MAX32664C

FIRMWARE RELEASE NOTES,

FEATURES & PERFORMANCE

CONTENTS

1. MAX32664C Firmware Release Notes

Version	Date	Importance	History	Known Issues
30.13.31	03/07/2022	High	- Wearable Algorithm Suite v8.4.0 - LP bug fix - Fast SpO2 mode fix - ARM-PC Discrepancy fix	- SCDSM not supported for ST LIS2DS12 accelerometer part - Initial HR setting configuration is not operational.
30.13.19	05/12/2021	High	- Wearable Algorithm Suite v6.5.4 - Configurable SpO2 Red-IR PI threshold - Updated IBI reporting mode - SpO2 orientation flag	- SCDSM not supported for ST LIS2DS12 accelerometer part - Initial HR setting configuration is not operational.
30.13.12	02/26/2021	High	- Wearable Algorithm Suite v5 - New AFE power control algorithm - Algo Hub mode - 1Hz IBI reporting mode - ST accel to high resolution mode - Fix on automatic accel part detection on power up	- SCDSM not supported for ST LIS2DS12 accelerometer part - Initial HR setting configuration is not operational.
30.13.0	10/16/2020	High	- Wearable Algorithm Suite 3.0.0 - Improved SpO2 performance - SCD only mode with selectable wavelength - Configurable accelerometer usage KX122/ST LIS2DS12 - 200Hz raw data streaming support - IBI reporting mode	
30.12.0	6/30/2020	High	- Wearable Algorithm Suite 2.10.0 - Improved SpO2 performance - Event reporting over mfio pin (MFIO mode) - Skin Contact State Machine in MFIO mode	
30.11.0	5/1/2020	High	- Wearable Algorithm Suite 2.7.0rable Algorithm Suite 2.7.0 - Fast converging SpO2 - Fast converge to resting HR	- Marked as Alfa Release due to HR spikes
30.10.2	2/17/2020	High	- Wearable Algorithm Suite 2.4.1 o Enhanced MLP model - Command added to change LED firing (0x07 0x19) - Definition of command (0x07 17 and 0x07 18) are changed. They specify Slot # rather than LED #. THIS MAY CAUSE BACKWARD COMPATIBILITY IF NON-DEFAULT LED/PD CONFIGURATION IS USED	
30.9.2	1/23/2020	High	- Wearable Algorithm Suite 2.2.0 o Peak detector module for IBI detection enhanced to reduce false detection rate - Default SpO2 calibration coefficients updated to better suite MRD103 platform: a = 0; b = -26.224999; c = 112.317421;	
30.9.1	01/15/2020	High	- Wearable Algorithm Suite 2.1.1 - MLP integration to improve HR accuracy - Fixed bug of skin detection when heart rate measurement is done on Red or IRed PPG signals	
30.8.3	12/13/2019	High	- Fixed bug of lagging PPG samples after long term run - Improved authentication commands	
30.8.1	12/06/2019	High	- Wearable Algorithm Suite 1.11.0 o Motion frequency tracking for HR measurement and skin contact detection are improved - Algorithm configuration command to set initial value of sensor sample rate/average and time integration - Fixed bug of sampled HR mode	

			- Authentication feature and commands - Automatically detects number of PDs supported by MAX86140 or MAX86141 sensors	

30.7.0	10/24/2019	Medium	- Wearable Algorithm Suite 1.9.3
			  o Motion frequency tracking for HR measurement improved
			- Bug fix in poll period > 1min causing overflow in I2C driver
			- Reported number of samples in output FIFO (Family byte=0x12, index=0x00) changed from 1 to two byte, LSB first
			- Sensor Hub status [7:0] bit 6 is used to flag for Host accel underflow if samples are not feed fast enough to sensor hub
			- Sensor Hub accelerometer sampling freq changed from 100Hz to 200Hz to support 100Hz raw streaming.
			- HR RR and RR confidence are reported only when calculated (typically once per several samples) and zero the rest of the time.
			- Initials sampling frequency of sensor set to 100Hz with avg=4.
			- Default LED PD Configuration changed to suit MRD103:
			  o WHRM: from 0x0073 to 0x0001 (both PDs are feed to WHRM algorithm)
			  o SPO2: from 0x1121 to 0x1020 (Uses far PD1 for red/Ir in Spo2).
				Same as 30.6.0
				
				Sampled mode HR (mode 3) does not produce correct result.

30.6.0	09/20/2019	Medium	- Wearable Algorithm Suite 1.9.1
			  o Improved HR measurement
			  o Max Sampling frequency default is 100Hz with avg=4
			- SpO2 R value is reported as 1000xR instead of 10xR to improve accuracy
			- Internal FIFO increased to support host poll time of once per up to 8min in 1sec algorithm report mode (Power Saving Mode) and with sensor hub accel.
				Same as 30.5.0

30.5.0	8/23/2019	Medium	- Wearable Algorithm Suite 1.7,
			  o Bug fix in not reporting SCD correctly after AFE adj.
			  o Waiting time for SpO2 motion increased 2->4sec
			  o Initial value of target PPG SNR and min PD current updated 30->40dB and 4->5uA respectively
			- Initialize sampling freq. and integration time of sensor to max. (400Hz avg4 and to 117usec), controlled by AEC
			- I2C Slave address configurable with a command
			- Shutdown command added
			- SCD based power saving support added, set accel to motion detection wake mode
			- Command added to check chip rev and sleep being enabled
				Same as 30.4.4

30.4.4 (custom)	7/22/2019	Medium	**This is not a general distribution:** - Custom release same as 30.4.3 with low power feature disabled (never goes to sleep). No need to use MFIO to wakeup MAX32664. Bust host still needs to periodically read MAX79356 FIFO according to desired report period (200msec for 40msec report, or 1sec for 1sec report).	Same as 30.4.3
30.4.3	7/22/2019	Medium	**-** PD configuration for WHRM and SPO2 changed to include both PD and LED (index 0x17 and 0x18), Default: LED1/PD1 for WHRM, LED2/3 for ir/red and PD2 for SPO2	- LED firing sequence is fixed to LED1>LED2>LED3 if each exists. - If using host side accelerometer, sampling frequency should be 25Hz. Host should queue 5 samples and feed sensor hub once every 200msec
30.4.2	7/16/2019	Medium	**-** PD configuration for WHRM and SPO2 added back (index 0x17 and 0x18), Default PD configuration of WHRM/SPO2 is PD1/PD2 respectively.	- If using host side accelerometer, sampling frequency should be 25Hz. Host should queue 5 samples and feed sensor hub once every 200msec
30.4.1 (custom)	7/11/2019	Medium	**This is not a general distribution:** - Custom release same as 30.4.0 with low power feature disabled (never goes to sleep). No need to use MFIO to wakeup MAX32664. Bust host still needs to periodically	- If using host side accelerometer, sampling frequency should be 25Hz. Host should queue 5 samples and feed sensor hub once every 200msec

			read MAX79356 FIFO according to desired report period (200msec for 40msec report, or 1sec for 1sec report).	
30.4.0	7/10/2019	High	- Fixed increasing delay with host accelerometer - If sampling of host accel is slightly slow/faster than 25Hz, accelerometer samples inside sensor hub will be repeated/decimated to provide synchronization with sensor samples. - Motion Threshold representation is changed from 0.1g to mili-g in the interface - KX122 sensor hub accelerometer configuration is changed from low power to high resolution due to higher noise in low power mode	- If using host side accelerometer, sampling frequency should be 25Hz. Host should queue 5 samples and feed sensor hub once every 200msec
30.3.1	6/24/2019	Medium	- Fixed bug of initializing maximum and minimum values of sample rate and time integration. - Maintain SpO2 state after reaching TIMEOUT or SUCCESS	
30.3.0	6/20/2019	High	- Wearable Algorithm Suite 1.6.0 supports simultaneous measurement of HR and SPO2. Algorithm index is 0x07. - Fixed bug of repeated/skipped accel samples - Extended report (mode 2) of algorithm output - KX122 accel polling rate is 100Hz, low power - Fixed bug of limiting range of green LED current to half of maximum. - Sampling frequency of sensor controlled by algorithm, default 100 Hz with avg.4, can go up to 400Hz with avg 16	

30.2.4	5/24/2019	High	- **LOW Power Feature added and MFIO functionality changed to support low power mode:**
			<u>MFIO is always input</u> and used to wake up MAX32664 and keep it active during normal application (not bootloader).
			HOST application should be update to:
			    o Pull MFIO LOW at least *250usec* PRIOR to start of any I2C command transaction to force a wake up.
			    o Keep MFIO LOW until the end of I2C transaction to ensure MAX32664 will not go to sleep.
			    o Set MFIO to HIGH after I2C transaction is complete.
			    o Periodically read MAX79356 FIFO according to desired report period (200msec for 40msec report, or 1sec for 1sec report).
			- Additional command to change report period from once per sample (40msec) to once per multiple sample (e.g. 1 per 25 sample for 1sec reporting) in sensor hub "CommChannel" family.
			- Detects chip rev A1 or A2 and switches to low power Sleep or Deep Sleep respectively.
				Accelerometer samples occasionally may be repeated or skipped.

30.2.3	6/04/2019	Medium	- MAX86141 DAC calibration - WHRM does not control ADC range - WHRM controls sensor sampling rate/average and time integration (TINT) - Single API algorithm enable, automatically enabling sensors as needed - Bug fix for repeated/skipped accel samples - Sensor Hub v.1.9.8 - Sensor Hub accel polling, sampling frequency is 200Hz and low power mode	- As below
30.2.2	3/20/2019	Medium	- Accelerometer is mandatory sensor for WHRM - Fixed initial delay of host accel data which caused out of sync with PPG signal - WHRM can be configured to use one of three LEDs (Green, Infrared or Red). For better WHRM performance it's recommended to set PD=PD2 in case of using Infrared or Red LEDs.	- As below

30.2.1	2/15/2019	Medium	- Sensor Hub v.1.9.4 - Device info command shows FW version in first 3 bytes, followed by sensor hub version - Bug fix for repeated accel data - Bug fix of reporting WHRM activity class	- As below

30.1.8	1/24/2019	Medium	- Updated libraries to Wearable Algorithm Union v.1.4.0
			  - WHRM_AEC_SCD: v.2.7.0
			  - WSPO: v.1.9.3
			- SpO2 timeout is increased from 60 to 120sec
			- Default values for SpO2 calibration coefficients are updated
			- WHRM only uses initial setting of 100Hz (4 samples average) and TINT=117usec.
				- As below

30.1.7	1/11/2019	High	- WHRM initial LED1 current range increased from 30 to 124mA - WHRM initial sample rate from 25 to 100Hz with avg=4 - Updated WHRM extended report to use debounced channel - Default PD configuration of WHRM is changed to PD1	- As below
30.1.6	1/10/2019	High	- Enable interrupt mode of KX122 to address accel data lagging	- As below

30.1.5	1/9/2019	High	- Updated libraries to Wearables Algorithm Unified library v.1.2.1
			- WHRM_AEC_SCD: v.2.6.3
			- WSPO2: v.1.8.2 supporting calibration mode
			- Status of Spo2 is changed to report algorithm state
			  - LED_ADJUSTMENT_STATE:0
			  - SPO2_COMPUTATION_STATE:1
			  - SPO2_SUCCESSFUL_TERMINATION_STATE:2
			  - SPO2_TIMEOUT_STATE:3
			  - SPO2_NOT_A_STATE :4
			- Bug fix in WHRM causing zero accel data being fed to algorithm.
			- Used debounced HR and conf instead of channel 0 in report
			- Use RR and activity of debounced channel instead of channel 0 in report
				- As below

30.1.4	12/18/2018	Medium	- Updated libraries to Wearables Algorithm Unified library v.1.0.0:
			  - WHRM_AEC_SCD: v.2.6.0
			  - WSPO2: v.1.6.8
			- WHRM uses two PPG channels. The default PD configuration is PD1 and PD2.
			- Combined PD1 and PD2 configuration is removed.
				- Wrist SpO2 100Hz sample rate mode is disabled

30.1.3	12/13/2018	Medium	- Fixed bug in scaling accel data before feeding to WHRM algorithm - Added combined PD1 and PD2 configuration, it averages PD1 and PD2 signals.	- Wrist SpO2 100Hz sample rate mode is disabled - WHRM algorithm only supports one PPG input.
30.1.2	11/29/2018	Low	- WHRM_AEC_SCD library v.1.7.0 - WSPO2 library v.1.5.10	- Wrist SpO2 100Hz sample rate mode is disabled

30.1.1	11/14/2018	Medium	- Photo Detector (PD) configuration parameter is added to control which MAX86141 PD input is used to read PPG signal and how to feed it into WristSpO2 and WHRM-AEC algorithms. - Disabled Wrist SpO2 100Hz sample rate mode due to limitation of heap size. - Cleared sensor LED sequence register after stopping algorithm to eliminate previous LED sequence register setting due to switching between WristSpO2 and WHRM-AEC algorithms.	- KX122 accelerometer interrupt can't be used on MAXREFDES101# v.P2 - Wrist SpO2 100Hz sample rate mode is disabled
30.1.0	11/9/2018	High	- Host accelerometer support - Updated library and CMSIS - Bug fix in WHRM_AEC_SCD configuration and mode 2 report size - If there is no connected sensor hub or host accelerometer default accel data are used	- KX122 accelerometer interrupt can't be used on MAXREFDES101# v.P2
30.0.0	11/2/2018	High	- Integrated WSPO2 v.1.5.2 and WHRM_AEC_SCD v.1.5.0 libraries - Configuration support for WHRM - Simple WHRM report for mode 1 and extended for mode 2 - Stack is adjusted to support both algorithms heap allocation - v.P2/P3 released based on version of MAXREFDES101# sensor board: v.P2: CS/IRQ pins of KX122 accelerometer are connected to P0.9/P0.0 of MAX32664C v.P3: CS/IRQ pins of KX122 accelerometer are connected to P0.0/P0.9 of MAX32664C	- Only supports KX122 accel connected to MAX32664C - No support of host accelerometer

2. MAX32664C Features and Performance: Heart Rate on Wrist

Wearable Heart Rate Monitoring – WHRM		
Category	**Features**	**Specifications**
Algorithm	Measurement principle:	Optical PPG signal from wrist, 3D Axis Accelerometer
	Measurement range:	HR: [30 240] BPM Cadence (steps per minute): [90 360]
	Measurement accuracy:	HR: Accuracy Definition -> within +/-10% error band vs. reference (chest strap) Resting: 94 – 100% Walking: 93 - 99% Biking: 91 - 97% Running: 91 - 97% Daily Life: 90 - 100% Step counting: Accuracy Definition: 100% – (Absolute Percent Error) Treadmill walking: 89 – 95% Treadmill running: 86 – 92% Outdoor walking: 80 – 90% Activity Classification: Accuracy Definition: 100% – (Absolute Percent Error) Rest: 87 - 93% Treadmill walking: 93 - 99% Treadmill running: 90 - 95% Outdoor walking: 91 - 97% Outdoor biking: 80 - 90% Energy consumption Kcal: calculated according to ACSM & ADA
	Reference measurement device:	HR: ECG based chest strap IBI: ECG based chest strap (sampling rate min 1kHz)
	Average response time	25Hz, first response time 15sec
	Inputs:	Single/Multiple Channel PPG signal 3-axis accelerometer signals
	Built-in features:	Activity Classifier Built-in Step Counter Motion compensation of PPG for accurate HR estimation Inter-beat interval estimator Energy expenditure estimation
Measurement Positions	Wrist, Ear, Finger, Chest, Abdomen	Sports and daily life activities
Sensor & Signal Requirements	LED requirements:	Please refer to "Reference Design Document" for details
	Perfusion index range:	Minimum AC to calculate HR is 20nA with average 0.8% PI
	Sampling rate:	25 Hz
Calibration	Calibration:	Algorithm activity classifier is tuned for the sensor placement on wrist, a calibration might be required to train algorithm to improve its performance for another body location.

3. MAX32664C Features and Performance: SpO$_2$ on Wrist

	SpO$_2$ on Wrist	
Category	**Features**	**Specifications**
Algorithm	Measurement principle:	Optical PPG signal from wrist
	Measurement range:	70 – 100% SpO2
	Measurement accuracy:	RMSE ≤ 3.5% as required by FDA for reflective mode pulse oximeters
	Clinical test:	Certified calibration lab
	Measurement time:	30 – 60 sec, on-demand operations, one shot
	Inputs:	Red and Infrared PPG signals 3-axis accelerometer signals
	Built-in features:	Precise motion detector Automatic AFE setting adjustment for optimum PPG quality Signal conditioning Signal selection according to signal quality for discarding noisy signal portions Adjustable time-out duration Adjustable confidence threshold
Measurement Positions	Standing:	Arm is kept horizontal at the level of heart; palm is facing the floor
	Sitting	Arms are placed on a table Arms are crossed, arm with wristwatch is above the other arm
	Lying down:	Arms are horizontal
Sensor & Signal Requirements	LED requirements:	Center wavelength shift ≤ ±5nm LED full width at half maximum (FWHM) ≤ 20nm
	Perfusion index range:	PI ≥ 0.05%
	Sampling rate:	25 Hz
	Optical layout design:	Please refer to "Design Guide for SpO2 Measurement"
Calibration	Calibration lab:	Lab calibration is required for wearable's finished industrial design. Please refer to lab calibration procedure guide "Design Guide for SpO2 Measurement"