# User's Guide
# TapRoot & Root 1

**Release 2.2**
**October 25, 2002**

# Contents

# 1. Overview

## 1.1 TapRoot and Root 1

TapRoot provides a convenient interface through which a user may become familiar with the basic capabilities of the Root 1 USB Test Host ('Root 1'). TapRoot also provides features and utilities that are useful during the development and implementation of test strategies using Root 1.

Root 1 provides a powerful command set for both interactive and RootScript applications. The "Root 1 Interface Specification", included on the CD-ROM "Root 1 Documentation and Support", provides a detailed description of the Root 1 control interface, modes of operation and command set. The "Applications" folder on the CD-ROM includes application notes discussing both interactive and RootScript applications. This folder also contains dynamically linked libaries (DLLs) for Windows, and examples, including C source code, for interactive and RootScript applications.

## 1.2 User's Guide

This guide contains an introduction to TapRoot and Root 1, followed by detailed information on the TapRoot features and utility functions. Once the basics of connecting to and communicating with Root 1 are accomplished, the TapRoot feature set and utility functions are covered in detail. For complete information on Root 1 functions, please refer to the "Root 1 Interface Specification" (see below).

- Section 2 shows how to connect a Root 1 and host PC, establishing control with the TapRoot application.
- Section 3 explores the TapRoot feature set and how the features are used to control or interact with a Root 1.
- Section 4 describes utility functions provided with TapRoot for building USB commands, viewing USB device descriptors and managing the Root 1 flash memory.

Names of TapRoot functions, commands, and windows or frames are italicized. (e.g. - *Root Port Status*, *File/New*, *Program*) Titles and names of Taproot features, labels, or controls are quoted. (e.g. - "Vcc Enable", "Suspend", "Applications")

## 1.3 Root 1 Interface Specification

This guide is intended to introduce the user to the capabilities of Root 1 and the TapRoot interface software. When the user is ready to put Root 1 to more advanced tasks, it will be necessary to have access to detailed information on all of Root 1's features. This is provided in the Root 1 Interface Specification, included on the Documentation and Support CD-ROM. In key sections of this guide, references to the Interface Specification section containing complete information on a topic are provided for the interested reader.

The Interface Specification contains a complete description of the command protocol for Root 1, including the different Root 1 operating modes. Byte-by-byte details of each command and the command/response sequences are provided. Root 1 can detect and report certain USB events and these are described. Root 1 script usage and management, introduced in sections 3 and 4 of this document are fully explained in the Interface Specification.

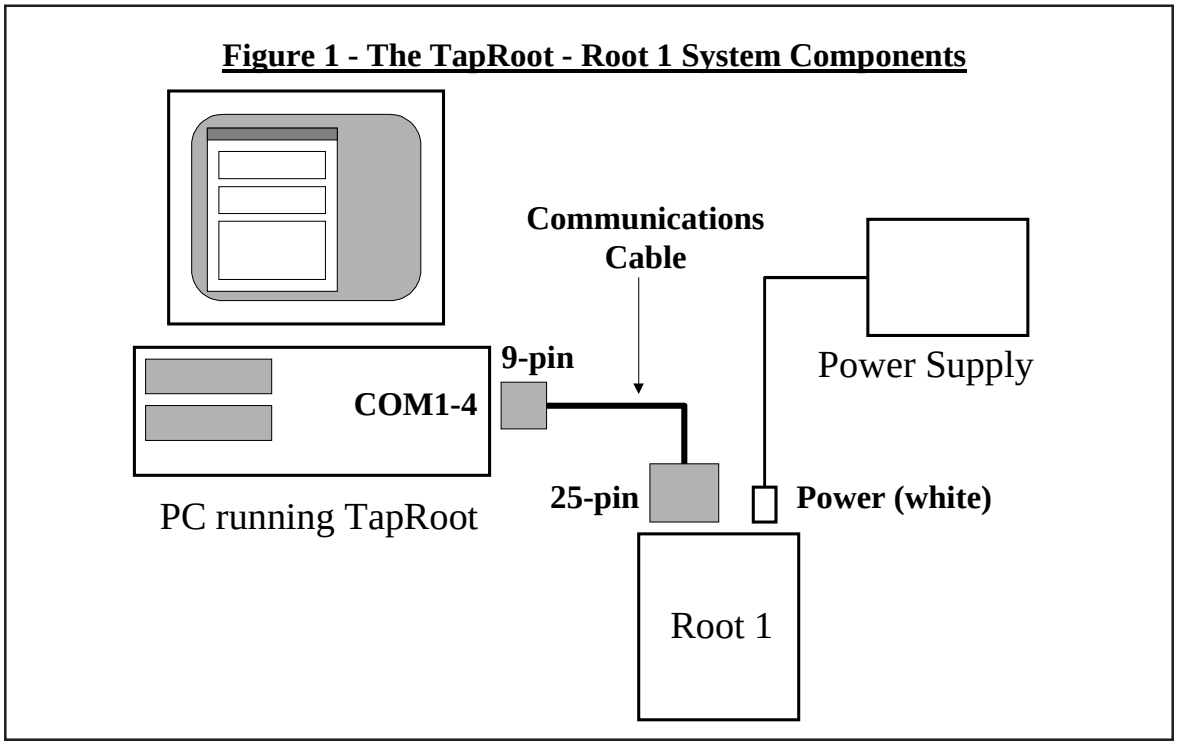
## 2. Root 1 Installation and Familiarization

The Root 1 installation kit includes the following items:

- Root 1 Documentation and Support CD-ROM
- Root 1-to- PC Host Communications Cable
- R1-PSW Root 1 Universal Input Power Supply

The set of instructions in this section of the User's Guide assume that Root 1 is not connected to any USB devices and that it has not been configured to use a default RootScript (see section 4.3).

**Figure 1 - The TapRoot - Root 1 System Components**




### 2.1 Install TapRoot on your PC

Insert the "Root 1 Documentation and Support" CD-ROM into the Host PC and open the "TapRoot" folder. The setup program is named *setup.exe.* Run it by double-clicking its icon or name. Follow the instructions to install the TapRoot program on the PC.

### 2.2 Connect the Communications Cable

Plug the communications cable's 25-pin connector into the Root 1 "Control" port. Plug the cable's 9-pin connector into a serial (COM) port of your host PC. TapRoot supports COM1 through COM4.

### 2.3 Apply Power to Root 1

Plug the white power connector from the power supply into the mating power connector on Root 1.

Plug the Root 1 power supply into a standard AC outlet to apply power to Root 1. (*Note: The R1-PSW power supply is a universal input power supply. It will provide the proper power to Root 1 from an AC line voltage from 100 to 240V and 50 or 60Hz*).

### 2.4 Root 1 Status LEDs

After Root 1 is powered and has configured its internal logic, it will display two solid green and one flashing red status LEDs. The green LED closest to the USB connector indicates that Root 1 is powered. The remaining green LED indicates that Root 1 has successfully configured its internal logic. The red LED flashes when Root 1 is configured and its control interface is ready to interact with a host.

### 2.5 Start TapRoot

Start TapRoot from the TapRoot program group in the Windows "Start/Programs" menu. (*Note: If the default program group was changed during installation, the TapRoot program will be accessed from a different program group*.) TapRoot can be terminated either via the "File/Exit" pull-down menu or the Windows Close Application button at the upper right.

### 2.6 Connect to Root 1

In the TapRoot "Comm Select" window, select the checkbox for the COM port to which Root 1 is connected and then click the "Connect" button. TapRoot will interrogate Root 1 for its firmware revision and the amount of installed RAM. That information will be displayed in the TapRoot *Host* frame. At this point, TapRoot is ready to control the configuration of Root 1.

### 2.7 Controlling Root 1

TapRoot's *Root Port Status* window will initially show that USB power is off and that no device is connected. Click the "Vcc Enable" button in the *USB Vcc Control* window to enable Root 1 USB bus power on the Vcc line. The *Root Port Status* window will now report that USB power is "On".

After initial power-up, Root 1 will be in its Automatic Mode (see section 3.5). In this mode, Root 1 will automatically enumerate and configure any devices as they are connected to the USB port. Plug a USB device into Root 1, and a "Connect" message will be displayed in TapRoot's *Root 1* frame. For example:

```
*** Connect
    Address: 0x02   DevClass: 0x00   Vendor ID: 0x0123   Product ID: 0x5678
```

# 3. TapRoot Feature Set

## 3.1 TapRoot Monitoring Frames

TapRoot has three monitoring frames that display Root 1 status or communications - *Root Port Status*, *Host*, and *Root 1*.

### 3.1.1 Root Port Status Frame

The *Root Port Status* frame displays Root 1 USB power and connection status. 'Root Port' refers to the Root 1 USB Test Port - the single series-A USB connector on Root 1's front panel.

The *Power* window indicates whether USB power is on or off.

The *Connect* window indicates whether a device is connected to the Root Port and, if so, whether it is a low-speed or full-speed device. The *Connect* window indicates only the type of device which is connected directly to the Root Port. If that device happens to be a USB hub, it will be properly identified as a full-speed USB device, even though low-speed devices may be attached downstream of the hub.

The *Root Port Status* frame also indicates whether the Root Port state is Active or Suspended.

### 3.1.2 Host Frame

The *Hos*t frame lists all control actions between the Host and Root 1. The messages in the *Host* frame can be cleared by clicking the "Clear" control.

### 3.1.3 Root 1 Frame

The *Root 1* frame shows a summarized and formatted view of the Root 1 USB messages. The messages in the *Root 1* frame can be cleared by clicking the "Clear" control.

## 3.2 TapRoot Sessions and the Comm Select Frame

The *Comm Select* frame contains selection buttons for the COM port (1 to 4) to be used for Host-to-Root 1 communications.

A TapRoot session begins by selecting a COM port and clicking the "Connect" button. TapRoot then interrogates Root 1 to determine its firmware revision and installed RAM. This information is displayed in the *Host* window. The session may be terminated at any time by clicking "Disconnect". Terminating a TapRoot session will not change the configuration of Root 1.

The COM port selection buttons are not enabled when a TapRoot session is active.

## 3.2 Power Control Using the USB Vcc Control Frame

Root 1 allows the user to enable and disable USB bus power and to control the voltage within the 4.40 to 5.25V range allowed for USB. These functions can be used regardless of whether Automatic mode (section 3.5 of this guide) is enabled or disabled. The Root 1 Interface Specification section 3.5 and 3.6 describe USB Power

Control functions.

3.2.1 Enabling and Disabling Power

At the beginning of a session, TapRoot initializes USB Vcc to 5.00V with bus power disabled. To enable and disable USB power, click on the "Vcc Enable" and "Vcc Disable" buttons in the *USB Vcc Control* frame.

The user may modify the bus voltage setting at any time, whether or not Vcc is enabled, by entering a new value in the voltage window and clicking "Set Vcc". If a value outside the allowed range is entered, the voltage is set and displayed at the closest allowed value.

Changes to USB bus power status or voltage are reported in the *Host* window.

3.2.2 Autorecovery

Selecting the *AutoRecovery* checkbox causes Root 1 to automatically attempt to reenable USB Vcc after a device overcurrent fault causes bus power to be disabled.

When an overcurrent fault occurs, a message is displayed in the Root-1 window. *Vcc Enable* status is changed to "Disconnected", and the *Connect Status* window will show "No Device". Once per second, Root 1 will then re-enable Vcc and check for faults. Because the overcurrent condition is typically still present, a list of "Device Fault" error messages will appear in the *Root 1* frame.

Should the overcurrent condition clear, a new "Connect" message will be displayed in the *Root 1* frame, *Vcc Enable* status will change to "Enabled", and the *Root Port Status* frame will display the normal device information.

**3.4 Current Measurement Using the Vbus Current Frame**

The *Vbus Current* frame allows the user to perform measurements of the USB Vcc current draw. Selecting the "Measure" option causes a single current measurement to be made and reported in the current window. Selecting the "Continuous" option causes TapRoot to request current measurements from Root 1 continuously, updating the displayed current measurement approximately once per second. (see section 3.6 of the Root 1 Interface Specification)

**3.5 AutoMode and the AutoMode Checkbox**

By default, TapRoot configures Root 1 to its Automatic Mode and will show the *AutoMode* checkbox as selected. In this mode, Root 1 performs many of the functions of a normal USB host controller automatically - devices connected to the USB port are reset, enumerated and placed in their default configuration. (see section 2.7 of the Root 1 Interface Specification)

Deselecting the *AutoMode* checkbox will disable Root 1's Automatic Mode. A prompt will require confirmation that Automatic Mode is to be disabled. After Automatic Mode is disabled, devices connected to Root 1 will not be automatically reset, enumerated or configured. (A complete description of Root 1 modes is available in the "Root 1 Interface Specification.") Reselecting *AutoMode* will result in a repeat of the device initialization and configuration sequence.

### 3.5.1 Enumeration and Configuration

The successful enumeration and configuration of a newly attached device results in the generation of a "Connect" message by Root 1 which is interpreted and displayed in the *Root 1* frame. The message includes the vendor ID and product ID information read from the USB device's Device Descriptor, and the USB address which Root 1 has assigned to the device. If the device connected to the root port is a USB hub, Root 1 enables the hub's downstream ports and monitors the hub status for connects and disconnects. Devices which attach downstream of the hub are also automatically configured when they are detected. (Section 4 of the Root 1 Interface Specification deals with the reporting of USB events by Root 1.)

Whether a device connects directly to the Root Port or to an external hub, the enumeration and configuration procedure employed by Root 1 is typical of a USB host controller. A delay of 100 msec follows the physical connection of the device so that it can stabilize. Following that delay, a USB Reset, lasting approximately 64 msec, is applied to the device.

Once the USB Reset is removed from the bus, a delay of 10 msec is allowed before the device must be prepared to respond to traffic at USB address 0. Root 1 reads the first eight bytes of the device's Device Descriptor to determine the device's control endpoint MaxPacketSize. (MaxPacketSize defines the maximum number of bytes the device can transfer in a single packet to or from the control endpoint.) The device is then assigned an address (enumerated). A delay of 2 msec follows enumeration, after which the device must be prepared to respond to traffic at its newly assigned address. Root 1 then reads the entire Device Descriptor and Configuration, relaying the information to TapRoot where it is displayed in the *Root 1* frame.

### 3.5.2 Disconnection

Physically disconnecting a configured device while Root 1 is in Automatic Mode results in a "Disconnect" message being generated by Root 1 and displayed in the *Root 1* frame. The "Disconnect" message includes the address assigned to the disconnecting device during enumeration.

### 3.5.3 Data Messages

In Automatic Mode, USB Interrupt IN endpoints defined in the device's default configuration are polled by Root 1. Any data returned by the device in response is displayed in the *Root 1* frame as a "Data" message. A "Data" message includes the address and endpoint from which the data was received and the data itself represented as hex bytes. NAK responses from interrupt endpoints are not reported by Root 1.

The following message samples show the contents of the *Root 1* frame after a device connect, data report, and disconnect:

```
*** Connect
     Address: 0x02   DevClass: 0x00   Vendor ID: 0x04B4   Product ID: 0x6370
*** Data -- Address: 0x02   EndPoint: 0x01
      00 00 01 00
*** Disconnect
     Address: 0x02
```

## 3.6 USB Controls Frame

The *USB Controls* frame controls *USB Reset* and *USB Suspend/Resume* functions (see section 3 of the Root

1 Interface Specification). Clicking the "USB Reset" button will issue a USB Reset on the Root Port. If AutoMode is enabled, a USB Reset will result in a complete re-enumeration and reconfiguration of all devices attached to the USB. If *AutoMode* is disabled, the USB Reset will be generated at the Root Port, but no other action will be taken automatically by Root 1.

"Suspend" and "Resume" enable and disable the generation of Start of Frame (SOF) packets on the USB. According to the USB specification, the absence of activity on the bus for more than 3 msec will cause devices attached to the bus to enter the Suspend state, and after 10 msec of no activity, affected devices must be completely in the Suspend state. The "Suspend" button places the USB in the Suspend state at the Root Port level. That is, the device attached to the Root Port and all devices attached downstream of that device, if it is a hub, will be suspended. Clicking the "Resume" button will restart SOF activity on the bus.

Root 1 fully supports USB Remote Wakeup functions from devices attached to the bus which are capable of generating remote wakeup signaling and enabled to do so.

### 3.7 RootScripts and the RootScript Frame

RootScripts are batches of the Root 1 commands listed in section 5 of the Root 1 Interface Specification. Using the RootScript frame controls allows the user to download and subsequently execute RootScripts on Root 1. Clicking the "Load" button opens a browse window, allowing the user to browse for the RootScript file to be loaded. The standard file extension used by TapRoot for RootScript files is ".rs".

Upon opening the file, TapRoot displays the script file name in the File Name window (next to the "Load" button), and downloads it to Root 1. (A complete description of RootScripts is available in the "Root 1 Interface Specification".) Two "Download" messages may be displayed in the *Host* frame because TapRoot issues a *Program* command before starting to download a script. Scripts typically also contain a *Program* command as the first line of the script. Both *Program* commands invoke a response from Root 1 and are reported.

During the download, the script index window (next to the "Run" button) increments to indicate the number of commands loaded. When the download is complete, the Script Index window indicates the index location of the script's *RS_End* command.

To begin execution of the script, click the "Run" button. (The "Run" button is disabled during download.) A script may terminate on its own, or the user may terminate it by clicking the "Stop" button. (The "Run" button label changes to "Stop" while the RootScript is running.) On termination of the script, the Script Index window will display the index at which script execution halted.

During script download and execution, AutoMode is disabled, no Root Port Status polling is performed, and continuous current measurement, if enabled, is temporarily suspended.

### 3.8 Session Logging

TapRoot can create time-stamped text files that record a log of messages and data from Root 1 and attached USB devices, including those caused by a TapRoot utility. Open a new logging file by using the "File/New" pull-down menu selection to open a browse window. Browse to or create the desired folder and enter a filename. If the destination filename already exists, a prompt will require that confirmation that it is to be overwritten. All subsequent messages shown in the *Root 1* frame will be recorded in the logging file. Use the "File/Close" pull-down menu selection to terminate logging and close the file.

# 4. TapRoot Utilities

TapRoot utilities are invoked by clicking the large buttons in the "Utilities" frame at the bottom of the TapRoot window or by using the "Utilities" pull-down menu.

## 4.1 Device Request Builder

The *Device Request Builder* utility allows the user to construct Root 1 *DevRqst* commands which generate USB Device Request commands to the control endpoint of an attached USB device. The standard Device Request fields are provided, and up to 32 bytes of data can be included with a Host-to-Device (Setup-Data Out) request. This command is described in section 3.1 of the Root 1 Interface Specification.

The information in the various Device Request fields will be displayed as hexadecimal values. The user may enter information either as decimal, or as hexadecimal values by prefixing the data with "0x". The data bytes will be accessible only for requests whose direction is Host-to-Device, as indicated by bit 7 of the *bmRequestType* field being set to 0.

If the device to be accessed was connected to Root 1 in Automatic Mode, Root 1 will be aware of the device's speed and MaxPacketSize requirements and these will be shown in the window. If the device was attached with Automatic Mode disabled, this information must be provided by the user in the windows provided. The device speed and *MaxPacketSize* windows will only be accessible if AutoMode is disabled.

Once the request is fully constructed in the *Device Request Builder* window, it may be sent to Root 1 by clicking the "Send" button. The Root 1's response to the command will be displayed in the *Root 1* frame.

For convenience, *Device Request Builder* allows requests to be saved and reused. The "Save" button will open a browse window, so that the user may specify a file name and location for the device request information. The standard file extension used by TapRoot for device request files is ".dr". To reuse the saved file, click the "Open" button, again invoking a browse window, which is used to locate and select the file to be loaded.

## 4.2 Descriptor Viewer

The *Descriptor Viewer* utility allows the user to specify a device by USB address and read its full set of standard descriptors by clicking the "Get Descriptors" button. Once read, the descriptors are displayed in *Descriptor Viewer's* scrolling window. In addition, the descriptor set may be saved to a file by clicking the "Save" button which opens a file browse window.

## 4.3 Flash Management

The mechanics of manipulating RootScripts in the Root 1 flash memory are described in section 6 of the Root 1 Interface Specification.

### 4.3.1 Default RootScripts

A default RootScript can be stored in Root 1 non-volatile flash memory. Root 1 can be configured to execute the default script on power up, rather than entering Interactive Mode. The *Flash Management* utility facilitates the programming and control of default scripts. As delivered from the factory, or after new firmware is loaded, Root 1's default script is undefined.

### 4.3.2 Loading a New Default Script

An existing RootScript can be loaded into Root 1 using the *Flash Management* utility. The script is loaded by selecting *File/Burn New Script* from the tool bar. A Windows browse box will appear, which will allow the desired script file to be selected. Once the script file has been selected, the progress of loading the script into Root 1 RAM will be shown in the TapRoot *RootScript* window. When the file has been successfully loaded, it can be named by entering up to eight characters in the *New Script Name* field. The script is then stored in Root 1's flash memory by clicking the "Program" button.

### 4.3.3 Enabling and Disabling the Default Script

When a default script has been stored in Root 1's flash memory, it can be enabled or disabled. When the *Flash Management* utility is activated, it will report the name and current status, enabled or disabled, of the default script. If no default script is loaded, status will be reported as "Undefined". The default script is enabled or disabled by clicking the "Enable/Disable" button next to the status window.

### 4.3.4 EZ USB Firmware Loading

The *EZ USB* utility allows firmware files stored on the host to be downloaded to a USB device via Root 1. Firmware files are first converted to RootScripts, then transferred to Root 1. The user then directs Root 1 to transfer the firmware file to a connected USB device.

Activate EZ USB by selecting it from the "Utilities" pull-down menu. Select the device address to which the the firmware is to be transferred. Click the "Load Firmware" button to open a file browse window. Locate and double-click the desired file or select it and click "Open". The file must have the extension ".hex" to be recognized as an EZ USB firmware file. The file will be transferred to Root 1 as a RootScript file. After transfer is complete, click "OK" to return to the TapRoot window. The RootScript frame will show the firmware filename in the Load window with an extension of ".rs" as the file has been converted to a RootScript file.

Connect the USB device to be reprogrammed and be sure that the Root-1 shows that the device is connected and that the USB address corresponds to that selected in the EZ USB dialog. The USB device may be connected and enumerated prior to entering the EZ USB utility, as well.

Click the "Run" button in the RootScript frame. "Running" will appear in the RootScript "Run" window. When the script has completed, "Stopped at (RootScript index)" will replace "Running" and the Root 1 window should display a "Disconnect" message, followed by a "Connect" message as the reprogrammed device re-enumerates itself, accompanied by a change in the appropriate ID fields.

## 5. Root 1 Firmware Upgrades

From time to time, RPM releases firmware upgrades for Root 1 - either to fix known bugs or to add additional features. These releases are made available via the Internet at RPM's web site - **www.rpmsys.com**.

In the event that you desire to upgrade the Root 1 firmware, a special application (*rlloader*, supplied on the "Root 1 Documentation and Support" CD-ROM) and cable adapter (Root 1 Upgrade Adapter) are required to download the new firmware to Root 1. To install *r1loader*, open the "Firmware Upgrade" folder on the CD-ROM, then double-click the "*setup.exe*" program.

Root 1 Upgrade Adapters can be purchased from RPM, or can be constructed by the customer from the drawing provided in the "Documentation" folder on the "Root 1 Documentation and Support" CD-ROM.