Honeywell

Technical Note

SAEJ1939 CAN Communication Protocol for Honeywell’s 6DF Series Inertial Measurement Unit, 6-D Motion Variant

1.0 Introduction

This Technical Note provides an example of a typical SAEJ1939 CAN message for Honeywell’s 6DF Series Inertial Measurement Unit, 6-D Motion Variant.

The 6DF IMU measures the motion of the equipment onto which it is attached (see Figures 1 and 2) and delivers the data to the equipment’s control module using CAN communications protocol, allowing the operator to focus on other equipment functions, enabling more precise control than can be achieved by using only the human eye, and increasing safety, stability and productivity.

The CAN baud rate and CAN 29 bit IDs are according to J1939. SAEJ1939 CAN 29 bit identifier communication output—the standard for the Transportation segment—allows more data to be transmitted than RS-485 output.

CAN baud rate = 250 kbps
CAN update rate = 100 Hz

The 6DF Series is available in two versions, one with a 2 g accelerometer and the other with a 6 g accelerometer, as shown in Table 1.

Table 1. Order Guide

Catalog Listing	Description
6DF-1N2-C2-HWL	6DF Series Inertial Measurement Unit, 6-D Motion Variant, 2 g accelerometer
6DF-1N6-C2-HWL	6DF Series Inertial Measurement Unit, 6-D Motion Variant, 6 g accelerometer

Table 2. Glossary of Terms

Term	Definition
SOF	Start of frame
CAN-ID	Message Identifier: The lower the value, the Higher the priority of the message (29 bits long for J1939)
RTR	Remote Transmission Request = 0 (Will only be “1” if requesting message be added to the network)
CONTROL	Control field: Specifies the number of bytes of data to follow (0-8)
DATA	Data field
CRC	Contains a sixteen bit cyclic redundancy check code
ACK	Acknowledge: An empty slot which will be filled by any and every node that receives the frame. It does not identify the location, just that at least one node on the whole network got it
EOF	End of Fame
PDU	Protocol Data Unit (i.e. Message Format)
PGN	Parameter Group Number

Figure 2. Sensor Axes Definitions

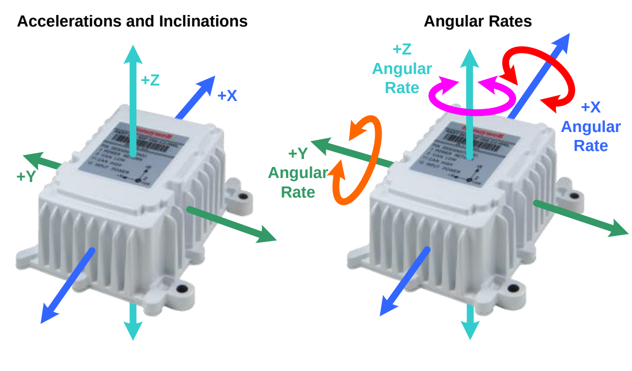
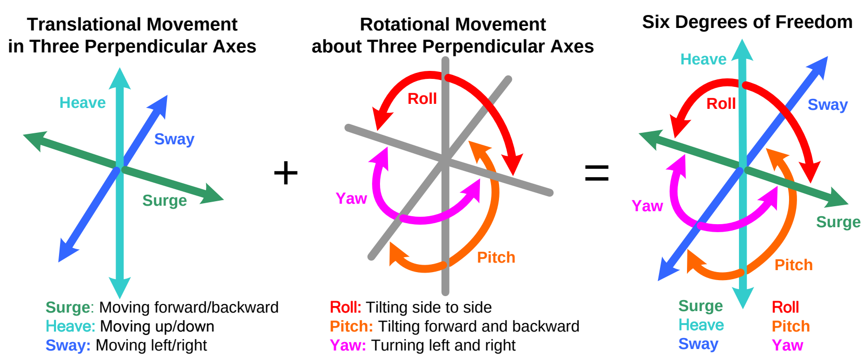


Figure 1. Six Degrees of Freedom General Definitions



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3.0 Parameter Group Number

The PGN refers to the value of the Reserve bit (R), Data Page (DP), PDU Format (PF), and PDU-specific (PS) fields combined into a single 18 bit value. The two types of PGNs are:

- Global: Parameter groups that are sent to all (broadcast).
- Specific: Parameter groups sent to particular devices.

The interpretation of the PDU-specific (PS) field changes is based on the PF value:

- If the PF is between 0 and 239, the message is addressable (PDU1) and the PS field contains the destination address.
- If the PF is between 240 and 255, the message can only be broadcast (PDU2) and the PS field contains a Group Extension.

Figure 3 shows how the Group extension expands the number of possible broadcast Parameter Groups that can be represented by the identifier. The last 8 bits of the identifier contain the address of the device transmitting the message. The address is the label or "handle" which is assigned to provide a way to uniquely access a given device on the network. For a given network, every address must be unique (254 available). This means that two different devices (ECUs) cannot use the same address. For the 8 bytes shown, remember that 1 byte = 8 bits for a total of 64 bits assigned.

Figure 3. Group Extension

SOF	CAN-ID	RTR	CNTL	DATA	CRC	ACK	EOF
1	29	1	6	0 to 64	16	2	7

PRIORITY	PGN	SOURCE ADDR
3	18	8

RESERVED	DATA PAGE	PDU FORMAT	PDU SPECIFIC	SOURCE ADDR
1	1	8	8	8

Data Bytes	05	00	80	07	80	2C	6A	00
Position	1	2	3	4	5	6	7	8

Example: 0xCFF955C
(Sensor Data – Lateral Acceleration and Yaw Rate)

0x0C				0xFF	0x95	0x5C
000	011	0	0	11111111	10010101	01011100
-	Priority	R	DP	PF	PS	SA

PGN = the R, DP, PF and PS fields, in this case 0x0FF95.
PF = 0xFF = 240, i.e. this is a PDU2 (broadcast) message
PS = 0x95, i.e. the Group Extension = 95

Table 3. Messages Transmitted from the IMU to the Host in the Base Software Build

CAN Message	Message Identifier	Data Length	Description
Sensor data (lateral acceleration and yaw rate)	0xCFF955C	8 bytes	IMU to system
Sensor data (longitudinal acceleration and roll rate)	0xCFF965C	8 bytes	IMU to system
Sensor data (vertical acceleration and pitch rate)	0xCFF975C	8 bytes	IMU to system
Sensor data (roll angle and pitch angle)	0xCFF985C	8 bytes	IMU to system
Serial number, SW version no., HW version no.	0xCFF9E5C (remote frame)	8 bytes	IMU to system (on request)
Error status/bits	0xCFF9F5C (remote frame)	8 bytes	IMU to system (on request)

Table 4. IMU to System (Yaw Rate and Lateral Acceleration Definition)

Message 0xCFF955C	Bits	Start Bit Position	Description
Rolling counter	8	0	increments the counter for every message sent; rolls from 255 to 0
Signal state for lateral acceleration	2	8	indicates if lateral acceleration data is valid
Signal state for yaw rate	2	10	indicates if yaw rate data is valid
Signal state for temperature	2	12	indicates if temperature data is valid
Vehicle lateral acceleration	16	16	digital filtered lateral acceleration signal
Vehicle yaw rate	16	32	digital filtered yaw rate signal
Module temperature	8	48	module temperature
<Unused>	10	14-15, 56-63	–

Table 5. IMU to System (Roll Rate and Longitudinal Acceleration Definition)

Message 0xCFF965C	Bits	Start Bit Position	Description
Rolling counter	8	0	increments the counter for every message sent; rolls from 255 to 0
Signal state for longitudinal acceleration	2	8	indicates if longitudinal acceleration data is valid
Signal state for roll rate	2	10	indicates if roll rate data is valid
Vehicle longitudinal acceleration	16	16	digital filtered longitudinal acceleration signal
Vehicle roll rate	16	32	digital filtered roll rate signal
Error information	16	48	error information
<Unused>	4	12-15	–

Table 6. IMU to System (Pitch Rate and Vertical Acceleration Definition)

Message 0xCFF975C	Bits	Start Bit Position	Description
Rolling counter	8	0	increments the counter for every message sent; rolls from 255 to 0
Signal state for vertical acceleration	2	8	indicates if vertical acceleration data is valid
Signal state for pitch rate	2	10	indicates if pitch rate data is valid
Vehicle vertical acceleration	16	16	digital filtered vertical acceleration signal
Vehicle pitch rate	16	32	digital filtered pitch rate signal
<Unused>	20	12-15, 48-63	–

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Table 7. IMU to System (Roll and pitch Inclination Angle Definition

Message 0xCFF955C	Bits	Start Bit Position	Description
Rolling counter	8	0	increments the counter for every message sent; rolls from 255 to 0
Signal state of roll inclination angle	2	8	indicates if roll inclination angle is valid
Signal state of pitch inclination angle	2	10	indicates if pitch inclination angle is valid
Vehicle roll inclination angle	16	16	digital filtered roll inclination angle signal
Vehicle pitch inclination angle	16	32	digital filtered pitch inclination angle signal
<Unused>	20	12-15, 48-63	–

Table 8. IMU to System (Serial Number Definition)[1]

Message 0xCFF9E5C	Bits	Start Bit Position	Description
Module serial number	24	0	module serial number
Software version	8	24	software version
Production date	16	32	software release year, week
<Unused>	16	48-63	–

Note 1: This message can be requested by transmitting a message with ID 0xCFF9E5C and RTR bit set, to the IMU.

Table 9. IMU CAN Resolution

Number of bits	Numerical format	Resolution	Measurement Range	Value Range (hex)
Vehicle Dynamic Rates				
16	unsigned value	0.0078125 °/s	75	70xA57F
			0	0x7FFF
			-75	0x5A7F
Vehicle Dynamic Accelerations (6 g version)				
16	unsigned value	0.01 m/s^2	58.86	0x96FD
			0	0x7FFF
			-58.86	0x6901
Vehicle Dynamic Accelerations (2 g version)				
16	unsigned value	0.01 m/s^2	19.62	0x87A9
			0	0x7FFF
			-19.62	0x7855
Inclination Angles				
16	unsigned value	0.002 °	50	0xE1A7
			0	0x7FFF
			-50	0x1E57

Table 10. IMU System (Error Information – ID 0xCFF965C)

Number of Bits	Start Bit Position	Position Error Description
12	48	reserved
1	60	software error
1	61	SPI
1	62	ADC
1	63	IIC

Table 11. Module Temperature Resolution[1]

Number of Bits	Numerical Format	Resolution	Measurement Range	Value Range
8	unsigned value	0•7812 ºC	150	0XFF
			0	0X40
			-49•2178	0X00

Note 1: Temperature is not calibrated.

Table 12. Signal States for Rotational Rates, Acceleration, Angles, and Temperature

Bit X	Bit X + 1	Signal State	Description
0	0	valid	signal in specification
0	1	invalid	signal not accurate; fault detected
1	0	unused	unused combination
1	1	unused	unused combination

Table 13. CAN Messages Bit Numbering

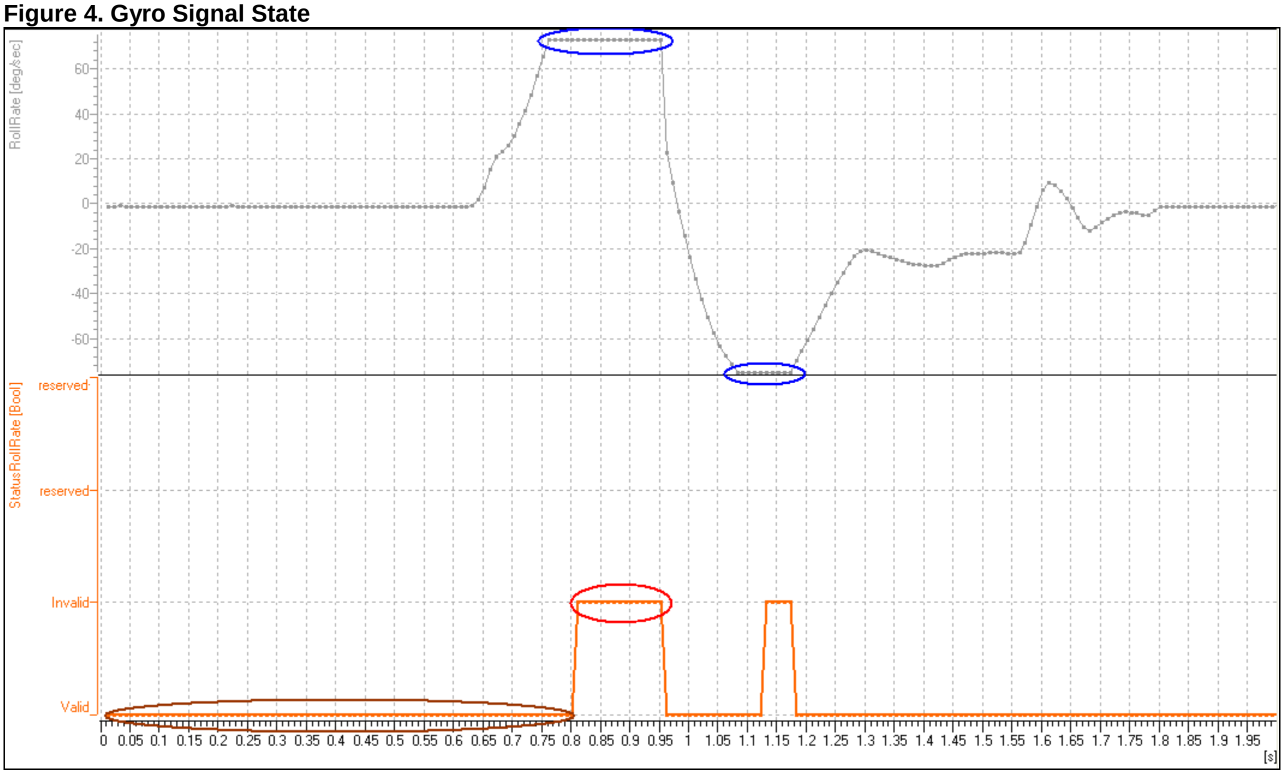
Byte/Bit	0	1	2	3	4	5	6	7
0	0	1	2	3	4	5	6	7
1	8	9	10	11	12	13	14	15
2	16	17	18	19	20	21	22	23
3	24	25	26	27	28	29	30	31
4	32	33	34	35	36	37	38	39
5	40	41	42	43	44	45	46	47
6	48	49	50	51	52	53	54	55
7	56	57	58	59	60	61	62	63

4.0 Sensor Signal States

4.1 Gyro Signal State

- If the angular rate is within the operating range (±75 °/s), the signal state is in a "Valid" state (circled in brown in Figure 4).
- If the angular rate exceeds ±75 °/s, even after a fault filter time of 40 ms, the signal state changes from a "Valid" state to an "Invalid" state and stays in the "Invalid" state until it recovers (circled in red in Figure 4). In the "Invalid" state previous valid data is transmitted (circled in blue in Figure 4).
- If a detectable internal hardware fault occurs on reset, the output value would be 0 °/s and the signal state would be in the "Invalid" state.

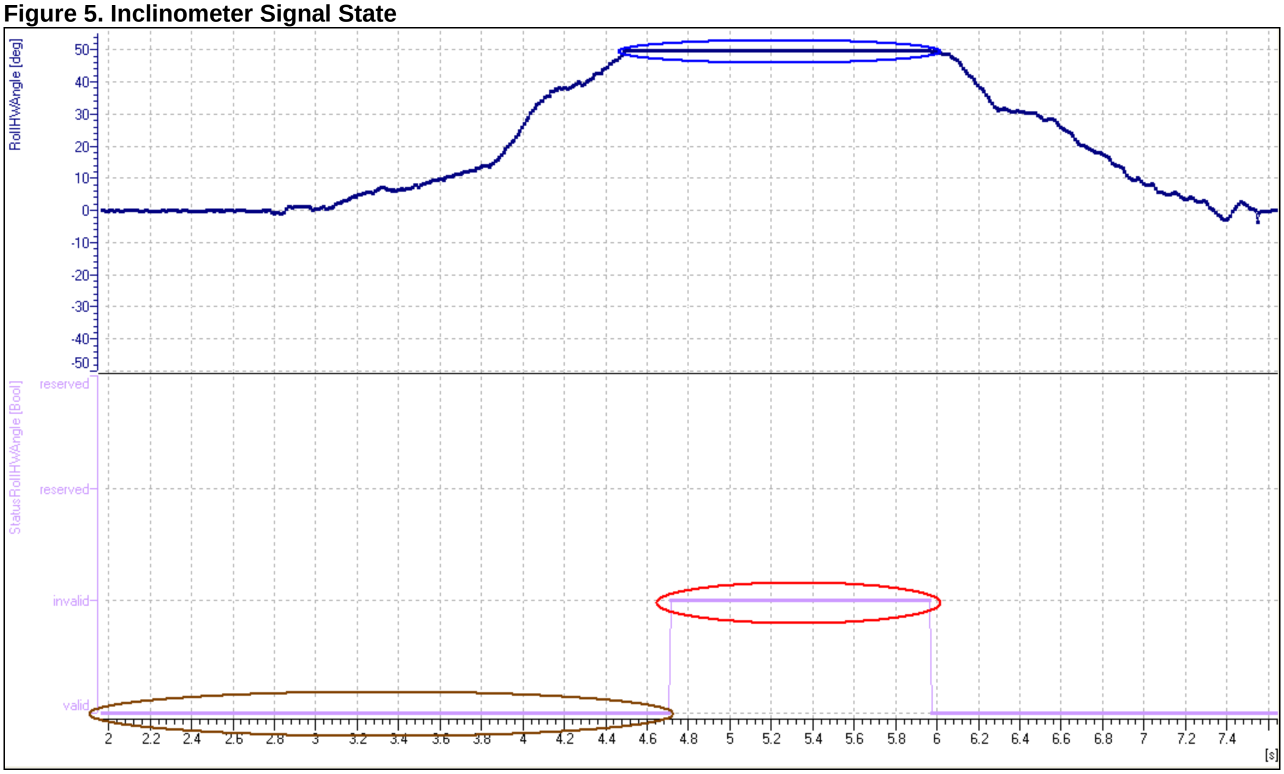
Figure 4. Gyro Signal State



4.2 Inclinometer Signal State

1. If the inclination is within the operating range (±50º), the signal state is in the "Valid" state (circled in brown in Figure 5).
2. If inclination exceeds ±50º, even after a fault filter time of 200 ms, the signal state changes from a "Valid" state to an "Invalid" state and stays in the "Invalid" state until it recovers (circled in red in Figure 5). In the "Invalid" state previous valid data is transmitted (circled in blue in Figure 5).
3. If a detectable internal hardware fault occurs on reset, the output value would be 0º and the signal state would be in the "Invalid" state.

Figure 5. Inclinometer Signal State



4.3 Accelerometer Signal State

1. If the acceleration is within the operating range (±6 g for the 6 g accelerometer or ±2 g for 2 g accelerometer), the signal state is in the "Valid" state.
2. If the acceleration exceeds ±6 g for the 6 g accelerometer or ±2 g for the 2 g accelerometer, even after a fault filter time of 200 ms, the signal state changes from the "Valid" state to the "Invalid" state and stays in the "Invalid" state until it recovers. In the "Invalid" state previous valid data is transmitted.
3. If a detectable internal hardware fault occurs on reset, the output value would be 0 g and the signal state would be in the "Invalid" state.

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E-mail: info.sc@honeywell.com

Internet: sensing.honeywell.com

Phone and Fax:

Asia Pacific	+65 6355-2828
	+65 6445-3033 Fax
Europe	+44 (0) 1698 481481
	+44 (0) 1698 481676 Fax
Latin America	+1-305-805-8188
	+1-305-883-8257 Fax
USA/Canada	+1-800-537-6945
	+1-815-235-6847
	+1-815-235-6545 Fax

Sensing and Control
Honeywell
1985 Douglas Drive North
Golden Valley, MN 55422
sensing.honeywell.com

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Honeywell