



**Revolution™ Compass Kit
User's Guide**

Revisions

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Introduction

The Revolution compass combines a precision 3-axis solid-state magnetometer and a rugged 2-axis electrolytic tilt sensor that have been factory calibrated to provide accurate heading and tilt measurements. The unit has been verified for accuracy at room temperature in an environment free from magnetic, electrical, and mechanical disturbances. Using the PDA provided, the compass can be immediately tested in an out-of-doors location away from any ferrous material and isolated from severe vibration.

A good first test is to hold the compass steady at different attitudes (heading, pitch, and roll), take readings, and verify that the horizontal field strength remains roughly the same for different orientations. Refer to the section on *Verifying Correct Operation in Starting Up the PDA* for instructions on how to take readings. Be careful to keep the PDA and 9V battery away from the compass, as they can affect the readings. Expect to see some variation in the horizontal field strength, but it should be less than one or two percent if the compass is steady and tilt is less than 20°.

Before installing the Revolution, make note of the dip angle measurement and compare it to the published value for your location. The two values should be very close, usually within 0.5°. It is also a good idea to capture and save a vertical reference as described in the section on *Calibrating the Compass*. After the compass is mounted in-situ, this reference is used to partially compensate for any local permanent magnetism (hard-iron) that may be present.

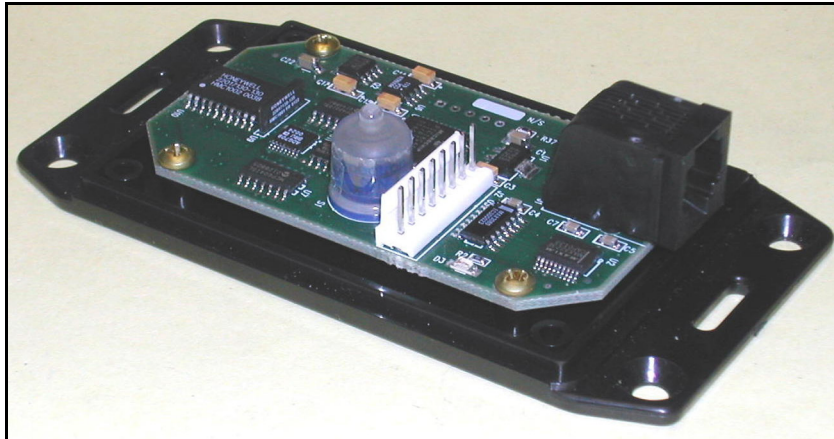
Contents of the Kit

The Revolution compass kit contains the following primary items described in detail in this section:

- Revolution Compass
- Palm™ PDA and Carrying Case
- Revolution Software CD
- Cables and Batteries

Revolution Compass

The Revolution represents the state of the art in magnetic compassing. It consists of a PC card housed in an ABS enclosure. The base of the enclosure has 4 mounting holes for permanent installation. Only brass or non-magnetic stainless steel screws should be used. Connection to the compass may be made via the RJ12 connector (for the PDA or PC) or by the 8 pin header (for system wiring). See the diagrams included with the cables.



Palm PDA and Carrying Case

The Palm m105 features 8MB of memory, a touch screen graphical display, and an integral serial RS-232 interface. It is pre-loaded with True North's Compass interface program. While the compass is in-place and without disconnecting system wiring, the PDA can be temporarily connected via the RJ12-style modular jack. This allows easy access during installation for calibration and tuning. It also provides a valuable diagnostic port and can be used for an auxiliary read-out

when needed. In situations where a fixed installation is not desirable, the RJ12 connection can be used exclusively.

The carrying case holds the PDA, compass interface cable, a 9V battery for compass power, and two extra AA batteries for the PDA. There's extra room available in several pockets.



Revolution Software CD

This is a mini, business-card style CD with both the Revolution interface software for a Microsoft Windows PC and software for the PDA. When the CD is loaded into a CDROM drive, the display shown in Figure 1 will automatically appear if the auto-run feature is enabled.

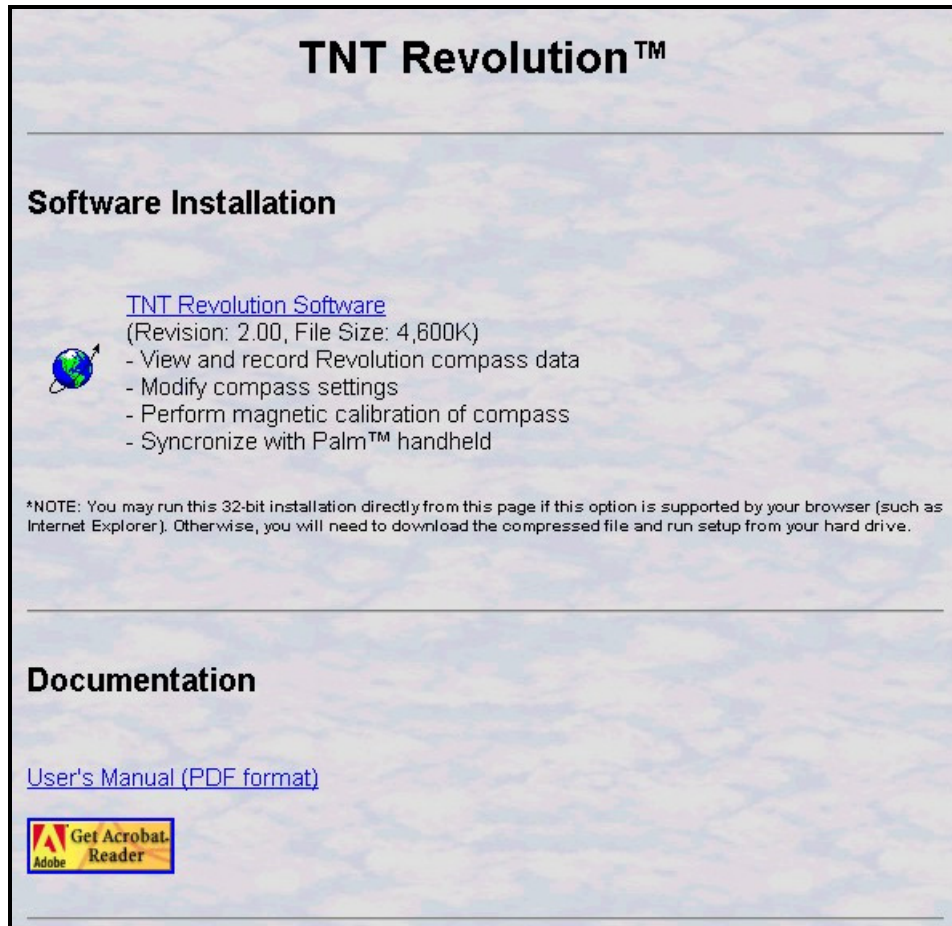


Figure 1

Cables and Batteries

Two AAA batteries are loaded in the PDA, and there are 2 extras in the PDA carrying case. A 9V battery for compass power is connected to the PDA cable in the carrying case.

The following cable assemblies are included:

4-Wire PDA to Compass: True North P/N 1570

8 ft. cable with Palm connector and 9V battery strap going to 6-pin RJ12 plug.

4-Wire PC to Compass: True North P/N 1540

8 ft. cable with DB9F connector and 9V battery strap going to 6-pin RJ12 plug. This cable is shown in Figure 2.



Figure 2

8-Wire Compass Interface (Optional): True North P/N 1580

8 ft. cable with 8-pin, 0.1" MTA connector going to open wire pairs (not terminated). Used for both RS-232 and RS-485 signals. This cable is shown in Figure 3.



Figure 3

Palm Hot Sync® Cradle: Palm P/N P10700U

Connects PDA to PC. Included with Palm m105 retail box.

Features

Compass Features

The Revolution compass is a third-generation, strap-down device that delivers high accuracy for its small size, low cost, and low power consumption. It provides both RS-232 and RS-485 communication links. For battery operation, a low-power standby mode is incorporated to reduce required current to 1mA. Wake up from standby requires only 1 millisecond.

Additional features of the compass include:

- Run (continuous) or Sample mode operation
- NMEA 0183 output data format with the following available sentences:
 - ⇒ HDT (True heading – standard sentence)
 - ⇒ HDG (Heading, deviation, and variation – standard sentence)
 - ⇒ XDR (Transducer data: pitch, roll, magX, magY, and magZ – standard sentence)
 - ⇒ HTM (Heading, tilt, and magnetic field – proprietary sentence)
 - ⇒ NCD (Normalized compass data – proprietary sentence)
 - ⇒ CCD (Conditioned compass data – proprietary sentence)
- Output data available:
 - ⇒ Heading, pitch, and roll
 - ⇒ Magnetometer X, Y, Z, and calculated total field
 - ⇒ N, E, H, and V - normalized magnetic field components
 - ⇒ Magnetic inclination (dip angle)
- Angles in degrees (0.0 to 359.9°), mils (0 to 6399), milliradians (0 to 6282), or 16-bit integer (0 – 65535)
- Tunable alarm on H field deviation in Run mode
- Selectable averaging time in Sample mode
- Separate magnetic and tilt IIR single-pole filters in Run mode
- Tunable heading filter in Run mode for quick response in hand-held applications where fast movements should be ignored
- Magnetic field measurement range: ± 1.6 G (gain 100)
- Magnetic field measurement sensitivity: 0.3 mG (30 nT, gain 500)
- Serial EEPROM for calibration coefficients and setup parameters

PDA Features

The Palm PDA is a convenient service and evaluation tool that can also be used for routine data acquisition tasks. It is used to perform the calibration procedure required to compensate for local hard and soft iron, to change compass tuning parameters, and to capture and store compass measurement data. For stand-

alone operation, the serial interconnect cable attaches to a 9V battery that can power the compass for over 500 hours (3 weeks) of continuous operation (standby mode). For servicing a compass attached to a host computer, it can be plugged in without disconnecting the system wiring. Calibration, tuning, and capture functions can be performed without affecting the host.

Additional features of the PDA software are:

- Database of calibration, tuning, and capture data that can be transferred to a PC or laptop using Hot Sync
- A single PDA can be used with more than one compass. Stored data automatically tagged with compass device ID
- Graphical user interface layout and navigation similar to what is used with PC software (Revolution PC program)
- Serial port hardware is turned off so that compass can automatically enter low-power standby mode when measurements are not needed. Also reduces PDA battery drain
- Straightforward calibration procedures minimize required user interaction and generate optimal compensation coefficients

PC Software Features

The Revolution PC program is designed to run on most Microsoft Windows platforms: 95, 98, NT, 2000, ME, and XP. There are two main components:

- A Visual Basic program (Revolution.Exe) that provides the graphical user interface, database, and logging functions, and
- A windowless ActiveX control (Compass.Ocx) that implements the compass serial interface, calibration functions, and Palm PDA data conversion routines.

The ActiveX control can be used separately from the Revolution PC program to simplify the task of integrating the compass into an end-user system. It provides methods for reading and writing parameters; for reading, parsing, and converting NMEA sentence data; for performing hard and soft iron calibration functions, and for converting a PDA database file to tab-delimited text records. It also maintains a text log of communication between the PC and compass that can be read by a host application.

Functions provided by the Revolution PC software are:

- Cockpit attitude display of heading, reciprocal heading, pitch, and roll
- Display and capture NMEA sentence data
- Modify Revolution operating parameters
- Perform hard and soft-iron calibration procedures
- Provide electronic compass deviation table
- Transfer PDA data using HotSync® manager, then convert to text files
- View and maintain communication logs

Getting Started

Starting Up the PDA

How the PDA is Prepared

We unpacked and tested the PDA and cable assembly at the factory. Two AAA batteries are already installed. Batteries in the carrying case pouch are extras. The PDA touch screen has been calibrated, and the time is set to USA Eastern Standard Time. The Revolution Compass program is already loaded, but a user account has not been assigned for the HotSync operation.

We also loaded the freeware program GeoMagInfo Version 1.1. For a given longitude and latitude, this program calculates magnetic declination (variation), inclination (dip angle), and total magnetic field based on the year 2000 USGS models. This program is unrelated to the Revolution compass program and can be deleted if no longer desired.

Before using the PDA extensively, it's probably a good idea to recalibrate the touch screen, set the time to your local time zone, and verify that the PDA batteries have adequate charge remaining. You may also need to adjust the screen contrast, and in low-light conditions, you may need to turn on the display backlight. If you have not used a Palm PDA before, familiarize yourself with the basic features of the device by skimming *Getting Started.pdf* on the Palm Desktop Software CD.

You will need to install the Palm Desktop Software on your PC or laptop prior to performing a HotSync operation to transfer PDA data to the PC. See *Getting Started.pdf* on the Palm Desktop Software CD for detailed instructions. You can install it either before or after the Revolution program is installed.

Once the Palm Desktop Software is installed, you can use the Revolution program to initiate a HotSync operation. Any compass data captured on the PDA will automatically be transferred to the PC or laptop. The Revolution program finds the data in a file named *Compass.pdb*, converts it to a tab-delimited, ASCII text format, and archives the raw data file in a separate folder.

PDA Battery Power

Turn the PDA on by pressing the power button located at the top center of the device. You should see the Application Launcher screen with the Compass category as shown in Figure 4. Tap the Home icon (picture of a house) to see the Application Launcher screen if it is not already shown. Continue tapping the Home icon to change categories.



Figure 4

The current time is shown in the upper left corner of the screen. To its right is a battery icon that will be completely shaded in black when the batteries are fully charged. As the batteries discharge, the shaded area recedes to the left. When the batteries need to be replaced, you have about one minute from the time you remove the old ones before memory is lost. You won't lose any programs or data if the new batteries are installed in time. Otherwise, the data will be permanently lost, and you will have to use HotSync manager to restore programs.

Calibrating the Touch Screen and Setting Local Time

Go to the Compass category in Application Launcher by tapping the Home icon. Tap the Welcome icon and follow the onscreen instructions. Be careful when calibrating the touch screen to orient the PDA as it will be held in normal operation.

Once you tap on the Welcome icon, you cannot exit without calibrating the touch screen and proceeding through the date and time setup. To avoid getting into this mode accidentally, you can change the Welcome category to System. To do this, tap the time in the upper left of the Application Launcher screen and choose "Category..." from the drop-down menu. Scroll down to Welcome and tap the inverted triangle ▼ to change the category.

Connecting the Revolution

Remove the connecting cable from the pocket in the PDA carrying case and insert the RJ12 plug into the jack on the compass. Verify that the 9V battery is connected properly to the battery strap. If the Revolution is operating in Run mode as shipped from the factory, you will hear an audible ticking that is amplified by the compass housing. This is normal and is an indication that the magnetometer Set-Reset circuit is operating properly.

The compass draws its power from the 9V battery wired to the PDA connector. This battery is not needed when the compass is already powered via the system wiring. It can, however, remain connected without damaging the compass or either power source. The compass incorporates protection diodes that prevent current flow from the higher to lower voltage source.

You can expect roughly 25-30 hours of Run-mode operation from a new 9V battery. Until the PDA is able to communicate with the compass, it cannot change to a lower power operating mode. To preserve 9V battery power, either remove the RJ12 plug from the compass or disconnect the 9V battery from the battery strap. **Disconnecting the 10-pin PDA connector from the PDA does not disconnect the 9V battery from the compass.**

Verifying Correct Operation

With the compass connected to the 9V battery, you can tap on the Compass icon. You should see the Compass display as shown in Figure 5. If the display appears as shown in Figure 6, then there is a communication problem. If this is

the case, first check that the PDA connector is completely seated in the PDA. Next, inspect the cable and make sure there are no wire breaks. If this is a new compass, verify that there is an audible ticking. Check the terminal voltage on the 9V battery and verify that it is 6V or greater.

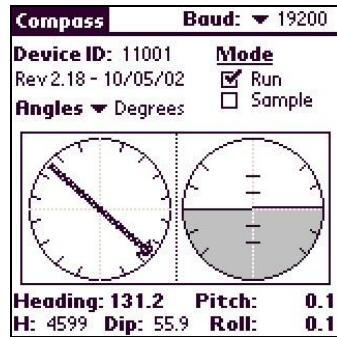


Figure 5

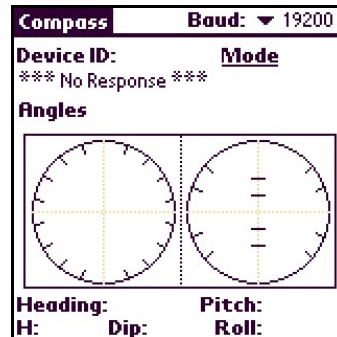


Figure 6

The display does not automatically update even when the compass is communicating properly. Tap anywhere in the heading or attitude display area to trigger an update, or press either of the hard plastic scroll buttons located at the bottom center of the PDA. Move the compass around as you trigger updates to see that the heading, pitch, and roll values change as expected.

The baud rate that the PDA uses to communicate with the compass is in the upper right of the display. Change to another baud rate, and the display will show no response as in Figure 6. Change back to 19200 to restore communication. This baud rate must correspond to the rate stored in the compass EEPROM. Once communication is established, you can change both the compass and PDA rates using the Serial category of the Settings page.

There are a few subtle features of the Compass display that require further explanation. Note that when you request an update, a black dot flashes to the right of the Run mode selection. This indicator is turned on when a query for compass data is sent and is extinguished when the response is received. In Run mode, the dot flashes quickly because data is returned quickly. In Sample mode, the dot is shown for a longer time while the compass averages data before it is sent. The sample averaging time is changed from the General category of the Settings page.

In Run mode, you may see that the heading value is followed by either an upper case M or lower case m. This happens because the compass is entering low-power standby mode between PDA updates. The M means that a magnetic alarm is indicated: upper case for a high excursion, lower case for a low deviation. The alarm is asserted because the compass has not run long enough to acquire the horizontal field strength. If you set the acquire time to zero (Magnetic category of Settings page – Filter section) the indicator will disappear. Also, the indicator does not appear in sample mode because the magnetic field alarm is disabled.

Other letter indicators that may follow the heading value are C, H, L, or V. These are indications of failures and will cause the heading direction arrow to blank.

The specific failures are:

- C: offset calibration for magnetic sensors failed
- H: measured total magnetic field strength too high
- L: insufficient total magnetic field strength
- V: magnetic sensor bridge voltage too low

The value for H just below the heading is an indication of the horizontal magnetic field strength, and the Dip value that follows is the calculated magnetic inclination. For a properly calibrated compass, these values should not change as you rotate, pitch, and roll. Any local magnetic field (permanent or induced), or horizontal component of acceleration, or other uncompensated measurement error will result in deviations. The magnitude of the deviation is a measure of compass inaccuracy.

You will probably notice that there is more variation between successive updates in Run mode than in Sample mode. This is because the Run mode smoothing filters on tilt and magnetic signals are reset when the compass enters low-power sleep mode. To let the filters stabilize, keep the compass in Run mode by disabling the “Sleep between samples” check box on the Preferences page (on the Options menu). Be aware that the 9V battery life is reduced by roughly a factor of 20 when the compass operates in continuous Run mode, and that the 9V battery remains connected even when the PDA powers down.

Capturing Data

A quick way to record discrete data points is to capture any of 5 available NMEA sentences: HDT (Heading True), HDG (Heading, Deviation, and Variation), HTM (Heading, Tilt, and Magnetic Field), CCD (Conditioned Compass Data), or NCD (Normalized Compass Data). Tap on the Compass title at the top left of the screen (or the menu icon at the bottom left of the silk screen) and select Capture. The display should appear as shown in Figure 7. Now tap the Capture button at the lower left of the page. If the compass is operating in Run mode, you will see the display in Figure 8 flash by quickly. In Sample mode, it will persist for the sample average time (see General category of Settings page). Then the details of the sample will appear as in Figure 9.

Capture		Mode ▾ Sample	
Time	Hdng	Pitch	Roll
1. 12:01:39	140.3	0.0	0.0
2. 12:01:41	140.4	0.0	-0.1
3. 12:01:43	140.1	0.0	0.0

Buttons: Capture | HDG | HDT | **HTM** | CCD | NCD

Figure 7

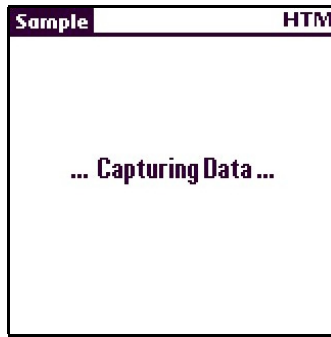


Figure 8

Sample		4 of 4		HTM	
Time	12:03:47 on 11/11/02				
Heading	140.1				
Pitch	0.0				
Roll	0.0				
Dip Angle	56.2				
Mag H	4559				
Note				
Done		Delete ...			

Figure 9

The compass device ID and a date-time stamp are saved with the data to help identify the sample. Tap on the Note line to enter a note (40 characters max) using either Graffiti or the pop-up keypad. Save or discard the sample by tapping Done or Delete... See the details of a previous sample by tapping on the sample line in the Capture display.

The saved samples remain in PDA memory until they are transferred to the PC using Palm HotSync operation. Following a successful transfer, the data in the PDA is automatically deleted. There is an audible beep at the end of the successful HotSync operation to confirm that PDA data has been deleted.

When you use more than one compass with the PDA, only samples for the current or last known compass device ID are shown on the Capture display. When switching between multiple compasses, the PDA finds and presents only data saved for the connected compass. Data associated with other device IDs remains stored in memory, but cannot be accessed until the corresponding compass is reconnected.

Getting to Know the PC Software

System Requirements

- PC running Windows 95 or greater
- VGA
- Keyboard
- 5 Mb disk space (more for log files, recorded data files, synchronized files)
- RS-232 serial port

System Recommendations

- PC running Windows 98 or greater
- SVGA 1024 x 768, High Color (16-bit), Large Fonts
- Keyboard and Mouse
- 50 Mb disk space

Revolution Software

The Revolution software allows you to use your PC to communicate with the Revolution compass and to retrieve data captured using the handheld device.

To install the Revolution software, insert the Revolution CD into the CD-ROM drive of your PC. If the CD does not autorun, run the RevolutionSetup.exe application from the Revolution directory on the CD. The InstallShield® wizard will guide you through the installation process.

During the installation, you may select the directory in which the Revolution software will be installed or accept the default directory of C:\Program Files\True North Technologies\Revolution. The installation will create the PalmData subdirectory to store any captured data files that will be transferred from the PDA. Once you run the Revolution software, the LogFiles subdirectory will be created to store log files. Once you record data using the Revolution software, the RecordedData subdirectory will be created to store files of data recorded from the compass.

The following list describes the files placed in the application directory:

- Revolution.exe TNT Revolution software application
- Revolution.ini Initialization file for Revolution software
- Revolution.hlp Help file for Revolution software
- Revolution.cnt File required by help file
- Revolution.gid File used by help file

- Compass.ocx ActiveX control for communicating with Revolution compass
- PalmCntl.ocx ActiveX control for performing the HotSync operation
- ComConduit.dll DLL required by PalmCntl.ocx
- Condmgr.dll DLL required by PalmCntl.ocx
- Hsapi.dll DLL required by PalmCntl.ocx
- Instaide.dll DLL required by PalmCntl.ocx
- Userdata.dll DLL required by PalmCntl.ocx

- TNTCompass.prc TNT Revolution PDA application
- Mathlib.prc Math library required by Revolution PDA application
- Geomag11.prc GeoMagnetic Info freeware PDA application by David W. Bray
- Gmillib.prc File required by GeoMagnetic PDA application
- WMM-2000.pdb File required by GeoMagnetic PDA application
- Upd352.prc Update for Palm operating system

To remove the Revolution software, use the Add/Remove Programs function from the Control Panel, or run the Revolution setup again and chose Remove. Do not simply delete the Revolution directory and files. Please note that any log files, PDA files, or recorded data files created since the software was installed

will not be deleted by the uninstall process. Once you have properly uninstalled the software, you may freely delete the additional files.

Palm Desktop Software

This software comes with the Palm PDA and is required to transfer data between the PDA and PC.

Insert the Palm Desktop Software CD into the CD-ROM drive of your PC and follow the instructions for installing the Palm Desktop Software. When prompted to enter a User Name, enter the name with which you desire to identify the handheld device. This name is required for HotSync operations.

See the Palm documentation for system requirements.

NOTE: If you experience problems with the Palm Desktop Software installation or the HotSync operation, refer to the Palm documentation. Also, if you experience problems using the Sync PDA feature of the Revolution software, try synchronizing through the Palm Desktop application to verify that the HotSync manager is configured properly.

Preliminary Compass Evaluation

How the Revolution Compass is Prepared

After factory calibration, test, and verification, the Revolution is setup as follows:

- 19200 baud serial data rate
- Run mode – no automatic NMEA data output
- 0.4 s magnetometer time constant (Mag TC)
- 0.8 s pitch and roll time constant (Tilt TC)
- 4.0 s magnetic field alarm time constant (Alarm TC)
- 2.0 s magnetic field alarm acquire time (Acquire Time)
- 5% magnetic field deviation limit (Alarm Limit)
- 1.5 s sample averaging time (used in Sample mode only)
- 35° pitch and roll warning level
- 44° pitch and roll alarm level (heading blanks above this)

The three time constants are for single pole, low-pass IIR filters that are enabled in Run mode. If you switch to Sample mode, these filters are reset and the magnetic field alarm is disabled.

The magnetometer gain is factory set to accommodate a full-scale range of approximately ± 750 mG (± 75 μ T). The gain can be reduced to allow more hard-iron, or it can be increased to provide greater sensitivity. A magnetic calibration procedure must be performed after changing the gain.

Prior to factory calibration, the compass is demagnetized to eliminate any residual magnetic fields from the circuit components. If the compass is exposed

to a strong magnetic field of 10 G or more, then it should be demagnetized again before performing a magnetic calibration. The residual magnetic field due to circuit components is compensated by the magnetic calibration procedure.

In the Magnetic category of the Settings page, you can see the results of factory calibration of the magnetometer. The X, Y, and Z offsets can only be viewed on this form. X, Y, and Zr are changed automatically after acquiring data using the Calibrate page. The value for Vref will be 32767 if a vertical reference has not been saved. Vref is changed automatically when a good vertical reference is calculated using the “Vertical Reference” category of the Calibrate page.

Pitch and Roll Check

This is a simple test to check pitch and roll accuracy near zero degrees tilt. Place the compass on a flat surface and take readings for pitch and roll angles. Now rotate the compass precisely 180° and take another set of readings. The second pitch and roll readings should be the same magnitude but opposite signs of the first, i.e. the sum of the two pitch readings should be zero and the sum of the two roll readings should be zero.

This test is valid even when the flat surface is oriented at a steep angle of 20° to 40°. It does not, however, verify the scale factor accuracy of the tilt sensor. A known angle reference is needed to verify that the scale factor is also correct.

Magnetometer Check

To verify that the magnetometer is calibrated and operating properly, place the compass on a flat surface along the edge of a fixed, non-magnetic straight-edge, like a wooden ruler. Make sure the compass environment is magnetically clean (no motors, ferrous materials, etc.). Using the Sample mode on the PDA Capture page, capture CCD samples to see MagX, MagY, and MagZ measurements from the magnetometer.

Rotate the compass and straight edge until either MagX or MagY approaches zero. Once there, hold the straight edge and rotate the compass exactly 180° by aligning the opposite side with the straight edge. Capture additional CCD samples to verify that the measurement that was near zero, MagX or MagY, is still near zero and ideally the opposite sign. Any variation should be within 1% of the magnitude of the other measurement which is near full scale.

This technique works with a flat surface at any orientation; it doesn't have to be perfectly level. The test verifies that the magnetometer offset is null. Additional steps can be performed to verify that the full-scale readings for MagX and MagY are the same.

Dip Angle Check

Use the PDA GeoMagInfo program to determine the predicted inclination for your location. To find your latitude and longitude, you can either use a GPS device or look up your city or zip code on the Internet. Compare the reference value for inclination to the value shown for dip angle on the PDA Compass page.

If the values do not correspond, try a different location nearby. Underground pipes, iron ore deposits, or steel reinforcement in concrete can affect the local dip angle.

Using the PC Revolution Program

Running the Revolution Software for the First Time

The first time you run the Revolution software, you will see the dialog in Figure 10 prompting you to enter the serial communication port and baud rate. The baud rate defaults to 19200 which is the rate used by the compass when it is shipped. Once you have established communication with the compass, you will not be prompted in this way unless the software is unable to communicate with the compass.

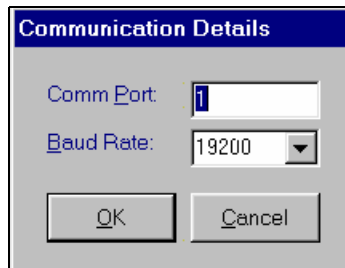


Figure 10

If the software cannot communicate with the compass, you will receive the dialog in Figure 11:

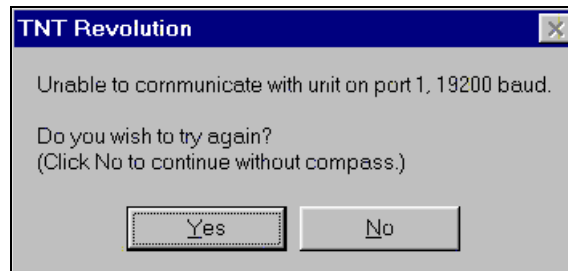


Figure 11

Click Yes from the dialog in Figure 11 to try again. You will be prompted to enter the communication port and baud rate as in Figure 10. Clicking No allows you to proceed without connecting a compass (in order to perform the HotSync operation with the PDA, for example).

If the software is able to communicate with the compass, a window similar to the one in Figure 12 (showing correct version information for the compass) will appear centered in the application's main window.

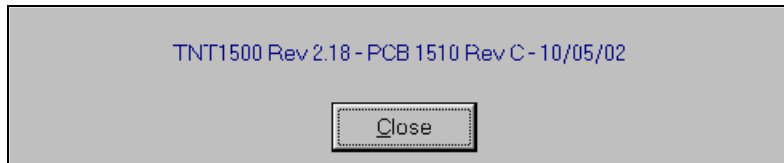


Figure 12

If you choose to proceed without connecting a compass, the window in Figure 13 will appear centered in the application's main window.



Figure 13

Any menu items and toolbar buttons requiring a compass will be disabled, but you will still be able to do the following functions:

- View log information
- View settings log information
- Modify software options
- Reconnect to the compass
- Test communication with the compass
- Synchronize with the PDA
- Convert the Compass.pdb file to text files containing data captured on the PDA
- View help

If there is only one serial communication port on your PC, you will need to switch between the compass and the HotSync cradle as necessary. To communicate with the compass, you must be connected to the compass, and the HotSync manager cannot be running. To perform a HotSync operation outside of the Revolution software, connect the HotSync cradle and make sure the HotSync manager is running. If you want to perform the Revolution software's Sync PDA function, switch the connection from the compass to the cradle when prompted. After the HotSync process, you will be prompted to switch back to the compass.

Description of the Software Main Screen

The Revolution Software Main Screen contains a menu, toolbar, information bar, and a scrollable area to hold application dialogs and windows. The toolbar allows easy access to a subset of the menu items. The information bar shows the Compass ID, Port, Baud rate, unique Unit ID, and Angles value. The Main Screen appears as shown in Figure 14.

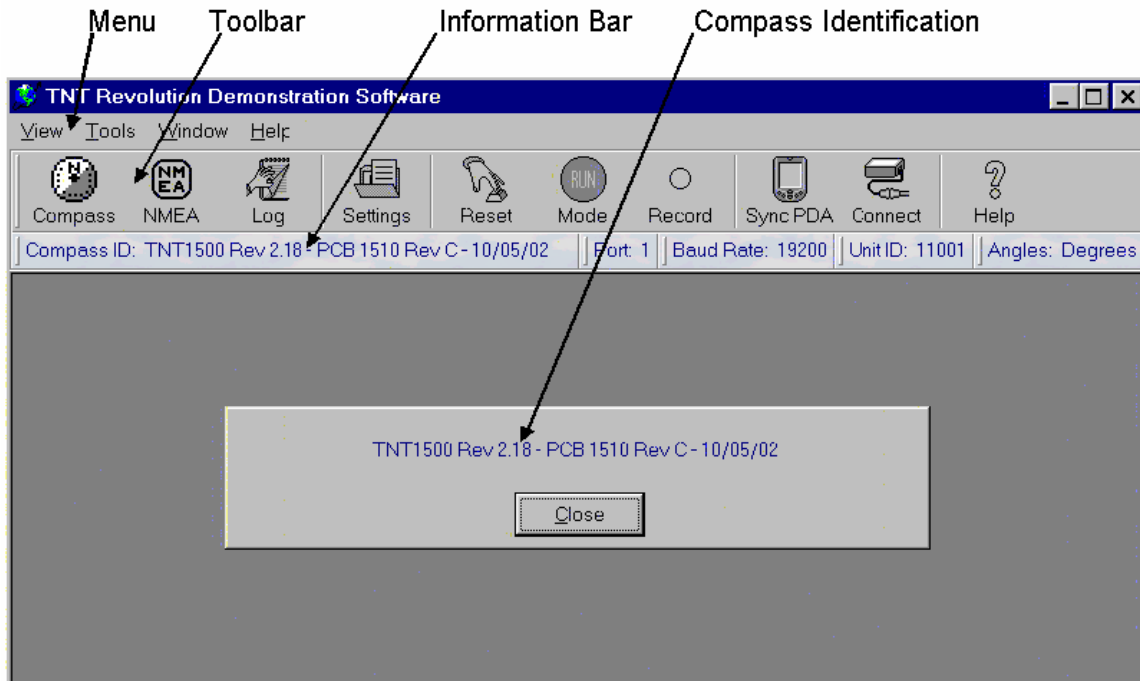


Figure 14

Compass Installation

Before installing the compass, consider the following:

- Verify that the compass performs as expected in a test location free from magnetic interference and mechanical vibration.
- If the target location is free of local magnetic fields (permanent and induced), then the magnetic calibration procedure should not be necessary.
- If a magnetic calibration will be needed, you will need to capture a vertical reference in a magnetically clean location. Refer to section on *Capturing a Vertical Reference*. The reference is used to determine the magnetometer Z-axis offset during calibration.
- If system wiring is going to be used, install the cable before permanently mounting the compass.

Location

Choose a location with as little magnetic interference as possible. If there is a lot of ferrous metal, it may be necessary to decrease magnetometer gain to keep

the X, Y, and Z signals from saturating. In this case, heading accuracy will decrease. The magnetization of the disturbing material may also change over time, which will require repeated calibrations to maintain compass accuracy.

Magnetic fields that arise from 50 or 60 Hz AC currents are significantly attenuated, because the compass averages magnetometer signals over 18.2 milliseconds, which corresponds to 55 Hz. However, intermittent magnetic fields generated by motors or solenoids being turned on and off may not be compensated. Also, nearby wires carrying DC current can affect the magnetometer. If the generated field is static, it can be compensated. Otherwise, the field may affect the compass reading.

Since horizontal components of acceleration affect compass accuracy and cannot be compensated, choosing a location near the center of a vehicle is best. For example, mounting the compass on a mast to get it away from a ship's steel hull may result in acceptable accuracy only in calm seas. A compromise location that minimizes both influences may yield the best overall performance.

Finally, consider mechanical vibration to minimize its affect on the tilt sensor. Most of the noise caused by a piston engine can be compensated by tuning algorithms in the compass firmware. However, it may be desirable to orient the compass on an axis that is not aligned with the vehicle so that engine noise affects pitch and roll equally. Use the Deviation setting to electronically shift the heading into alignment with the vehicle.

Mounting

Use brass or stainless steel screws to secure the compass in place. The label on the Revolution enclosure indicates directions for positive pitch, roll, and magnetometer readings. The compass indicates North when the magnetic field is maximum in the positive X direction, and null in Y.

If the mounting platform is not level, pitch and roll offsets can be zeroed without affecting compass accuracy. An auto-zero function is provided on the tilt settings page in both the PDA and PC Revolution software. Although it can be mounted in any orientation within range, the best compass accuracy is achieved for small tilt angles because scale factor errors do not affect the tilt readings near zero.

Wiring to the Internal Connector (J2)

Perform the following sequence of steps to install the system wiring cable provided in the Revolution compass kit. If a cover is not required, it can be removed and the MTA connector can simply be plugged into J2 as shown in Figure 15. In this case, the connector will not be retained in place by the cover. Contact True North about supplying a locking header and connector instead.



Figure 15

1. Remove the Revolution cover by unscrewing the 4 stainless steel screws from the bottom of the case. If the screws are lost, replace with 10mm, M3-05, flat, philips-head, non-magnetic #316 stainless. With the screws out, lift the cover first from the end opposite the connectors to remove.

TAKE CARE. DO NOT DISTURB THE POSITION OF U9.

This is a vertical, thru-hole IC (HMC1002). Bending this sensor from its factory-set position will invalidate the magnetometer factory calibration.

2. Remove the black, snap-in plug from the 5/16" hole in the cover.
3. Insert the supplied grommet into the hole. Make sure it is properly seated on both sides and that the opening for the wire is uniformly circular.
4. Feed the supplied wire (4-pair, #24 AWG, CAT5, non-plenum) through the grommet starting from inside the cover. The entire length of the wire will have to be fed through the grommet.
5. Rotate the wire to align the connector so that it can be plugged into the header on the card. Pin 1 will line up naturally so there is little chance of reversing the connection.
6. Plug the connector onto the 8 J2 header pins, making sure all 8 pins are inside the body of the connector. Also make sure that the connector is fully seated onto the pins.
7. If there will be any tension on the wire, it may be desirable to clamp a plastic cable tie or non-magnetic clamp around the wire on the inside edge of the grommet to relieve strain. Otherwise, cable stress will be transferred directly to the connector.
8. Pitch the cover down at the connector end and work it back over the RJ12 connector until it is properly seated.
9. Turn the compass over and replace the 4 stainless steel screws.

Selecting RS-232 or RS-485

The system wiring cable provides signals for power, ground, RS-232 transmit, RS-232 receive, RS-485 transmit (2 wires), and RS-485 receive (2 wires). Refer to True North drawing 1580 for details. A separate 4 or 6 wire cable can be used if only RS-232 (4) or RS-485 (6) signals will be needed.

If both RS-232 and RS-485 inputs are connected, the RS-232 input overrides. NMEA sentence output appears on both RS-232 and RS-485 lines. Commands sent to the compass using RS-232 may conflict with commands from a PDA or laptop connected to the RJ12 port. If commands are being sent via RS-485, they are automatically disconnected when a valid RS-232 signal level is detected on either port.

For low-power applications, the compass can be set up to automatically enter standby mode when the RS-232 input becomes invalid. Devices like the PDA disable their RS-232 drivers to conserve power when no serial I/O is in progress. The Revolution's RS-232 receiver detects this condition and signals the microcontroller to automatically shut down. To take advantage of this feature using RS-232 on J2, insert a blank plug into the RJ12 jack with pins 1 and 6 shorted.

Connecting the PDA While the Compass is Operating

When an RJ45 plug with pins 1 and 6 shorted is inserted into the jack, the compass disconnects the RS-485 input and begins checking for a valid RS-232 input signal on either of two channels. If neither signal is valid, operation depends on the setting of a volatile flag in the microcontroller's RAM. When power is first applied, the flag is reset and the compass will not enter standby mode. Once the control flag has been set, the compass will automatically enter and exit low-power standby mode depending on the states of both input signals. Allow at least 1 millisecond after setting the RS-232 signal to a valid marking level before sending the first character.

Calibrating the Compass

Once the compass is mounted in its target location, the detrimental effects of local magnetic fields, both permanent and induced, can be largely compensated. An advantage of an electronic compass over its mechanical predecessor is that the compensation can be performed without additional hardware. A strap-down electronic compass like the Revolution can be compensated more precisely than a mechanically gimbaled compass because the magnetometer remains fixed in its surroundings.

Compensation for permanent and induced fields is generally separated and referred to as hard-iron and soft iron calibration. Hard-iron errors are usually most severe and have the effect of shifting the center of a sphere from the origin within a 3 dimensional coordinate system. The purpose of a hard-iron calibration procedure is to determine where the center of the sphere lies so that appropriate X, Y, and Z offsets can be subtracted from the corresponding magnetometer

signals to return the center to the origin. In algebraic form, hard-iron is represented by the a, b, and c coefficients in:

$$(x - a)^2 + (y - b)^2 + (z - c)^2 = r^2,$$

where x, y, and z are orthogonal components of the earth's magnetic field and r is the total field strength, which is an unknown constant.

Soft iron effects distort the shape of the sphere into an ellipsoid. The purpose of a soft-iron calibration procedure is to determine parameters of the ellipsoid, such as the relative lengths of the 3 axes and their orientation in space, so that an appropriate transformation can be generated that will reshape the ellipsoid into a sphere.

In both cases, it can be difficult or impossible to get good calibration data. The compass must remain fixed in its environment (vehicle, robot, boat, etc.) and both must be rotated together in the earth's magnetic field, ideally in all three dimensions. Since the effects of local magnetic fields remain fixed relative to the magnetometer as it rotates, they can be determined and compensated.

Since a boat or vehicle of any size cannot be inverted, True North uses a two-step calibration that relies on first acquiring a vertical reference outside the influence of the vehicle, then performing a simple, two-dimensional rotation while roughly level to determine all three components of hard iron. The rotation can be performed continuously, or individual samples can be captured. In both cases, the data collection algorithms are designed to ensure that in-range data from a complete rotation is collected before being analyzed.

Both the PC and PDA software implement least squares algorithms that determine both hard-iron and two-dimensional soft-iron compensation coefficients. A minimum of 7 sampled data points or one complete rotation is required. After data is collected and new coefficients are calculated, the variation in total magnetic field is calculated using both old and new coefficients to determine which are best. Results are presented with suggested best choices for the user to accept or override.

Capturing a Vertical Reference

To collect data for a vertical reference, position or hold the compass close to level in an open area free from magnetic disturbances. Go to the Calibrate page on the PDA and select Vertical Reference in the upper right of the display (see Figure 16). When connected to the compass, tap the Start button to begin collecting data.

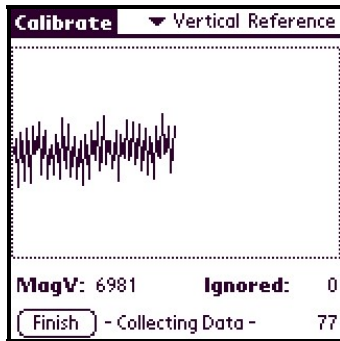


Figure 16

With the default tuning, if either pitch or roll is greater than 1.5°, the data is ignored. In this case, the *Ignored* count to the bottom right of the graph increments, and a status message advises on how to correct the problem. When the measured tilt is within limits, the calculated vertical component is plotted and the unlabeled count to the right of the status message increments.

When a sufficient number of good readings are available, the Cancel button label changes to Finish. Tap it to complete the process and display the results dialog shown in Figure 17. The calculated variation percentage means that 97% of the collected data fell within a range centered on the average plus or minus the indicated percent of average.

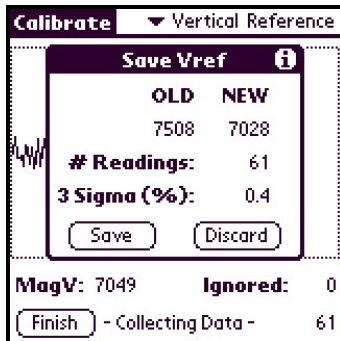


Figure 17

Collecting Data in Continuous, Circular Motion

For situations where it is difficult or impossible to stop and sample individual points, use the Offsets-Moving category on the PDA Calibration page (Figure 18). The data collection algorithm requires one complete rotation to be made at a nominal rate of one revolution per minute. Magnetometer X,Y coordinate pairs are plotted on the graph during collection. The faint circle is shown for reference relative to collected actual data.

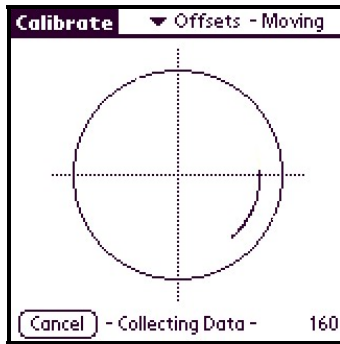


Figure 18

Excessive hard-iron may cause repeating resets due to magnetic field strength alarms or apparent rotation that is too fast or too slow. It may be necessary to first perform an Offsets-Stopped calibration to roughly determine hard-iron offsets. This procedure can then be used to fine-tune the calibration.

When a complete set of data is stored, the PDA beeps and starts processing. At this point, it is okay to stop moving. The status message indicates different phases of the required data processing and, for long sequences, the count to the right of the message is decremented as a progress indicator.

If the processing is not aborted, results are displayed as shown in Figure 19. Refer to the section on *Applying Calibration Results* for an explanation of this dialog. Both Moving and Stopped calibration procedures culminate in the same dialog.

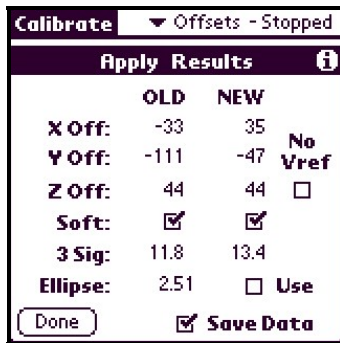


Figure 19

Collecting Discrete Samples when Stopped

This is the preferred method of calibration for most situations. As few as 7 samples are sufficient to calculate results. Use the Offsets-Stopped category on the PDA Calibration page (Figure 20). Tap the Start button to put the compass in calibration mode. When stopped, tap the Sample button in the center of the plot to collect a sample. During collection, the position of the X marking the sample will move if the compass is moved.

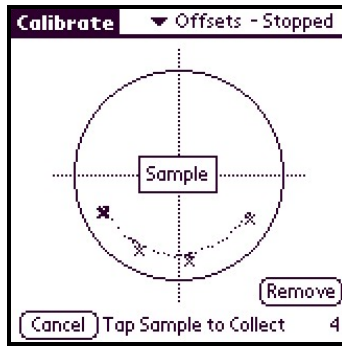


Figure 20

After the first sample, magnetometer X,Y coordinate pairs are faintly plotted on the graph to trace the path of the vehicle. This is intended as an aid to determine where the next sample will be located. If a sample is removed, the trace is deleted when the plot is refreshed.

When 7 samples have been saved, the label on the Cancel button changes to Finish. Continue taking additional samples, or tap Finish to proceed to the data processing phase. An error is indicated if the samples do not span enough of the magnetic field range. Otherwise, results are displayed as shown in Figure 19.

Applying Calibration Results

If the new results produce less variation in total magnetic field strength than the old, then the *Use* checkbox will be checked in Figure 19. Likewise, if the application of soft-iron gains produces the least variation, this checkbox is checked. Either or both of these can be overridden. If you don't want to use the new values, collected data and calculated results can still be saved for later analysis. To discard everything, clear both the *Use* and *Save Data* checkboxes before tapping *Done*.

The value labeled 3 Sig in the dialog is a percentage that means that 97% of the calculated total field magnitudes fell within a range centered on the average, plus or minus the indicated percent of average. It indicates the calculated variation with and without soft-iron, depending on whether the *Soft* box is checked.

The value labeled *Ellipse* is the percentage difference between the major and minor axes of the calculated ellipse that best fits the data. The value shown is 100 times the ratio of the major axis divided by the minor axis. Using soft-iron compensation will not be suggested if the two axes differ by less than 0.5%.