BNO080/BNO085 Migration Guide

Date: October 2017
Document Revision: 1.6

Proprietary and Confidential

CEVA Technologies, Inc. 15245 Shady Grove Road, Suite 400 Rockville, MD 20850

Version History

Version	Date	Changes
V1.0	8/15/2016	Creation
V1.1	10/27/2016	Fixed typos
V1.2	11/11/2016	Added note that 32K crystal required for BNO080
V1.3	11/16/2016	Modified crystal loading caps to 22pF
V1.4	12/7/2016	Removed comments regarding FW upgrade from BNO070 to BNO080. This feature is not supported
V1.5	02/16/2017	Update Notices.
V1.6	10/23/2017	Update for BNO085

Contents

1.0 INTRODUCTION 4
1.1 BNO070 Overview 4
1.1.1 BNO070 Connection 5
1.1.2 BNO070-RVC Connection 6

2.0 BNO080/BNO085 MIGRATION 7
2.1 Pinout Comparisons 8
2.2 Host Interface 9
2.2.1 I²C Interface 10
2.2.2 UART-RVC Interface 11
2.2.3 UART-SHTP Interface 12
2.2.4 SPI Interface 14

3.0 REFERENCES 16
4.0 NOTICES 17

1.0 Introduction

This application note provides customers that are designing with CEVA's Hillcrest Labs business unit's BNO070 Sensor Hub device design details that will allow that design to migrate to the future BNO080/BNO085 device. While the BNO080/BNO085 and BNO070 use the same physical device, there are software differences that provide new features and make subtle changes to the I/O provisioning of the device.
With the approach suggested in this application note a customer could evaluate many of the features of the BNO070 today and then by populating the BNO080/BNO085 use the same evaluation hardware to investigate the BNO080/BNO085 features.

1.1 BNO070 Overview

The BNO070 is a System in Package (SiP) that integrates a tri-axial accelerometer, tri-axial gyroscope, tri-axial magnetometer and a 32-bit ARM® Cortex™-M0+ microcontroller running Hillcrest's SH-1 firmware. The SH-1 firmware includes the MotionEngine™ software, which provides sophisticated signal processing algorithms to process sensor data and provide precise real-time 3D orientation, heading, calibrated acceleration and calibrated angular velocity, as well as more advanced contextual outputs. It is fully compatible with Android (4.x and 5.x) and provides a turn-key sensor hub solution, eliminating the complexity and investment associated with a discrete design. The BNO070 is integrated into a single 28 pin LGA 3.8mm x 5.2mm x 1.1mm package.

There are two variants of the BNO070, the standard BNO070 and the BNO070-RVC. The BNO070-RVC provides a simplified UART interface that is useful for Robot Vacuum Cleaners.

1.1.1 BNO070 Connection

The BNO070 uses I²C to communicate with the host. This along with an interrupt line and a bootloader enable signal constitutes the host interface. Typical connectivity is depicted in Figure 1.

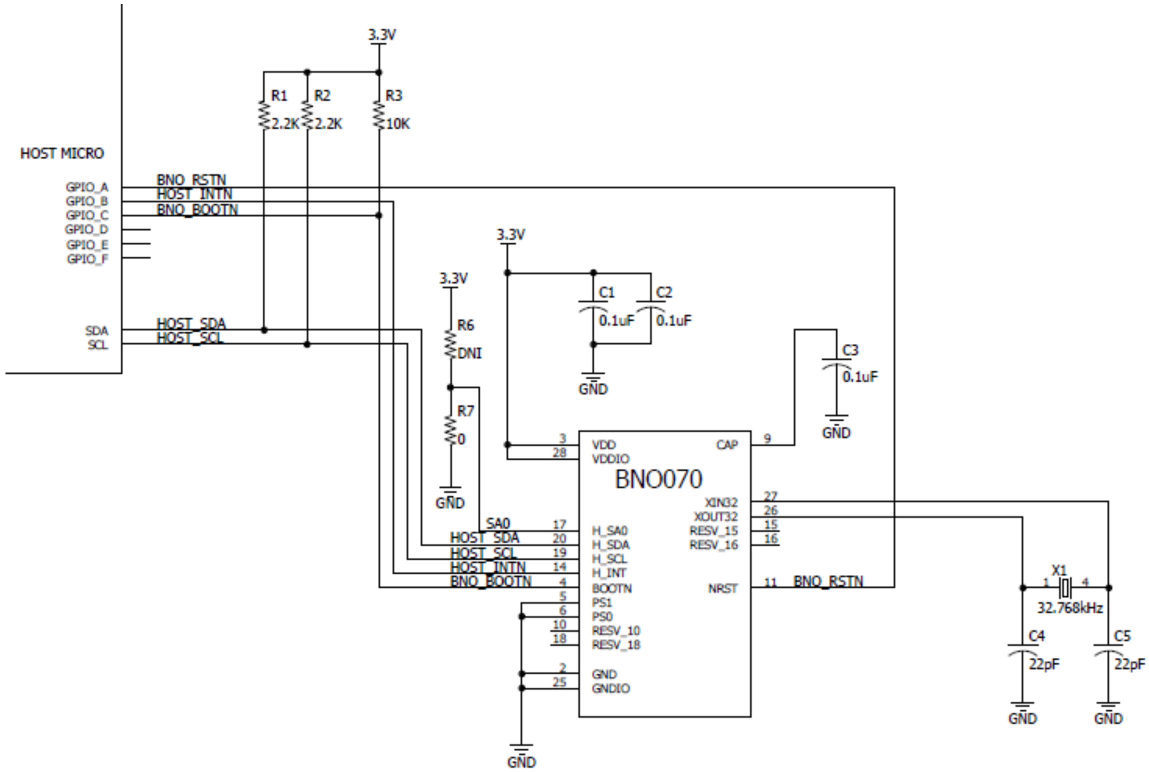

Figure 1: BNO070 typical connection

Where:

SA0 is the lower address bit of the BNO070's I²C device address.
HOST_SDA/SCL are the data and clock respectively of the I²C interface
HOST_INTN is the interrupt line that informs the host that the BNO070 needs servicing
BNO_BOOTN is used to enable the bootloader
BNO_RSTN is the reset line of the BNO070
The PS0/PS1 pins on the BNO070 are used to select the host protocol type.

1.1.2 BNO070-RVC Connection

The BNO070-RVC is a custom version of the BNO070 targeted for robot vacuum cleaners (RVC). The BNO070-RVC provides a simplified interface to allow for simpler integration. After the reset line is released the BNO070-RVC will provide heading data over a UART interface without any configuration by the host. A typical connection is as follows:

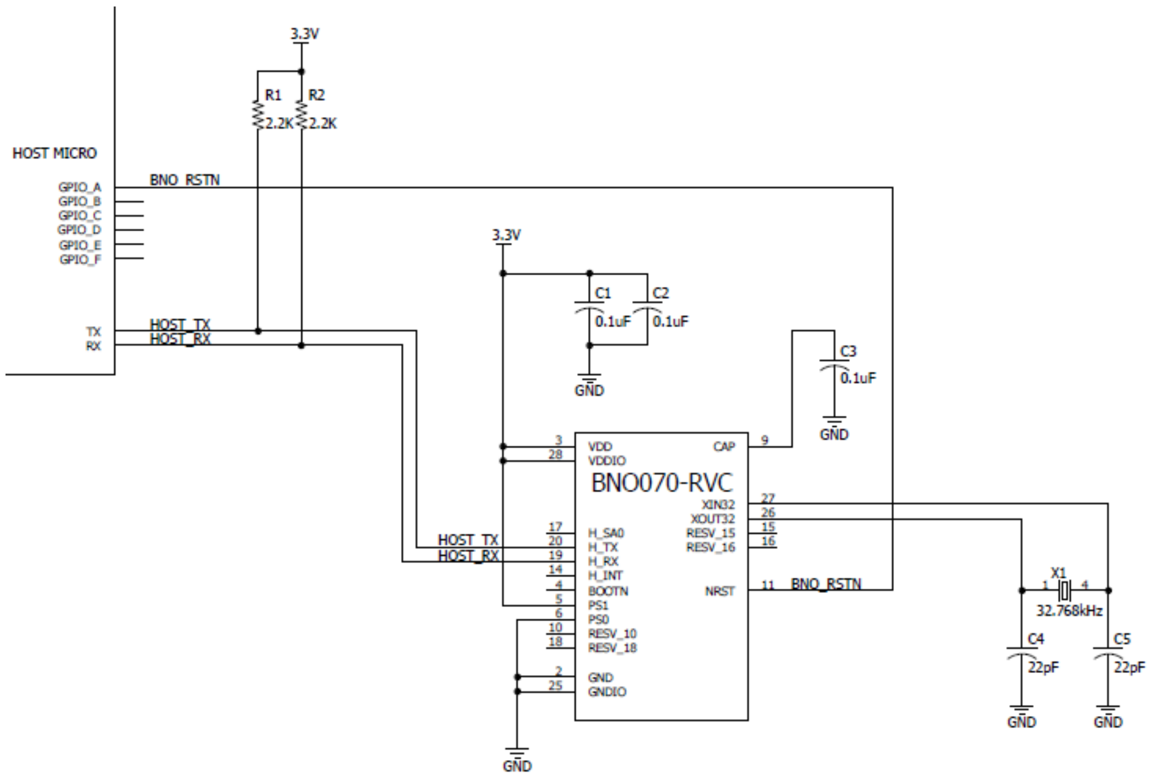

Figure 2: BNO070-RVC typical connection

Where:

HOST_TX is the UART data to the host
HOST_RX is the UART data from the host
BNO_RSTN is the reset line of the BNO070
The PS0/PS1 pins on the BNO070 are used to select the host protocol type.

2.0 BNO080/BNO085 Migration

The BNO080/BNO085 is the successor to the BNO070 and provides additional features and performance improvements. The BNO085 is an optimized version of the BNO080 that allows for the use of add-on libraries for use in VR controllers and other specialized applications. Code written to work with the BNO080 will work without changes with the BNO085.

The purpose of this application note is to detail the changes in interface between the BNO070 and BNO080/BNO085. The BNO080/BNO085 adds support for SPI and UART serial interfaces, allowing for higher data throughput. In addition the BNO080/BNO085's firmware is upgraded to SH-2 (from SH-1) which incorporates Hillcrest's SHTP (Sensor Hub Transport Protocol) protocol and provides additional features.

The user is advised to read the BNO080/BNO085 datasheet and supporting collateral to understand the new features of the device plus the relevant BNO070 collateral (references 4 through 6).

2.1 Pinout Comparisons

Figure 3 captures the change in pinout from the BNO070 to the BNO080/BNO085.

Pin Number	BNO070 Name	BNO080 Name	Mode	Description
1	RESV_NC	RESV_NC	NC	Reserved. No connect.
2	GND	GND	Input	Ground
3	VDD	VDD	Input	Supply voltage (sensors) (2.4V to 3.6V)
4	BOOTN	BOOTN	Input	Bootloader mode select
5	PS1	PS1	Input	Protocol Select pin 1
6	PS0	PS0/WAKE	Input	Protocol Select pin 0, also used to wake processor in SPI mode
7	RESV_NC	RESV_NC	Input	Reserved. No connect.
8	RESV_NC	RESV_NC	NC	Reserved. No connect.
9	CAP	CAP		External capacitor (100nF to GND)
10	RESV_NC	EXTSYNC	Input	External synchronization (future feature)
11	RSTN	RSTN	Input	Active low reset
12	RESV_NC	RESV_NC	NC	Reserved. No connect.
13	RESV_NC	RESV_NC	NC	Reserved. No connect.
14	HOST_INTN	HOST_INTN	Output	Interrupt to host device
15	RESV_NC	ENV_SDA	Bidirectional	Environmental sensor I²C data
16	RESV_NC	ENV_SCL	Bidirectional	Environmental sensor I²C clock
17	SA0	SA0/H_MOSI	Input	Lower address bit of device address. In SPI mode, data input
18	RESV_NC	H_CSN	Input	SPI chip select, active low
19	HOST_SCL	H_SCL/SCK/RX	Bidirectional	Host Interface I²C clock, SPI clock or UART RX
20	HOST_SDA	H_SDA/H_MISO/TX	Bidirectional	Host Interface I²C data, SPI data out or UART TX
21	RESV_NC	RESV_NC	NC	Reserved. No connect.
22	RESV_NC	RESV_NC	NC	Reserved. No connect.
23	RESV_NC	RESV_NC	NC	Reserved. No connect.
24	RESV_NC	RESV_NC	NC	Reserved. No connect.
25	GND	GND	Input	Ground
26	XOUT32	XOUT32	Output	32K crystal output.
27	XIN32	XIN32	Input	32K crystal input.
28	VDDIO	VDDIO	Input	Supply voltage (core and I/O domain) (1.65V to 3.6V)

Figure 3: BNO070/BNO080 pin comparison

Note that the 32.768 kHz crystal is required for the BNO080/BNO085. A crystal with 50ppm tolerance and 22pF capacitor loading should be used.

2.2 Host Interface

The BNO080/BNO085 can support connections to a host microcontroller through various serial interfaces:

- I2C interface
- UART-RVC interface – a simplified UART interface
- UART-SHTP interface
- SPI interface

In addition, the BNO080/BNO085 includes a bootloader to allow for firmware upgrades. The bootloader can support I²C, SPI or UART, where the BNO070 only supported I²C. Access to the bootloader is achieved by setting BOOTN to 0.
Configuration of the communication interface is achieved by setting the protocol selection (PS1/0) pins appropriately:

PS1	PS0	BNO070 (BOOTN = 1)	BNO070-RVC (BOOTN=1)	BNO070 bootloader (BOOTN=0)	BNO080 (BOOTN=1)	BNO080 bootloader (BOOTN=0)
0	0	I²C	Reserved	I²C	I²C	I²C
0	1	Reserved	Reserved	Reserved	UART-RVC	Reserved
1	0	Reserved	UART-RVC	Reserved	UART-SHTP	UART
1	1	Reserved	Reserved	Reserved	SPI	SPI

Figure 4: Protocol selection for BNO devices

The protocol selection and BOOTN pins are sampled at reset.
PS0 is repurposed as a WAKE signal in SPI mode following reset (see reference 4 for timing). Note that there is no support for upgrading a BNO070 to a BNO080 by use of the bootloader.

The pinout for the BNO080/BNO085 indicates support for external synchronization (EXTSYNC). This feature allows the fusion processing and output to be triggered by an external strobe. This can be useful in applications where the orientation should be synchronized to an outside reference (for instance in an HMD where the video frame sync can be provided). If this feature may be required the user is encouraged to layout their PCB with the connectivity depicted in the figures below such that an upgrade from BNO070 to BNO080/BNO085 can take advantage of the new feature. Note that EXTSYNC is still in planning and will not be present in the first production release of the BNO080.

2.2.1 I²C Interface

The BNO080/BNO085 provides an I²C interface that implements Hillcrest's full SHTP protocol. A typical connection is shown in the figure below:

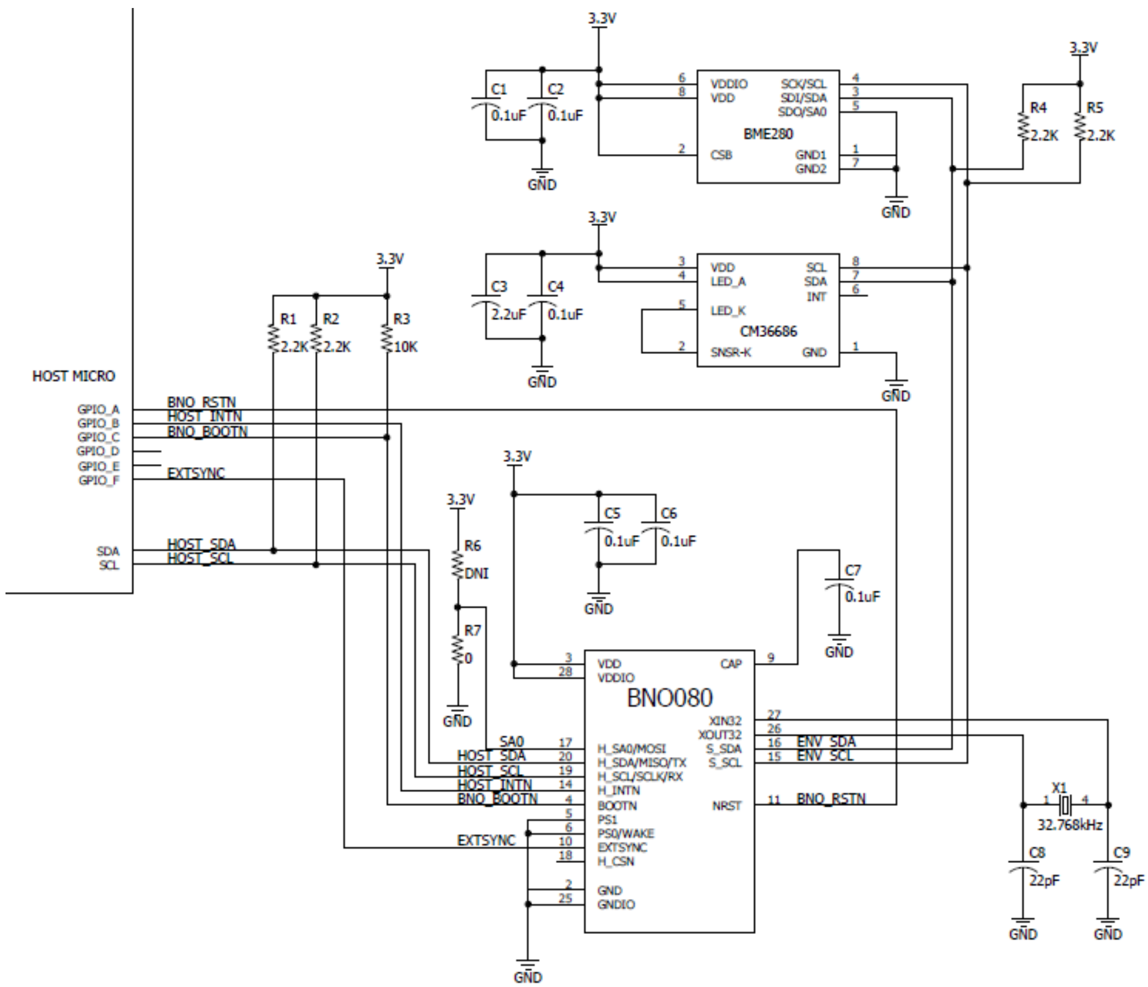

Figure 5: BNO080 I²C connection diagram

In this example both the BNO070 and BNO080/BNO085 are operated in I²C mode, so connectivity is almost identical. However the BNO080/BNO085 supports a BME280 temperature/humidity sensor and a Capella CM36686 ambient light/proximity sensor. Even if these sensors are not required the pullups R4 and R5 should still be present to ensure the secondary I²C bus is terminated correctly.

2.2.2 UART-RVC Interface

The BNO080/BNO085 provides a simplified UART interface for use on robot vacuum cleaners (RVC). When configured in this mode the BNO080/BNO085 simply transmits heading and sensor information at 100Hz over the UART TX pin. A typical connection is shown in Figure 6.

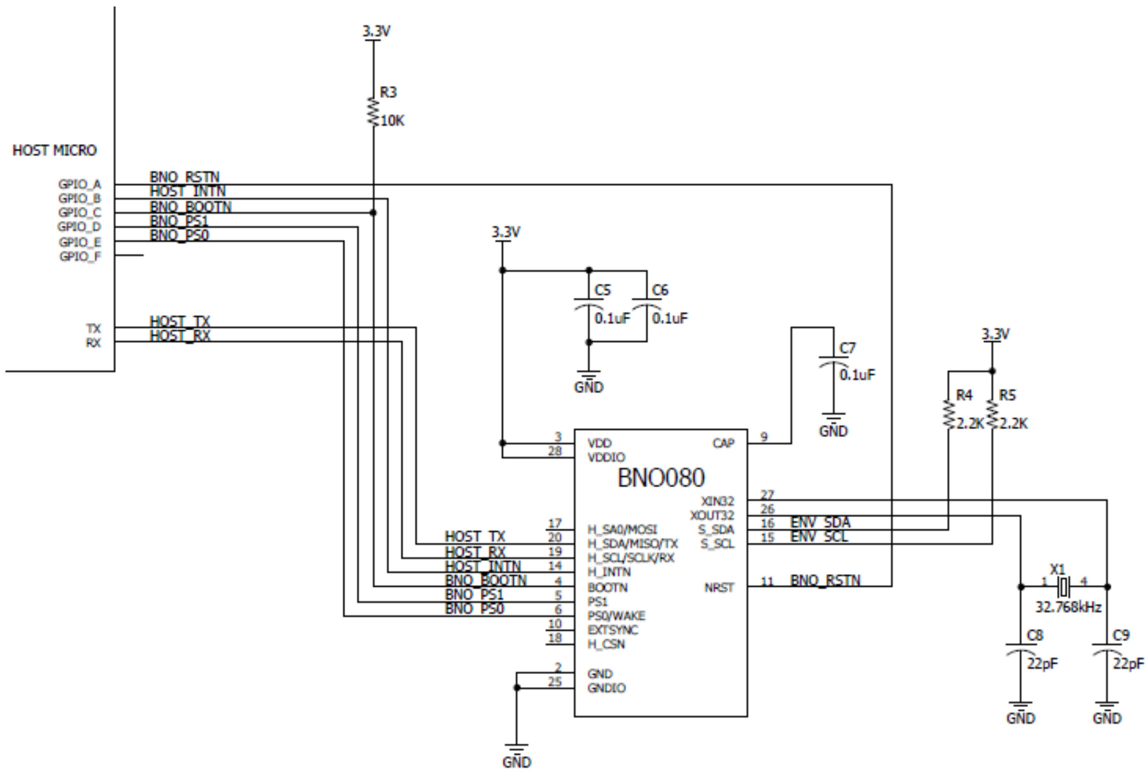

Figure 6: BNO080 UART_RVC connection

The host will require control over the PS0 and PS1 protocol select pins if access to the bootloader is required (this circuit assumes the use of UART mode for the bootloader). If firmware upgrade is not required then BOOTN and HOST_INTN can be omitted and the PS1/0 pins tied appropriately (low and high respectively).

A circuit design that allows for a change of BNO070 to BNO080/BNO085 should take into consideration the change in PS0 and PS1 lines (Figure 4). If these are controlled by the host processor then the selection is under control by the host software, otherwise the circuit design must allow for the change via resistor stuffing.

BOOTN, driven by the host microcontroller in conjunction with the reset signal (BNO_RSTN) and protocol select lines, allows the host to control the device firmware upgrade of the BNO080/BNO085.

The BNO080/BNO085 supports a BME280 temperature/humidity sensor and a Capella CM36686 ambient light/proximity sensor. These sensors are not used when configured for UART-RVC mode, however, the pullups R4 and R5 should still be present to ensure the secondary I²C bus is terminated correctly.

2.2.3 UART-SHTP Interface

The BNO080/BNO085 provides a UART communication interface that supports Hillcrest's SHTP protocol. A typical connection is shown in the figure below:

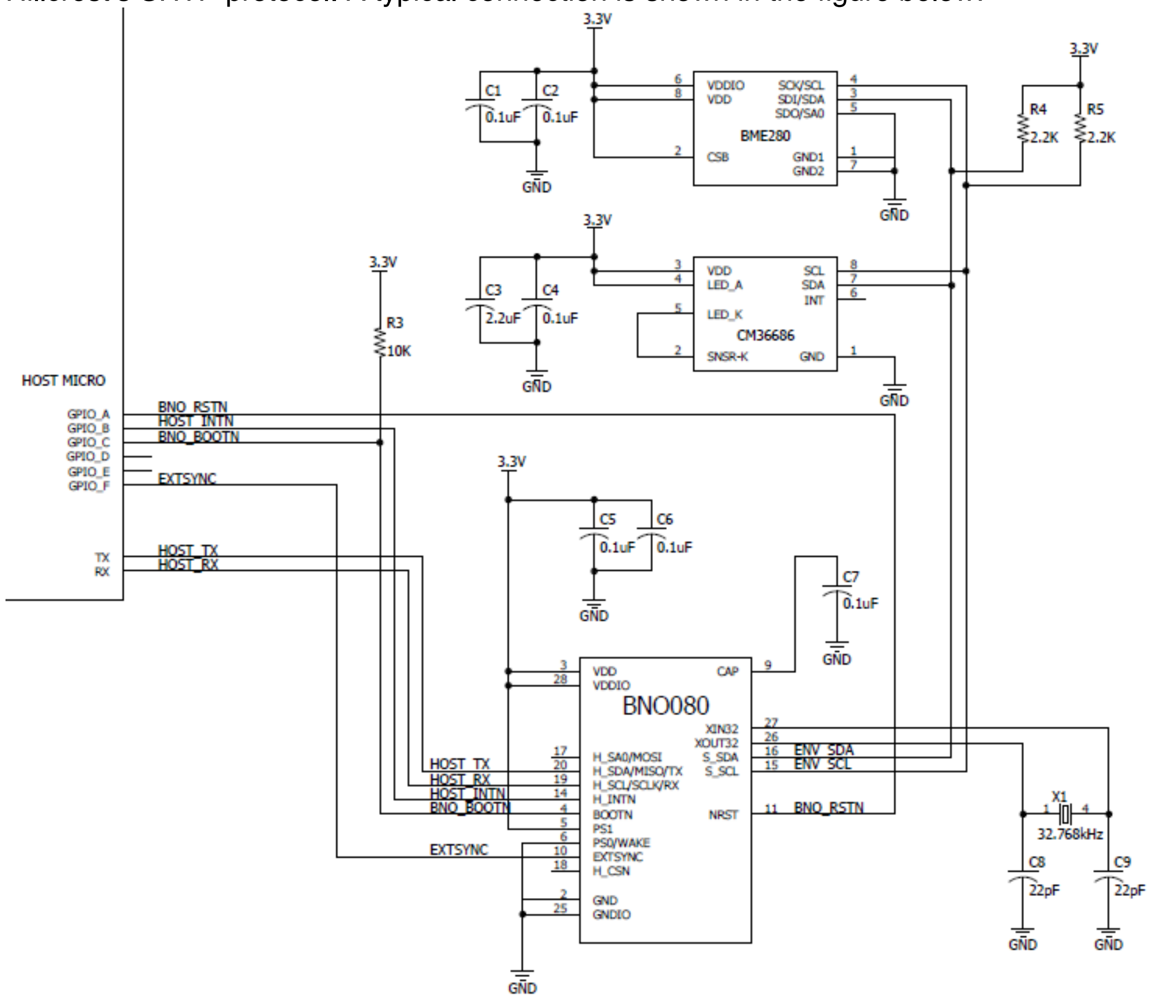

Figure 7: BNO080 UART-SHTP connection

Note that if upgrading (or planning to upgrade) from a BNO070 to the BNO080/BNO085 and migrating from I²C to a UART interface connectivity as follows is recommended.

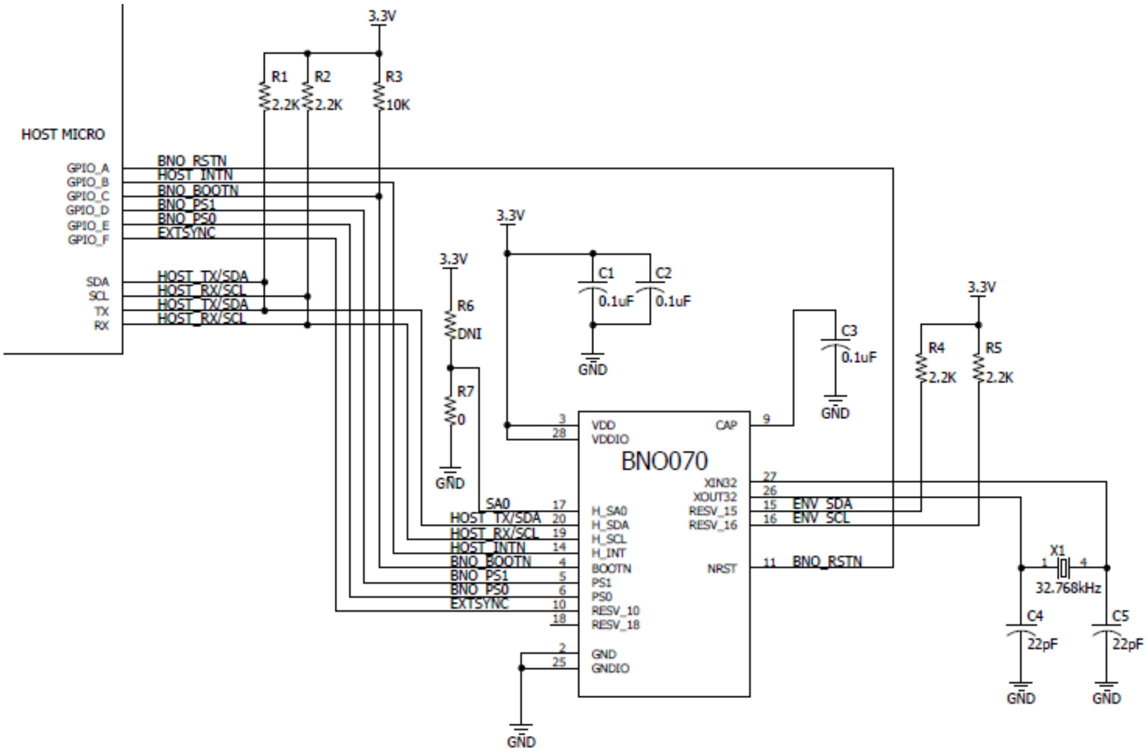

Figure 8: Upgrading from BNO070 to BNO080 in UART mode

BNO_PS0 and BNO_PS1 provide the protocol selection via SW control.

While evaluating the BNO070, I²C connectivity is required for either the bootloader or the BNO070 application. This is achieved by setting PS0 and PS1 low.

After migrating from BNO070 to BNO080/BNO085, the UART-SHTP protocol can be selected by setting PS0 low and PS1 high. The BNO080 will then operate in UART-SHTP mode.

R6 or R7 control the lowest address bit of the BNO070/BNO080/BNO085's I²C device address. The value of the R1 and R2 resistors is design dependent based on the capacitance of the implementation.

BOOTN, driven by the host microcontroller in conjunction with the reset signal (BNO_RSTN) and protocol select lines, allows the host to control the device firmware upgrade of the BNO070/BNO080.

The BNO080/BNO085 supports a BME280 temperature/humidity sensor and a Capella CM36686 ambient light/proximity sensor. The pullups R4 and R5 should be present even if the sensors are not to ensure the secondary I²C bus is terminated correctly.

2.2.4 SPI Interface

The BNO080/BNO085 provides a SPI communication interface that supports Hillcrest's SHTP protocol. A typical connection is shown in the figure below:

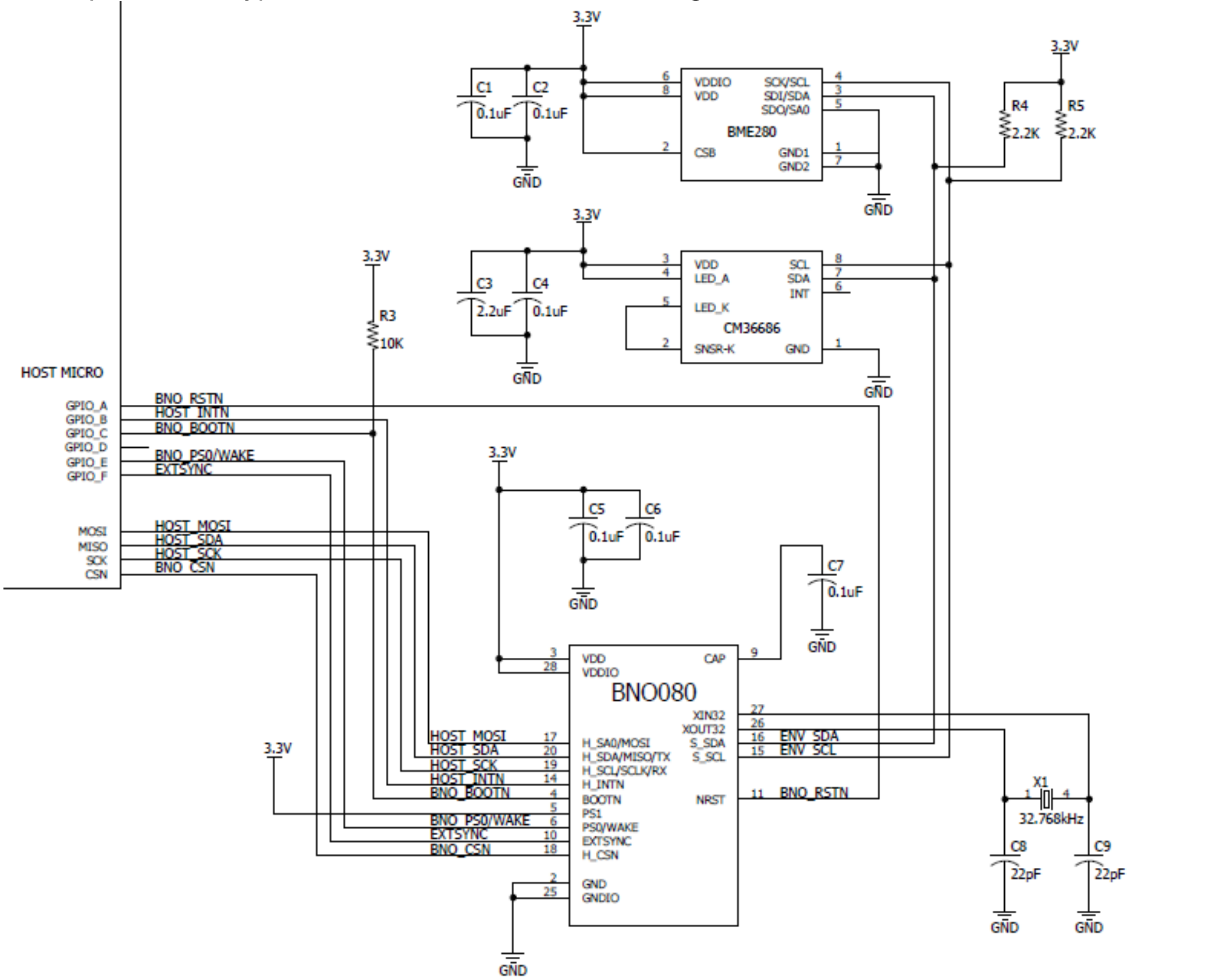

Figure 9: BNO080 SPI connection

The protocol select line PS0 must be controlled by the host microcontroller. During reset of the BNO080 the PS1 and PS0 lines should be high to select the SPI. After reset the PS0 signal is interpreted by the BNO080/BNO085 application as a 'wake' signal taking the device out of sleep mode and into active mode. During bootloader operation the wake signal has no function.

If upgrading (or planning to upgrade) from a BNO070 to the BNO080/BNO085 and migrating from I²C to a SPI interface connectivity as depicted in Figure 10 is recommended.

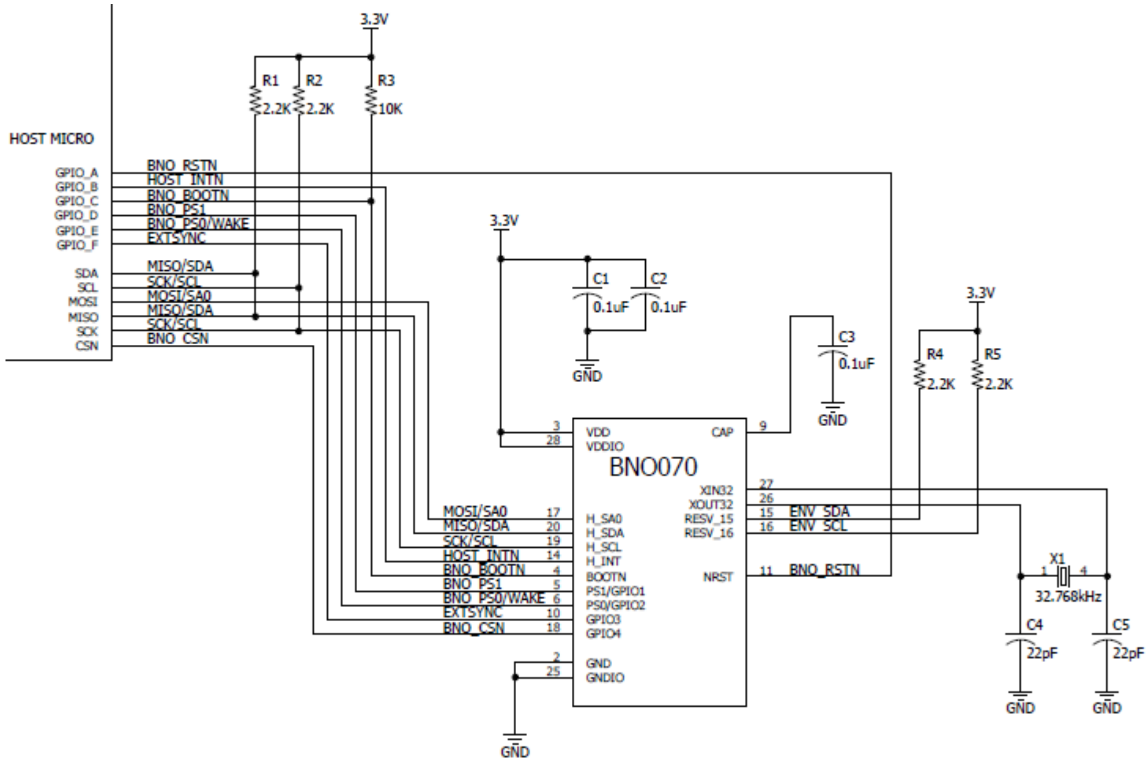

Figure 10: Upgrading from BNO070 to BNO080 in SPI mode

PS0 and PS1 provide the protocol selection via SW control. The BNO070/BNO080/BNO085 I²C connectivity for either the bootloader or the BNO0x0 application is available while PS0 and PS1 are low. After migrating to the BNO080, PS1 and PS0 should be driven high to enable SPI mode during the release of the reset line (BNO_RSTN).

The MOSI line also controls the lower address bit of the BNO070/BNO080/BNO085's device address during I²C operation. If a mixed system of I²C and SPI is developed then the user should connect SA0 appropriately and set it either high or low in software depending on their I²C driver.

BOOTN, driven by the host microcontroller in conjunction with the reset signal (BNO_RSTN) and protocol select lines, allows the host to control the device firmware upgrade of the BNO070/BNO080/BNO085.

The value of the R1 and R2 resistors is design dependent based on the capacitance of the implementation.

The BNO080/BNO085 supports a BME280 temperature/humidity sensor and a Capella CM36686 ambient light/proximity sensor. The pullups R4 and R5 should be present even if the sensors are not to ensure the secondary I²C bus is terminated correctly.

3.0 References

1. 1000-3374 BNO070 datasheet
2. 1000-3778 BNO070-RVC Configuration
3. 1000-3168 SH-1 Reference Manual
4. 1000-3927 BNO080/BNO085 datasheet
5. 1000-3600 SHTP-Reference Manual
6. 1000-3625 SH-2 Reference Manual

4.0 Notices

www.ceva-dsp.com

FOR MORE INFORMATION: