Auxiliary information

The Alarm Event Information is a block of 16 bytes of data. The first byte always contains an event code. The subsequent bytes may contain auxiliary data, dependant on event code. Event codes and associated data are defined in section 4.

Reading this information automatically clears this information block and the Alarm Event signal in the ALARM_STATUS register and in the ALARM_INT_STATUS register.

3.2.3.8 WARN_SYSTEM_INFO (0Ah), SelectID = 0Ah, Rsp Data = 16, Data Block

The WARN_SYSTEM_INFO request gives information about system warnings that occur during operation. Information about the warning is automatically cleared by reading the information with this request. The occurrence of a system warning is flagged in the WARN_STATUS register.

Byte 1	Bytes 2 - 16
System code	Auxiliary information

The System Warn Information is a block of 16 bytes of data. The first byte always contains a system code. The subsequent bytes may contain auxiliary data, dependant on system code. System codes and associated data are defined in section 4.

Reading this information automatically clears this information block and the System Warning signal in the WARN_STATUS register and in the WARN_INT_STATUS register.

3.2.3.9 WARN_EVENT_INFO (0Bh), SelectID = 0Bh, Rsp Data = 16, Data Block

The WARN_EVENT_INFO request gives information about warning events that occur during operation. Information about the warning is automatically cleared by reading the information with this request. The occurrence of a warning event is flagged in the WARN_STATUS register.

Byte 1	Bytes 2 - 16
Event code	Auxiliary information

The Warn Event Information is a block of 16 bytes of data. The first byte always contains an event code. The subsequent bytes may contain auxiliary data, dependant on event code. Event codes and associated data are defined in section 4.

Reading this information automatically clears this information block and the Warning Event signal in the WARN_STATUS register and in the WARN_INT_STATUS register.

3.2.3.10 TEMPERATURE (10h), SelectID = 10h, Rsp Data = 2, Int16

The modulator's current base-plate temperature can be read from this register. The 16-bit value is in degrees Celsius and is in **signed two's complement** format.

15	14	13	12	11	10	9	8
Most-significant byte of base-plate temperature							

7	6	5	4	3	2	1	0
Least-significant byte of base-plate temperature							

3.3 RD_DEVICE_INFO (03h) Requests

3.3.1 RD_DEVICE_INFO (03h) Host Requests Overview

RD_DEVICE_INFO requests are used to access product information on the Modulator.

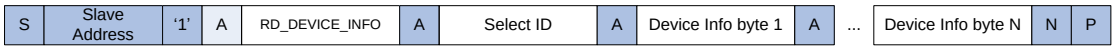
As well as containing Product IDs, serial numbers and versioning information, the device information also contains parametric information such as output voltage swing range, and peak output power rating.

All Device information is read-only.

All Device Information requests have no parameter data in the Host request transaction. The Select ID is used to identify the particular device information to return in the response. The Host Response transaction contains the requested device information as a varying amount of result data.

S = Start Condition, A = Acknowledgement, P = Stop Condition

Figure 3-4 Read Device Information Request I^2C write transaction



S = Start Condition, A = Acknowledgement, N = Negative Acknowledgement, P = Stop Condition

Figure 3-5 Read Device Information Response I^2C read transaction

3.3.2 RD_DEVICE_INFO (03h) Host Requests Summary

The following table summarises the RD_DEVICE_INFO requests.

Select ID (hex)	Device Info Select IDs	Device Info value	Device Info byte size
01h	PRODUCT_ID	<product_id>	12
03h	SERIAL_NUM	<serial_num>	20
12h	MIN_OUTPUT_VOLTAGE	<min_output_voltage>	4
13h	MAX_OUTPUT_VOLTAGE	<max_output_voltage>	4
16h	DEVICE_DELAY	<device_delay>	4

3.3.3 RD_DEVICE_INFO (03h) Host Request Details

3.3.3.1 PRODUCT_ID (01h), SelectID = 01h, Rsp Data = 12, String

A string holding the Product Code of the modulator, consisting of 12 ASCII characters conforming to the Nxnpppxxx-xx.

3.3.3.2 SERIAL_NUM (03h), SelectID = 03h, Rsp Data = 20, String

A string holding the Serial Number of the modulator, consisting of 20 ASCII characters and conforming to the PPP-ZZ-YYWW-XXXXXXXX format.

3.3.3.3 MIN_OUTPUT_VOLTAGE (12h), SelectID = 12h, Rsp Data = 4, Uint32

A 32-bit unsigned integer holding the minimum value of the modulator's output voltage swing range, in millivolts.

3.3.3.4 MAX_OUTPUT_VOLTAGE (13h), SelectID = 13h, Rsp Data = 4, Uint32

A 32-bit unsigned integer holding the maximum value of the modulator's output voltage swing range, in millivolts.

3.3.3.5 DEVICE_DELAY (16h), SelectID = 16h, Rsp Data = 4, Uint32

A 32-bit unsigned integer holding the input-to-output delay of the modulator, in picoseconds.

3.4 RD_CONFIG_INFO (04h) Requests

3.4.1 RD_CONFIG_INFO (04h) Host Requests Overview

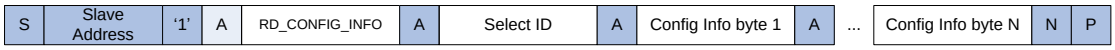
RD_CONFIG_INFO requests are used to access information that can be changed by the user to configure the modulator for its particular system environment.

All Configuration information is readable and writeable.

All RD_CONFIG_INFO requests have no parameter data in the Host request transaction. The Select ID is used to identify the particular configuration information to return in the response. The Host Response transaction contains the requested configuration information as a varying amount of result data.

S = Start Condition, A = Acknowledgement, P = Stop Condition

Figure 3-6 Read Configuration Information Request I²C write transaction



S = Start Condition, A = Acknowledgement, N = Negative Acknowledgement, P = Stop Condition

Figure 3-7 Read Configuration Information Response I²C read transaction

3.4.2 RD_CONFIG_INFO (04h) Host Requests Summary

The following table summarises the RD_CONFIG_INFO requests.

Select ID (hex)	Config Info Select IDs	Config Info value	Config Info byte size
02h	LDVS_PHASE	<Lvds_phase>	1
04h	ALARM_OUTPUT_ENABLE	<Alarm_output_enable>	2
05h	WARN_OUTPUT_ENABLE	<Warn_output_enable>	2
06h	LVDS_TDD_MODE	<Lvds_tdd_mode>	1
09h	SLA_1	<sla1>	1
0Ah	SLA_2	<sla2>	1
0Bh	SLA_3	<sla3>	1

3.4.3 RD_CONFIG_INFO (04h) Host Request Details

3.4.3.1 LVDS_PHASE (02h), SelectID = 02h, Rsp Data = 1, Uint8

An 8-bit value that determines the phase of sampling LVDS data relative to the LVDS clock signal. The LVDS interface only currently supports Single Data Rate (SDR) transfers

0 **SDR 0°** (rising edge sampling)
1 **SDR 90°** (data sampled ¼ period after clock rising)
2 **SDR 180°** (falling edge sampling)
3 **SDR 270°** (data sampled ¼ period after clock falling)

All other values are reserved.

3.4.3.2 ALARM_OUTPUT_ENABLE (04h), SelectID = 04h, Rsp Data = 2, Uint16

The ALARM_OUTPUT_ENABLE register controls the functionality of the HOST_INT line, that can be used to generate a hardware interrupt to the System Controller whenever an Alarm occurs in the ALARM_INT_STATUS register.

15	14	13	12	11	10	9	8
Global Enable	System Alarm Enable	Alarm Event Enable				Vsh High Enable	Vsh Low Enable

7	6	5	4	3	2	1	0
	No LVDS clk Enable	Base plate Temp High Enable	Base plate Temp Low Enable		Va Low Enable	Vsl High Enable	Vsl Low Enable

Each signal in the ALARM_INT_STATUS register has a corresponding Output Enable signal in this ALARM_OUTPUT_ENABLE register. To generate an active level on the HOST_INT line the Output Enable signal and Interrupt Status signal must both be set.

There is an additional Global Enable signal in the Output Alarm register. The HOST_INT line will remain inactive if the Global Enable signal is unset, irrespective of the other enable bits.

NOTE: The WARN_OUTPUT_ENABLE register also controls the HOST_INT line. The HOST_INT line will be active if the ALARM_OUTPUT_ENABLE register or WARN_OUTPUT_ENABLE register or both activate the line.

3.4.3.3 WARN_OUTPUT_ENABLE (05h), SelectID = 05h, Rsp Data = 2, Uint16

The WARN_OUTPUT_ENABLE register controls the functionality of the HOST_INT line, that can be used to generate a hardware interrupt to the System Controller whenever a warning occurs in the WARN_INT_STATUS register.

15	14	13	12	11	10	9	8
Global Enable	System Warning Enable	Warning Event Enable				Vsh Low Enable	Vsh Low Enable

7	6	5	4	3	2	1	0
		Base plate Temp High Enable	Base plate Temp Low Enable			Vsl High Enable	Vsl Low Enable

Each signal in the WARN_INT_STATUS register has a corresponding Output Enable signal in this WARN_OUTPUT_ENABLE register. To generate an active level on the HOST_INT line the Output Enable signal and Interrupt Status signal must both be set.

There is an additional Global Enable signal in the Output Warn Enable register. The HOST_INT line will remain inactive if the Global Enable signal is unset, irrespective of the other enable bits.

NOTE: The ALARM_OUTPUT_ENABLE register also controls the HOST_INT line. The HOST_INT line will be active if the ALARM_OUTPUT_ENABLE register or WARN_OUTPUT_ENABLE register or both activate the line.

3.4.3.4 LVDS_TDD_MODE (06h), SelectID = 06h, Rsp Data = 1, Uint8

An 8-bit value that determines if LVDS TDD Power Saving Mode is enable. When enabled LVDS TDD Power Saving Mode sets the modulator in to a lower power sleep mode when consecutive zeros LVDS data values are detected. To work correctly, the modulator needs to be woken up out of lower-power mode before correct operation can be resumed.

When LVDS Power Saving Mode is enabled, any LVDS envelope code with value equal to or less than 3 will force the Modulator to enter power saving mode. In order to exit power saving mode, the LVDS code has to be equal to or greater than 4. Therefore, care should be taken that the LVDS envelope data is processed accordingly, so that the power saving mode is not triggered unintentionally.

See ref [3] for further details on how to use power saving mode.

0 **TDD Mode Power Saving Disabled**
1 **TDD Mode Power Saving Enabled using in-band signalling**
2 **TDD Mode Power Saving Enabled using hw signalling**[1]

All other values are reserved.

3.4.3.5 SLA_1 (09h), SLA_2 (0Ah) – SLA_3 (0Bh), SelectID = 09h – 0Bh, Rsp Data = 1, Uint8

The 7-bit I^2C Slave Address on the Host interface can be one of four different values selected by the Host SLA_SELECT lines. The other 8-bit SLA registers are configurable.

[1] Although TDD Power Saving functionality through TDD_PWR_SAVE pin signalling has been implemented, this feature is still undergoing proving trials and will be released for customer use at a later date. Please contact Nujira for further details.

3.5 RD_DIAGNS_INFO (05h) Requests

3.5.1 RD_DIAGNS_INFO (05h) Host Requests Overview

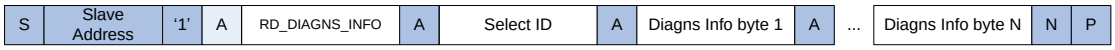
RD_DIAGNS_INFO requests are used to access miscellaneous information useful in various diagnostic activities.

All Diagnostic information is read-only.

All Diagnostic Information requests have no parameter data in the Host request transaction. The Select ID is used to identify the particular diagnostic information to return in the response. The Host Response transaction contains the requested diagnostic information as a varying amount of result data.

S = Start Condition, A = Acknowledgement, P = Stop Condition

Figure 3-8 Read Diagnostic Information Request I^2C write transaction



S = Start Condition, A = Acknowledgement, N = Negative Acknowledgement, P = Stop Condition

Figure 3-9 Read Diagnostic Information Response I^2C read transaction

3.5.2 RD_DIAGNS_INFO (05h) Host Requests Summary

The following table summarises the RD_DIAGNS_INFO requests.

Select ID (hex)	Diagnostic Info Select IDs	Diagnostic Info value	Diagns Info byte size
01h	LVDS_TEST_DATA_SIZE	<Lvds_test_data_size>	2

3.5.3 RD_DIAGNS_INFO (05h) Host Request Details

3.5.3.1 LVDS_TEST_DATA_SIZE (01h), SelectID = 01h, Rsp Data = 2, Uint16

The 16-bit unsigned value indicates the number of bytes of LVDS capture data that is available for reading back via a RD_BLOCK_DATA request.

NOTE: this information differs from the command START_LVDS_TEST, capture_len, where capture_len is number of samples not bytes

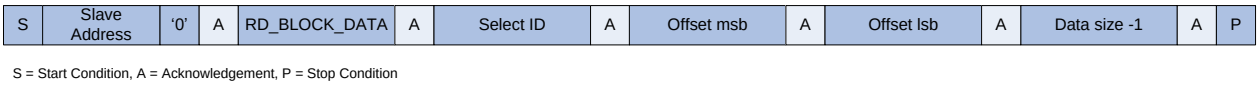
3.6 RD_BLOCK_DATA (08h) Requests

3.6.1 RD_BLOCK_DATA (08h) Host Requests Overview

RD_BLOCK_DATA Requests are used to read miscellaneous bulk information from the modulator. This data is too large to return in a single request-response transaction, so the complete data block is read using multiple RD_BLOCK_DATA requests. Each request specifies an offset in to the data block and the number of data bytes from this offset to return in the response, (up to a maximum of 256 bytes).

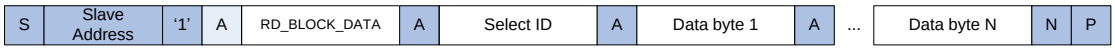
All Read Block Data requests have the same the Host request transaction format:
<Block Data Select ID>, u16Offset, u8len-1

The Select ID is used to identify the data to return in the response. The first 2 parameter bytes contains the 16-bit offset in to the data block, the third parameter byte contains the number of data bytes to return *minus one*, (i.e. 0 = 1 byte, 255 = 256 bytes). The Host Response transaction contains the requested data.



S = Start Condition, A = Acknowledgement, P = Stop Condition

Figure 3-10 Read Block Data Request I^2C write transaction



S = Start Condition, A = Acknowledgement, N = Negative Acknowledgement, P = Stop Condition

Figure 3-11 Read Block Data Response I^2C read transaction

3.6.2 RD_BLOCK_DATA (08h) Host Requests Summary

The following table summarises the RD_BLOCK_DATA requests.

Select ID (hex)	Block Data Select IDs	Block data value	Block Data byte size
01h	LVDS_TEST_RESULT_DATA	<Lvds_test_result_data>	Up to 256

3.6.3 RD_BLOCK_DATA (08h) Host Request Details

3.6.3.1 LVDS_TEST_RESULT_DATA (01h), SelectID = 01h

This request is used to read back the LVDS byte data captured during the LVDS Test command. The amount of byte data available for read back can be determined via the RD_DIAGNS_INFO, LVDS_TEST_DATA_SIZE request.
For offset and length request parameters see section 3.6.1 above.

NOTE: each 16-bit LVDS sample generates 2 bytes of data (msb first).

3.7 COMMAND (80h) Requests

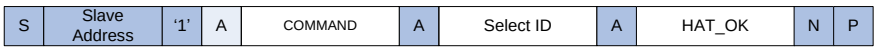
3.7.1 COMMAND (80h) Host Requests Overview

Command Requests are used to control the modulator or to get the modulator to perform a specific operation.

Command requests may or may not include parameter data in the Host request transaction. The normal Host Response transaction contains a 1-byte HAT_OK status as result data. If an error occurs during the request, the Error response is returned, (see section 3.1).

S = Start Condition, A = Acknowledgement, P = Stop Condition

Figure 3-12 Command Request I²C write transaction



S = Start Condition, A = Acknowledgement, N = Negative Acknowledgement, P = Stop Condition

Figure 3-13 Command Response I²C read transaction

3.7.2 COMMAND (80h) Host Requests Summary

The following table summarises the COMMAND requests.

Hex	Commands	Cmd_len (bytes)	Response
01h	MODULATOR_START	1	none
02h	MODULATOR_STOP	1	none
10h	START_LVDS_TEST, capture_len	3	none

3.7.3 COMMAND (80h) Host Request Details

3.7.3.1 MODULATOR_START (01h), SelectID = 01h

This command is issued to get the modulator to start an inactive modulator in to its active state.

While the modulator is starting up, the MAIN_STATUS, Busy signal will be set. When the modulator is fully started the MAIN_STATUS, Active signal will become set and the Busy signal will be unset.

This command is only allowed in certain modulator states. If the modulator is not in an allowable state, this command will generate the HOST_ERROR_NOT_ALLOWED Error Response.

This command is not allowed if:

- MAIN_STATUS, FATAL_ERROR bit is set
- Any bit in ALARM_STATUS is set

3.7.3.2 MODULATOR_STOP (02h), SelectID = 02h

This command is issued to get the modulator to stop an active modulator and return it to its inactive state, or to stop an LDVS Test Capture command.

While this command is being performed the MAIN_STATUS, Busy signal will be set. When the Busy signal is unset the modulator is in the inactive state.

When the modulator is in its inactive state or stopping the MAIN_STATUS, Active signal is unset.

3.7.3.3 START_LVDS_TEST (10h), capture_len, SelectID = 10h

This command is issued to get the modulator to start an LVDS Test capture on an inactive modulator. The command contains a 16-bit parameter that determines how many LVDS samples to capture during the test. The maximum number is 4096 samples.

While the modulator is performing the LVDS Test and capturing the LVDS data samples, the Main Status Busy signal will be set. The Busy signal will be unset when the test is complete. The modulator returns to its inactive state when the test is complete.

The LVDS captured data can be read back via the RD_BLOCK_DATA, LVDS_TEST_RESULT_DATA Request.

3.8 WR_STATUS_INFO (82h) Requests

3.8.1 WR_STATUS_INFO (82h) Host Requests Overview

WR_STATUS_INFO requests are used to clear the information in the Modulator's status registers.

The WR_STATUS_INFO requests include the new value as parameter data in the Host request transaction. The normal Host Response transaction contains a 1-byte HAT_OK status as result data. If an error occurs during the request, the Error response is returned, (see section 3.1).

S = Start Condition, A = Acknowledgement, P = Stop Condition

Figure 3-14 Write Status Information Request I²C write transaction

S = Start Condition, A = Acknowledgement, N = Negative Acknowledgement, P = Stop Condition

Figure 3-15 Write Status Information Response I²C read transaction

3.8.2 WR_STATUS_INFO (82h) Host Requests Summary

The following table summarises the WR_STATUS_INFO requests.

Wr	Status Info Select IDs	Status Info value	Stats Info byte size
04	ALARM_INT_CLR	<Alarm_int_clear>	2
05	WARN_INT_CLR	<Warn_int_clear>	2

3.8.3 WR_STATUS_INFO (82h) Host Request Details

3.8.3.1 ALARM_INT_CLR (04h), <mask>, SelectID = 04h

This request clears one or more bits in the ALARM_INT_STATUS register. Each bit set in the <mask> value will clear the corresponding bit in the ALARM_INT_STATUS register. Each bit unset in the <mask> value will leave unchanged the corresponding bit in the ALARM_INT_STATUS register.

See Section 3.2.3.4for further details on the ALARM_INT_STATUS register.

3.8.3.2 WARN_INT_CLR (05h), <mask>, SelectID = 05h

This request clears one or more bits in the WARN_INT_STATUS register. Each bit set in the <mask> value will clear the corresponding bit in the WARN_INT_STATUS register. Each bit unset in the <mask> value will leave unchanged the corresponding bit in the WARN_INT_STATUS register.

See Section 3.2.3.5 for further details on the WARN_INT_STATUS register.

3.9 WR_CONFIG_INFO (84h) Requests

3.9.1 WR_CONFIG_INFO (84h) Host Requests Overview

WR_CONFIG_INFO requests are used to change the information that configures the modulator for its particular system environment.

The WR_CONFIG_INFO requests include the new value as parameter data in the Host request transaction. The normal Host Response transaction contains a 1-byte HAT_OK status as result data. If an error occurs during the request, the Error response is returned, (see section 3.1).

The modulator takes a small amount of time to process the write request, during which the MAIN_STATUS Busy signal is set. The Busy signal will be unset when the write is complete.

It is only possible to write certain information when the modulator is inactive. See each request for details.

S = Start Condition, A = Acknowledgement, P = Stop Condition

Figure 3-16 Write Configuration Information Request I²C write transaction

S = Start Condition, A = Acknowledgement, N = Negative Acknowledgement, P = Stop Condition

Figure 3-17 Write Configuration Information Response I²C read transaction

3.9.2 WR_CONFIG_INFO (84h) Host Requests Summary

The following table summarises the WR_CONFIG_INFO requests.

Select ID (hex)	Config Info Select IDs	Config Info value	Config Info byte size
02h	LDVS_PHASE	<Lvds_phase>	1
04h	ALARM_OUTPUT_ENABLE	<Alarm_output_enable>	2
05h	WARN_OUTPUT_ENABLE	<Warn_output_enable>	2
06h	LVDS_TDD_MODE	<Lvds_tdd_mode>	1
09h	SLA_1	<sla1>	1
0Ah	SLA_2	<sla2>	1
0Bh	SLA_3	<sla3>	1

3.9.3 WR_CONFIG_INFO (84h) Host Request Details

For details of each item refer the appropriate RD_CONFIG_INFO section. This section contains information only relevant to the write operation.

3.9.3.1 LVDS_PHASE (02h), SelectID = 02h

It is only possible to write this information when the modulator is inactive.

3.9.3.2 ALARM_OUTPUT_ENABLE (04h), SelectID = 04h

This information can be written at any time.

3.9.3.3 WARN_OUTPUT_ENABLE (05h), SelectID = 05h

This information can be written at any time.

3.9.3.4 LVDS_TDD_MODE (06h), SelectID = 06h

It is only possible to write this information when the modulator is inactive.

3.9.3.5 SLA_1 (09h), SLA_2 (0Ah), SLA_3 (0Bh), SelectID = 09h – 0Bh

This information can be written at any time. However, the modulator does not use the new values until it is power cycled.

Note: SLA_0 has a fixed value (55h) and it is not possible to change it with a WR_CONFIG_INFO request.

4 Modulator Event Codes

Event information consists of 16 bytes. The first byte is the Event code, shown below. The rest of the data provides ancillary information specific to each event. This data is reserved.

4.1 Alarm System Info Codes

Code	Name	Description
1	HAT_ERROR	General Unspecific Error
2	HAT_ERROR_PARAM	Software Bug: Error in parameters to function calls
3	HAT_ERROR_RESOURCE	Software Bug: Run out of a system resource
4	HAT_ERROR_CODE	Software Bug: Logic/coding error
5	HAT_ERROR_FPGA_CONFIG	Bad FPGA image in Flash memory
6	HAT_ERROR_TIMER	Software Bug: Software Timer error
7	HAT_ERROR_NV_INVALID	Invalid NV data in EEPROM
8	HAT_ERROR_FLASH_CRC	Bad CRC for Internal Flash memory
9	HAT_ERROR_FLASH_DATA	Invalid data in Internal Flash memory
10	HAT_ERROR_PWR_CMD_ILLEGAL	Software Bug: Start Cmd not allowed in current state
11	HAT_BUSY	Hat in BUSY state
>11		Reserved codes. Contact Nujira.

5 References

[1] coolteq.h™ Modulator Baseband Interface Physical Specification, Nujira Ltd. PD002091
[2] The I^2C Specification, version 2.1, January 2001, Philips Doc No 9398 393 40011.
[3] coolteq.h Modulator User Guide, Nujira Ltd. AN002098

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