VERICOM VC2000PC
DYNAMOMETER AND
BRAKING TEST COMPUTER
OWNERS MANUAL

Released June 30, 1999

1. INTRODUCTION

Welcome to state of the art technology in Vehicle Testing. The VC2000PC has been designed for ease of use and simplicity of operation for quick and easy results. The two most common uses of the VC2000PC in the Braking Mode are: (1) Determining the coefficient of friction of the road surface and (2) Analyzing the vehicle's braking ability. The five most common uses of the VC2000PC in the Acceleration mode are: (1) Measuring the ¼ mile time and speed, (2) Determining the best shift point, (3) Measuring wheel spin, (4) Measuring horsepower and torque, (5) Practicing reaction time.

Your VC2000PC will also measure lateral G Force. The more acquainted you become with your unit the more applications you will discover.

How it works

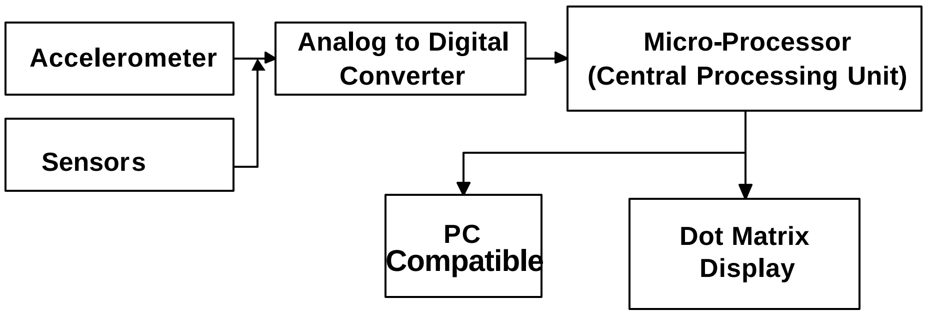
The measuring device built into the VC2000PC is a high-precision accelerometer, which measures motion as a rate-of-change of speed (deceleration & acceleration). The computer not only measures Peak G Force but also measures Average G Force, which is Drag Factor. The computer samples G-force 100 times per second to calculate Average G (Drag factor). With the use of a crystal clock the VC2000PC uses the G-force data and the time to calculate speed and distance through a mathematical process called integration. This entire procedure is referred to as inertial navigation. The VC2000PC is literally calculating speed, distance and horsepower 100 times per second.

G-force: One G is equal to the gravitational pull of the Earth on an object 32.17398 ft/sec^2 or 9.80665 m/sec^2.

If a car accelerates from a stop at the rate of one G (32.174 ft/sec × 3600 sec ÷ 5280 ft = 22 mph/sec) its speed is 2.2 mph after 0.1 second, 4.4 mph after 0.2 second, 6.6 mph after 0.3 second and so forth. Similarly, If a car accelerates from a stop at the rate of one G (32 ft/sec^2) it will have traveled 0.0016 ft after 0.01 sec, 0.16 ft after .1 sec, 16 ft after 1 second and so forth.

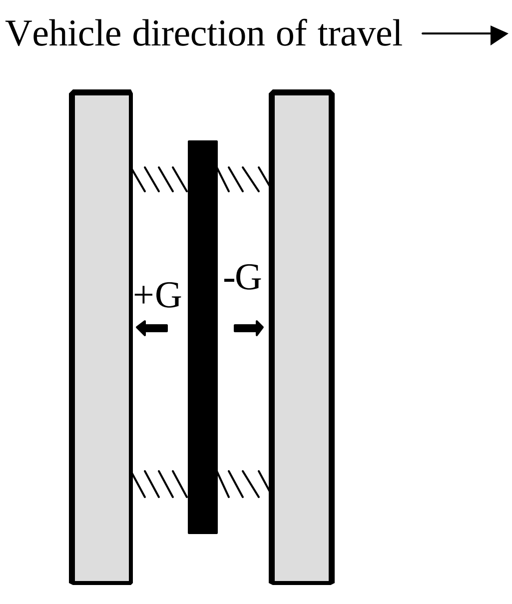
The sensor device is a spring-mass type accelerometer. G-force causes a deflection in the spring-mass and this minute movement is measured electronically. The complete device is referred to as a capacitance accelerometer.

Figure 1: VC2000PC Block Diagram



The accelerometer is composed of a transducer and hardware. The transducer is constructed of three layers in the form of a sandwich. The two outside layers are made of a rigid non-conductive material and the middle layer is a rigid central mass suspended by tin. The acceleration (G force) causes a minute deflection of the spring mass. The accelerometer measures the capacitance of the movement and converts that capacitance to one volt per G.

Figure 2

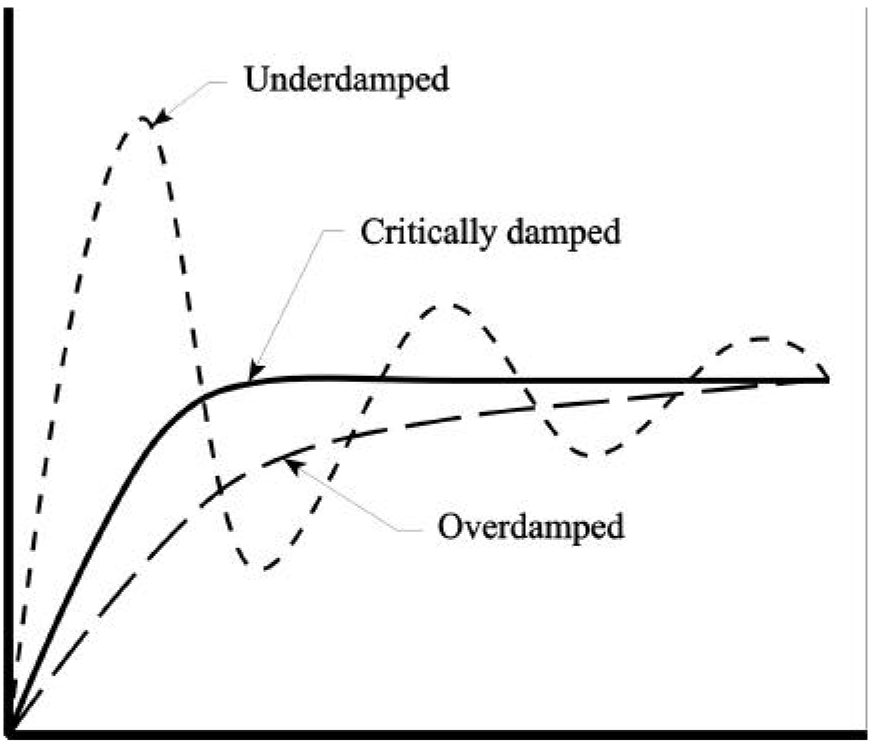


Spring Mass Accelerometer

In order to apply the laws of inertial navigation to calculate speed and distance accurately the accelerometer must be accurate and critically damped. A critically damped accelerometer will measure the change in G force in real time and allow you to record the true G force at the precise moment in time at which it occurred. An over damped accelerometer will measure the change in G force but not in real time, therefore showing a sudden change in G force as a slow change extended over a longer period of time. An under damped accelerometer will measure the change in G force but will show an overshoot in G force, therefore showing a higher peak G than actual.

The accelerometer in the VC2000PC is critically damped. Its ability to calculate speed and distance accurately as well as its ability to display the difference between static friction and kinetic friction demonstrates this.

Figure 3: Damping Examples



Improvements over previous models

The VC2000PC is new and improved. It is easier to operate, offers more information, is more versatile and it has twice the battery life.

1. A lithium battery backed Date/Time chip has been added to upload the date and time of each run.

2. Vehicle weight can be entered via the keypad.

3. Braking and acceleration runs are automatically saved in RAM sequentially starting with run number 1.

4. The setup such as tach factor, cal factor, threshold, number of sensors and weight are stored in permanent RAM.

5. A Data Acquisition Box may be added to monitor up to 16 extra sensors.

Options, Upgrades and Accessories

- Tachometer (VC2000PC-Tach).
  - a. Coil Pickup.
  - b. Inductive Pickup.
  - c. Magnetic Pickup.

- Portable, thermal printer.
- Transit software which gives distance at 20mph, and allows vehicle ID entry.
- Push button vacuum suction cups.

- 16 channel Data Acquisition Box.
- Lateral G sensor.
- Crash G sensor.
- Brake pedal pressure sensor.
- Contact factory for other sensors.

- Also available is a Brake Reaction Timer.

Putting your VC2000PC together

Check to see that the following items are supplied with your VC2000PC:

2 mounting brackets
4 vinyl suction cups
2 plastic knobs
2 plastic shoulder washers
4 screws
1 power cord
1 serial interface cable with adapter
2 3½" floppy disks
1 battery charger
1 external activation cable
1 VC2000PC manual, 1 Profile manual

With Tachometer option:

1 Tachometer decoder box

With Data Acquisition Box:

1 Data Acquisition Box
1 VC2000DA to DAB cable
Extra sensors purchased

1. Screw two suction cups into each mounting bracket with the screws provided. The screws should be snug, but not so tight as to strip out the holes in the suction cups.

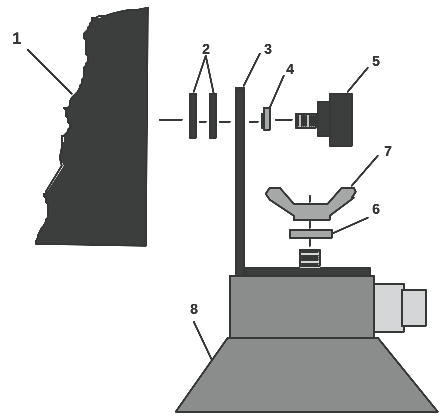
2. With a plastic shoulder washer seated on each bracket, screw the plastic knobs through the holes in the brackets and into both sides of the VC2000PC as shown in Figure 4. Do not tighten them until unit is leveled.

3. If you do not wish to use the batteries, plug the power cord into the back of the VC2000PC and into the vehicle's cigarette lighter.

Figure 4: VC2000PC Assembly

4. Plug cable with round DIN connectors into VC2000DA and DAB if extra sensors are going to be used. See page 30 for connection description.

With vacuum suction cups:



1. Adhere item 2 to item 1 & align mounting holes.
2. Adhere item 2 to item 3 & align mounting holes.
3. Insert item 4 into item 3.
4. Insert item through items 3 & 4 then screw into item 1.
5. Repeat steps 1-4 for other side.
6. Attach item 8 to item 3 using items 6 & 7.
7. Repeat step 6 for other side.

2. OPERATING YOUR VC2000PC: THE BASICS

Leveling

Choose a location on your windshield that best allows for viewing the display and operation of the function keys. Do not mount the VC2000PC on the windshield if that is in violation of federal, state or local laws. Be sure the windshield and suction cups are clean. You may have to moisten the suction cups. To release them pull the release tab located on the edge of each cup. Square the VC2000PC to within 3 degrees to the direction of travel and attach it to the windshield. Usually this means selecting a location that is roughly in the middle of the windshield.
You may position the vehicle level on a flat road surface or parking lot and use the supplied bubble level. Align the VC2000PC to within 3 degrees of level and tighten the plastic knobs. The VC2000PC will calibrate itself before each run, so you do not need an external bubble level to get full accuracy. Eyeballing it is sufficient. Your VC2000PC is ready for operation.

Turn on the VC2000PC. You will see a sign-on message scroll across the display. You may cut the message short by pressing any key. The VC2000PC will then display:

WAIT! !
Checking memory

briefly then

SELECT A MODE
OR OPTION
.

Modes of Operation

From 'SELECT A MODE' you may select from the three basic modes of operation of the VC2000PC: Acceleration runs, Braking runs and Continuous display of G or RPM with the Tach version.

If at any point you would like to back up and redo your steps, you can get back to 'SELECT A MODE' by pressing the **CLEAR** button a few times. Should you want further instructions on what to do next any time press the 9 (HELP) button.

Slope of the road and calibration

When performing a test the VC2000PC will calibrate itself for the slope of the road. The Average G-Force (Drag Factor) given by the VC2000PC will include the grade of the road.

When doing a long (¼ mile) acceleration test you will need a level test track to get good data from your VC2000PC. A rise or fall of several feet over a quarter mile will not effect the accuracy of the VC2000PC, but if you make your runs on a hilly road you will not get good data.

The VC2000PC will also give you accurate data if you operate it on a test track that is not strictly level but is of a constant grade. You must allow the VC2000PC to perform its calibration on that same grade. When investigating an accident on a grade, calibrate the VC2000PC at the scene of the accident and the data will be accurate.

When testing on an incline if you calibrate on the slope the VC2000PC's average G will be the Drag Factor and the number to use in speed formulas. Drag factor equals Coefficient of friction - (downhill) or + (uphill) gradient. When measuring Coefficient of Friction or Braking Efficiency do your skid test on a level road surface.

Just before a run the VC2000PC will calibrate itself. During calibration the vehicle must be at a complete stop and on the same grade that the test is being run.

See page 14 for how to measure gradient.

3. BRAKING MODE

The braking mode allows you to accurately measure a vehicle's braking performance and the average G (drag factor) of the road surface. To test a vehicle's braking performance you will need to perform the test over a straight and level surface. During the test the attitude of the vehicle must be straight and level within 4 degrees. When testing or measuring Drag Factor the road surface does not have to be level; however, you must calibrate the VC2000PC at the same spot you are testing. This will allow the VC2000PC to compensate for gradient and all data will be accurate. See page 14 for how to measure gradient. The VC2000PC will calibrate itself before each run. The vehicle must be at a complete stop during calibration.

After each run you will have data for:

- Braking run time
- Initial speed of braking run
- Braking distance
- Peak G during braking run
- Average G (DRAG FACTOR)
- G force every 1/10 second

Braking Data may be displayed in metric (see page 43).

Press **CLEAR** to get back to 'SELECT A MODE' and start a new run.

Getting VC2000PC ready

If you do not wish to use the batteries on the VC2000PC plug provided power cord into back of VC2000PC and into vehicle's accessory jack if one is available. Plug external activation plugs into VC2000PC if you are using them (see page 12 for external activation). Mount and plug in DAB if using it (see page 30) and install sensors if using them (see page 32). Mount the VC2000PC using the suction cups near the center of the windshield, but not so it blocks your vision of the road. Level the VC2000PC as described above. Drive to the spot you will be testing and bring the vehicle to a complete stop. Do not use this unit in violation of federal, state or local laws. For safety reasons the driver should never press any buttons on the VC2000PC while the vehicle is in motion. If observation and operation of the VC2000PC is required from a moving vehicle, use a separate observer/passenger. Please buckle up and drive safely.

How to determine DRAG FACTOR

1. From 'SELECT A MODE' press [1 Braking]. The VC2000PC will then show the time left in seconds, calibrate itself and display the file number being saved and then display:

   Push AutoStart

   Vehicle must be stopped at the scene of the accident on the same gradient.

2. Position the vehicle 300 feet before the scene of the accident (back up 300 feet).

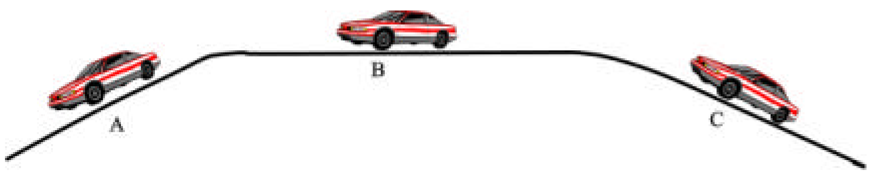
3. Press [4Auto Start]. The VC2000PC will display 'AutoStart ready'.

4. Accelerate to approximately 30 MPH, just before the scene of the accident hit the brakes hard and fast applying full brake pedal pressure until the vehicle comes to a complete stop. This will simulate an emergency stop.

Measuring coefficient of friction on a slope

When measuring drag factor the VC2000PC calibrates itself for the slope of the road; therefore the slope of the road is included in the drag factor measured by the VC2000PC.

calibrate at point B
do skid test at point B
$\mu = F \div W$
$f = \mu$ = Vehicle braking efficiency = .7



Calibrate at point A	Calibrate a point C
Do skid test at point A	Do skid test at point C
P = W(µcos +sin)	P = W(µcos -sin)
f = µ+sin	f = µ-sin
-.7+.1 = -.6	-.7-.1 = -.8
VC2000PC will display -0.600 Ave G	VC2000PC will display -0.800 Ave G

How to test a vehicle's brakes

1. From 'SELECT A MODE' press [1 Braking]. The VC2000PC will then show the time left in seconds, calibrate itself and display the file number being saved and then display:

   Push AutoStart

2. Turn DAB on if using extra sensors.

3. Press [4Auto Start]. The VC2000PC will display 'AutoStart ready'.

4. Accelerate the car to the desired initial braking speed.

5. After reaching the desired initial braking speed, hit the brakes hard and fast, applying maximum brake pedal pressure until the vehicle comes to a complete stop.

Using the VC2000PC in a Semi Tractor Trailer

Do not mount the VC2000PC inside the Cab if the tractor has an air ride suspension system. Vibration will cause faulty triggering.

Many of the newer tractors have an air ride suspension system that allow the cab to move up and down causing the VC2000PC to prematurely terminate a run. In this type of a vehicle do not mount the VC2000PC inside the cab. Mount the VC2000PC outside the cab on any portion of the vehicle that is mounted solid to the frame. Remove the mounting brackets from the VC2000PC and use a bungy cord or other tie down device to secure the VC2000PC to a flat surface.

How to avoid false triggering

To avoid false triggering of your braking run, you may press 4Auto Start any time after calibration.

The 3Countdown button may be used instead of the 4Auto Start button. To use countdown start, press the 1 Braking button, allow the VC2000PC to calibrate itself then accelerate the vehicle to the desired initial braking speed and press 3Countdown. The VC2000PC will initiate a countdown sequence after which time you should as efficiently as possible perform your braking run. The data will be of limited use because the time will be longer therefore giving a low average G, and Distance will be longer than actual braking distance.

Information available after a braking run

After a braking run time, speed, distance and average G will be displayed. Press the G button for more information.

```
2.18 sec.    39.1 mph
  59 ft   Avg G=0.818
```

Press 8G HP and it will display:

☞ Peak G and Average G.

```
Peak  G  =  -0.948  G
Average G = -0.818 G
```

☞ G force every 0.10 second up to 5 seconds.

```
G(0.0)sec  =  -0.22  G
Average G = -0.818 G
```

Time or Speed: The time from when the brakes were applied (see threshold page 41) until the vehicle came to a complete stop. The speed of the vehicle when the brakes were initially applied (see threshold page 41). The distance the vehicle traversed during the braking time. Average G force after the brakes were applied.

Distance (Transit version only):
Stopping distance assuming the vehicle was traveling at exactly 20 mph when the brakes were applied.

G: The average, maximum and instantaneous G force after the brakes were applied.

* The VC2000PC's Average G force (Drag Factor) is calculated using velocity and time.

$$f = \frac{V}{(g)(t)}$$

f = Drag Factor.

V = velocity in feet per second.
g = acceleration due to gravity (32.174 ft/sec²).
t = time in seconds.

To convert mph to ft/sec: $V_{(ft/\sec)} = \frac{V_{(MPH)}(5280)}{3600\ Seconds}$

Or just use: $f = \frac{V_{(MPH)}(0.04559)}{t}$

The Braking mode operating limits are:

	English	Metric
Maximum time	99.9 seconds	99.9 sec
Maximum speed	255 MPH	511 KPH
Maximum distance	9000 feet	1800 meters
Maximum acceleration	-2G	-2G

ABS Brakes

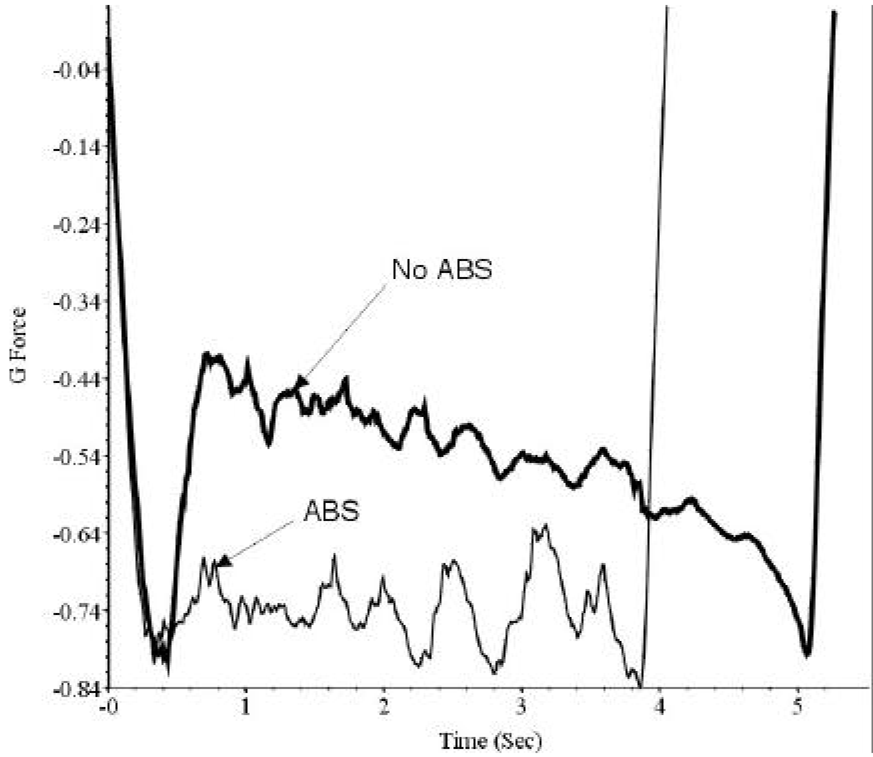
ABS will give you better steering control of the vehicle during an emergency stop and normally you can expect a higher drag factor with ABS brakes. The VC2000PC is an excellent device for testing vehicles with or without ABS brakes. Variations in anti-lock brake systems will occur due to:

1. The manufacturer of the ABS system.
2. Vehicle equipment with 2 wheel or 4 wheel ABS.
3. Road surface:
   a. Conditions: dry, wet or icy.
   b. Contaminated surfaces: snow or gravel.

With these variables the hypothesis follows:

1. All vehicles with ABS are easier to control during a braking skid.
2. Some vehicles equipped with four wheel ABS will produce a drag factor 15% to 20% higher on both a wet or dry surface.
3. All vehicles with ABS will produce a higher drag factor on a wet surface than the same vehicle equipped with standard brakes.
4. Some vehicles with two wheel ABS will show little or no difference in drag factor when compared to the same vehicle with standard brakes.
5. On snow and gravel standard brakes may produce a higher drag factor than ABS.

Figure 5: ABS vs. Non-ABS



4. FRICTION

The definition of friction is the resistance to motion between 2 surfaces. f = Force ÷ Weight.

Static Friction- The resistance to motion between two surfaces when the two surfaces are at rest. (spin velocity = longitudinal velocity)

Kinetic Friction- (sliding friction) The resistance to motion between two surfaces when one surface is sliding over the other at a constant speed.

Slip Friction- The friction between the tire and road surface when the spin velocity of the tire is less than the longitudinal velocity. Peak friction occurs at approximately 17% slip on a wet surface and 20% on a dry surface.

Drag factor- Coefficient of friction between that particular vehicle on that particular road surface under those particular weather conditions while that vehicles brakes are being applied. Drag factor is display by the VC2000PC as “Average G”.

Peak G- The absolute maximum instantaneous G Force experienced during the duration of the run. It usually happens just before the tires begin to slide. See Figure 5.

Average G- The G values added together and divided by the number of samples taken. In the VC2000PC the Average G is calculated using velocity divided by a conversion constant multiplied by time (see page 47). Profile adds the G values and divides by the number of samples. Average G is the drag factor or braking efficiency of the vehicle.

Table 1: Values for Coefficients of Friction

Material	Static	Kinetic
Steel on steel	0.74	0.57
Aluminum on steel	0.61	0.47
Metal on metal (lubricated)	0.15	0.06
Rubber on concrete	1.0	0.8
Glass on glass	0.94	0.4
Ice on ice	0.1	0.03
Teflon on Teflon	0.04	0.04

5. USING THE BRAKING SWITCH (External Activation Input)

When using the brake switch the brake run will start the instant the brake lights come on, which is typically before the .2G threshold is reached. Drag Factor (Average G) will be significantly less when using the external activation switch because of the increase in time due to the braking systems mechanical reaction time. The activation switch may be connected to other actuating devices other than the braking system.

This switch allows the operator to bypass the AutoStart G threshold. When using the brake switch the activation will be either a 12 volt surge or the G threshold (0.2G default) which ever comes first. This switch may be used in the Acceleration mode as well as the Braking mode. This external switch option is identified by a dual jack located in the back of the VC2000PC.

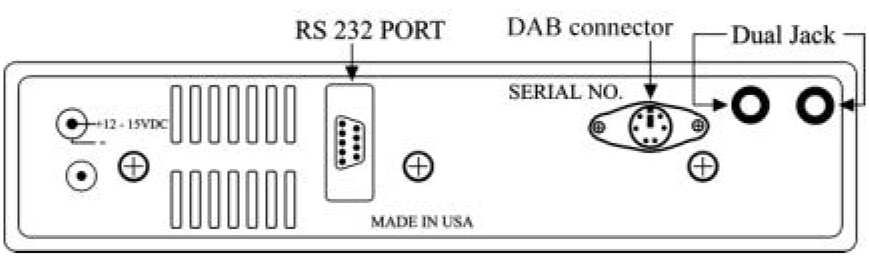


Figure 6: External Activation Switch

To install the external activation input, use the dual connector cable provided with optional alligator clips or banana plugs. When using external activation input as a brake switch, connect the dual cable to one of the following outputs:

1. Trailer light output jack (banana plugs fit most standard jacks).

2. Exposed terminals leading to brake light bulb.

3. Exposed terminals on brake light switch under dash.

Options with additional accessories:

4. Contact can be made to lead wires without removal of insulation with use of solder-less crimp-type connectors. (Available at most hardware stores or U-Haul locations).

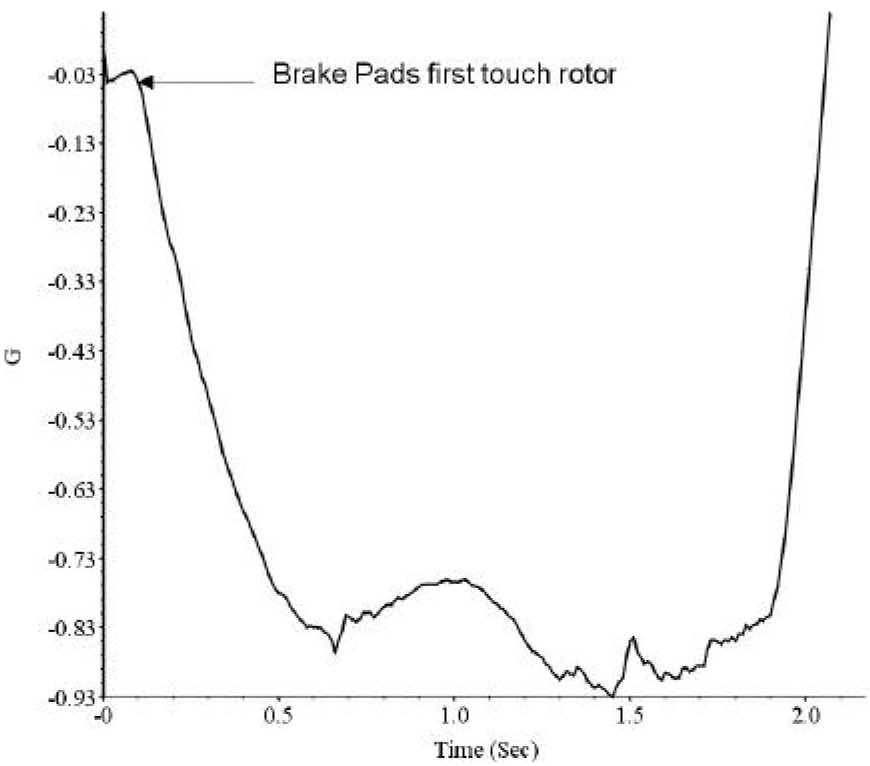
5. Custom brake light bulb with output leads. (Available at most U-Haul locations).

6. Brake pedal switch of electronic detonator (bumper gun).

7. Brake pedal switch of a fifth wheel.

Now insert dual male connector of cable into dual female connector located in the back of the VC2000PC. The tab on the double banana plug marked GND goes to the black connector on the VC2000PC.

Figure 7: Externally activated graph



To perform a braking run using the brake switch:

1. From 'SELECT A MODE' Press 1 Braking (VC2000PC will calibrate itself).
2. Press 4Auto Start. The VC2000PC will display 'AutoStart ready'.
3. Accelerate the vehicle to the desired initial braking speed.
4. After reaching the desired initial braking speed, brake as efficiently as possible until the vehicle comes to a complete stop.

Time will be the time from when the switch was activated to when the vehicle came to a complete stop. Distance will be the distance from where the switch was activated to where the vehicle came to a complete stop. Speed will be the speed when the switch was activated.

To avoid false triggering of your braking run, you may press 4Auto Start at any time after calibration. Your foot may be on the brake pedal when the 4Auto Start button is pushed but the next time the brake lights come on the unit will activate. You can test the operation of the switch before doing a run by pressing the [1 Braking] button, let it calibrate, push the [4Auto Start] button, then press the brake pedal. The VC2000PC should run momentarily then shut off.

6. MEASURING GRADIENT AND SUPERELEVATION USING THE VC2000PC

With this method it is critical that step 1 is conducted on a perfect level surface. Even slight angles will produce errors.

Method 1

1. Position the VC2000PC level in the axis of measurement (Figure 8). This should be conducted by placing the computer on a known level surface or with use of a level.

2. While in the level position, press the [2Continuous] button. The VC2000PC will calibrate itself, establishing a Zero G reference at level, and will display 0.000 G.

3. Place the VC2000PC directly on the surface where measurement is desired. Be sure the axis of measurement is directly in line with the measurement desired. A flat board may be placed under the VC2000PC to average unevenness.

4. The VC2000PC will now display a given number representing the sine of the angle. Conversion Table 2 will convert the sine number to percent gradient.

This procedure may also be conducted from a vehicle while the vehicle is parked on the surface of measurement. It will now be critical that the vehicle itself be level in the axis of measurement during calibration (step #2). Be aware that slight errors may be introduced due to vehicle suspension and payload weight distribution. Any change in weight and balance may produce a slight error.

Method 2

1. Position the VC2000PC in the axis of measurement (Figure 8). This can be conducted by placing the computer on the windshield and leveling (see page 5) and then positioning the vehicle on the incline. Be sure the axis of measurement is directly in line with the measurement desired.

2. While on the incline, press the [2Continuous] button. The VC2000PC will calibrate itself, establishing a Zero G reference at that angle, and will display 0.000 G.

3. Turn the vehicle 180° and position it at the same place as the unit was calibrated. Be sure the axis of measurement is directly in line with the measurement desired and that the VC2000PC was not readjusted since calibration.

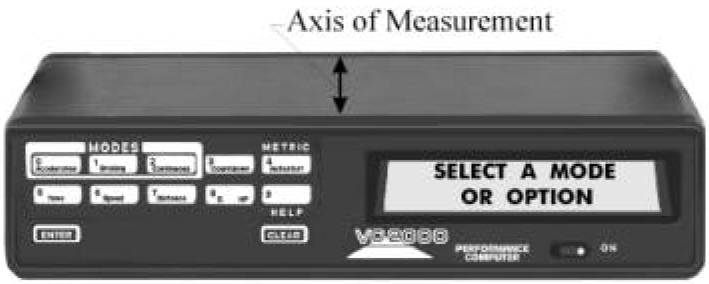
4. The VC2000PC will now display a number representing two times the sine of the angle. Divide the G force number by two and use table 2 to convert the sine number to percent gradient.

Table 2: Sine and % Gradient

Use Method 1 or 2 on the previous pages to determine the angle. Use a calculator to convert Sine to Degree, Superelevation, or Grade. G force = Sine of the angle.

Sine (G reading)	Degree (Sin^{-1})	Superelevation (Tangent)	% Grade ($Tan \times 10^2$)
0.000	0	0.0000	0.0
0.017	1	0.0174	1.7
0.035	2	0.0349	3.5
0.052	3	0.0524	5.2
0.069	4	0.0699	7.0
0.087	5	0.0874	8.7
0.105	6	0.1051	10.5
0.122	7	0.1227	12.3
0.139	8	0.1405	14
0.156	9	0.1583	15.8
0.174	10	0.1763	17.6
0.190	11	0.1943	19.4
0.207	12	0.2125	21.3
0.224	13	0.2308	23.1
0.241	14	0.2493	24.9
0.258	15	0.2679	26.8
0.342	20	0.3639	36.4
0.500	30	0.5773	57.5
0.707	45	1.000	100
0.866	60	N/A	N/A
0.984	80	N/A	N/A
0.996	85	N/A	N/A
0.997	86	N/A	N/A
0.998	87	N/A	N/A
0.999	88	N/A	N/A
0.999	89	N/A	N/A
1.000	90	N/A	N/A

Figure 8: Axis of Measurement



7. ACCELERATION MODE

Getting the VC2000PC ready

If you do not wish to use the batteries on the VC2000PC plug provided power cord into the back of the VC2000PC and into the vehicle's accessory jack if one is available. Plug Tachometer 9 pin D-Sub connector into VC2000PC if you are using it. (See page 27 for Tachometer). Mount and plug in DAB if using it (see page 30) and install sensors if using them (see page 32). Mount the VC2000PC using the suction cups near the center of the windshield, but not so it blocks your vision of the road. Level the VC2000PC as described on page 5. Drive to the spot you will be testing and bring the vehicle to a complete stop. Do not use this unit in violation of federal, state or local laws. For safety reasons the driver should never press any buttons on the VC2000PC while the vehicle is in motion. If observation and operation of the VC2000PC are required from a moving vehicle, use a separate observer/passenger. Please buckle up and drive safely.

The VC2000PC allows you to choose between two different ways of starting the run: **Auto Start or Countdown.**

Auto Start will start the VC2000PC timing when you launch the vehicle. It does this by sensing when the vehicle exceeds the G force threshold, which can be changed by pressing the 8G HP button at 'SELECT A MODE' (see page 41). To avoid false triggering you may press 4Auto Start any time after calibration.

Countdown start simulates a drag strip timer or "Christmas Tree." In a countdown start, the VC2000PC will display 'STAGED' for two seconds. The countdown will then start with '3333333' and countdown '2222222', '1111111' then 'R U N N I N G' and beep. Each count is displayed for 0.5 seconds for a total 1.5 second countdown. The timer starts when 'R U N N I N G' is displayed and the beeper sounds. The Reaction Timer starts when the VC2000PC displays '1111111'. Just like at a Drag Strip a reaction time of 0.500 seconds is perfect. It will display your reaction time at the end of the run when the time data is retrieved. The vehicle is allowed to move about one foot before the end of the countdown. If the VC2000PC senses more than one foot movement during the countdown it will display your Red Light reaction time and the run will cancel. The times the VC2000PC give from a countdown start is the time from when it displays 'R U N N I N G' to the QuickData™ point. In other words, the timer starts at the end of the countdown, not after 1 foot so to calculate actual E.T. you must subtract reaction time and add 0.50. You add 0.50 because the reaction timer started when it displayed '1111111'. Example: ¼ mile time = 13.94 sec. and reaction time = 0.68 sec., therefore 13.94-0.68+0.50 = **13.76 sec.** If Auto Start is used reaction time will display 0.00.

QuickSet™ Acceleration Runs

QuickSet™ assumes a ¼ mile acceleration run so programming to 1320 feet is not necessary. QuickSet™ records data at 7 other distance points and 2 speeds within the ¼ mile (QuickData™ table). See "Reading the data from the QuickSet™ run" on page 18.

To perform a QuickSet™ acceleration run:

From 'SELECT A MODE' press 0Acceleration. The VC2000PC will calibrate itself and then display:

Select an option or
Cntdown or AutoStart

Press either 4Auto Start or 3Countdown. Now start your run. If you selected Auto Start, launch the car hard enough to trigger the Auto Start threshold (see threshold page 41). If you selected Countdown, start your run when the VC2000PC displays 'RUNNING' or slightly before. Remember that each count is 0.5 sec long just like a "Christmas tree" and the VC2000PC allows 1 foot of travel before "Red Lighting." During a QuickSet™ run Time, Distance, Speed and G Force are displayed. RPM is displayed instead of G Force with the tachometer version.

If testing at a racetrack the VC2000PC can be calibrated in the lanes before the burn out box if it is level to save time. Then press 4Auto Start just before pre staging or staging. It won't start timing until the vehicle accelerates by more than 0.2 G's so creeping forward slowly will not trigger the VC2000PC.

Sample operating sequence for a QuickSet™ Auto Start run:

1. From 'SELECT A MODE' press 0Acceleration (VC2000PC will calibrate itself).
2. Prepare for run, such as heating the tires.
3. Press 4Auto Start. Run starts when 0.20 G is reached.
4. !Accelerate! Time, Distance, Speed and G Force display during the run.

Sample operating sequence for a QuickSet™ Countdown run:

1. From 'SELECT A MODE' press 0Acceleration (VC2000PC will calibrate itself).
2. Prepare for run, such as heating the tires.
3. Press 3Countdown. 'STAGED' is displayed, then it counts down: '33333' '22222' '11111' then 'RUNNING'.
4. !Accelerate! when 'RUNNING' is displayed or slightly before. Time, Distance, Speed and G Force display during the run.

The QuickSet™ run will end when:

1. The ¼ mile is completed.
2. 99.9 seconds has elapsed.
3. The vehicle exceeds 255 MPH.

4. Any key is pressed.

If you end at the quarter mile, the VC2000PC will display the quarter mile time, speed and G (or RPM). If you end the run sooner, the VC2000PC will display the last time, speed, distance and G (or RPM). Any information gathered up to that point will be available. Press [9] (HELP) to find out why the run ended. You can still read all the data gathered before the run ended.

The VC2000PC is accurate through the ¼ mile, however, it is not recommended for use over ½ mile.

Reading the data from the QuickSet™ run

After a QuickSet™ acceleration run, bring the vehicle to a complete stop. Press the option keys and the respective data will be displayed. When you get to the end of the data, the VC2000PC will loop back to the beginning. Press the following keys to scroll through the corresponding data:

QuickData™ table:
[5Time], [6Speed] or [7Distance]:

☞ Time, Speed and G at the ¼ mile.

☞ Time, Speed and G at 1000 feet.

☞ Time, Speed and G at the ⌨ mile.

☞ Time, Speed and G at 330 feet.

☞ Time, Speed and G at 60 feet.

☞ Time, Speed and G at 30 feet.

☞ Time, Speed and G at 15 feet.

☞ Time, Distance and G at 60 MPH.

☞ Time, Distance and G at 30 MPH.

[8G HP]:

☞ Peak G force and the speed and distance where it occurred.

☞ Average G force (Drag Factor).

Note: Peak horsepower is no longer displayed after a QuickSet™ run because it will almost always be the result of a shift (see page 25). Peak horsepower is displayed if you programmed the VC2000PC to a time, speed or distance.

Tach versions only:
[8G HP]:

☞ G force at ¼ mile.

☞ G force at 1000 feet.

☞ G force at ⌨ mile.

☞ G force at 330 feet.

☞ G force at 60 feet.

☞ G force at 30 feet.

☞ G force at 15 feet.

☞ G force at 60 mph.

☞ G force at 30 mph.

☞ Peak G force and the speed and distance where it occurred.

☞ Peak G force and the speed and RPM where it occurred.

☞ Average G force.

3Countdown: (Tach versions only)

☞ Peak RPM and the speed at which it occurred.

☞ Peak RPM and the horsepower and torque where it occurred.

Horsepower and Torque are calculated using actual vehicle weight. The default weight is 1000 pounds. If you didn't change the weight before the run started, the computer assumes the vehicle weighs 1000 pounds. In this case to get the correct working (rear wheel) HP or torque multiply the VC2000PC HP or torque number by your vehicles weight (including cargo) and divide by 1000. See the HP formula on page 47.

Press **CLEAR** to get back to 'SELECT A MODE' to start over.

Example table available after an acceleration run:

QuickData™ table

DISTANCE	TIME (sec)	SPEED (MPH)	G-FORCE	RPM *
¼ MI	1	10	19	28
1000 Feet	2	11	20	29
⌨ MI	3	12	21	30
330 Feet	4	13	22	31
60 Feet	5	14	23	32
30 Feet	6	15	24	33
15 Feet	7	16	25	34
17 ____________	8	**60 MPH**	26	35
18 ____________	9	**30 MPH**	27	36

Reaction time ___ . ___ ___

Peak G _______, occurred at ______ feet, at ________ mph, at _________ rpm

Pk rpm _______ , occurred at______ hp, at ______ tq, at_______mph *

*Available only with tachometer versions.

Data can be uploaded to a PC after the run by pressing the ENTER key. See "Transferring data to Profile" in the Profile manual.

Programmed Acceleration Runs

The programmed acceleration mode allows you to enter your own run parameter into the VC2000PC's program. You can design any run parameter you wish to measure by time, speed, distance or G force. In addition to QuickData™ information a programmed run will also give the end parameter data, peak HP and peak torque.

After a run the VC2000PC will display the following data:

- Time, speed, distance, G and RPM (tach versions) of the programmed duration.
- Any QuickData™ points reached.
  Reaction Time. (Countdown start)
- Peak G and the speed, distance and RPM where it occurred.
- Average G force.
- Peak HP and the speed and RPM where it occurred.
- Peak Torque and the speed and RPM where it occurred (tach versions only).
- Peak RPM and the speed, HP and torque where it occurred (tach versions only).

This information is available in metric (see page 43).

Sample operating sequence for 0 to 11.0 second run:

1. From 'SELECT A MODE' press 0Acceleration (VC2000PC will calibrate itself).
2. Press 5 Time.
3. Key in 11.0 sec. by pressing [1], [1], [0].
4. Press ENTER.
5. Press 4Auto Start or 3Countdown.
6. !Accelerate! Time, Distance, Speed and G Force display during the run.

Sample operating sequence for 20 to 65 MPH run:

1. From 'SELECT A MODE' press 0Acceleration (VC2000PC will calibrate itself).
2. Press 6 Speed.
3. Key in 20 MPH by pressing [2], [0].
4. Press ENTER.
5. Key in 65 MPH by pressing [6], [5].
6. Press ENTER.
7. Press 4Auto Start or 3Countdown.
8. !Accelerate! Time, Distance, Speed and G Force display during the run.

Sample operating sequence for 1000 ft run:

1. From 'SELECT A MODE' press 0Acceleration (VC2000PC will calibrate itself).
2. Press 7Distance.
3. Key in 1000 ft by pressing [1], [0], [0], [0].
4. Press ENTER.
5. Press 4Auto Start or 3Countdown.
6. !Accelerate! Time, Distance, Speed and G Force display during the run.

Sample operating sequence for .500 G run:

1. From 'SELECT A MODE' press 0Acceleration (VC2000PC will calibrate itself).
2. Press 8G HP.
3. Key in 0.500 G by pressing [5], [0], [0].
4. Press ENTER.
5. Press 4Auto Start or 3Countdown.
6. !Accelerate! Time, Distance, Speed and G Force display during the run.

Reading the data from a programmed run

The VC2000PC will display the end distance, speed, time and G (or RPM) when the run ends.

After a programmed acceleration run, bring the vehicle to a complete stop. Press the option keys and the respective data will be displayed. When you get to the end of the data, the VC2000PC will loop back to the beginning. The same information is available as a QuickSet™ run with the addition of the end parameter data, peak HP and peak torque.

Peak hp ________ occurred, at ________ rpm, at _______ mph
Peak Torque ________, occurred, at _________ rpm, at _______mph

Press the following keys to scroll through the corresponding data:

QuickData™ table plus end parameter:
5 Time, 6 Speed or 7Distance:

☞ Ending Time, Speed and G (or RPM).
☞ Time, Speed and G (or RPM) at the ¼ mile.
☞ Time, Speed and G (or RPM) at 1000 feet.
☞ Time, Speed and G (or RPM) at the ⌨ mile.
☞ Time, Speed and G (or RPM) at 330 feet.
☞ Time, Speed and G (or RPM) at 60 feet.
☞ Time, Speed and G (or RPM) at 30 feet.
☞ Time, Speed and G (or RPM) at 15 feet.
☞ Time, Distance and G (or RPM) at 60 MPH.
☞ Time, Distance and G (or RPM) at 30 MPH.
☞ Reaction Time.

8G   HP:

☞ Peak G force and the speed and distance where it occurred.

☞ Average G force.

☞ Peak HP per weight.

☞ Peak HP and the speed where it occurred.

Use Peak G to determine the hook up point. Peak G should generally occur in less than 10 mph and 2 feet. Note: Peak horsepower is no longer displayed after a QuickSet™ run because it will almost always be the result of a shift (see page 25). Peak horsepower is displayed if you programmed the VC2000PC to a time, speed or distance.

Tach versions only:

8G   HP:

☞ G force at ¼ mile.

☞ G force at 1000 feet.

☞ G force at ⌨ mile.

☞ G force at 330 feet.

☞ G force at 60 feet.

☞ G force at 30 feet.

☞ G force at 15 feet.

☞ G force at 60 mph.

☞ G force at 30 mph.

☞ Peak G force and the speed and distance where it occurred.

☞ Peak G force and the speed and RPM where it occurred.

☞ Average G force.

☞ Peak HP per weight.

☞ Peak HP and the speed and RPM where it occurred.

☞ Peak Torque per weight.

☞ Peak Torque and the speed and RPM where it occurred.

3Countdown: (Tach versions only)

☞ Peak RPM and the speed at which it occurred.

☞ Peak RPM and the horsepower and torque where it occurred.

Press **CLEAR** to get back to 'SELECT A MODE' to start over.

The Program Mode operating limits are:

	English	Metric
Maximum time	99.9 seconds	99.9 sec
Maximum speed	255 MPH	511 KPH
Maximum distance	9000 feet	1800 meters
Maximum acceleration	+3G	+3G
Maximum RPM	15,000 RPM	15,000 RPM

Data can be uploaded to a PC after the run by pressing the **ENTER** key. See "Transferring data to Profile" in the Profile manual.

Comparing track times to VC2000PC times

Consistency is the key to winning races at the drag strip. Quicker cars tend to be more consistent. The quickest car is not necessarily the car with the fastest speed. The car that reaches a higher speed more quickly goes at a higher speed for a longer time and therefore reaches the end of the track quicker. For example; a car that increases an extra 3 mph for 2 seconds at the beginning of the run has a quicker time than a car that increases an extra 5 mph for 2 seconds at the end of the run.

If you have the opportunity to compare your VC2000PC data against a drag-strip timer, you will notice that the speed will be about right on but the time will be 0.2 to 0.4 seconds slower than the track timer. The reason for this is roll-out. Roll-out-distance is the distance that the front tire of the vehicle rolls before clearing the light beam that starts the drag strip timer. Roll-out-time is the time between when the vehicle starts to move (the time the VC2000PC exceeds the Auto Start threshold) and the time the vehicle triggers the starting beam. The VC2000PC starts when the vehicle is launched hard enough to pull 0.2 G (see Auto Start threshold page 41). The VC2000PC starts timing the run this fraction of a second before the drag strip timer starts. Roll-out distance is only about a foot, but because the car is just starting to move it will take a few tenths of a second to travel that foot. You cannot just add that distance to your end distance (that is, program the VC2000PC to end at 1321 feet) because traveling a foot at the end of the run takes only a small fraction of the time to travel a foot at the start.

Shallow staging allows the car to be in motion when the track timer starts, therefore you will get the quickest ¼ mile time and fastest ¼ mile speed when shallow staging. Deep staging gives the slowest E.T. and is closest to the VC2000PC time. Assuming the difference between shallow staging and starting the timer is 18 inches, also assuming the average acceleration for the roll-out period is 0.6G:

Roll-out Time =

$$\sqrt{\frac{Rollout\ Distance_{(inches)}}{Acceleration_{(G)}}} \times 0.072 = \sqrt{\frac{18}{0.6}} \times 0.072 = 0.40 \text{ sec.}$$

In this scenario the time difference between a shallow stage at the track and the VC2000PC time would be 0.40 sec. If your launches are clean and consistent, then your roll-out time will be consistent.
The VC2000PC will measure the speed at the given distance. The track timers will average the speed for 60 feet. However, these two speeds should be within 2%. The VC2000PC also measures seven other intermediate speeds inside the ¼ mile (see QuickSet™ runs page 17).

Increase your engines breathing ability and you increase Torque and Horsepower. An increase in horsepower or an increase in torque means an increase in the vehicles ability to accelerate. Without going to the drag strip use the VC2000PC to measure the performance enhancements you have made on your engine. Selecting the proper suspension, tires and best gear ratio will give maximum acceleration as soon as possible, therefore resulting in the lowest possible E.T.

Interpreting your data

An accurate history of the performance of your vehicle is an essential tool when achieving maximum performance. To analyze the performance of your vehicle you must keep complete and accurate records of the test runs you have been performing.

Reaction timer

Reaction Time is a measurement of the divers skills. Reaction time is the time between the last yellow light and the time the front tire clears the starting photocell. Therefore reaction time does not effect the ending time or speed. However if two cars are exactly equal, the car with the best reaction time will cross the finish line first. The VC2000PC has a built-in reaction timer allowing you practice launching your vehicle. When countdown is used to start an acceleration run the countdown numbers are used to simulate “Christmas tree” lights. See countdown start on page 16 for more details.

What is G force?

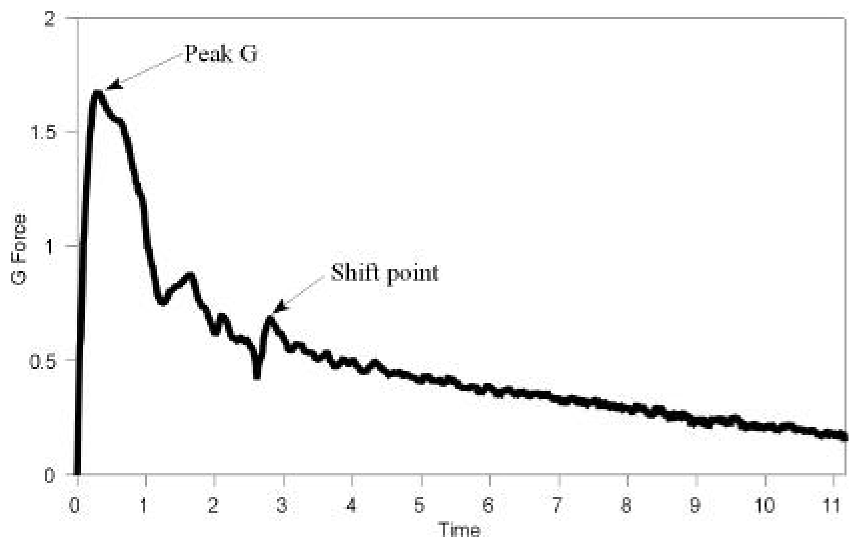
If you drop a ball it will gather speed as it falls toward the center of the earth. The rate at which it gathers speed is acceleration due to gravity or one G. One G = 32.174 feet per sec per sec, or ft/sec^2. The ball is gathering speed at the rate of 32 feet/sec^2 or 22mph per sec or 9.807 meters/sec^2. If a car accelerates at a constant one G it will be increasing its speed 2.2mph every 1/10 second, it will be going 22mph in one second, 44mph in two seconds, 66mph in three seconds, etc.

G Force is how we measure acceleration. Acceleration is the rate of change of speed (how quickly we are increasing our speed). The higher the G Force the quicker we increase our speed. It is difficult to get more acceleration forward on a vehicle than what the earth can do holding the vehicle down. Consequently, with street tires on the typical paved surface it is almost impossible to exceed one G in a vehicle when accelerating, braking or measuring lateral G force. Full race tires on a prepared surface, such as a drag strip, can exceed one G. Our accelerometer on the fastest top-fuellers and funny cars routinely measure over four Gs off the line.

Wheel spin - Peak G

In Drag racing consistency is very important. The VC2000PC will help you to be more consistent by telling you where the car is hooking up at. The peak G and speed at which it occurs should be consistent from run to run. If these are consistent then the rest of the run will be consistent. Speed and distance at peak G is generally where the tires stopped spinning, assuming there was no other slippage in the system and the car didn't bog. You want to develop the most acceleration as soon as possible to get the quickest time. Ideally, your peak G should occur near zero or at a few MPH and under two feet. Figure 9 has an ideal launch. Peak G is reached very early therefore gaining speed very early.

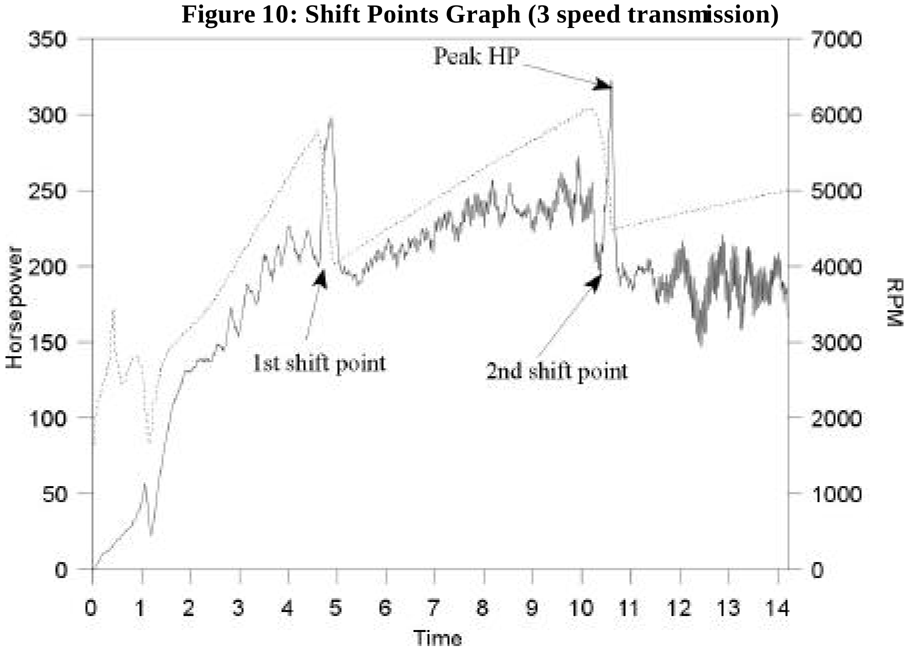
Figure 9: Time vs. G graph (2 speed transmission)



Shift Point - Peak Horsepower

The VC2000PC will give you Peak Horsepower and the speed where it occurred. This is net horsepower at the rear wheels. Use the MPH figure to find out which shift point it was when you developed peak horsepower. Peak Horsepower usually occurs at a shift point because of the surge of energy released after the shift. In the case of a torque converter energy is stored in the flywheel and torque converter while slipping into the next gear and released when the transmission fully engages into the next gear. During a normal run you will get peak horsepower just after the shift point from 1st gear to 2nd gear or from 2nd to 3rd. With the Tachometer versions or when calculating RPM, RPM will be low here because it is after the shift point.

Figure 10: Shift Points Graph (3 speed transmission)



Doing a run to find your optimum shift point

Net Peak Horsepower occurs at your optimum shift point. To make the most out of the horsepower available, you should shift at or just after peak horsepower. This will keep the RPM in the peak horsepower band after the shift. Its best to use peak HP from second to third gear as opposed to 1^{st} to 2^{nd} gear because a low gear ratio reduces HP output such as first gear, and higher speeds have more aerodynamic drag such as third gear. (See wind resistance and Rotational Inertia later in this section). Using Profile, graph using Primary and Overlay time on the X-axis, speed on the Y-axis and horsepower on the Y'-axis. You will be able to see the horsepower increasing and decreasing every 1/100 second. Use a smooth factor of 10 or greater to make the graph look more uniform. If horsepower decreases as RPM increases then the engine is over-revving and you should shift sooner. As speed increases wind resistance becomes a larger factor. So if horsepower seems to drop in high gear as speed increases it could be wind resistance increasing. Compensate for wind resistance in Profile by selecting accurate values for FlatPlate Area, Drag, Altitude, Wind and Temperature.

VC2000PC Horsepower

The VC2000PC gives you horsepower as a power-to-weight ratio. The VC2000PC defaults to 1000 pounds so if you didn't set it the horsepower will be horsepower per 1000 pounds. If you want to convert that figure to net horsepower of useful load at the rear wheels, multiply it by the weight of the vehicle (including cargo), in thousands of pounds. You only need to set the weight once in the VC2000PC and it will stay at that weight until changed again.

Example: The VC2000PC tells you that you developed 44 HP per 1000 pounds and your car weighs 2500 pounds (that's 2.5 thousand pounds). Your power at the rear axle is 2.5 X 44 = 110 HP.

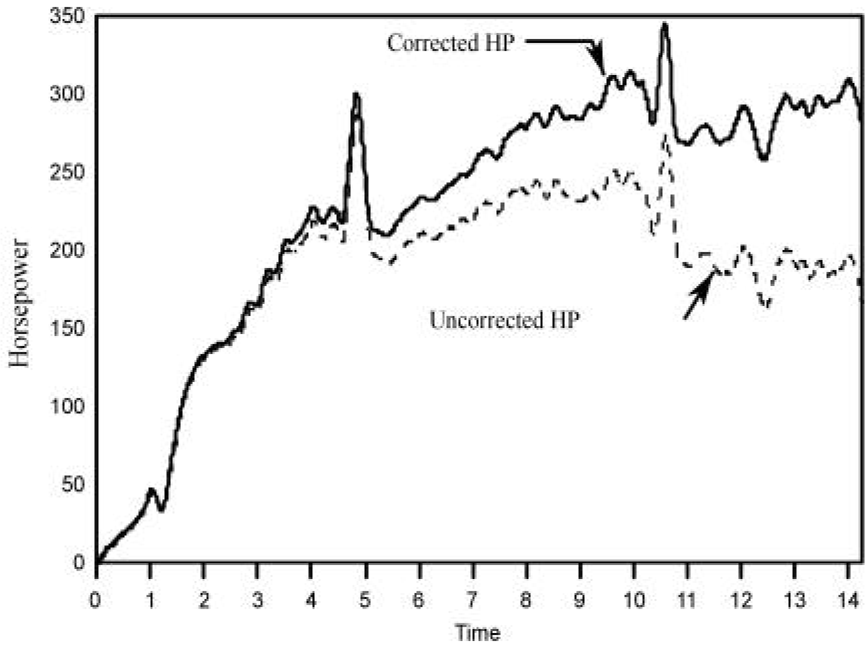
The horsepower measured by the VC2000PC is the net effective power acting on the vehicle. This figure takes into account all of the losses acting on the vehicle, therefore it will be lower than the figure you would get on a chassis dynamometer, and lower still than an engine dynamometer. An engine dynamometer measures only the performance of the engine and not the performance of the vehicle, it does not consider any losses caused by the drive train or wind resistance and is inconvenient to use. A Chassis dynamometer does not consider losses caused by wind resistance and is inconvenient to use. The VC2000PC is easy to use, inexpensive and takes into account all losses of power. The VC2000PC gives the best picture of how much effective horsepower your vehicle can actually deliver.

Here are some things that affect the Net Rear Wheel Horsepower.

Drive Train Losses. Losses of horsepower in the transmission are typically between 10-20 HP for standard transmissions, and about 20-40 HP for automatic transmissions. Friction in the bearings and rear end also are a source for horsepower loss.

Wind Resistance. This gets much greater at higher speeds. At 60 MPH wind resistance will absorb about twenty horsepower. As speed increases it takes even more horsepower to overcome wind resistance. The VC2000PC horsepower numbers displayed on the 40 character display will look like the uncorrected curve as shown in Figure 11. The VC2000PC and our Profile© application software can compensate for wind resistance losses (flat plate area) as shown in Figure 11 as corrected HP. You can use your VC2000PC to measure coast down drag at any speed and add the HP back into your HP figures (see page 36).

Figure 11: Wind effects on HP



Rotational Inertia. It takes a certain amount of horsepower to get the parts of the engine spinning as it increases in RPM. This is not a loss as such but it is horsepower that does not make it to the driven wheels. The effect of rotational inertia is significant enough that most cars will reach their peak effective horsepower in second gear (where the rotational inertia effects and gear ratio are less) instead of first gear (where wind resistance is lower). With a low gear ratio, such as first gear, more energy is transferred to the flywheel instead of to the driven wheels. A gear that max's out at about 70 MPH is the best gear to use for peak HP because the gear ratio is higher and wind resistance is negligible.

Transient Peaks. It is possible to get erratic horsepower readings with a standard transmission if you 'dump' the clutch or with an automatic transmission that shifts hard. If you are getting erratic horsepower figures that occur at one of your shift points, it is possible you are measuring such a transient peak rather than actual horsepower from the engine. As shown in the peak horsepower of Figure 11 the uncorrected curve would have been at the shift from 1^{st} to 2^{nd} gear.

Weather conditions. Altitude, Humidity, Temperature and barometric pressure affect horsepower a great deal and can be compensated for in Profile©.

VC2000PC Torque (Tach versions only)

Torque is calculated using horsepower x 5252/RPM. Like horsepower, torque is a power-to-weight ratio. The units are in foot-pounds for English and Newton-meters for metric. Also, like horsepower, torque is the net effective torque at the driven wheel after all losses. Transient peaks will still occur at a shift point and can be eliminated by the same procedure used for horsepower. On most engines max torque is low in the RPM range, while max horsepower is high in the RPM range. Therefore to find peak torque and the RPM where it occurs using the VC2000PC, do a programmed speed run from 0 MPH to about where the car would normally shift into 3^{rd} gear. Then take off hard enough to start the VC2000PC in first gear and allow it to shift into second gear so it is just above an idle in second gear. Now hold the throttle wide open until max RPM is reached in second gear. Don't allow the car to shift back into first or up into third gear.

8. TACHOMETER VERSIONS

The tachometer version of the VC2000PC gives RPM, Torque and gear ratio as well as the standard data (Time, Speed, Distance, G and Horsepower).

Tachometer options and Tach Factors

Three tachometer sensors are available:

1. Coil pick-up
2. Inductive pick-up
3. Magnetic pick-up

Coil pick-up

The coil pick-up uses signals from the low-tension side of the coil or the tach output of a spark controller unit to calculate RPM.

Connecting Coil Pick-up Assembly (CPA)

1. Connect wire from CPA box to VC2000PC connector.

2. Connect the red alligator clip to the low-tension side of the coil, or spark controller unit "Tach output" if a spark controller unit system is used, and the black clip to vehicle ground. Usually the red alligator clip will connect to the same signal wire as your current tachometer. Make all connections with engine and key off.

3. Secure CPA box with cable ties.

4 stroke engine with distributor and 1 coil

Num. of Cylinders	1	2	4	5	6	8	10
Tach Factor		2	4	5	6	8	10

4 stroke engine no distributor 1 coil for each 2 cylinders

Num. of Cylinders	1	2	4	5	6	8	10
Tach Factor		2	2		2	2	2

4 stroke engine no distributor 1 coil for each cylinder

Num. of Cylinders	1	2	4	5	6	8	10
Tach Factor	1	1	1	1	1	1	

2 stroke engine no distributor single coil

Num. of Cylinders	1	2	3				
Tach Factor	2	4	6				

2 stroke engine no distributor 1 coil for each 2 cylinders

Num. of Cylinders	1	2	3	4			
Tach Factor		4		4			

2 stroke engine no distributor 1 coil for each cylinder

Num. of Cylinders	1	2	3	4			
Tach Factor	2	2	2	2			

Inductive pick-up

The inductive pick-up measures current through the spark plug wire just as a timing light does. The current through the wire must be large enough to trigger an electrical switch. When there is little or no compression when the spark plug fires, such as in distributor less ignition systems, there will not be enough current through the wire to trigger the electrical switch. Therefore, a coil or magnetic pick-up should be used with this type of ignition system.

Connecting Inductive Pick-up Assembly (IPA)

1. Connect wire from IPA box to VC2000PC connector.

2. Connect ground wire (alligator clip) from IPA box to vehicle ground.

3. Connect inductive sensor to spark plug wire within 6 inches of spark plug.

4. Secure IPA box with cable ties.

Use Tach Factor 1 for all 4 stroke engines with a distributor when using the inductive pickup.

Magnetic pick-up

The magnetic pick-up uses magnets to trigger a switch in the sensor. The time between the magnets is measured to calculate RPM. It can also be used to measure drive shaft RPM if the magnets are installed on the drive shaft.

Connecting Magnetic Pick-up Assembly (MPA)

1. Connect wire from MPA box to VC2000PC connector.

2. Install magnets on a rotating shaft that is on a 1:1 ratio with the crankshaft. Be certain to space the magnets evenly or it will make the tachometer inaccurate and cause the engine to be out of balance. If used to measure drive shaft RPM, install the magnets just behind the front knuckle so suspension doesn't affect the distance between the sensor and the magnets. Use 2, 3, or 4 magnets to balance the engine or shaft.

3. Install the sensor in the supplied bracket or use your own if more convenient, then mount so the sensor is about ¼" away from a magnet. Point the sensor at one end of the magnets since the magnetic strength is greatest at its poles. Route wires away from rotating objects.

4. Secure MPA box with cable ties.

Figure 12

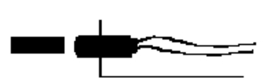


Figure 13

Number of Strips	1	2	3	4
Tach Factor	2	4	6	8

How to change the Tach Factor

1. From 'SELECT A MODE' push the 3Countdown button.
2. VC2000PC will display current tach factor and prompt for a new tach factor:

O l d TACH FACTOR = 8
New TACH FACTOR = 0

Now type a number for the correct Tach Factor then push **ENTER** or push **CLEAR** to abort.

The VC2000PC will remain at that Tach Factor until the Tach Factor is changed again.

Tach Factor = Number of signals per two engine revolutions.

To use as a Digital Tachometer

1. From 'SELECT A MODE' push the 2Continuous button.

2. Push the 3Countdown (RPM) button, the VC2000PC will now continuously display RPM.

3. Current RPM is displayed on the 1st line and peak RPM is displayed on the 2nd line

9. DATA ACQUISITION VERSIONS

The Data Acquisition versions (VC2000DA) come with a 12 bit analog to digital converter box that connects to the VC2000PC via cable. Up to 16 more sensors can be connected to this box. Lateral G accelerometers, Brake pedal pressure, Fluid pressure, and temperatures are only a few examples of the sensors that can be monitored along with the VC2000PC information.

Mounting and Connecting DAB:

Mounting the Data Acquisition Box (DAB) is not critical since it does not have any sensors inside. Secure it using screws, tape, seat belt, Velcro, etc. so it does not move around in the car when testing. Its best to face the switch in an easy to reach direction so the power can be turned on and off to conserve battery power. The cable connecting the DAB to the VC2000DA is a 6-foot long straight through 6 pin mini DIN cable. It is the same cable used for PS/2 mouse or keyboard extensions. Connect one end to the VC2000DA and the other end to the DAB.

Power and recharging:

The DAB has a NiCad rechargeable battery pack just like the one in the VC2000PC. To charge it plug the supplied charger into a wall socket and the other end into the DAB. The green light will come on indicating it is charging. The light will go out when the battery is fully charged. The red light comes on when the battery is low. A cigarette lighter adapter can be used on the DAB to charge the battery or to power the DAB when testing.

The DAB has both positive 5-volt and 12-volt regulated outputs to power your sensors. It is not necessary to use these as the power source for your sensors, it's just more convenient. Generally sensors will have 3 wires: one for power (usually red), one for ground (usually black), and one for signal. The 5 and 12-volt outputs can power up to 0.5 Amps of total current draw. That means all your sensors combined can draw no more than 0.5 Amps. If an over-current condition occurs a resettable fuse will break connection protecting internal circuitry. Once the power is turned off or the over-current condition removed the fuse will cool down and reset itself. The power output connectors are wired together internally so if all sensors require, for example, 12 volts you may put more than one wire in a terminal socket. The ground connectors are also wired together.

Push the Power button to turn the DAB on. The button will stay locked and illuminate when the power is turned on. Push it again to turn it off.

Sensor Connections:

The sockets in the DAB are designed for unterminated stripped wires. The wires should be stripped 6mm / 0.24in. Insert the wire so no bare wire is sticking out then tighten the screw. Some small wires may need to be doubled or tripled over for the connector to grasp it.

The signal wire will go into one of the numbered sockets (or G), the ground wire will go into any GND socket, and if using power from the DAB the power wire will go to either 5 volt or 12 volt. If the sensor has two ground wires one is for grounding the power and the other is for grounding the signal. When powering from the DAB both grounds can go to the same terminal.

Sensor Requirements:

Sensors connected to the DAB must have an output in the range of 0 – 5 volts. The sensor does not necessarily have to have an output of exactly 0 to 5V, but it has to be within that range. For instance a sensor from 1V to 4V will work. In the case of the Lateral G and Z-axis sensors, it is really a 2 G accelerometer that has a range from 0.5V (-2G) to 4.5V (+2G).

Note on Port 1 (G):

Port 1 on the DAB is different than the other ports because it filters any input to 3.5Hz and is calibrated to 0 when the VC2000PC calibrates its own accelerometer. It is intended for use in lateral acceleration. Other sensors may give erroneous information if connected to this port. If a lateral G accelerometer is not used connect other sensors to port 2 through 16. Port 1 will be wasted. The VC2000DA selects the ports sequentially so to use port 2, port 1 will be active. Set the number of sensors to 2 to use only port 2. Port 1 information will be bogus.

Setting the number of sensors:

The number of sensors must be set in the VC2000PC before it will read any data from the DAB. It only has to be set once and is stored in permanent memory. It will remain at that number until changed again even after the power has been turned off. Reading the ports is done sequentially so in order to read port 16 the number of sensors must be set to 16 in the VC2000PC. To set the number of sensors press the 3Countdown button. Type 0 to 16 then press ENTER or push CLEAR to abort. DA-Tach versions will bring up the tachometer factor screen first. Enter a new tach factor or press CLEAR, then set the number of sensors. See Port 1 note above.

Mounting the lateral G sensor:

It should be mounted near the center of gravity of the car and as level as possible. The center of the dash or a center console will work. It can be tilted in the front to back axis of the car but not in the side to side axis.

The positive wire goes to 12 volts, ground to ground and the signal wire to G (port 1).

Mounting the Brake Pedal load cell:

Slip the hook over the back of the brake pedal so the load cell is on the rubber surface of the brake pedal where your foot will press on it when braking. Make sure there is no mechanical interference due to the load cell that may cause the brakes not to work.

The positive wire goes to 12 volts, ground to ground and the signal wire to port 2 or above. The number of sensors must be set to 2 or above in the VC2000PC even if no sensor is connected to port 1 in order to read port 2 or above.

Test preparation when using DAB:

1. Set the number of sensors in the VC2000. (See page 32.)
2. Ensure mini-DIN cable is connected.
3. Check sensor connections.
4. Turn DAB on. Green light in switch should be on.
5. Check DAB low battery indicator. Lights when battery is low.
6. Press a mode key to begin test.

10. TRANSIT VERSIONS

The VC2000PC-TRS transit version is the same as a VC2000PC except it allows the user to insert a vehicle ID for each brake test, it calculates the distance at 20 mph for a brake test and it can print the information on a portable thermal printer.

Vehicle ID:

After pressing the **1Braking** button the VC2000 will display

Enter Vehicle ID:
0

The VC2000 saves the ID in memory so if it had been previously set it will display the saved ID. Up to 5 digits may be entered. Press **ENTER** to accept the ID shown on the display, or **CLEAR** to start over.

Distance at 20 mph:

After the test is complete, press the **7Distance** button to display what the distance would have been if the test were conducted at exactly 20 mph. Press the Time or Speed button to display the stopping time, speed, distance and average G. Press the G button to display the peak G and G every $1/10^{th}$ of a second.

Printing on the Thermal Printer:

Brake run information can be printed on a portable thermal printer using the same serial cable for uploading to your computer.

1. Connect the serial cable from the VC2000 to the Printer.
2. Turn the printer on.

3. From 'Select A Mode' or after a run, press the **ENTER** button.

4. Then press

Print or Upload?
1=Print 2=Upload

1 to print a run. After pressing 1 it will display:

File to transfer: 0
Use 99 to copy all.

A single file or all the files in memory can be printed.

5. Enter a file number to print or enter 99 to print all the files in memory. If file 99 is entered it will print the files sequentially from memory.

Example print out:

VERICOM VC2000

Vehicle ID Number: 12345
Run Number: 01

Time: 09:43 am Date: 06/30/1999

Time: 1.44 sec Speed: 18.8 mph
Distance: 20 ft Average G: -0.595

Distance at 20 mph: 22.7 ft

Signature________________

11. CONTINUOUS G MODE

In this mode the VC2000PC functions as a high resolution G meter, measuring acceleration in the front-to-back axis of the unit. The display is updated 12 times a second with an average of several accelerometer readings. This is useful for coast-down and lateral G measurements (see page 41).

To get into the Continuous G Mode:

1. From 'SELECT A MODE' press [2Continuous]. Vehicle must be stopped and level so the VC2000PC can calibrate itself accurately.

2. Push [8G HP] button. (Tach & Transit versions only)

3. The

Save in memory?
ENTER-yes CLEAR-no

message appears.

Push **ENTER** or **CLEAR**

Figure 14: Lateral G Mounting

4. Watch the G force increase or decrease as you accelerate or decelerate. Peak G force will be displayed on the second line.

When you come to a stop, G force will read out zero within 2%.

Lateral G Force

To measure lateral G force rotate the unit 90°. The unit should be mounted in the center of the windshield so that the top of the unit is parallel to the windshield and the front of the unit is facing the passenger side of the vehicle. Use the aid of a passenger to observe the G force. In this position the VC2000PC will read a negative G force for a right turn and positive G force for a left turn. Calibration factors do not affect lateral G force (see page 41).

Example:

1. From 'SELECT A MODE' press 2Continuous. Vehicle must be stopped and level so the VC2000PC can calibrate itself accurately.

2. Drive the vehicle through a turn or in a circle.

3. The message Save in memory? ENTER-yes CLEAR-no appears.

Push ENTER or CLEAR

4. Peak G will be displayed on the second line.

Max Lateral Acceleration can be measured using the VC2000PC. The vehicle is driven in a circle accelerating and turning inward toward the center of the circle making the radius smaller until the vehicle skids laterally (sideways). This is called a skid pad test. When using the Coefficients of Friction to compare different road surfaces for skid pad testing static friction should be used instead of kinetic friction because "peak" G is being measured.

Pylon testing can also be performed but the VC2000PC will only read the peak G force for positive or negative, not both. The VC2000PC is best suited for pylon testing because the G force can be loaded into a PC compatible computer and analyzed every 1/100 sec.

Average lateral acceleration can be calculated by using the formula:
$Lf = V^2 \div (R \times g)$
where Lf is lateral acceleration, V is velocity in ft/sec, R is radius in feet and g is 32.2 ft/sec².

Example:

$V = 30$ mph or 44 ft/sec, and $R = 80$ ft.
$Lf = (44 ft/sec)^2 \div (80 ft \times 32.2 ft/sec^2)$
$Lf = 1936 \div 2576$
$Lf = 0.75$ G

The Data Acquisition Box and a lateral G sensor will provide both lateral and longitudinal G force at the same time.

Superelevation of curves

$e + f = V^2 \div (R \times g)$
$e + f = V^2 \div (R \times 32.2)$
$e + f = (S^2 \times 1.467^2) \div (R \times 32.2)$
$e + f = (S^2 \times 2.152) \div (R \times 32.2)$
$e + f = S^2 \div (15R)$

Where:
e = Superelevation
f = Coefficient of friction (sleet & rain conditions ie .18)
S = Speed in mph
R = Radius in feet

When using the VC2000PC to measure centripetal force compensated by Superelevation.

	Ball Bank Indicator	VC2000PC Reading
0 to 25 mph	14^0 or less	.240
25 to 35 mph	12^0 or less	.210
35 mph and up	10^0 or less	.170

Coast down drag

You can use coast down G to find what your road horsepower losses are.

VC2000PC alone method:

To measure coast down drag you will need a long flat test sight and two people. At a level stopped reference point enter Continuous G mode. Accelerate to the desired speed and coast. Do this by disengaging the clutch or putting the automatic transmission in neutral. Have the observer record the G-meter value while you simultaneously count off the speed given by your car's speedometer. Travel in each direction to compensate for wind, then take the average.

Road Horsepower loss = Speed (MPH) X G (at that speed) X .002667 X vehicle weight (including cargo).

Example of Coast Down:
At 60 MPH we record .056 G of drag, so that means that the combined loss of wind and rolling resistance is:
60 x .056 x .002667 x 2340 = 20.97 HP.

Profile method:

Using Profile is the easiest and most accurate way to perform a coast down test. Use a timed acceleration run or continuous mode. Accelerate to about 60 mph then disengage the clutch or put the automatic transmission in neutral. Coast for about 5 seconds or more. Let the timer run out or press a button if using the continuous mode. Then upload the file to Profile and use the flatplate calculation feature under the Tools menu. See profile’s help about using the flatplate calculation.

12. CONTINUOUS RPM MODE

In this mode the VC2000PC is used as a digital storage tach. It will display the max RPM obtained since entering this mode. Mounting has no effect in this mode since the RPM sensor is independent of G force.

To get into Continuous RPM mode:

1. From 'SELECT A MODE' press 2Continuous.

2. Push the 3Countdown (RPM) button.

3. The message Save in memory? ENTER-yes CLEAR-no appears.
Push ENTER or CLEAR If saving the run the VC2000 will calibrate the accelerometers.

4. Watch the RPM on the digital display. Peak RPM will be displayed on the second line of the display.

13. CONTINUOUS SENSOR MODE

In this mode you can check or monitor any sensor connected to the DAB. It is useful to check sensors for connectivity or functionality. The VC2000 displays the voltage of the sensor.

The number of sensors must be set to the sensor you want to monitor or higher. For example if you want to monitor sensor number 9 the number of sensors must be set to 9 or higher. To set the number of sensors press the 3Countdown button form 'Select A Mode'. Type 0 to 16 then press ENTER.

To get into Continuous Sensor Mode:

1. From 'SELECT A MODE' press 2Continuous.

2. Press the 4Auto Start button.

3. The message appears.

Save in memory?
ENTER-yes CLEAR-no

Push ENTER or CLEAR If saving the run the VC2000 will calibrate the accelerometers.

4. Then it will display:

No. of sensors = 9
Sensor to Monitor: 0

The top line displays what the current number of sensors is set to. The sensor to monitor must be equal to or less than it.

5. Enter a number less than or equal to the current number of sensors then press ENTER.

6. The display will show the voltage of the selected sensor. Activate the sensor to show a change in the sensor. In the case of accelerometers tilt them to sense gravity to see the voltage change.

If the sensor shows no change, check the wire connections, make sure the DAB power is on and make sure the mini-DIN cable is connected. A voltmeter may be used to check the sensor also if you suspect a problem with the sensor. Leave the sensor wires connected to the DAB and use the red probe on the sensor output (usually the white wire) and the black probe to ground. Check the supply power also, 12V or 5V.

If the sensor has no output, 0 V, a wire could be broken inside the insulation or the sensor could be malfunctioning.

14. OPERATING VC2000PC: FURTHER CONSIDERATIONS

Four methods to confirm the accuracy of the VC2000PC

1. Gravity: When measuring a slope the G force reading equals the sine of the angle. The sine of 90^0 is one.

2. Radar gun: Compare the VC2000PC speed to the radar speed.

3. Shot marker: Compare the VC2000PC distance to the shot marker distance.

4. Timer: Compare the VC2000PC time to the drag strip time.

An accelerometer is a single axis instrument that can measure both acceleration and deceleration. For traffic accident investigation an accelerometer is used almost exclusively in the horizontal position and is normally used to measure longitudinal G-force; however it can be rotated 90° to the left or right to measure lateral G-force but it can only be used to measure one axis at a time. Likewise it can be rotated 90° up or down to measure the vertical axis such as the acceleration of an elevator, in the vertical position an accelerometer can be used to measure the gravitational pull of the earth.

When measuring drag factor the VC2000PC calibrates itself for the slope of the road; therefore the slope of the road is included in the drag factor measured by the VC2000PC.

The VC2000PC is calibrated to ±0.005 G.

To check the calibration of the VC2000PC using gravity only four items are needed:

1. A VC2000PC (without the mounting brackets)
2. A known flat and level surface
3. Gravity
4. A small mirror

Place the VC2000PC on its top so the unit is upside down and flat on the level surface with the display facing you.

1. Turn the unit on.

2. 'SELECT A MODE' will be displayed.

3. Press the 2Continuous button: Unit will calibrate itself for temperature and incline, do not move the unit during this time.

4. '+0.000 G' or '-0.000 G' will be displayed on the top line. Unit may now be moved. The bottom line of the display shows the peak value only.

5. Rotate the unit 180° so its bottom is flat on the level surface and the display is facing you.

6. '0.000 G' ±0.010 will be displayed on the top line. Calibration check step 1 is complete.

7. Rotate the VC2000PC 90° so the front panel is facing up and parallel to the level surface. If there is a switch or connector on the rear panel the unit will not set flat; Therefore, allow that portion of the unit to hang off the edge of the level surface. Now only approximately ½ of the unit will be resting on the level surface.

8. Press the **CLEAR** button: 'SELECT A MODE' will be displayed.

9. Press the 2Continuous button: Unit will calibrate itself for temperature and incline, do not move the unit during this time.

10. '+0.000 G' or '-0.000 G' will be displayed on the top line. Unit may now be moved.

11. Rotate the VC2000PC 180° so the front panel is facing down and parallel to the level surface, allowing the display portion of the unit to hang over the edge of the level surface.

12. Using a mirror '+2.000 G' ±0.020 will be displayed on the top line. Calibration check is completed.

To confirm accuracy using a radar gun:

On a flat, level surface perform a QuickSet™ acceleration run. Stop accelerating at 1000 ft and maintain a constant speed up to the ¼ mile. The radar should record the speed at the ¼ mile. The VC2000PC should be within 2% of the radar's speed.

To confirm accuracy using a Shot Marker:

The optional external brake switch for the VC2000PC must be used. Plug the double banana plug into the VC2000PC, with ground tab to black. Connect the red end to the same source that activates the shot marker, usually a brake pedal switch or the brake lights. Connect the black end to ground. The distance should be within 2%.

Tips on getting accurate results

Keep the vehicle's direction of travel as straight as possible, no more than 4 degrees variance. When testing a vehicle's performance be sure the track is level.

Be sure you are launching or braking hard enough to trigger the AutoStart threshold right away. If you launch or brake too gradually you will be increasing or decreasing a few miles per hour before the VC2000PC starts timing.

The VC2000PC will calibrate itself to accommodate for slight mounting tilt and for the track grade before each run. Be sure the spot where the VC2000PC calibrates itself is the same spot where you perform your test, also be sure the vehicle is at a complete stop during calibration.

The VC2000PC itself must be secure enough so that it does not tilt in its mounting during the run.

Errors in the VC2000PC build up with time into the run. A short aggressive run on a level road will give a more accurate result than a leisurely run over a hilly road.

When testing a vehicle's performance keep the vehicle level, an angle of up to 5 degrees will not substantially effect the VC2000PC.

When comparing the VC2000PC to any other device the two devices must start at exactly the same time for the data to be meaningful. For instance if you compare the VC2000PC to a Shot Marker the external activation switch must be used on the VC2000PC from the same source that activates the Shot Marker.

Vibration:
Some vehicles vibrate causing errors in the VC2000PC. Mount the VC2000PC using the shortest holes in the brackets if possible. If you feel vibration is a problem, move it low enough on the windshield so it rests on the dash. If vibration is still a problem it may be necessary to mount it in foam. Place the VC2000PC on about 1 inch of foam and secure using rubber, nylon or other flexible straps. Be sure to keep the VC2000PC level to the road surface.

Using and changing the AutoStart threshold

When using the AutoStart mode, the VC2000PC starts timing your run when the vehicle reaches a ±0.2G threshold. If you launch or brake too gently you will be accelerating or decelerating before the VC2000PC considers the run to have started, so your run will be off by that much. Be sure to launch or brake hard enough to trigger the VC2000PC the instant the car changes motion; otherwise your data will be off by the time and speed it takes for the car to reach the ±0.2G threshold. If you have trouble launching or braking hard enough to trigger the AutoStart threshold, use the Countdown mode or change the G threshold to 0.1G. If the VC2000PC is starting too soon such as in a large truck that decelerates quickly when there is no throttle applied, use a 0.3G threshold.

To change the 0.2G default threshold:

1. From 'SELECT A MODE' press 8G HP.
2. The display shows the current threshold on the top line.

   Old Threshold = 0.20
   0, 1, 2, 3 HELP?

3. Choose new G threshold.
   a. Press 0Acceleration to select 0.05G threshold.
   b. Press 1Braking to select 0.1G threshold.
   c. Press 2Continuous to select 0.2G threshold.
   d. Press 3Countdown to select 0.3G threshold.
   e. Press 9 (HELP) for instructions.
   f. Press **CLEAR** to exit.

This will be the G threshold until you change it again with this function.

Entering your vehicles weight

The VC2000PC defaults to 1000 pounds unless you have changed it. It recalls the last weight you typed in even if the batteries have gone dead. Profile reads the VC2000PC's weight when uploading to a computer. Vehicle weight is used in horsepower and torque calculations. If you do not change the weight, horsepower and torque will be per 1000 pounds. Simply multiply by vehicle weight (including cargo) and divide by 1000 to get actual rear wheel HP and torque.

1. From 'SELECT A MODE' press 6 Speed.
2. The VC2000PC displays:

   Old weight= 1000 lbs
   New weight= 0 lbs

3. Type in a number from 1 to 9999, then press **ENTER**.

This will be the weight until you change it with this function again.

Pitch and calibration factors

The VC2000PC is affected slightly by the tilt of the car caused by suspension shifts under acceleration or deceleration. This effect is slight and for the purposes of the VC2000PC is considered to be similar for all vehicles designed to be driven on the highways including motorcycles, passenger cars, semi tractor trailers and most off road vehicles. The VC2000PC is set at a common calibration factor (Cal. factor 1) for all vehicles with useful suspension systems.

The VC2000PC is shipped with “Cal. factor 1". Once the Cal factor is changed it will default to the new Cal factor every time the VC2000PC is turned on.

1. Press 7Distance from 'SELECT A MODE' to change cal factor.

2. The display shows the current cal factor on the top line:

```
Old CAL FACTOR = 1
0, 1, 2, 3, 4   HELP?
```

3. Choose a new cal factor, press HELP or CLEAR.

For rail cars, vehicles with abnormal or no suspension system and marine application the following guide will help you decide which calibration factor to use:

Cal. factor 0: Low Cal. factor, for vehicles with no suspension system such as transit rail cars, fork lifts or farm tractors.

Cal. factor 1: Normal Cal. factor or default Cal. factor, for all highway vehicles with useful suspension systems. Including motorcycles, passenger cars, semi tractor-trailers and most off road vehicles.

Cal. factor 2: High Cal. factor, for marine application and experimental vehicles.

Cal. factor 3: Very high Cal. factor, for marine or similar application when the bow rises higher that the stern.

Cal. factor 4: Extreme high Cal. factor, for marine or similar application when the bow rises higher that the stern.

The selected Cal. factor will remain until a different Cal. factor is selected.

Setting the Time and Date

All VC2000PC’s now have a date chip that maintains time and date even in the absence of power. It contains a lithium battery supply which will last a minimum of 10 years. It is Year 2000 compatible good through the year 2098. The time and date of each run is stored in memory and then uploaded to Profile and stored in the header of Profile for each run. This is useful if the file numbers do not correlate to the test number because you have had to clear memory after making some tests. At least you have the time of day for a reference point.

To set the Time and Date:

1. From 'SELECT A MODE' press 5 Time twice.
2. The display shows:

```
11:23 am
06/30/1999
```

3. Set the time for your time zone by entering every number, including zeros. To enter time of 9:00 enter 0, 9, 0, 0.

4. After entering the minutes the display will change to:

```
  11:23 am
1=am    2=pm
```

5. Enter 1 for am or 2 for pm.

6. Press **ENTER** to accept the time and date shown or enter the date including zeros. A year of 00 – 98 assumes year 2000 and 99 assumes 1999. After the date is entered or **ENTER** is pushed the VC2000PC sets the time and date in memory.

CLEAR may be pushed anytime to abort setting the time and date.

Getting into metric mode

The VC2000PC can give metric data for braking or acceleration runs. Once metric or English is set it will stay set until changed again.

The Metric data will be displayed in the following units:

KPH:	Kilometers Per Hour
M:	Meters

Metric runs are limited to 511 KPH and 1800 meters and the start to stop speed must be 10 KPH apart. The QuickSet™ mode will give distance QuickData™ points in English units and speed in metric.

To switch from English to Metric from 'SELECT A MODE' Press [4Auto Start] before the run.

Summary: What can be done from 'SELECT A MODE'

Key	Action
[0Acceleration]	QuickSet™ and Programmed Acceleration runs.
[1 Braking .]	Braking runs.
[2Continuous.]	G meter mode.
[3Countdown]	Set tachometer factor and/or set number of sensors connected to VC2000DA.
[4Auto Start .]	Toggle between Metric and English mode.
[5 Time .]	Set the current Time and Date
[6 Speed .]	Change vehicle weight.
[7Distance .]	Change the Calibration Factor.
[8G HP]	Change the Auto Start threshold G.
[9 .]	Scroll through a help message.

CLEAR Clear the 128K RAM and all data stored in the VC2000PC, or get back to 'SELECT A MODE'

ENTER Upload a file from the VC2000PC to a computer.

[5 Time], [7Distance], [9] Read the copyright message.

Charging the NiCad battery equipped unit

The battery charger inside the VC2000PC NiCad Battery equipped unit requires 12 to 16 Volts DC at 800 milli Amps or greater to operate, so most 12V battery chargers will work. Suitable chargers are available from Vericom Computers, Inc. The VC2000PC will not charge from a 12V battery. The center conductor of the VC2000PC power adapter is positive, and the connector has a 5mm OD and a 2.5mm ID. The VC2000PC will charge from a vehicle's cigarette lighter if the vehicle is running. The VC2000PC power must be off for the batteries to charge. It takes about four hours to fully charge them. The batteries take about five hours to fully discharge and should be fully discharged before recharging.

How to get the longest battery life from your VC2000PC

1. New and current batteries may require four or five discharge cycles before they attain their designed capacity.
2. Nickel Cadmium batteries may be stored as long as 2 to 3 years without harm. However, for best results they should be charged periodically and stored in a cool dry place.
3. It is normal for a battery to "self-discharge" during storage. Always fully charge your battery before you use it after it has been stored for over 1 month at a time.

Like all NiCad batteries, the batteries in the VC2000PC will develop a 'memory' if frequently only partially discharged. That is if you frequently operate your VC2000PC for only a short period without fully discharging the batteries, your batteries will lose their ability to accept a complete charge and your VC2000PC will have a short battery life. If you have noticed a decrease in battery life, completely discharging the batteries before fully recharging may restore the batteries to full effectiveness. You may have to discharge, then recharge up to 5 times to restore batteries to full effectiveness.
To recharge the batteries:

1. Discharge the batteries fully. The VC2000PC will operate for five hours on a single charge. After the display goes blank, leave the unit on for at least one more hour.

2. Recharge the batteries fully using a 120V AC adapter as recommended above. While charging, an internal red light will come on. This red light may be seen through the slots in the rear of the VC2000PC. The red light will go out when the VC2000PC is fully charged. This will take about four hours at 13.5V, 800mA DC. Unplug the charger after the unit is fully charged.

The VC2000PC has an overcharge current limiting circuit, which protects the battery from being overcharged, therefore extending the life of the batteries.

Replacing the Batteries:

It's best to send the unit back to Vericom for repairs but if you must repair it yourself follow these guidelines for replacing the batteries.

Use 7 AA NiCad batteries, 500 – 850mA, 1.2V, soldered in series. Wire or steel tabs will work to solder the batteries together. Look at the old batteries to see how to arrange them. Wrap the batteries tight with tape or shrink plastic. Solder a positive wire to the first batteries positive end and a negative wire to the last batteries negative end. Then install into the VC2000PC using plastic strap ties.

Replacing the fuse

All VC2000's have two fuses. One is an automatic circuit breaker built into the VC2000. When an overload condition occurs the circuit breaker trips. Once it cools down it will automatically reset the circuit breaker. The other fuse is located in the power cord, shown in Figure 15. To replace the fuse in the power cord:

1. Unscrew the top portion of the plug housing.

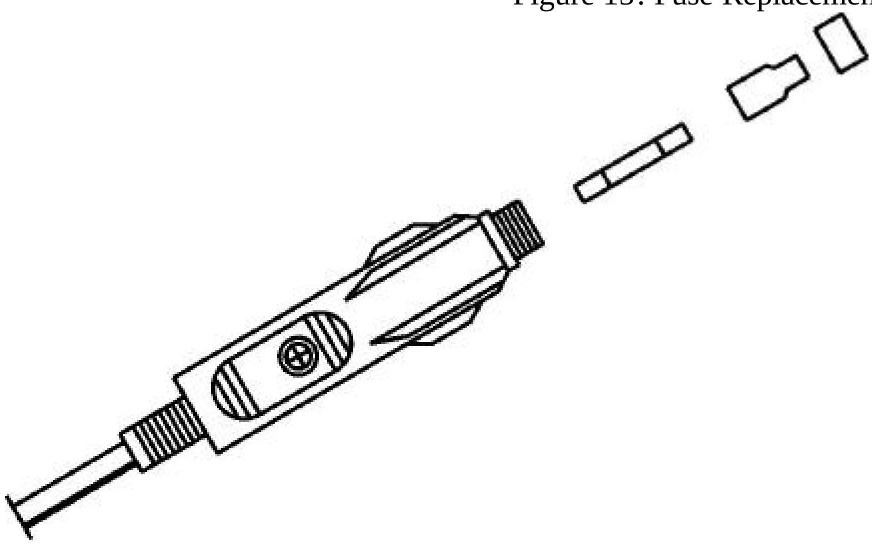
2. Remove the contact pin.

3. Remove the fuse from the plug housing.

4. Replace the fuse with a standard 3AG 1 Amp fuse.

Note: The VC2000PC is protected against momentary 24V DC surges. If the fuse blows immediately after you replace it, contact the factory for repairs.

Figure 15: Fuse Replacement



15. VC2000PC TO PC INTERFACE

The VC2000PC version is designed for use with the PC compatible software "Profile©". With Profile, Time, G, Speed, Distance and Horsepower can be analyzed every 1/100 sec. With the Tachometer option

RPM, Torque and Gear ratio can be analyzed every 1/100 second as well. With the VC2000DA an additional 16 sensors can be monitored.

See Profile Software Manual for software description.

VC2000PC Memory

This version has a 128K X 8 bit Random Access Memory (RAM) chip as well as the 32K X 8 bit Read Only Memory (ROM) and 256 bytes of on-Microcontroller RAM. The 128K RAM has two lithium batteries for power backup, which have a life of at least ten years. It can store 10.8 minutes of run data in the non-tach version and 5.4 minutes in the tach version. If sensors are monitored the storage time goes down depending on the number of sensors. The VC2000PC's are limited to 80 seconds of run storage per run. Even if the run is longer than 80 seconds, it will only store the first 80 seconds in memory. Files stored in the VC2000PC are saved consecutively from 1 to 98. (File 99 is used to upload all data in the VC2000PC to Profile at once.) It stores the runs starting at the beginning of the RAM. Therefore the more runs that are stored in memory the longer it will take to find a run near the end of the RAM. Memory should be cleared periodically to ensure safe data storage. To clear memory push **CLEAR** at 'SELECT A MODE', then push **ENTER** . A warning message will scroll across the screen. After the message is done push **ENTER** again to clear memory. After the memory has been cleared the VC2000PC checks it for proper setup and displays 'MEMORY CLEARED' if it is setup and cleared, or gives an error message if it is not. Be sure you have transferred any useful data before clearing memory.

When the unit is turned on it will check memory for proper setup. If it finds a problem this means that the internal lithium batteries may have gone dead, or the RAM chip may be malfunctioning. Before a run is saved in memory it will calculate how much memory is left.

VC2000PC Serial Port

The output port is an RS232 serial port that can be connected to a communications port of a PC compatible computer. After gathering data into the VC2000PC connect the serial cable to a PC compatible computer. **The serial cable should be connected when the VC2000PC is off.** The serial cable uses straight through pin-out.

16. FORMULAS

Units of measurement:

a = Acceleration- ft/sec^2
V = Velocity- ft/sec
D = Distance- feet
S = Speed- miles/hour (mph)
G = G-Force-G
f = Drag factor- G
T = Time

f = G = Acceleration Factor
Deceleration Factor
Drag Factor
Coefficient of friction
Average G-Force

$V = a \times T$ Velocity = acceleration × Time

$D = \frac{1}{2}(V_f + V_o) \times \Delta T$ Distance = ½ (final Velocity + initial Velocity) × change in Time.

$D = \frac{1}{2} a T^2$ Distance = ½ acceleration × time squared, assuming acceleration is constant.

$a = \frac{V^2}{2 \times D}$ Acceleration = Velocity squared divided by 2 times Distance. This formula gives an average acceleration.

$f = \frac{S^2}{29.915 \times D}$ Drag factor = Speed (MPH) squared divided by Distance (FT) times the conversion constant 29.915. This formula assumes constant acceleration.

$G = \frac{a}{g}$ G-Force = Acceleration ÷ Acceleration due to gravity. If "a" is in ft/sec^2 then "g" is 32.174 ft/sec^2.

$f = \frac{Force}{Weight}$ Drag factor = Force ÷ Weight.

$f = \frac{V}{(g)(T)}$ f = Drag Factor.

V = velocity in feet per second.
g = acceleration due to gravity (32.174 ft/sec^2).
T = time in seconds.

To convert mph to ft/sec: $V_{(ft/\sec)} = \frac{V_{(MPH)}(5280)}{3600\ Seconds}$

or simply use:

$f = \frac{V_{(MPH)}(0.04559)}{T}$ Drag factor = Velocity in MPH × .04559 ÷ Time.

Horsepower = HP (from VC2000PC) X Vehicle Wt. (in thousands of lbs.) if VC2000PC vehicle weight was 1000 pounds.

$$HP = \frac{VC2000\ HP \times vehicle\ weight}{1000}$$

If you know the speed and the G at that speed, such as QuickData™, you can calculate horsepower:

HP = Speed (MPH) X G (at that speed) X .002667 X vehicle weight.

Engine RPM:

$$RPM = \frac{168 \times Overall\ Gear\ \ Ratio \times Speed(MPH)}{Tire\ Radius\ (inches)}$$

(Overall Gear Ratio = transmission ratio times rear end ratio)

Torque (RPM versions):
Torque (ft. lbs.) = Horsepower X 5252.113/RPM

$$Torque_{(ft\ lbs)} = \frac{HP \times 5252.113}{RPM}$$

If HP is per thousand pounds then Torque will be per thousand pounds also.

Gear Ratio (RPM versions):

Revolutions per Foot = RPM X (60) /(MPH X (5280/3600))

$$RPF = \frac{RPM \times 60}{MPH \times (5280 \div 3600)} \quad RPF = \frac{RPM}{MPH} \times 0.011363636$$

Roll-out time in sec. = $\sqrt{\frac{Roll\ out\ Dis\tan ce_{(inches)}}{Peak\ G}} \times 0.072$

This formula assumes constant acceleration for the roll out period therefore rollout time will probably be slightly longer than this formula suggests.

17. CUSTOMER SERVICE

Limited Warranty

The manufacturer warrants that the VC2000PC computer will be free from defects in material or workmanship appearing under normal use and service. This warranty extends only to the original purchaser and does not apply if the product has been connected, installed or adjusted other than in accordance with the instructions furnished by the Manufacturer.

The manufacturer will repair or replace any parts that are defective in workmanship or materials for a period of one year from the date of purchase. The manufacturer does not warranty the installation of the VC2000PC computer and therefore will not be responsible for installation or reinstallation charges or damage caused by installation.

This warranty covers only the VC2000PC computer and is not extended to equipment or component parts used in conjunction with the VC2000PC computer. The manufacturer will not be liable for incidental and consequential damages or the loss of use of your vehicle.

This warranty gives you specific legal rights and you also may have rights that vary from state to state.

Repairs

Repairs not covered by warranty are available by returning the unit, prepaid postage, to the manufacturer. Repair charges and shipping will be billed to the customer prior to repairing or returning the unit to the customer.

Please include the following information when returning a VC2000PC:

1. Your name
2. Company name
3. Shipping address
4. Daytime telephone number
5. Model and Serial number of unit being returned
6. Description of problem
7. Method of payment
8. Description of any upgrades or repairs since purchased

For service, repair or product information contact:

Vericom Computers, Inc.
14320 James Rd, Suite 200
Rogers, MN 55374
763-428-1381
Fax 763-428-4856

18. TROUBLESHOOTING

Problem	Solution
Unit doesn't turn on	1. No power to cigarette lighter plug. Check connection to plug, or fuse in plug, or power to cigarette lighter. 2. Cigarette lighter cord not making connection to VC2000PC. Push right angle plug all the way into VC2000PC.
Unit turns off during run	1. Loss of power to VC2000PC. Check power cord and fuse. 2. Battery went dead. Recharge battery. 3. Electrical noise interference. Eliminate noise from source.
Inaccurate data	1. VC2000PC was not at same incline as when calibrated or level of VC2000PC

	changed since calibration. See page 5 for leveling. 2. VC2000PC started timing too soon. See page 41 to adjust threshold. 3. Electrical noise interference. Eliminate noise from source. 4. Wrong cal. Factor for vehicle. See page 41 to adjust cal. Factor. 5. Vibration: See page 40.
RPM inaccurate	1. Wrong Tach factor. Set correct tach factor for engine. 2. Tachometer not connected properly. See page 27 for proper connection. 3. Wrong sensor for application. Contact factory for proper sensor.
"MEMORY OVERFLOW"	1. Memory has bogus data. Clear memory and try again. 2. Lithium battery went dead. Sent in for new battery.
Sensor connected to DAB not working	1. DAB power not on. 2. Sensor wire not making connection to screw terminal. Make sure insulation is not pinched in terminal. 3. Broken wire inside insulation. 4. Bad sensor. Send in for replacement.
Two adjacent ports on the DAB seem to have the same curve	1. One of the sensors is not working or not connected to the screw terminal. Check sensors using continuous sensor mode. (page 37) 2. The scaling in Profile is different for the two ports. Try setting the scaling the same. Also check the raw numbers in the data window.
Calculation for Average G when using speed and distance don't correlate to the VC2000 Average G	1. When using distance in a formula to calculate average G assumes a constant acceleration. The VC2000 uses velocity over time, which is the same as summing the samples and dividing by the number of samples. This is the correct way to calculate an average. 2. The VC2000 distance is a cumulative calculation from samples every $1/100^{th}$ second. Straight formulas such as $f=S^2/(30D)$ assume constant f, which is impossible with any vehicle. To get the correct numbers you have to integrate G and Speed 100 times per second.

19. SPECIFICATIONS

Power input:	12V-16V DC (negative ground)
Momentary surge:	24V DC (10 seconds)
Nominal current draw:	160 mA
Temp. Range:	-20° F to 160° F
Charging voltage:	13V-16V DC
Nominal battery life:	5 hours
Accelerometer	
Dynamic range:	5G (+3G, -2G)
Minimum resolution:	0.00156G
Sample rate:	100 Hz
Computer clock speed:	11.0592 MHz
RAM:	128.3 Kbytes
ROM:	32 Kbytes
Power cord	
Length:	6 feet
Plug:	2.5 mm ID
(center positive):	5 mm OD
(Right angle Preferred):	10 mm L
Fuse:	1.25 inches, 3 AG, 1 Amp

Dimensions: 9.25 inches long, 2.12 inches high, 4.50 inches deep

Manufacturer: Vericom Computers, Inc.
14320 James Rd, Suite 200
Rogers, MN 55374

DAB Specifications:

Power input:	12V-16V DC (negative ground)
Momentary surge:	24V DC (10 seconds)
Nominal current draw:	30 mA
Temp. Range:	-20° F to 160° F
Charging voltage:	13V-16V DC
Nominal battery life:	5 hours

Power output:	12V ±0.25
0.5 Amp total draw	5V ±0.25

A/D converters:	16 12-bit sample and hold successive approximation.
Diode clamp over-voltage protection.	
Serial transfer rate:	1MHz
Analog input:	0 to 5 volts

Dimensions: 6.75 inches long, 2.25 inches high, 4.00 inches deep

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