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USING SENT COMMUNICATION OUTPUT PROTOCOL WITH A17700 PRESSURE INTERFACE SENSOR

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INTRODUCTION

Single Edge Nibble Transmission (SENT) protocol is a three-wire digital communication protocol commonly used in automotive applications for efficient transmission of data from a sensor to a controller. The protocol is defined by the SAE J2716 (2016) specification.

This paper provides an overview of the general format of a SENT message and explains how the Allegro A17700 pressure interface sensor can be configured to use SENT to communicate pressure, temperature, and other useful application specific information.

SENT PROTOCOL OVERVIEW

When using SENT protocol, information is communicated via a SENT message. The message is a series of nibbles which are defined as a low-voltage fixed interval followed by high-voltage variable interval. The length of the combined pair of intervals is measured in ticks which is the fundamental time unit used by the transmitting device. The low voltage interval *SENT_FIXED* is typically 5 ticks long. The number of ticks in a nibble corresponds to a 4-bit binary value. The decimal equivalent of the 4-bit value can be calculated by taking the length of the nibble in ticks and subtracting 12.

$$\text{4-bit Value} = N_{ticks} - 12$$

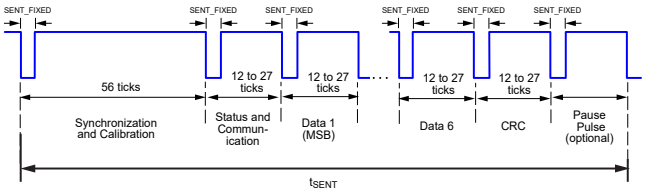

Figure 1: SENT Message Structure

The pulse and nibbles of a SENT message are arranged in the following required sequence:

1. Synchronization and Calibration Pulse: flags the start of the SENT message
2. Status and Communication Nibble: provides miscellaneous information such as device status, error codes, or additional serial data
3. Data Nibbles: sensor data
4. CRC Nibble: error checking
5. Pause Pulse (optional): sets timing relative to device updates

Synchronization and Calibration

The Synchronization and Calibration Pulse is 56 ticks wide, measured from falling edge to falling edge, and delineates the start of a new message frame. The controller uses this pulse to rescale the subsequent nibble values to correct for clock variation between the controller and the sensor. The tick time can be calculated with the following equation:

$$t_{TICK} = (t_{SYN(END)} - t_{SYN(START)}) / 56$$

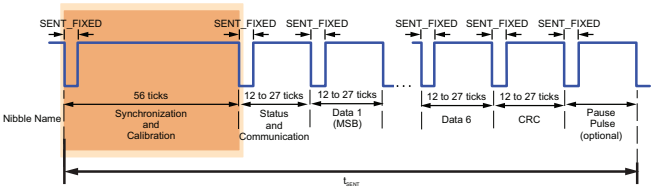

Figure 2: Synchronization and Calibration Nibble

Status and Communication Nibble

The Status and Communication Nibble (SCN) can provide diagnostic information along with additional data from the Short Serial Message or Enhanced Serial Message. By default, contents of the SCN are not included in the 4-bit CRC at the end of each SENT frame.

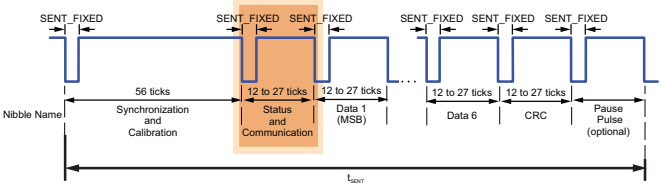

Figure 3: Status and Communication Nibble

Bits 2 and 3 of the SCN can be configured to be used as the Serial Data and Serial Sync bits, respectively, for communication of serial data. This allows for data to be transmitted one bit at a time over consecutive SENT messages.

Table 1: SCN Bit Function

SCN Bit Number	3	2	1	0
Bit Function	Serial Sync	Serial Data	Reserved for Specific Application	Reserved for Specific Application

Data

The SAE J2716 (2016) SENT standard allows for up to six 4-bit nibbles (24 total bits) of data to be transmitted per message. This data can be whatever information that is relevant to the application. In the case of the A17700, the data nibble contains information on pressure, temperature, diagnostics, or some combination of the three.

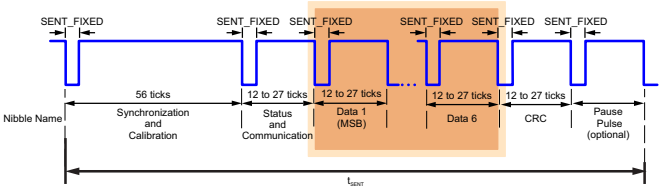

Figure 4: Data Nibble

CRC

The CRC nibble is a 4-bit error checking code that is defined by the SAE J2716 SENT standard. The value is calculated using the polynomial $x^4 + x^3 + x^2 + 1$, initialized to 0101. By default, the checksum only covers the contents of the data nibbles.

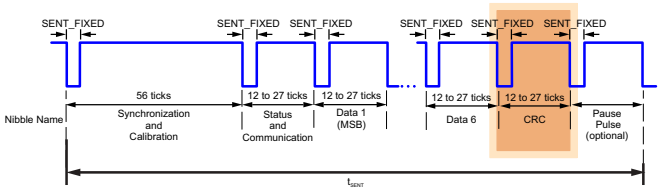

Figure 5: CRC Nibble

Pause Pulse

The Pause Pulse is an optional pulse added to the end of the SENT message frame, transmitted following the CRC nibble. It acts to "fill-in" the frame until the beginning of the next SENT transmission in order to have a constant total frame length and, therefore, a constant output rate. The minimum length of the Pause Pulse is 12 ticks; however, the length can be varied such that the total length of the message is always equal to:

$$TICK_{FRAME} = TICK_{SYNC(MAX)} + TICK_{SCN(MAX)} + TICK_{DATA(MAX)} + TICK_{CRC(MAX)} + TICK_{PAUSE(MIN)}$$

$$TICK_{FRAME} = 56 + 27 + (27 \times N_{DATA}) + 25 + 12$$

$$= 120 + (27 \times N_{Data})$$

where N_{DATA} is the number of data nibbles in the frame.

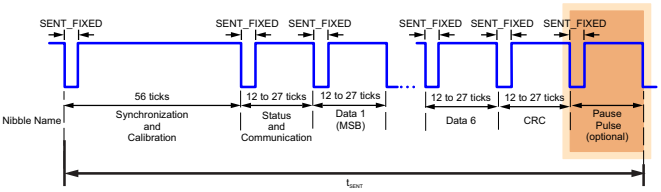

Figure 6: Pause Pulse

A17700 SENT IMPLEMENTATION

The A17700 includes several configurable options in order to be compliant to the SAE J2716 (2010) SENT standard. The SENT tick time can be adjusted with the *out_freq_rate* value in EEPROM as defined in Table 2.

Table 2: A17700 SENT Tick Time Options

out_freq_rate	SENT Tick Time [µs]
0 (default)	3
1	5
2	2.5
3	2
4	1.5
5	1
6	0.75
7	0.5

The A17700 can support Fast SENT mode with a 0.5 µs tick time, which provides an increased data rate for high bandwidth applications.

Status and Communication Nibble

The SCN can be configured to provide diagnostic data and device information through the Short Serial Message. The nibble contents are controlled via the *scn_mode* field in EEPROM (see Table 3).

Table 3: A17700 SCN Nibble Options

SCN Mode	SCN Nibble Bit			
	3	2	1	0
0	0	0	Fault Flag	0
1	Serial Sync	Serial Data	Fault Flag	0
2	Serial Sync	Serial Data	0	0
3	0	0	0	0

When SCN Modes 0 or 1 are selected, bit 1 conveys diagnostic information. When a diagnostic is fired, the Fault Flag bit is temporarily latched to 1 and is cleared on the following SENT frame unless a fault is still asserted and considering that any of the following diagnostics are enabled: Undervoltage, Overvoltage, Overtemperature, Undertemperature, Signal out of Range, or Open/Short Bridge Connection.

When SCN Modes 1 or 2 are selected, bits 3 and 2 communicate serial data in the form of the Short Serial Message (per SAE J2716 Section 5.2.4.1). With these two bits, additional data can be communicated one bit at a time over consecutive SENT messages. The Serial Sync Bit indicates the start of a 16-bit serial message, while the Serial Data bit contains the message ID, data, and CRC information. Following a reset, the first message ID transmitted is 0, following in order of the message ID until the final message, at which point the messages are repeated. See Table 4 and Table 5 for the Short Serial Message format and Message ID description. The CRC for the Short Serial Message is derived for the Message ID and data and is the same checksum algorithm used for the SENT CRC.

Table 4: A17700 Short Serial Message Format

SCN Bit	Frame #															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Serial Sync	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Serial Data	Message ID			Data [7:0]									CRC			

Table 5: A17700 Short Serial Message ID

Message ID	Data
0	9-bit diagnostics, MSB always 0
1	9-bit internal temperature
2	9-bit customer scratch [8:0]
3	9-bit customer scratch [17:9]
4	9-bit customer scratch [25:18], MSB always 0

Data

The data nibble format is determined by the *sent_data_cfg* EEPROM parameter. The A17700 includes three options for a range of 3 to 6 data nibbles as defined in Table 6. For each option, data to be transmitted is sampled at the end of the SCN.

Table 6: A17700 Data Configuration

sent_data_cfg	Data Nibble						# of Nibbles
	1	2	3	4	5	6	
0 (default)	Pressure [11:8]	Pressure [7:4]	Pressure [3:0]	–	–	–	3
1	Pressure [11:8]	Pressure [7:4]	Pressure [3:0]	Diag. [7:4]	Diag. [3:0]	–	5
2	Pressure [11:8]	Pressure [7:4]	Pressure [3:0]	Int. Temp. [11:8]	Int. Temp. [7:4]	Int. Temp. [3:0]	6

CONCLUSION

Using the SENT protocol with the A17700 allows for communication of additional information that is not possible with analog output. Both devices are not only able to communicate pressure, but also temperature, diagnostics, and customer scratch information. The A17700 is highly configurable and can be used in a wide range of pressure sensing applications. Contact Allegro for the most up-to-date product information and availability.

Revision History

Number	Date	Description	Responsibility
–	June 30, 2021	Initial release	K. Suyderhoud
1	February 10, 2022	Corrected Figure 3	B. Benedix

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