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BULLETIN
BUL-060

Wheel Odometry Interface Control Documentation

The wheel odometry system of the Pronto4 passes its serial information to the host computer through a simple protocol. A jumper is placed on the board for usage with optional front wheel sensors.

The wheel odometery system has two types of control boards. One based on software only and another based upon a high-speed, quad channel, quadrature decoder.

Software Based Quadrature

Jumper installed

[Wlra:lrb,rra:rrb]

lra — lower 14 bits of left rear wheel accumulator
lrb — upper 14 bits of left rear wheel accumulator
rra — lower 14 bits of right rear wheel accumulator
rrb — upper 14 bits of right rear wheel accumulator

Jumper removed

[wlfa:lfb,rfa:rfb]

lfa — lower 14 bits of left front wheel accumulator
lfb — upper 14 bits of left front wheel accumulator
rfa — lower 14 bits of right front wheel accumulator
rfb — upper 14 bits of right front wheel accumulator

Note that there is a lower case “w” when front wheels are used.

Hardware Based Quadrature

Default power up packet format, 4 wheels and delta

[Wlr,rr,lf,rf,dlr,drr,dlf,drf]
[W000000,000000,000000,000000,0000,0000,0000,0000]

lr — 24 bit hex accumulator for left rear wheel accumulator
rr — 24 bit hex accumulator for right rear wheel accumulator
lf — 24 bit hex accumulator for left front wheel accumulator
rf — 24 bit hex accumulator for right front wheel accumulator
dlr — 16 bit hex differential for left rear wheel accumulator
drr — 16 bit hex differential for right rear wheel accumulator
dlf — 16 bit hex differential for left front wheel accumulator
drf — 16 bit hex differential for right front wheel accumulator

Default power up packet format, 4 wheels and delta, timing measurement enabled

[Wlr,rr,lf,rf,lrus,rrus,dlr,drr,dlf,drf]

lrus — 16 bit timing measurement count for left rear

rrus — 16 bit timing measurement count for right rear
Checksum enabled, always at end
[Wlr,rr,lf,rf,lrus,rrus,dlr,drr,dlf,drf,cc]
cc — 8 bit checksum of characters from “W” to last value before cc
Delta packets occurring every other packet after [DA] sent
[Wlr,rr,lf,rf,lrus,rrus,cc]
[Wlr,rr,lf,rf,lrus,rrus,dlr,drr,dlf,drf,cc]
[Wlr,rr,lf,rf,lrus,rrus,cc]
[Wlr,rr,lf,rf,lrus,rrus,dlr,drr,dlf,drf,cc]
[Wlr,rr,lf,rf,lrus,rrus,cc]
Data packet is transmitted at 20hz rate
Differential is calculated at 50ms interval from one read to the next
[Z] — command sent to device to reset all counts
[C] — continuous transmission
[P] — polled/poll request transmission
[Dx] — delta calculation rate (0 to 26), per ‘x’ packet cycles
x = @ - Z where @=0, A = 1, etc
0 = every cycle, 1=every 1 cycle, 2=every 2 cycles, etc
[Ux] — enable/disable reporting of edge-to-edge timing measurement
0 = disable, 1 = enable
[Kx] — enable/disable reporting of checksum
0 = disable, 1 = enable
[Sx] — set timing measurement clock prescaler
x = 1 to 8
1 - Divide by 2 (.2us units)
2 - Divide by 4 (.4us units)
3 - Divide by 8 (.8us units)
4 - Divide by 16 (1.6us units)
5 - Divide by 32 (3.2us units)
6 - Divide by 64 (6.4us units)
7 - Divide by 128 (12.8us units)
8 – Divide by 256 (25.6us units)
[Wx] — number of wheels to sense
2 = two wheels, 4 = four wheels
Baud rate is 115,200 bits per second, 8 data, 1 stop, no parity

All values are signed using 2 complement math. The split values are treated as unsigned values prior to assembly and then assigned values after assembly.

Message Transactions

Messages are transmitted from the sensor at a 10 or 20hz rate (100ms or 50ms) based upon setting. The default is 20hz or [F2].

Delta Calculations

The change in wheel positions are calculated and transmitted between one or more message transactions. The default is 0 or [D@]. The delta calculation rate command sequence sets the number of message transactions that must occur before reporting a wheel position delta. The possible values are 0 to 26 where the wheel position deltas would be reported every 26th message. After the wheel deltas are reported the delta is zeroed and a new delta is calculated.

Edge Timing Measurement

When edge timing measurement is enabled, values are returned that represent the edge to edge timing between a single pair of arms on the rotational stimulator. Two wheels are measured in alternating fashion. It is required that the wheels be rotating for the measurement to take place. One or both wheels must be rotating. The value returned is a unipolar 16 bit value. The value of FFFF indicates that the rotation is too slow and that the measurement is longer than 65535 units or that the wheel has stopped rotating for 40 message transactions. Note that the measurements alternate between wheels. This can become an issue at low rotation speeds, less than 2hz signal or so based upon application. The range or resolution of the measurement can be set by changing the clock prescaler. The default is 6, [S6] or 6.4us units. Larger prescalers should be used for slower speeds or bigger tires.

Checksum Calculation

The transmitted message may have a checksum enabled if desired. When enabled it is always the last value in the framed message transaction. The checksum value is a simple modulo 256 addition of all the ASCII character values in the message starting with the “W” and ending with the last hexadecimal digit in the value just before the checksum. The comma between the last value and the checksum is not included in the checksum calculation. The transmitted hex checksum value is the lower 8 bits of that streaming character addition. All characters in a valid message must be included in the following set. Characters outside that set are invalid. It is also acceptable in some cases simply to perform a type check on each character received.

Framing [ ]
Message W,0123456789ABCDEF

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Wheel Math

The following calculations show the wheel math used to work with the KA Wheel Odometry sub-system.

Assuming a 19.5 inch diameter wheel with 8 stimulators evenly distributed in a radial pattern around the interior of the wheel.

Diameter: 19.5 inches

Circumference: 2pi * R = 61.261 inches or 5.1051 feet per rotation

While driving the vehicle at two speeds 5mph and 30mph:

Mile = 5280 feet

30mph = 158400fph or 2640fpm or 44 fps

5mph = 26400fph or 440fpm or 7.33 fps

With our wheel, RPM is:

At 30mph — 2640fpm / 5.1051fpr = 517 rpm = 8.619rps

At 5mph — 440fpm / 5.1051 = 86 rpm = 1.4365rps

With our wheel stimulator of 8 spokes:

At 30mph — 8.619rps * 8 spokes = 68.951hz

1/68.951 = 14.503ms

At 5mph — 1.4365rps * 8 spokes = 11.492hz

1/11.492 = 87.019ms

We expect these measurements from edge to edge with a 6 prescaler:

At 30mph — 14.503ms / 6.4us = 2266 units

2266 decimal is 8DA hex

At 5mph — 87.019ms / 6.4us = 13597 units

13597 decimal is 351D hex

So what happens when we give the wheel a spin with our hand? What is the result?:

Hand spin yields 75rpm based on spinner's variables (e.g., angle, muscle mass)

At 75rpm the measured frequency is 10hz

10hz yields an expected count of 3D09 hex