

$$RPM = \frac{1}{n} \cdot \left(\frac{N}{1 \text{ msec}} \cdot 1000 \cdot 60 \right) \quad (2)$$

pulses/sec
pulses/min

where n represents the number of pulses corresponding to one complete revolution and N represents the counting pulses.

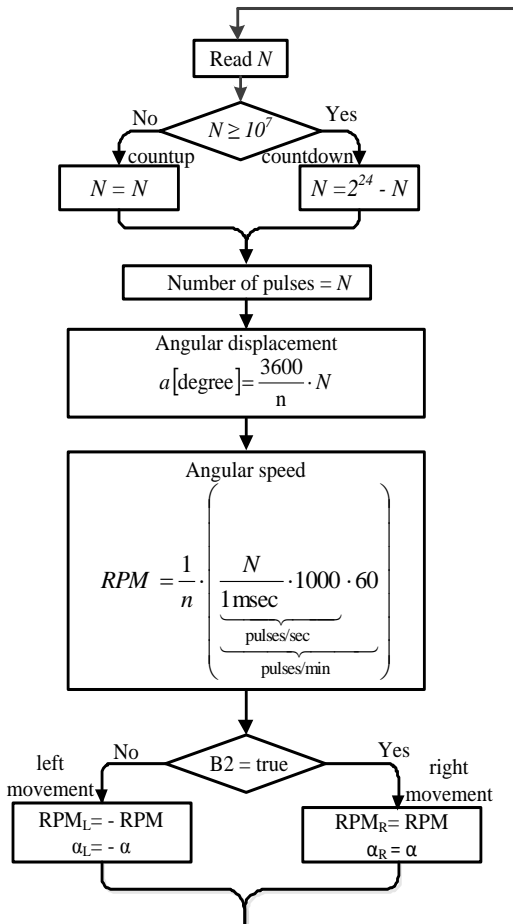


Fig.16. Angular displacement and velocity measurement algorithm

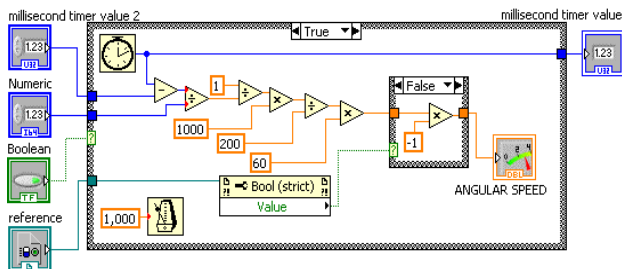


Fig.17. Algorithm implementation by virtual instrumentation

Getting prescribed time necessary for calculating speed is achieved by using function **Tick Count** (msec) that returns the timer value, in milliseconds between consecutive loops in the **While Loop**.

4.1 System Implementation with Virtual Instrument

The main program algorithm is shown in Fig.18 and this includes SubVI's SELECT and RPM. We use a **While Loop** structure that ensures the continuous running of the program until the user stop it through the STOP button.

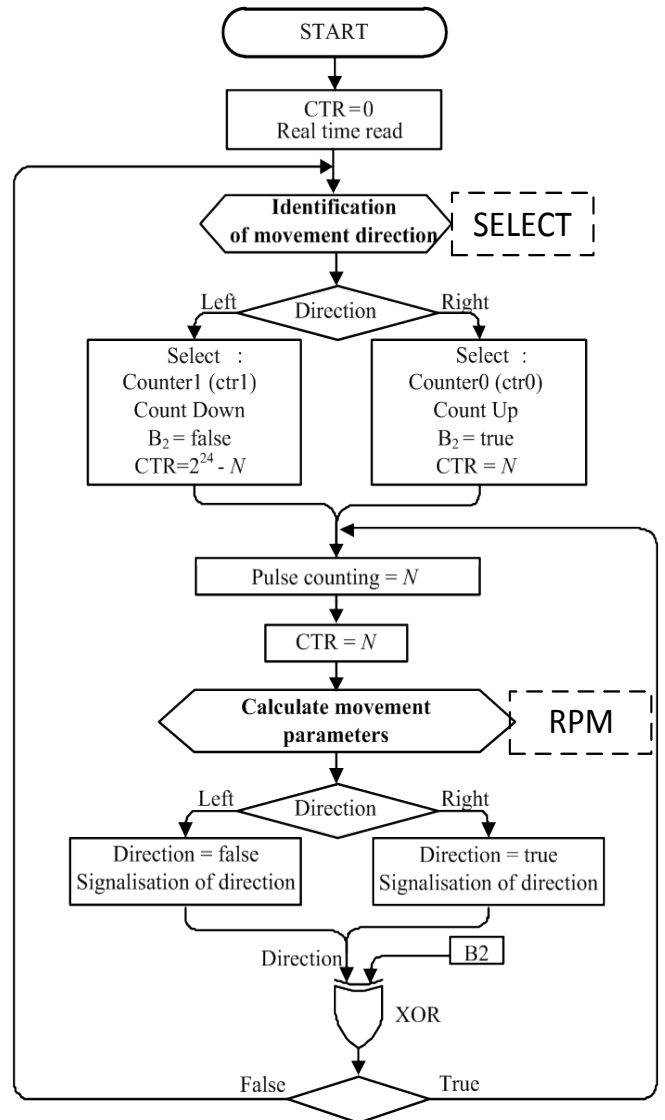


Fig.18. Main program algorithm

Based on this algorithm the virtual instrument is built, and the block diagram is shown in Fig.19

Acquisition is executed in two sequences and the program begins with reset of the local variable CTR and timing setting that will be used to define the graphical representation of X-signal for the Channel A respectively Channel B graphical indicators.

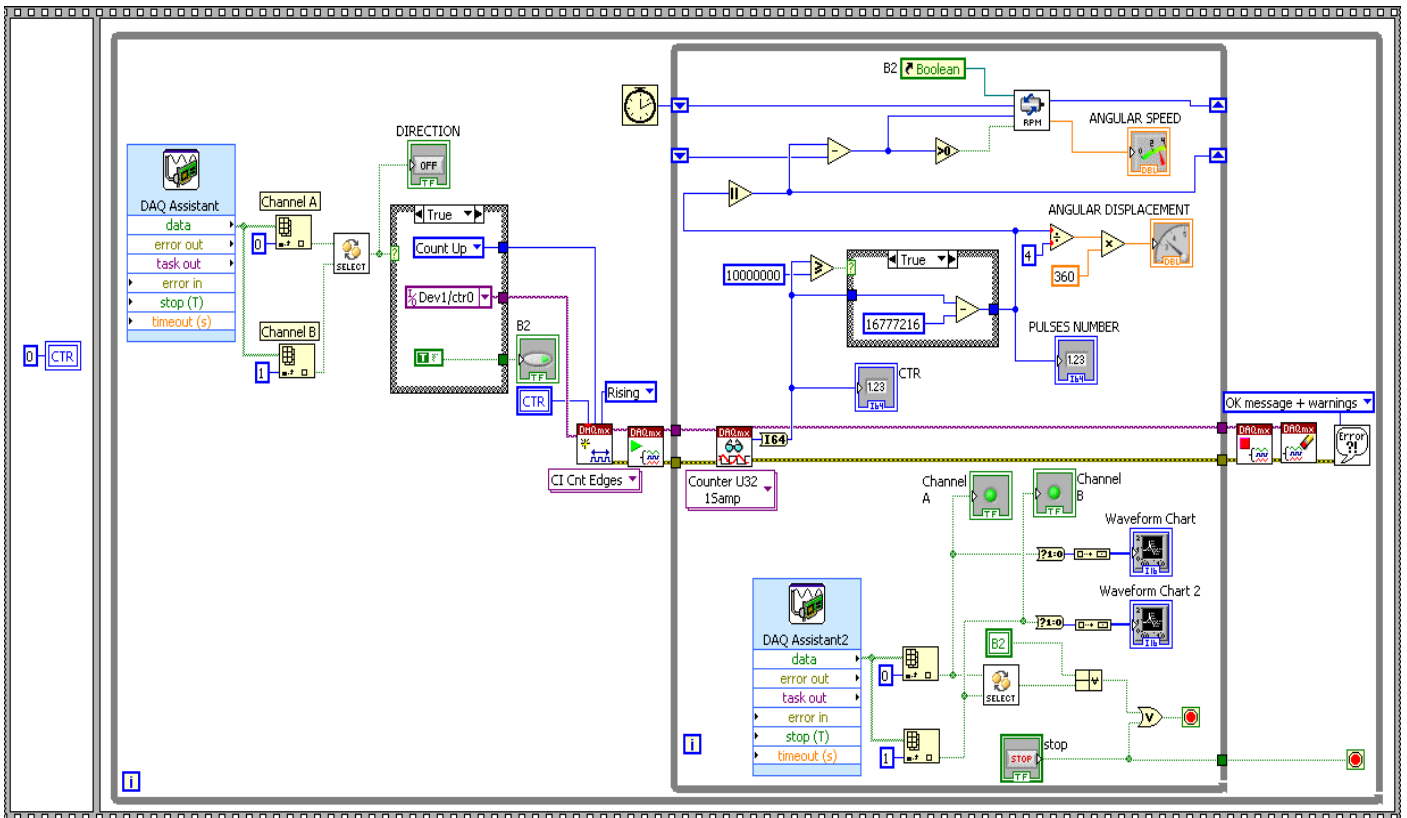


Fig.19. Diagram bloc of the virtual instrument

The input signals Channel A and Channel B are taken from the incremental sensor by *line 1* and *line 0* of the digital *port 0* port of the data acquisition board PCI – 6024E using **DAQ Assistant** function.

As we mentioned above the direction is selected through **Counting Selection** signal [15].

Once direction is selected, this it will be displayed on the front panel. The selection signal is also used for selecting the direction of counting (Count Up or Count Down) by applying it to the selection terminal of the **Case** structure. Through this structure, we can also select one of the counters *ctr1* or *ctr0* so that the counting upwards is performed by counter *ctr0* and counting downwards is performed by counter *ctr1*.

For the two counters *ctr1* and *ctr0* counting values may increase (Count Up) when their value increases with each pulse applied to the entry *CtriSource* ($i = 0$ or 1) in domain $[0 \dots 2^{24} = 16777216]$ or may decrease (Count Down) when its value decreases with each pulse applied to the entry *CtriSource* ($i = 0$ or 1) in domain $[2^{24} = 16777216 \dots 0]$. If it detects a number N higher than 10^7 , counter *ctr0* is considered selected and counting is carried downwards since (2^{24}) which represent the maximum counter value. Number of pulses is obtained by the difference between constant 2^{24} and the value of N representing the output of function **DAQmx Read (Counter U32 1CH 1Samp)**. Based on

this pulses number is calculated the displacement and angular speed values [16].

Clockwise motion is considered to be displayed with a positive sign and counterclockwise motion is considered to be displayed with a negative one. This convention requires continuous tracking of the value of the two counters. The continuous tracking is achieved by using local variable *CTR* whose value is loaded into each of the two counters selected according counting sense through the input parameter *initial count* of the **DAQmx Create Virtual Channel** function.

Displaying number of pulses and calculating the displacement and angular speed, based on the relation between the direction of motion and sign of these dimensions, is achieved through a **Case** structure.

Selection of the two cases is done through the comparison between the value N that represents the output of the function **DAQmx Read** and constant 10^7 (considered to be cover for measurements made under the following conditions: measurement time for one direction of displacement about 33 minutes, $n = 200$ slots and maximum speed 1500 revolutions per minute.)

In Fig.20 we can observe screen captures of the front panel, which is also the user interface, corresponding to two states of operation for the virtual instrument for the two directions of movement. The sign "-" is chosen by convention for the values of movement to the left and

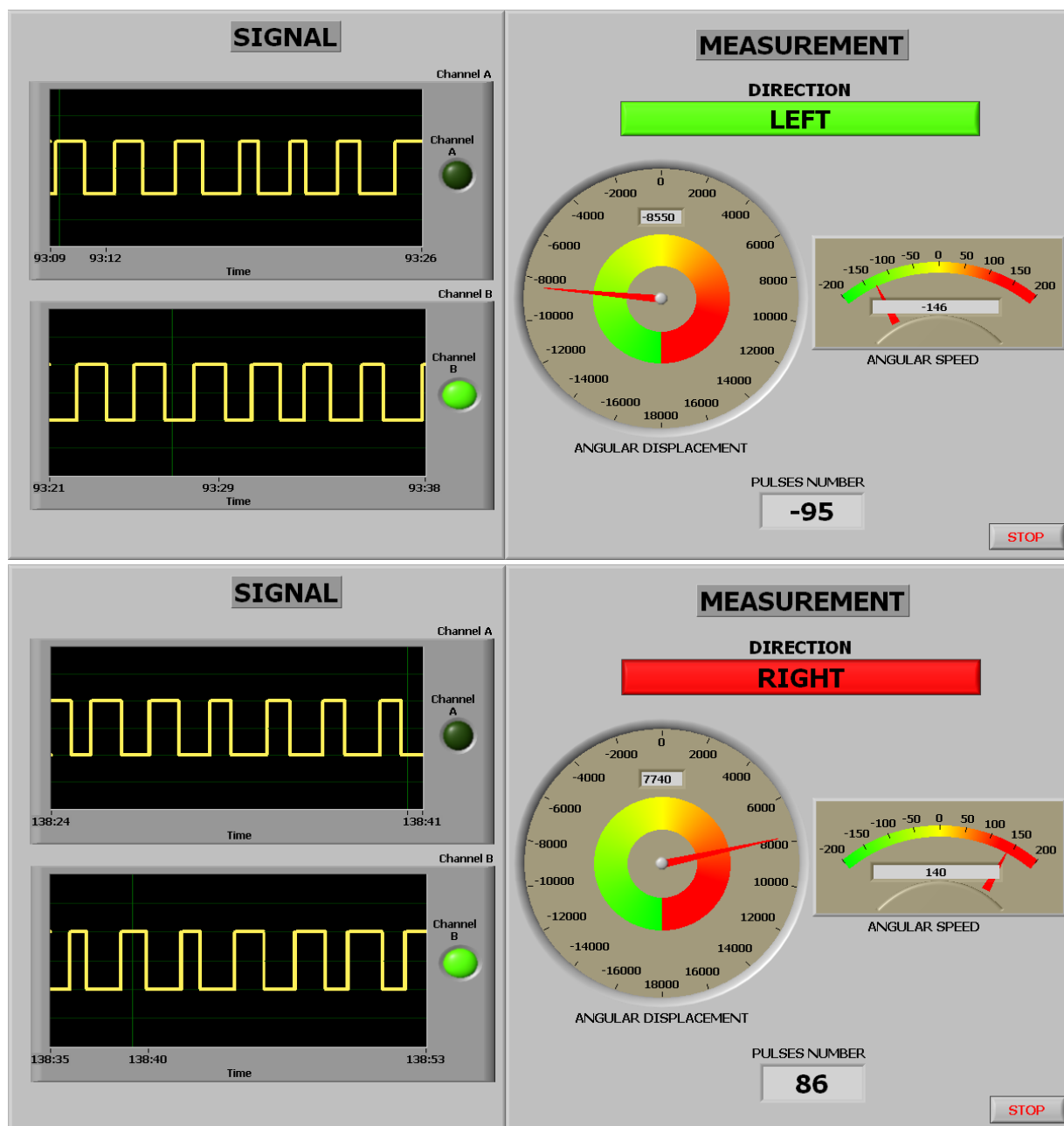


Fig.20. User interface of the virtual instrument

the sign "+" is chosen for the values of movement to the right.

Experiments with this virtual instrument, whose results are shown in Fig.20, were performed with an incremental encoder with 4 slots, which means 4 pulses per revolution ($n = 4$). As we can see in the case of movement to the left by the $N = 95$ pulses counting is obtained angular displacement, α :

$$\alpha(\text{degree}) = -\frac{3600}{n} \cdot N = -\frac{3600}{4} \cdot 95 = -8550 \quad (3)$$

The sign "-" which appears before the displacement value is obtained by downward counting of pulses and corresponds to the convention mentioned above.

Also, in the case of movement to the right by the $N = 86$ pulses counting is obtained an angular displacement, α :

$$\alpha(\text{degree}) = \frac{3600}{n} \cdot N = \frac{3600}{4} \cdot 86 = 7740 \quad (4)$$

The sign in this case is "+" and is obtained by upwards counting of pulses and corresponds to movement in the right (the same convention).

5 Conclusion

Using of this virtual instrument has a very high interest for data acquisition systems that do not accept at their counters signals provided by quadrature encoder, and these systems are used to measure displacements or angular velocities.

Testing the functionality of the system was realized for direction displayed and also for measuring displacements and angular velocities. Tests were performed using quadrature encoders with 4, 200 (E6A2-CW5C) respectively 500 (HEDS – 5500) pulses per revolution for a wide range of speeds, connected to digital inputs of the PCI – 6024E data acquisition board, from which were used the two counters *ctr1* and *ctr0*.

The solution presented can be applied to any data acquisition boards which no accept to their input signals in quadrature but have a FPGAs chip embedded that make possible to implement the logic functions (1) and the algorithms shown in Fig.16 and Fig.18

Also, the same software solution can be implemented in an 8-bit microcontroller even making it possible to connect directly a quadrature encoder for local control of processes where there are rotation or translation movements.

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