PROTEGE CYLCOCOMPUTERS AS REVOLUTION COUNTERS IN THE RRTC METHOD FOR COURSE MEASUREMENT

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ABSTRACT

I describe the operation of Protege electronic cyclocomputers that allows them to be used as precise revolution counters for bicycle wheels in the RRTC method for the measurement of running courses. A slightly simplified description of the operation is as follows. A wheel circumference of 10 meters is set into computer memory, so that for every revolution it senses that the wheel has traveled 10 meters and it therefore increments the displayed trip distance correspondingly by 10 meters or one digit. Thus the trip distance display can be taken as showing the number of whole revolutions, and precise synchronization with a graduated wheel rim allows measurement to within 0.01 rev.

Protege counters offer many advantages over the Jones, a non-zeroing mechanical counter, recommended in the current RRTC method:

1. Clarity of readings -- The standard Jones is mounted on the wheel axel with the display at right angles to the normal direction of eye scan. In contrast, the Protege is mounted on the handlebars and has a display that is 50% larger, so that it can be read comfortably while riding. Road safety, the ability to do night measurements, and error rate are all improved.

2. Instant zeroing capability -- Far fewer readings and calculations are necessary, so that efficiency is improved and error rate reduced.

3. Permanent installation -- Many measurers will want to remove the Jones after use because of noise, drag, and wear. The Proteges can stay in place and be instantly converted to normal bicycle computers.

4. Availability -- The Jones is available from only one supplier whereas the Proteges are available at many bicycle stores and on-line sites.

5. Cheapness -- The Jones costs $80-120 whereas a Protege can be had for as little as $15.

6. No wrap-around -- With the Protege counters the meter display never returns to zero before the end of the measurement, whereas this is always a possibility with the Jones.

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I. Introduction

In recent years I have described the operation of bicycle cyclocomputers as precise revolution counters with fractions of a revolution read from synchronized wheel-rim markings. These are advantageous replacements for the mechanical Jones meter in the RRTC Method for race-course measurement.

Unfortunately many of the suitable cyclocomputers are no longer available, and there has been a proliferation of wireless models which do not work because they do not register trip distance at slow speeds. However production of the Protege cyclocomputers by Planet Bike will continue indefinitely, and happily these are by far the best as revolution counters. They are unique in suitable cyclocomputers in that wheel circumference can be set as high as 9.999 meters, so that they can be operated as single-revolution counters with only a single magnet on the wheel .

In view of the importance of the Proteges I decided to devote this report exclusively to a detailed description of their operation for course measurement

II. Models and Availability

The Protege is available in three very similar models: 5, 8, and 9.

Shown is the Protege 9 which has the following functions:

1. Current speed

2. Ride time

3. **Trip distance (can be used to display revolutions)**

4. Dual odometers for two wheel sizes

5. Odometer for total of dual odometers

6. Average speed

7. Maximum speed

8. Clock

9. Speed comparator (speed compared with average speed)

10. Temperature

The first three functions are continuously displayed on the first three lines and the others are selected for the fourth by momentarily pushing the body of the computer forward.

The Protege 8 has the same functions as the 9 except that it does not display temperature.

The Protege 5 does not display temperature, average and maximum speed, and a speed comparator. It has only a single wheel size setting for a single odometer and therefore cannot be instantly converted to a normal bicycle computer. Also it cannot be used to make secondary measurements while suspending the primary one. Although it works as well as a revolution counter and may be simpler to program, the slightly smaller price does not justify its purchase over the other models.

The above models can be purchased at many bicycle stores and on-line sites such as planetbike.com. Jensonusa sells model 5 for $15 and 9 for $20 at their Ontario, CA, store and also on-line for the same price with an additional cost for shipping of $5.95 for one and $6.95 for two computers.

III. Computer Programming

1. Complete reset

1. Select "ODO" or "AVE" on fourth line of computer by pressing mode button.

2. Hold set button using a hairpin or large paper clip for 4 seconds.

3. Use mode button to select KM/H between KM/H and M/H. Press set button.

4. First digit of wheel circumference 1 will be flashing and change to 9 by pressing mode button. Press set button.

5. Repeat 4 until all four digits of circumference have been set to 9.

6. First digit of odometer for circumference 1 will be flashing, and all digits are changed to 0 or desired values as for the circumference above. (Confusingly this screen is labeled "ODO" whereas on the normal screen it is labeled "BIKE ODO".)

7. First digit of circumference 2 will be flashing. Repeat 4 to 6.

8. First (hour) digit of clock will be flashing. Set time to complete programming.

2. Reset of clock only

1. Select clock on fourth line.

2. Hold set button using a hairpin or large paper clip for 4 seconds.

3. First (hour) digit of clock will be flashing. Set time as above.

3. Instant conversion to normal bicycle computer mode

It is very useful to have both circumferences to set to 9999 mm as above because it allows the measurer to freeze primary measurement while he makes secondary measurements (eg overshoot correction).

However the second circumference can be set with the real value in mm so that if this is selected by pressing the circumference switch, conversion to normal metric computer mode can be made instantly. The mm value can be derived from the calibration data by dividing the course length in mm by the revolutions found. For instance I typically get 191.21 rev over a 400-meter calibration course for tire of 700 x 23 and this corresponds to a circumference setting of 400 x 1000 mm /191.21rev = 2092 mm/rev.

The best way to convert to normal mile mode is not as obvious. One can go through a complete reset and select M/H, but this is very tedious as it means operating the awkward rubber set button many times. Also one as to go through this all over again on conversion back to KM/H. A slightly better way is to set the computer aside for five minutes immediately after selecting M/H until it goes into sleep mode. One can then start using it in mile mode. The best way though is to calibrate circumference 2 in millionths of a mile. Then one can switch back and forth between revolution counter mode and normal mile mode by simply pressing the circumference button. With the tire mentioned above one has to set circumference 2 to 400 m x 1,000,000/(1609.344 m per ml x 191.21 rev) = 1300 millionths of mile/rev. Although the computer will then operate in mile mode, the screen displays in km/h.

IV. Wheel-Rim Marking

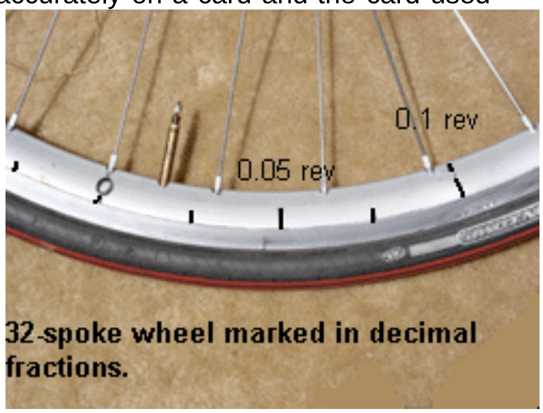
1. General instructions

Use a black Sanford Sharpie Permanent Marker to create very permanent marks on the rim. Red can be used to designate smaller divisions. Designate a zero spoke on the same side of the wheel as is desired for the computer sensor. (With some mountain bikes do the opposite.) Assign increasing values in an anticlockwise direction as viewed from the right-hand side of the wheel and clockwise from the left-hand side. (If it is found that the wheel has been marked in the wrong direction, simply turn it around in the forks.)

Time to mark a rim in decimal fractions of a revolution is less than 25 min. Time to mark in spoke intervals is 5 min.

2. Marking in decimal fractions of a revolution

Marking the rim requires estimation of 1.6 and 0.8 of a spoke interval for a 32-spoke wheel and 0.5, 0.6, 0.7, 0.8, and 0.9 for a 36-spoke. These can be measured accurately on a card and the card used repeatedly or simply eye-balled.



32-spoke wheel marked in decimal fractions.

(i) 32-spoke wheel

Mark the first divisions using the following precise correlations:

Spoke	0	4	8	12	16	20	24	28
Rev	0	0.125	0.250	0.375	0.500	0.625	0.750	0.875

Finally, using the fact that 0.8 spoke intervals equals 0.025 rev and 1.6 spoke intervals equals 0.050 rev, work on either side of the first marks until the whole rim is marked in divisions

(ii) 36-spoke wheel

Mark the first divisions using the following precise correlations:

Spoke	0	9	18	27
Rev	0.00	0.25	0.50	0.75

36-spoke rim marked in decimal fractions.

Finally, work on either side of the first marks until the whole rim is marked in divisions of 0.025 rev using the following correlations:

Spoke interval	4.5	3.6	2.7	1.8	0.9
Rev interval	0.125	0.100	0.075	0.050	0.025

3. Marking in spoke intervals

Marking a rim in spoke intervals is very fast and subsequent readings are very fast and accurate. Rotation can be read down to 0.003 rev equivalent to 0.06 of a count on the Jones, but the downside is that in order to correlate with meter readings in revolutions, the measurer has to divide rim readings by the number of spokes. Obviously though, this would be the method of choice when using a rented bicycle or a wheel that is only going to be used temporarily.

VI. Basic Measurement

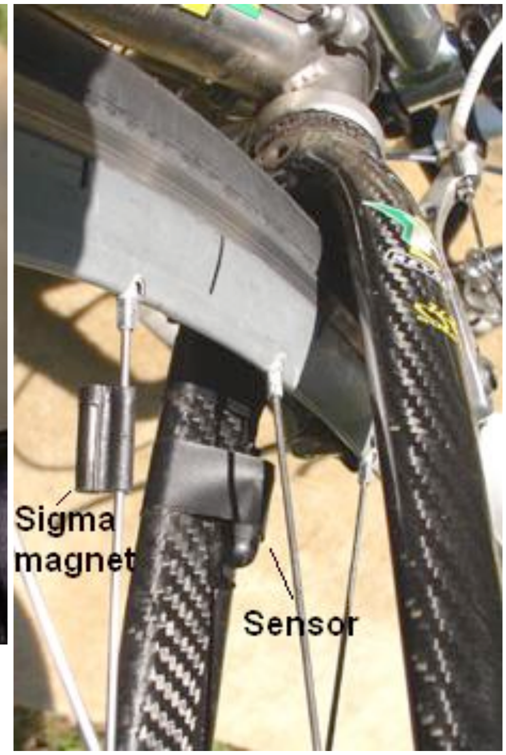
Align the zero graduation on the rim accurately with the starting point on the ground, **roll the wheel backward about 20 degrees**, and zero the trip distance on the third line of the meter by pushing the body of the meter forward in the bracket for about three seconds. Ride continuously until the desired revolutions are registered on the third line of the meter (ignore the decimal point) or until about one revolution before the desired finish. Stop the bicycle immediately and roll forward slowly until the desired fraction of a revolution is indicated on the wheel rim or until the wheel is aligned with the desired finish line. If there is a need to go backward through the zero point on the rim, note the meter reading at the stop and decrement this by one for every passage through the zero point. Repeat the whole process for measurements beyond the first finish point.

Do not roll backward through the rim zero point unintentionally as this can generate one or two spurious revolutions. Avoid stopping the bicycle during measurement, but if this is necessary do so immediately after the meter increments or glance down at the rim reading and stop remote from the zero point. The wheel can then be allowed to rock backward and forward moderately without affecting the revolutions displayed on the meter.

V. Installation

1. Install the computer bracket on the handlebars and insert the computer by pushing it forward into the bracket.

Meter mounted on a plastic tube between aero bars.



2. With electrical tape mount the sensor on the upper inside of the forks. Use the same side of the bicycle as was used to designate the zero spoke in rim marking. The foam backing may be discarded as it tends to squirm later.

3. Mount a magnet on spoke 20 of a 36-spoke wheel or 18 of a 32-spoke wheel. (Spoke numbers increase in the forward direction of rotation.)

4. Adjust the sensor - magnet clearance to about 1mm. The Protege magnet is nonadjustable for this clearance and to achieve this it may be necessary to move the magnet and the sensor downwards to a point where the spokes come closer to the forks. I prefer the much lighter Sigma Sport magnet that can be instantly snapped onto the spoke and easily twisted to adjust clearance very accurately. (This magnet is available from Nashbar for $0.99.) The only downside to the design is that by rough manhandling of the wheel the magnet can be knocked out of alignment. Use of the metal sleeve provided with the magnet protects the alignment slightly, but I usually do not use it. The sleeve slightly reduces the response of the sensor. Note that clearance is not critical as both magnets will operate up to a clearance of 8 mm.

5. Adjust the alignment of the magnet with the sensor. The center of the Protege magnet has to be aligned with one of the two circles marked on the sensor. The Sigma Sport magnet has to be centered on the sensor with each end of the magnet aligned with the center of a circle. Neither alignment is critical since both magnets will continue to operate up to 5 mm from these positions.

6. With mountain bicycles, mount the sensor low down on the forks on the opposite side to that of the zero spoke. Put the magnet on spoke 21 of a 36-spoke wheel.

7. Test the installation as follows. Roll the wheel to a ground reading of about 0.9 rev on the rim and zero the trip display by pushing the meter forward in its bracket for about three seconds. Roll the wheel forward for over a revolution until the trip distance increments by one. This should occur precisely at a rim reading of 0.00 rev. If this reading is off by a few hundredths of a revolution, correct by moving the sensor forward or backward on the forks. Note that the closeness of synchronization of the rim zero with that of the meter does not affect the accuracy of reading fractions of a revolution.


Rear of mtn-bike forks with magnet on spoke 21.

VII. Advanced Measurement Procedures

1. Suspending measurement

To suspend measurement, push the computer partially out of its mount to break contact with the sensor and freeze the display. Mark the wheel contact with the ground and note the rim reading. To resume measurement, reestablish the rim reading at the mark and push the computer all the way into its mount.

To avoid the requirement of noting the rim reading proceed as follows. Push the computer partially out of its mount and roll back the wheel to the zero point and mark it. To resume, establish the rim on the zero point at the mark, roll forward a partial revolution, and push the computer all the way into its mount.

Suspending measurement has many useful applications many of which will be described in detail later:

1. Miscellaneous functions such as eating and recovering dropped objects.

2. Marking splits with paint and nails while retaining overall measurement.

3. Overshoot correction while retaining overall measurement.

4. Making secondary measurements using the second-wheel setting to correct for overshoot and to explore alternative routes.

5. Offset correction to avoid temporary obstructions.

6. Measurements close to the zero point while ensuring overall measurement is retained.

2. Recovering from sleep mode

If the sensor receives no impulses for five minutes the computer enters sleep mode in which only the clock is displayed. The computer can be awakened on receiving a impulse by simply riding off, but this impulse will not be recorded . Therefore to resume measurement, first awaken the computer by briefly pushing it forward in its mount.

3. Readings within a few hundredths of a revolution from the rim zero

Measurers can get confused as to what meter reading of whole revolutions to combine with rim readings within a few hundredths of a revolution of the rim zero especially if the meter is not precisely synchronized with the rim zero. To avoid this confusion note the meter reading long before the rim reading is at the zero point, Take the rim reading at the desired measurement point, and if this is before the rim zero, combined it with the previously noted meter reading. If it is after the rim zero combined it with the previously noted reading plus one.

To retain the overall measurement be careful to avoid rolling back when near the rim zero point. Alternatively, freeze the meter reading before reaching the region by pushing the computer back slightly in its mount. After making the rim measurement near the zero, move the wheel well back from the zero and reconnect the computer.

The simplest method of taking readings close to the zero point is to stop the bicycle with a rim reading of say 0.025 rev before or after and estimate what the rim reading is for the desired point. Combined this with the meter reading.

4. Obstacles

To correct for an obstacle, suspend measurement as described in 1 above and move the bicycle at right angles to the side of the road to clear the obstacle. Resume measurement until past the obstacle and then reverse the procedure back to the side of the road.

A cruder method is to lock the font wheel with the brake while dragging the bicycle out and into the side of the road at right angles.

5. Calibration simplification

On the first two rides of the calibration course make measurements as usual. However on the last two rides do not use the meter but assume the same number of whole revolutions as previously found. Simply start the wheel on the rim zero and note the rim reading at the end of the ride.

6. Secondary measurements

Sometimes in the middle of primary measurements it is useful to suspend these as described in 1 above and make secondary measurements. For instance different possible routes can be explored or a missed split can be located.

Suspend primary measurement as above and select the second wheel size by pressing the switch at the top right-hand side of the back of the computer. Since the circumference should also have been set to 9999, the computer is now ready to function as a secondary revolution counter.

VIII. Methods for Splits

Two methods are used for splits the first of which involves using a table of revolution values calculated from the start or finish and the second involves simply the repeated use of the revolution value calculated for the length of each split.

The first method is more suitable when both km and mile splits are being measured on the same ride, and when determining all the mile splits during the ride of one leg of an out-and-back course with identical legs. After determining the working constant, a table of revolution values is prepared giving the location of the splits from the start or the finish. Since the meter is zeroed before the start of each measurement, this table is valid for the whole day and might possibly be printed from a computer at home. A similar table for the Jones usually has to be prepared by hand in the field at the start of each run. The suspension-of-measurement method should be used while marking the splits with nails and paint.

The second method is ideal where only one type of split is determined on the ride. The revolution value for each split is measured repeatedly along the course with zeroing of the meter and rim before each measurement. (With mile splits on a 5-km course, the distance of 0.171968 km between the 3-mile split and the finish also has to be measured.) Where both km and mile splits are desired on the course, km splits can be done on one ride and mile splits on another.

IX. Correction for Overshoot Errors

1. Introduction

The use of the Protege counter as compared with the Jones will greatly reduce the error of overshoot. The Protege can be read comfortably while riding and the marking of splits with rezeroing involves only being alert for the same three-digit number on the meter repeatedly. In contrast the Jones can only be read after stopping the bicycle and the finish estimated from the last stop while riding. Moreover a different five-digit number must be used for each split.

Notwithstanding the advantages of the Protege, correction of overshoot sometimes has to be made. With this type of correction, the Protege is sometimes at a disadvantage as compared with the Jones in that unlike the Jones it cannot be run backwards. When overshoot is short and there is a parallel reference such as a curbstone, correction can be made by simply backing-up the bicycle and the Jones is at an advantage. However, when overshoot is long there is no parallel reference, the bicycle must be ridden back and the advantage lies with the Protege.

Presented below are some correction methods. The precise method selected will depend on whether overshoot is short or long, whether correction is being made for a specific measurement value or a marked point, and whether retention of overall measurement is desired.

2. Return to last point measured

Returning to the last point measured is one of the simplest corrections for overshoot. Usually it involves only rezeroing and no calculation before remaking the measurement. This is in contrast with the Jones where a new table of values has to be calculated.

3. Specific measurement value

(i) Back-up

1. Note the excess number of revolutions.

2. Roll back through the zero point on the rim for the same number of times as the excess number and on to desired fraction of a revolution..

3. The meter can be used to count the number of times through zero. First roll forward through zero and rezero the meter.

(ii) Ride-back

1. Adjust wheel position to get reading for desired fraction of a revolution and mark on ground.

2. Note excess number of revolutions.

3. Turn bicycle around, place rim zero on the mark, back-up slightly, rezero meter, and ride for the excess number of revolutions.

4. Specific mark or point

(i) Back-up

1. Note the meter reading at stop.

2. Roll back to the mark or point counting the number of times passing through zero.

3. The meter can be used to count the number of times through zero. First roll forward through zero and rezero the meter.

4. Desired measurement = reading at stop - number of times through zero + rim reading at mark

(ii) Ride-back

1. Note the meter reading at stop, back-up to the rim zero, and mark ground.

2. Turn bicycle around, place rim zero on the mark, back-up slightly, rezero the meter, and ride to mark or point.

3. Desired measurement = reading at stop - final meter reading + rim reading at mark

5. Retention of overall reading

If retention of overall measurement is desired during correction in the methods described in 3 and 4, use the suspension-of-measurement method described in Section VII. If necessary use the meter in the second-circumference mode.

X. Half-Marathon and Longer Distances

This section need only concern the rare measurer who plans to measure a distance of 10,000 revolutions or more (approximately equivalent to a half-marathon or more) through a continuous ride. For this measurement the meter will display 9999 revolutions for two revolutions and the measurer should add one to all displays after the first one. Similarly, the meter will display 19998 revolutions for two revolutions and the measurer should add two to all displays after the first one.

What happens is that although through the basic mode of operating in this report the computer seems to increment trip distance by 10 meters for every revolution, it actually only increments 9.999 meters. The following table for the first nine revolutions makes clear what happens:

Rev from start	Meters sensed by computer	Trip dist
Rezeroing	0	0.00
0	9.999	0.00
1	19.998	0.01
2	29.997	0.02
3	39.996	0.03
4	49.995	0.04
5	59.994	0.05
6	69.993	0.06
7	79.992	0.07
8	89.991	0.08
9	99.990	0.09

After 9999 revolutions nothing remains in trip memory that is undisplayed, and at 10,000 revolutions the computer does not change the display but simply puts 9.999 meters into memory. At 10,001 the computer resumes incrementing with a display of 100.00.

The above correction to the display can be avoided if the circumference in computer memory is set to 5000 and a second magnet is placed diametrically opposite the first on the same side of the wheel. Note that in this mode of operation after aligning with the start, the wheel must be rolled forward not backward before zeroing the meter. Care will have to be taken to avoid rolling back unintentionally near a rim reading of 0.5 as well as 0, but no correction to the display need be made no matter how long the continuous ride.

XI. Advantages

1. Clarity of readings

The standard Jones is mounted on the wheel axel with the display at right angles to the normal direction of eye scan and is impossible to read while riding. Measurement finish has to be estimated from the reading at the last stop. Even after stopping digits cannot always be read if they are in the middle of a transition. In contrast, the Protege is mounted on the handlebars and has a display that is 50% larger, so that it can be read comfortably while riding.

Road safety is somewhat improved because the measurer does not have to take his eyes off traffic as much.

With the Jones I occasionally made errors in reading the meter such as omitting a digit. I have found that this never happens with the Protege where numbers are much smaller in value on the meter and fractions of a revolution on the rim are distinctly separate.

Although I have never done any, I imagine that night measurements would be greatly facilitated as compared with the Jones. Sigma Sport sell a light that can illuminate cyclocomputers.

2. Instant zeroing capability

The instant zeroing capability of the Protege means that far fewer readings and calculations are necessary than with the Jones. Obviously, efficiency is improved and error rate reduced.

It often allows particularly easy laying out of a course complete with splits. For instance after determining the working constant in rev/km, this value can be used repeatedly to mark km splits and complete a metric course by zeroing before measuring each split. Should anything go wrong in any one measurement, all that need be done is to return to the last split and rezero. To do this with a Jones would require calculation of a new table of values for the remaining splits.

3. Permanent installation

Many measurers will want to remove the Jones after use because of noise, drag, and wear. The Proteges can stay in place and be instantly converted to normal bicycle computers.

4. Availability

The Jones is available from only one supplier whereas the Proteges are available at many bicycle stores and on-line sites.

5. Cheapness

The Jones costs $80-120 whereas a Protege can be had for as little as $15.

6. No wrap-around

With the Protege counters the meter display never returns to zero before the end of the measurement, whereas this is always a possibility with the Jones.

7. No skip

In contrast with the Jones, the Protege never skips impulses without indication. In fact a measurer recently checked a Jones counter for skipping by using a Protege. If both counters are run simultaneously, counts shown by a new model Jones should be exactly 23.6363 times the revolutions found by the Protege. Those from an original Jones should be 20 times.

XII. Example of Actual Course Certification

1. Introduction

During the last two years I have certified over thirty courses of all types using the Protege counter. The example described here is that of a simple loop.

2. Course identification

Tiger Trot 5K, Fuquay-Varina, NC (NC04034PH)

3. Calibration

Tire: 700 x 20C at 105 psi

Length: 400 meters

Pre-measurement rides (69.7 degrees): 192.312, .31, .29, .29; ave, 192.30 rev .

Post-measurement rides (89 degrees): 192.09, .07, .05, .065; ave, 192.069 rev .

Constant for the day: 192.30 x 1.001 x 1000/400 = 481.23 rev/km = 774.466 rev/ml = 2406.15 rev/5km

4. Course measurement

Ride 1 (73-74 degrees): From the chosen start to a reading of 2406.15 rev, where a temporary finish was marked.

Ride 2 (76 degrees): Permanent marks were made at mile intervals of 774.47 rev. The distance from the 3-mile mark to the temporary finish was measured as 82.875 rev.

Total rev = 3 x 774.47 + 82.875 = 2406.285

The second ride gave 0.135 rev more than the first, so the temporary finish was made the permanent one.