



Measuring Blood Pressure, Heart Rate, and SpO₂ Using MAX32664D – A Quick Start Guide for Programmers

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Abstract

The MAX32664D is a variant of the MAX32664 sensor-hub family, which is specifically targeted for finger-based measurement of blood pressure, heart rate, and SpO₂. Combined with the MAX30101 pulse oximetry and heart-rate monitor module and powered by Maxim's BPT algorithm, it provides sensors' raw data, as well as calculated systolic and diastolic blood pressure, SpO₂, and heart-rate data to a host device through its I²C slave interface. This document provides step-by-step instructions that enable a user to communicate with the MAX32664D, and to calibrate, configure, and receive measurement and monitoring data.

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Introduction

The MAX32664D is a variant of the MAX32664 sensor-hub family that enables users to capture raw data, as well as calculated systolic and diastolic blood pressure (BP), SpO₂, and heart-rate data through finger contact. The part is preprogrammed with the firmware, drivers, and algorithm that are required to interface with the MAX30101 sensor device through an I²C port. The I²C slave interface is also used for establishing communication with a host microcontroller.

This document provides the instructions necessary to create a sensor data measurement solution with the MAX32664D based on the MAXREFDES220 reference design.

1 Architecture

A typical health-sensing design includes a host microcontroller that communicates with the MAX32664D through the I²C bus. Two GPIO pins are needed to control the reset and the startup in Application or Bootloader mode through the RSTN and multifunction I/O (MFIO) pins. An MFIO pin is also used in Application mode to interrupt the host for I²C communication. The MAX32664D interfaces with the MAX30101 optical sensor through a second I²C bus. The algorithm does not use accelerometer data. Figure 1 **Figure 1** shows the top-level architecture.

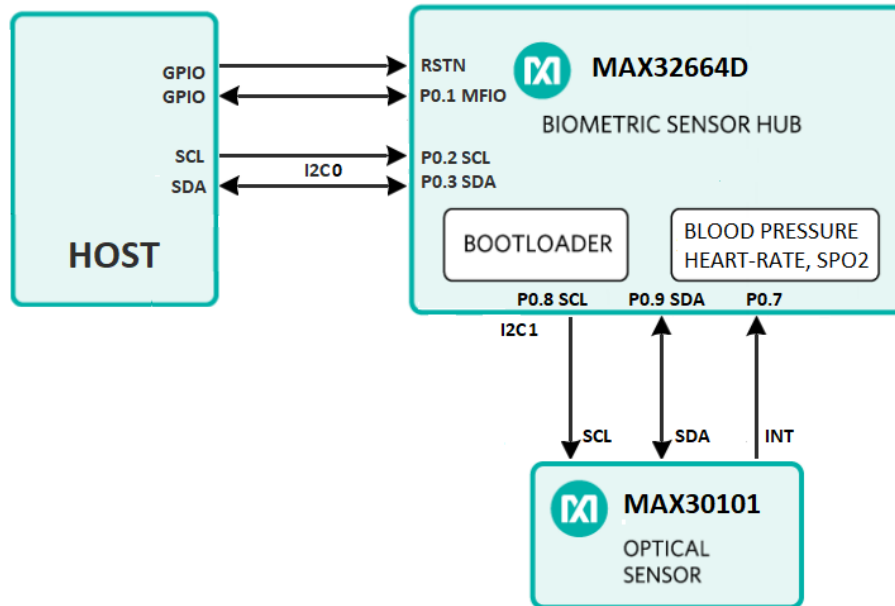


Figure 1. Architecture diagram for health-sensing applications.

1.1 Communicating with MAX32664D

A host should use the I²C bus to communicate with the MAX32664D (slave) using a series of commands. See the MAX32664 User Guide for details. The default CMD_DELAY is 2ms.

A generic write command includes the following fields:

```
Slave_WriteAddress(1 byte) | Command_Family(1 byte) | Command_Index(1 byte) | Value(multiple bytes)
```

A generic response includes the following fields:

```
Slave_ReadAddress(1 byte) | Status(1 byte) | Value(multiple bytes)
```

Slave_WriteAddress and Slave_ReadAddress are set to 0xAA and 0xAB respectively.

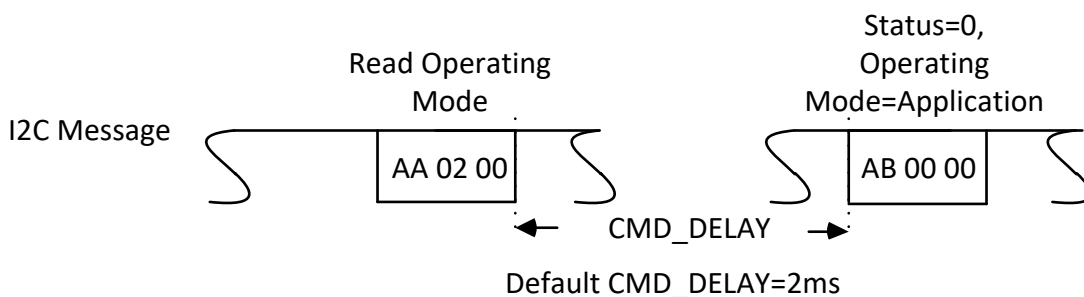


Figure 2. Example I²C CMD_DELAY timing diagram.

The read status byte is an indicator of success (0x00) or failure, as shown **Table 1**.

Table 1. Read Status Byte Value

STATUS BYTE VALUE	DESCRIPTION
0x00	The write transaction was successful.
0x01	Illegal Index Byte and/or Write Byte was used. Verify that the Index Byte and Write Byte(s) are valid for the host command sent. Verify that the latest .msbl is flashed.
0x02	Incorrect number of bytes sent for the requested Family Byte. Verify that the correct number of bytes are sent for the host command. Verify that the latest .msbl is flashed.
0x03	Illegal configuration value was attempted to be set. Verify that the Index Byte is correct for Family Byte 0x44. Verify that the samples report period is not 0 for host command 0x10 0x02. Verify that the Write byte for host command 0x10 0x03 is in the valid range specified. Verify that the latest .msbl is flashed.
0x04	Not used in application mode. (In bootloader: Device is busy. Insert delay and resend the host command.)
0x05	Application mode: Not used in application mode.
	Bootloader mode: Device is busy. Insert delay and resend the host command.
0x80	Bootloader mode: General error while receiving/flashing a page during the bootloader sequence. Not used.
0x81	Bootloader mode: Bootloader checksum error while decrypting/checking page data. Verify that the keyed .msbl file is compatible with MAX32664A/B/C/D.
0x82	Bootloader mode: Bootloader authorization error. Verify that the keyed .msbl file is compatible with MAX32664A/B/C/D.
0x83	Bootloader mode: Bootloader detected that the application is not valid; the application checksum is not correct, or the application interrupt vector table is missing. Verify that the latest .msbl is flashed.
0xFE	Device is busy. Try again. Increase the delay before the command and increase the CMD_DELAY.
0xFF	Unknown error. Verify that the communications to the AFE/KX-122 are correct by reading the PART_ID/WHO_AM_I register. For MAX32664B/C, the MAX32664 is in deep sleep unless the host sets the MFIO pin low 250us before and during the I2C communications.
NAK	NAK received. Sensor hub was busy. Resend command after 1ms with a maximum of five retries. If this issue persists, then empty the FIFO by reading all the data or reduce the report rate. Verify that the hardware I2C/MFIO rise times, voltage levels, and grounding are correct.

After the sensor hub is properly configured and the algorithm is enabled via I2C, the sensor hub FIFO may be polled or the MFIO interrupt pin may be used to signal to the host when data is available in the sensor hub output FIFO. The use of the MFIO interrupt is illustrated in Figure 3.

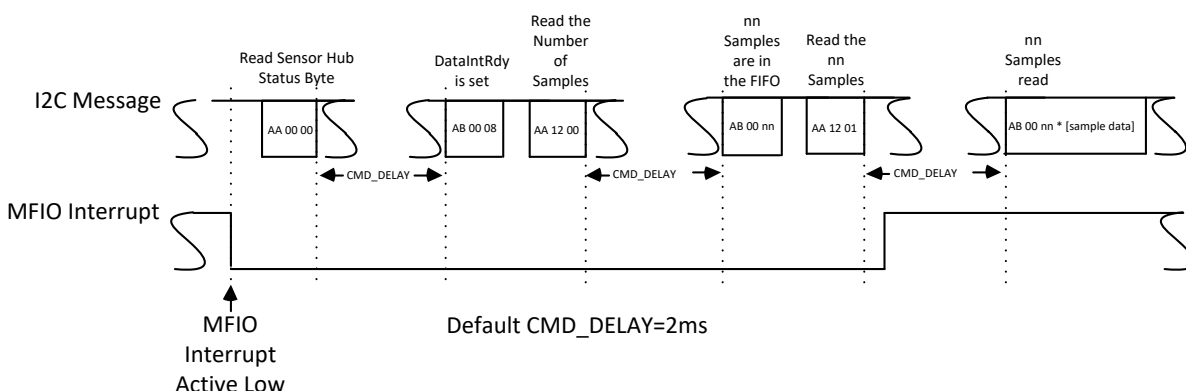


Figure 3. Reading Data from the sensor hub output FIFO after the MFIO Interrupt

This document provides examples of commands for establishing communication with the MAX32664D. For a complete list of commands and instructions for the I2C interface, see the **MAX32664 User Guide**.

2 Calibration of SpO₂ and Blood Pressure Trending (BPT) Algorithm

2.1 Calibration of SpO₂ Coefficients for Final Product

Due to variations in the physical design and optical shield of the final product, a calibration procedure is required to be performed once in a controlled environment. This procedure is important to ensure the quality of SpO₂ calculation. This step is typically performed in a standard lab with a reference SpO₂ device to determine three calibration coefficients: A, B, and C. The details of the calibration procedure are described in the Maxim **Application Note 6845**.

Once three calibration coefficients are obtained, they need to be loaded to the MAX32664D every time prior to starting the algorithm. But first, they are required to be converted to 32-bit integer format using the following:

- $A_{int32} = \text{round}(10^5 \times a)$
- $B_{int32} = \text{round}(10^5 \times b)$
- $C_{int32} = \text{round}(10^5 \times c)$

For example, the default measured calibration coefficients are:

- $a = 1.5958422$
- $b = -34.659664$
- $c = 112.68987$

They are sent to the MAX32664D in integer format after conversion:

- $A_{int32} = \text{round}(10^5 \times a) = 0x00026F60$
- $B_{int32} = \text{round}(10^5 \times b) = 0xFFCB1D12$
- $C_{int32} = \text{round}(10^5 \times c) = 0x00ABF37B$

The calibration coefficients may be stored in the host flash separately and loaded to the MAX32664D after every reset.

To perform the SpO₂ calibration process, the BPT algorithm is started in Estimation mode, as shown in **Table 5**.

Table 4 shows the format of received samples. Typically, R values are needed for the calibration process, as described in Maxim **Application Note 6845**. Note that the algorithm will keep updating R values, even after progress has reached 100%. Error! Reference source not found.

2.2 User Calibration Vector

A multi-point (maximum of five) calibration process is required for each user to tune the estimation algorithm. This step is typically done by first measuring user's reference systolic and diastolic BP using a medically approved device. Next, the time and date, and the reference values are provided to the MAX32664D before each of the user calibration procedures are performed. This process takes about 1 minute. After the user calibration procedure is complete (progress is at 100% and BP status is 2, as shown in **Table 4**), a calibration vector is generated. For optimal results, it is recommended that five sets of these vectors be generated for the user. The user calibration vector is valid if the MAX32664D has not restarted and the user has not changed. However, the host is recommended to read the calibration vectors and store it in memory (or flash) for a user and reload it to the MAX32664D prior to future estimation measurements.

The user calibration procedure is needed once a month to ensure the accuracy of BP estimation for the current user. **Table 2** shows the sequence of commands for completing BPT user calibration.

Table 2. Host Commands—BPT User Calibration

	#	HOST COMMAND (HEX)	COMMAND DESCRIPTION	RESPONSE (HEX)
INITIALIZE ALGORITHM AND START USER CALIBRATION		Host initializes MAX32664D in Calibration mode:		
	1.1	AA 02 00 (optional)	Read the operating mode	AB 00 00 application mode
	1.2	AA 50 04 00 00 (if user does not take any BP medication) AA 50 04 00 01 (if user takes BP medication)	Set if the user is on blood pressure medication. THIS STEP IS NOT NEEDED IN FW VER. 40.2.2+. Deprecated	AB 00
	1.3	AA 50 04 05 00	Set if user is in Rest mode. THIS STEP IS NOT NEEDED IN FW VER. 40.2.2+. Deprecated	AB 00
	1.4	AA 50 04 04 FE A1 33 01 E0 DF 01 00 (example <i>date</i> 20161022 and <i>time</i> 122848) (CMD_DELAY is 5 ms)	Set data and time as two 32-bit numbers for YYYYMMDD and HHMMSS in little-endian format. THIS COMMAND CHANGED FROM YYMMDD TO YYYYMMDD in FW VER. 40.5.0+.	AB 00
	1.5	AA 50 04 01 78 7A 7D (example of three systolic BP references)	Set three systolic calibration values. Provided example is for 120, 122, and 125. THIS COMMAND IS DEPRECATED AND NOT USED IN FW VER. 40.5.0+	AB 00
	1.6	AA 50 04 02 50 51 52 (example of three diastolic BP references)	Set three diastolic calibration values. Provided example is for 80, 81, and 82. THIS COMMAND IS DEPRECATED AND NOT USED IN FW VER. 40.5.0+	AB 00
	1.7	Optional: Any other command to change the algorithm settings and configurations (Table 3) from default should appear here BEFORE enabling algorithm.		

	1.8	AA 10 00 03	Set output mode to sensor + algorithm data (streamed data will include PPG and algorithm data).	AB 00
	1.9	AA 10 01 0F	Set sensor hub interrupt threshold.	AB 00
	1.10	AA 52 00 01 (CMD_DELAY is 20 ms)	Enable AGC.	AB 00
	1.11	AA 44 03 01 (CMD_DELAY is 40 ms)	Enable MAX30101 AFE	AB 00
	1.12	AA 02 00 (optional)	Read the operating mode	AB 00 00 application mode
	1.13	AA 41 03 FF (optional)	Read register FF (PART_ID) of [MAX30101/MAX30102]	AB 00 15
	1.14	AA FF 03 (optional)	Read the sensor hub version (40.x.y)	AB 00 28 XX YY
	1.15	AA 41 04 0F (If KX-122 is connected to the sensor hub, optional)	Read register 0F (WHO_AM_I) of KX-122	AB 00 1B
	1.16	AA 50 04 07 00 75 4C (example cal_index 0, reference <i>systolic</i> 117 and <i>diastolic</i> 76) (CMD_DELAY is 5 ms)	Set the cal_index to 0, set the systolic and diastolic values. NEW COMMAND FOR MULTI-POINT CALIBRATION in FW VER. 40.5.0+.	AB 00
	1.17	AA 52 04 01 (CMD_DELAY is 500 ms)	Enable BPT algorithm in User Calibration mode.	AB 00
	1.18	Wait for 100ms before sending next command. Any command to change sensor registers should appear AFTER enabling algorithm or they will be overwritten.		
READING SAMPLES	2.1	AA 00 00	Read sensor hub status byte: Bit 0: Sensor comm error Bits 1 and 2: Reserved Bit 3: FIFO filled to threshold (DataRdyInt) Bit 4: Output FIFO overflow (FifoOutOvrInt) Bit 5: Input FIFO overflow (FifoInOverInt) Bit 6: Sensor hub busy (DevBusy) Bit 7: Reserved If DataRdyInt is set, proceed to next step.	AB 00 08
	2.2	AA 12 00	Get the number of samples (nn) in the FIFO.	AB 00 nn
	2.3	AA 12 01	Read the data stored in the FIFO; nn samples will be read. The format of samples is shown in Table 4 .	AB 00 data_for_ nn_samples
	Repeat 2.1 to 2.3 until BPT status is 2 and progress is at 100%. See Table 4 . If there's an error status or host timeout, then host should ask the user to restart the user calibration for this cal_index.			
	3.1	AA 51 04 03	Read user calibration vector. Host saves the calibration vectors to the user profile.	AB 00 [512 bytes of user calibration vector]
	Increment the cal_index in step 1.15 and repeat steps 1.15 to 2.3 until the user calibration has been completed for cal_index 0 to 4.			
STOP	Host ends the procedure:			
	4.1	AA 44 03* 00 (CMD_DELAY is 40 ms)	Disable AFE (e.g., MAX30101)*.	AB 00
	4.2	AA 52 04 00 (CMD_DELAY is 500 ms)	Disable BPT algorithm.	AB 00

2.3 Algorithm Settings and Configurations

Table 3 shows the settings that are available for the BPT algorithm. To update the algorithm settings, be sure to send the appropriate commands BEFORE enabling the algorithm, as shown in **Table 2**.

Table 3. Configurations and Settings—BPT

FAMILY BYTE	ALGORITHM INDEX	CONFIGURATION INDEX	DESCRIPTION	DEFAULT VALUE
0x50 for write	0x04	0x00	Blood pressure medication. Byte 1: User is using <i>blood pressure medication</i> . Set to 1 if the user is on blood pressure medication, otherwise 0. NOT SUPPORTED IN FW VER. 40.2.2+.	0x00
0x50 for write	0x04	0x01	Three systolic BP calibration values Byte 1: <i>reference systolic 1</i> Byte 2: <i>reference systolic 2</i> Byte 3: <i>reference systolic 3</i> Deprecated – Use 0x50 0x04 0x07 in FW VER 40.5.0+	0x78, 0x78, 0x78
0x50 for write	0x04	0x02	Three diastolic BP calibration values Byte 1: <i>reference diastolic 1</i> Byte 2: <i>reference diastolic 2</i> Byte 3: <i>reference diastolic 3</i> Deprecated – Use 0x50 0x04 0x07 in FW VER 40.5.0+	0x50, 0x50, 0x50
0x50 for write 0x51 for read	0x04	0x03	BP calibration vector. Read 512 bytes of BP calibration data after calibration is complete and store in host memory. Write the stored calibration data prior to running the BPT algorithm. CHANGED TO 512 bytes in FW VER. 40.5.0+	512 bytes of zeros
0x50 for write	0x04	0x04	Set the date and time as two 32-bit unsigned values (little-endian format) in following order: Value 1: Date in YYYYMMDD decimal form Value 2: Time in HHMMSS decimal form	0xFE, 0xA1 0x33, 0x01 0x7C, 0xD9, 0x01, 0x00 for date = 180101, time = 12:12:12
0x50 for write	0x04	0x05	Non-resting estimation Byte 1: <i>Non-resting</i> , Set 0 if user is resting, otherwise 1. NOT SUPPORTED IN FW VER. 40.2.2+.	0x0
0x50 for write 0x51 for read	0x04	0x06	SpO ₂ calibration coefficients x100,000 (12 bytes comprised of three 32-bit signed values) Value 1: <i>A SpO₂ coefficient</i> Value 2: <i>B SpO₂ coefficient</i> Value 3: <i>C SpO₂ coefficient</i>	A = 1.5958422 (0x00026f60) B = -34.659664 (0xffcb1d12) C = 112.68987 (0x00abf37b)
0x50 for write	0x04	0x07	Set the cal_index, reference systolic, reference diastolic. This command is sent before command 52 04 01 (enable user calibration mode) as part of the multi-point calibration procedure.	

			<p>Byte 1: <i>cal_index</i>: 0 to 4: Set this to 0 for the first subject calibration. Increment up to 4 for each subject calibration</p> <p>Byte 2: <i>reference systolic</i></p> <p>Byte 3: <i>reference diastolic</i></p> <p>NEW COMMAND in FW VER. 40.5.0+</p>	
<p>0x50 for write</p> <p>0x51 for read</p>	0x04	0x08	<p>Set or get the <i>cal_index</i>. Set the <i>cal_index</i> 0 to 4. This command is sent before the command 50 04 03 (set calibration vector command) when restoring the user calibration vectors.</p> <p>Byte 1: <i>cal_index</i></p> <p>NEW COMMAND in FW VER. 40.5.0+</p>	

Table 4. Format of Received Samples—BPT Algorithm

DATA SOURCE	BYTE INDEX	DATA ITEM	NUMBER OF BYTES (MSB FIRST)	DESCRIPTION
MAX30101 (12 Bytes)	0	LED1	3	IR counter
	3	LED2	3	Red counter
	6	LED3	3	N/A
	9	LED4	3	N/A
BPT Algorithm (17 Bytes)	12	BP status	1	Status: 0: No signal 1: User calibration/estimation in progress 2: Success 3: Weak signal 4: Motion 5: Estimation failure 6: Calibration partially complete 7: Subject initialization failure 8: Initialization completed 9: Calibration reference BP trending error 10: Calibration reference Inconsistency 1 error 11: Calibration reference Inconsistency 2 error 12: Calibration reference Inconsistency 3 error 13: Calibration reference count mismatch 14: Calibration reference are out of limits (systolic 80 to 180, diastolic 50 to 120) 15: Number of calibrations exceed maximum 16: Pulse pressure out of range 17: Heart rate out of range 18: Heart rate is above resting 19: Perfusion Index is out of range 20: Estimation error, try again 21: BPT estimate is out of range from calibration references (systolic +-30, diastolic +-20) BPT estimate is beyond the maximum limits 22: (systolic 80 to 180, diastolic 50 to 120) 23: No contact. No object on sensor (ignoring first 5s) 24: No finger. Status 23 reported continuously for > 7s (~5s to 7s if multiple lifts)
	13	Progress	1	% complete
	14	Heart rate	2	10x heart-rate value
	16	Systolic blood pressure	1	Estimate systolic blood pressure
	17	Diastolic blood pressure	1	Estimate diastolic blood pressure
	18	SpO ₂	2	10x SpO ₂ value
	20	R	2	1000x actual R value
	22	Pulse Flag	1	0 – not R peak 1 - R peak detected flag

	23	IBI	2	Inter-beat interval, pulse interval. LSB = 1 msec
	25	SpO2 Confidence	1	SpO2 confidence level. LSB=1%
	26	BPT Report Flag	1	0 - BPT estimation values have not been updated 1 - BPT estimation values have been updated (added in 40.5.0)
	27	SpO2 Report Flag	1	0 – SpO2 values have not been updated 1 – SpO2 estimation values have been updated (added in 40.5.0)
	28	EndBPT - Reserved	1	0 – not used (added in 40.5.0)

2.3 Algorithm Mode: BPT, SpO₂ and Heart-Rate Estimation

Once calibration of SpO₂ coefficients are configured and user calibration are complete, the algorithm can estimate BP, SpO₂ and heart rate. **Table 6** shows the list of commands to start the algorithm in Estimation mode.

Table 5. Host Commands—BPT Estimation

	#	HOST COMMAND (HEX)	COMMAND DESCRIPTION	RESPONSE (HEX)
START BPT ESTIMATION		If the MAX33664D has been reset, then the host will load the User Calibration.		
	1.1	AA 50 04 08 00 (set the <i>cal_index</i>) (CMD_DELAY is 5 ms)	Set the <i>cal_index</i> to 0 NEW COMMAND FOR MULTI-POINT CALIBRATION in FW VER. 40.5.0+.	AB 00
	1.2	AA 50 04 03 [512 bytes of calibration vector] (CMD_DELAY is 30 ms)	Load BPT calibration vector data as captured in step 3.1 in Table 2 for <i>cal_index</i> 0.	AB 00
	1.3	AA 50 04 08 01 (set the <i>cal_index</i>) (CMD_DELAY is 5 ms)	Set the <i>cal_index</i> to 1 NEW COMMAND FOR MULTI -POINT CALIBRATION in FW VER. 40.5.0+.	AB 00

1.4	AA 50 04 03 [512 bytes of calibration vector] (CMD_DELAY is 30 ms)	Load BPT calibration vector data as captured in step 3.1 in Table 2 for cal_index 1.	AB 00
1.5	AA 50 04 08 02 (set the cal_index) (CMD_DELAY is 5 ms)	Set the cal_index to 2 NEW COMMAND FOR MULTI -POINT CALIBRATION in FW VER. 40.5.0+.	AB 00
1.6	AA 50 04 03 [512 bytes of calibration vector] (CMD_DELAY is 30 ms)	Load BPT calibration vector data as captured in step 3.1 in Table 2 for cal_index 2.	AB 00
1.7	AA 50 04 08 03 (set the cal_index) (CMD_DELAY is 5 ms)	Set the cal_index to 3 NEW COMMAND FOR MULTI -POINT CALIBRATION in FW VER. 40.5.0+.	AB 00
1.8	AA 50 04 03 [512 bytes of calibration vector] (CMD_DELAY is 30 ms)	Load BPT calibration vector data as captured in step 3.1 in Table 2 for cal_index 3.	AB 00
1.9	AA 50 04 08 04 (set the cal_index) (CMD_DELAY is 5 ms)	Set the cal_index to 4 NEW COMMAND FOR MULTI -POINT CALIBRATION in FW VER. 40.5.0+.	AB 00
1.10	AA 50 04 03 [512 bytes of calibration vector] (CMD_DELAY is 30 ms)	Load BPT calibration vector data as captured in step 3.1 in Table 2 for cal_index 4.	AB 00
Host initializes the MAX32664D in Estimation mode:			
1.2	AA 50 04 00 00 (if user does not take any BP medication) AA 50 04 00 01 (if user takes BP medication) (CMD_DELAY is 5 ms)	Set if the user is on BP medication. THIS STEP IS NOT NEEDED IN FW VER. 40.2.2 AND LATER. Deprecated	AB 00
1.3	AA 50 04 05 00 (CMD_DELAY is 5 ms)	Set user in Resting mode. THIS STEP IS NOT NEEDED IN FW VER. 40.2.2 AND LATER. Deprecated	AB 00
1.5	AA 50 04 06 00 02 6F 60 (example for A) FF CB 1D 12 (example for B) 00 AB F3 7B (example for C) (CMD_DELAY is 5 ms)	Set SpO ₂ calibration coefficients as described in the document. Provided example for: A = 1.5958422, B = -34.659664, C = 112.68987.	AB 00
1.6	Optional: Any other command to change the algorithm settings and configurations (Table 3) from default should appear here BEFORE enabling algorithm.		
1.7	AA 10 00 03	Set output mode to sensor + algorithm data (streamed data will include PPG and algorithm data).	AB 00
1.8	AA 10 01 0F	Set sensor hub interrupt threshold.	AB 00
1.9	AA 52 00 01 (CMD_DELAY is 20 ms)	Enable AGC.	AB 00
1.10	AA 44 03 01 (CMD_DELAY is 40 ms)	Enable MAX30101 AFE.	AB 00
1.11	AA 41 03 FF (optional)	Read register FF (PART_ID) of [MAX30101/MAX30102]	AB 00 15
1.12	AA FF 03 (optional)	Read the sensor hub version (40.x.y)	AB 00 28 XX YY
1.13	AA 41 04 0F (If KX-122 is connected to the sensor hub, optional)	Read register 0F (WHO_AM_I) of KX-122	AB 00 1B

	1.14	AA 52 04 02 (CMD_DELAY is 500 ms)	Enable BPT algorithm in Estimation mode.	AB 00
	1.15	Wait for 100ms before sending next command. Any command to change sensor registers should appear AFTER enabling algorithm or they will be overwritten.		
READING SAMPLES	Host reads samples upon receiving MFIO interrupt by the MAX32664D. For BPT estimation, repeat until BPT status is 2 and progress is at 100%. For SpO ₂ calibration, continue as needed to capture R value. See Table 4 .			
	2.1	AA 00 00	Read sensor hub status byte: Bit 0: Sensor comm error Bits 1 and 2: Reserved Bit 3: FIFO filled to threshold (DataRdyInt) Bit 4: Output FIFO overflow (FifoOutOvrInt) Bit 5: Input FIFO overflow (FifoInOverInt) Bit 6: Sensor hub busy (DevBusy) Bit 7: Reserved If DataRdyInt is set, proceed to next step.	AB 00 08
	2.2	AA 12 00	Get the number of samples (nn) in the FIFO.	AB 00 nn
	2.3	AA 12 01	Read the data stored in the FIFO; nn samples (23 bytes each) will be read. The format of samples is shown in Table 4 .	AB 00 data_for_ nn_samples
STOP	Host ends the procedure:			
	3.1	AA 44 03* 00 (CMD_DELAY is 40 ms)	Disable AFE (e.g., MAX30101).*	AB 00
	3.2	AA 52 04 00 (CMD_DELAY is 20 ms)	Disable BPT algorithm.	AB 00
	3.3	AA 52 00 00 (CMD_DELAY is 20 ms)	Disable AGC.	AB 00

3 Measuring BPT, SpO₂, and Heart Rate on Finger

3.1 Raw Data Collection Mode

For hardware testing purposes, the user may choose to start the MAX32664D to collect raw PPG samples.

3.1.1 Raw Data Collection in Algorithm Mode

In Algorithm mode, AGC may be turned off to collect raw PPG data, as shown in step 1.6 in the table below. In this case, LED currents will not be adjusted automatically; the BPT, SpO₂ and heart-rate measurement algorithm may not converge and should be discarded. Although the algorithm is running, it will not affect the PPG samples. If the reported PPG data is saturated, you can reduce the LED currents as shown. Note that updating MAX30101 registers should appear AFTER enabling the algorithm and the MAX30101, or they will be overwritten during initialization. By setting the output mode to sensor data in step 1.2, only the 12-byte PPG data of the MAX30101 will be reported in received samples.

Table 6. Host Commands—BPT Raw Data Collection

	#	HOST COMMAND (HEX)	COMMAND DESCRIPTION	RESPONSE (HEX)
START ALGORITHM		Host initializes the MAX32664D in Estimation mode:		
	1.1	Optional: Any other command to change the algorithm settings and configurations (Table 3) from default should appear here BEFORE enabling algorithm.		
	1.2	AA 10 00 01	Set output mode to sensor data (streamed data will include only PPG data).	AB 00
	1.3	AA 10 01 0F	Set sensor hub interrupt threshold.	AB 00
	1.4	AA 44 03* 01 (CMD_DELAY is 40 ms)	Enable AFE (e.g., MAX30101).	AB 00
	1.5	AA 52 04 02 (CMD_DELAY is 20 ms)	Enable BPT algorithm in Estimation mode	AB 00
	1.6	AA 52 00 00 (CMD_DELAY is 20 ms)	Disable AGC.	AB 00
	1.7	Wait for 180ms before sending next command. Any command to change sensor registers should appear AFTER enabling algorithm or they will be overwritten.		
	1.8	AA 40 03 0C [7F]	Set MAX30101 LED1 (red) current to half of full scale. Reduce [7F] if signal is saturated.	AB 00
	1.9	AA 40 03 0D [7F]	Set MAX30101 LED2 (IR) current to half of full scale. Reduce [7F] if signal is saturated.	AB 00
READING SAMPLES		Host reads samples upon receiving MFIO interrupt by the MAX32664D. For BPT raw data, repeat as needed to collect PPG counters.		
	2.1	AA 00 00	Read sensor hub status byte: Bit 0: Sensor comm error Bits 1 and 2: Reserved Bit 3: FIFO Filled to threshold (DataRdyInt) Bit 4: Output FIFO overflow (FifoOutOvrInt) Bit 5: Input FIFO overflow (FifoInOverInt) Bit 6: Sensor hub busy (DevBusy) Bit 7: Reserved If DataRdyInt is set, proceed to next step.	AB 00 08
	2.2	AA 12 00	Get the number of samples (nn) in the FIFO.	AB 00 nn
	2.3	AA 12 01	Read the data stored in the FIFO; nn samples will be read. The format of samples is shown in Table 4 .	AB 00 data_for_nn_samples
STOP		Host ends the procedure:		
	3.1	AA 44 03* 00 (CMD_DELAY is 40 ms)	Disable AFE (e.g., MAX30101).*	AB 00
	3.2	AA 52 04 00 (CMD_DELAY is 500 ms)	Disable BPT algorithm.	AB 00

*Provided indexes are example for sensors such as the MAX30101 AFE.

Revision History

REVISION NUMBER	REVISION DATE	DESCRIPTION	PAGES CHANGED
0	4/19	Initial release	—
1	9/19	Updated Table 4 byte index 20 description	9
2	11/20	Added Figure 2, 3. Updated Tables 1-6, Move Estimation section 3.2 to section 2.3, Renumbered Table 5, 6	5-15

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