Technical Review and Configuration Details of Intel Smart Response Technology on HP Workstations

Table of contents

Introduction

In the last few years Solid State Devices (SSDs) have been offered on the market as an alternative to Hard Disk Drives (HDDs). These new solid state devices based on NAND technology have performance and latency advantages compared to HDDs, but have a cost per bit that is much higher. These trade-offs have led to several hybrid solutions that attempt to provide the performance of the SSD with the capacity of a HDD. Intel Smart Response Technology (SRT) is one of these solutions. It provides a software layer to cache data on the SSD so that it can be accessed more quickly. It is available on HP Z220 Workstation and HP 8470w, HP 8570w and HP 8770w EliteBook Mobile Workstations. It is also available on other classes of HP products which are not referenced in this paper.

Technical Details

Intel's Smart Response Technology combines the benefits of an HDD and SSD through changes in the storage stack for Microsoft Windows 7 based systems. It is a software solution that effectively modifies the storage architecture so that logically the SSD drive is between the system memory and an HDD or single RAIDed volume. The SSD acts as cache for the HDD and is not visible to the system or the user as it does not show up as a logical volume. SRT implements a monitoring system that captures the most used data and caches this data into the SSD.

One advantage of Intel's SRT is that it doesn't require an additional storage controller since it uses the same chipset SATA controller as used by the HDD. In order to enable SRT Intel's Advanced Host Controller Interface (AHCI) SATA storage controller must be configured in RAID mode with both the SSD and a single HDD volume. SRT cannot be run with HDDs connected to other storage controllers, e.g. PCIe add-in card controllers.

SRT can be configured in two different modes: Enhanced Mode and Maximized mode. Please refer to the Additional Resources section at the end of this paper for more information.
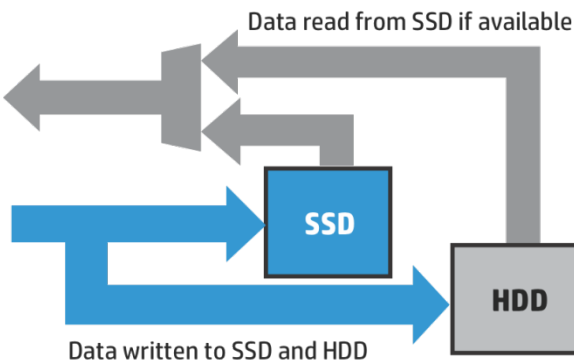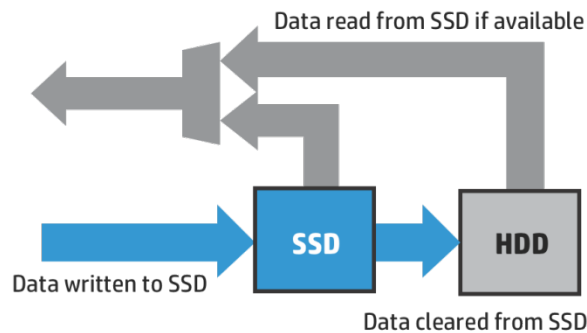

Figure 1: Enhanced Mode

Figure 2: Maximized Mode

Enhanced Mode is a write-through mode offering low risk of data loss since all data is being written to both SSD cache and Host HDD. In enhanced mode the user can consider the HDD as being up to date. The SSD is used for improving read performance only since writes always go directly to the HDD. If the data is in the SSD during reads it is read from the SSD otherwise it is read from the HDD.

Using Maximized Performance Mode provides a write-back caching solution. In this mode data is written to the SSD, but not the HDD. Data is removed from the SSD and stored in the HDD opportunistically. Maximized mode offers a faster performance at a slightly higher risk of data loss. In this mode the HDD and SSD cache both contain a portion of the system image and both devices are needed in order to create a complete image. SRT software must maintain coherency between the SSD and HDD. If there is a failure in any of the components then recovery of the system image becomes difficult.

Solid State Drive trade-offs

SSDs are built using NAND technology and provide much higher read performance than rotating media but have some unique attributes that must be considered before determining their usefulness as a caching device for a hard drive. First

and foremost SSDs are consumable components with a limited number of program erase (P/E) cycles. The more writes or the smaller the capacity the more P/E cycles required to clean up the drive and make space available for future data. Since caching by its very nature sends many writes to a small capacity drive, it reduces the useful lifetime of the drive.

SSDs capacity should be selected correctly according to workload, endurance requirements, and system configuration. SSD sizing is somewhat dependent on dataset sizes, as it will not provide the expected benefits to improve application performance if your dataset is larger than the cache and cannot be managed in the cache. SSD cache sizing is not based on any hard and fast rule but a reasonable first estimate on the size of cache is 4x the amount of memory in the system.

There are new devices being offered in many platforms called Hybrid Hard Drives (HHD). These devices combine both a NAND array with rotating media in a single device. HHD can manage the NAND array in the firmware of the drive requiring no software stack changes. These drive managed solutions are typically not as efficient as caching algorithms that have some level of user and file-system awareness. The first HHDs on the market have been targeted at the Notebook segment and are focused on low-cost adder to improve HDD performance and do not have a large enough NAND array to hold many of the typical workstation datasets.

Performance Expectations

Intel's SRT caching technology is designed to enhance performance. It has the potential to improve system boot, system resume, application load, and application runtime. The first two charts shown in Figure 3 show the advantage of using SRT while booting and resuming in the HP Z220. In the example configuration Intel's SRT is shown to reduce boot time by 50 percent and resume time by 25 percent. Performance gains for boot and resume will vary based on many factors including but not limited to the number of services and applications that have to start, management overhead, number of accessories attached, configuration of storage subsystem, and amount of memory in system. Although not shown application startup can also be improved but performance gains vary dramatically dependent on the application's profile during startup. The amount of data read, the amount of computation done on the data that is read, and the amount the application waits on the data being read will all impact performance.

Figure 3: Boot and Resume Performance

HP Z220 Boot Time Comparison
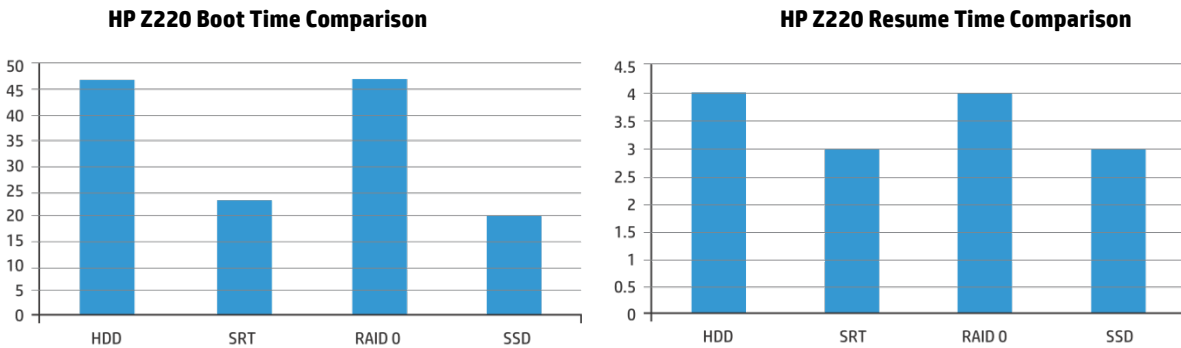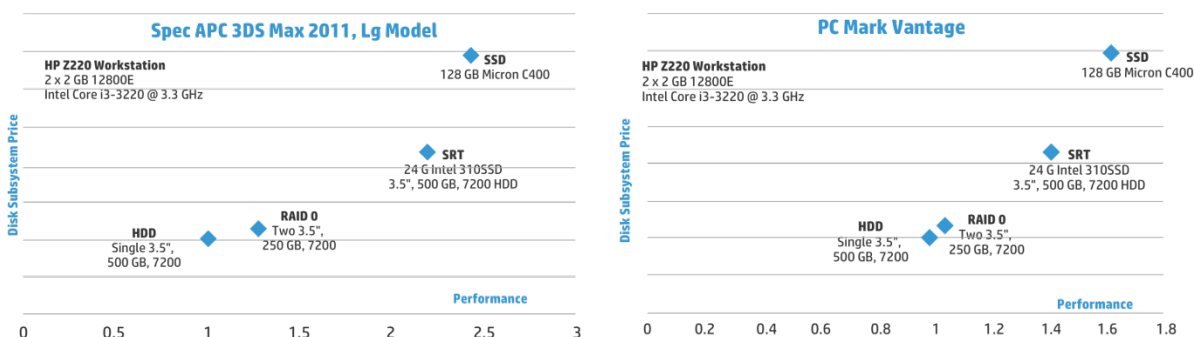
HP Z220 Resume Time Comparison

Figure 4 shows that application runtime can also be improved using Intel's SRT, but the biggest gains are seen when application datasets do not fit in memory. If an application's data fits in memory then improvements will be seen while the data is being read from the storage subsystem, but once it all resides in memory the application performance will be similar regardless of whether SRT is enabled.

Figure 4: Application Performance

Spec APC 3DS Max 2011, Lg Model

HP Z220 Workstation
2 x 2 GB 12800E
Intel Core i3-3220 @ 3.3 GHz

SSD
128 GB Micron C400

SRT
24 G Intel 310SSD
3.5", 500 GB, 7200 HDD

RAID 0
Two 3.5",
250 GB, 7200

HDD
Single 3.5",
500 GB, 7200

PC Mark Vantage

HP Z220 Workstation
2 x 2 GB 12800E
Intel Core i3-3220 @ 3.3 GHz

SSD
128 GB Micron C400

SRT
24 G Intel 310SSD
3.5", 500 GB, 7200 HDD

RAID 0
Two 3.5",
250 GB, 7200

HDD
Single 3.5",
500 GB, 7200

The price performance chart shows the advantage for memory limited systems. Spec APC 3D Studio Max 2011 large model benchmark was run on a HP Z220 with 4 GB of memory and Intel SRT in enhanced mode. The large model dataset is 12 GB in size, much larger than the physical memory configured for this test. PC Mark Vantage was also run on the HP Z220 system with 4 GB of memory. Results show some incremental performance improvements can be achieved at almost no cost using RAID 0 by switching from one large 500 GB hard drive to two 250 GB hard drives that are striped. Intel's SRT solution provides much better performance and has a similar price performance advantages as a single HDD. SSDs provide even better performance but command a much higher cost. Those users interested in improving their performance for a minimal price increase should consider RAID 0. Those who wish to improve their storage performance to near SSD speeds with a modest price increase should consider SRT.

Performance benefits will vary based on workload and type of work being performed. The Intel SRT caching algorithm will avoid caching some applications and workloads including: virus scanning, web surfing, and video playback. If your application is similar to one of these functions there may be no performance benefit.

Platform Support

In order to use Intel's Smart Response Technology the following Intel guidelines must be met.

- Intel® chips that supports SRT such as the C216 workstation chipset
- Intel® Core™ Processor in the LGA 1155 package
- System BIOS with SATA mode set to RAID
- Intel Rapid Storage Technology software 11.1 version release or later for Intel Xeon CPUs
- Single hard disk drive or multiple drives in a single RAID volume
- Solid State Drive (SSD) with a minimum capacity of 18.6 GB; maximum capacity is 64 GB
- Operating systems:
    o Windows® 7 Professional 32-bit Edition and 64-bit.
    o Windows® 8 with RST v11.5 or greater.
    o Linux is not supported.

The HP Z220 Workstation, HP 8470w, HP 8570w, and HP 8770w EliteBook Mobile Workstations with Windows® 7 Professional each meet the above requirements. At the time of this writing, these platforms support a 24 GB disk caching module. Other modules may be supported, please check with your sales representative or reseller. HP supports the most common configurations out of the factory. For example HP preconfigures SRT when both an HP supported caching device is ordered with a single hard disk drive. If less common configurations are required like a RAIDed HDD with a cache device then the system will need to be ordered and configured. There are two ways to do this:

- Order a single cache device and HDD, order a second HDD and install.
- Order a RAIDed HDD solution, order a supported caching device and install.

The HP Z220 has only two 6 Gb/s SATA ports; the remaining ports are 3 Gb/s. Adding a second HDD to create a RAID in conjunction with a SSD device for caching requires use of at least one 3 Gb/s port which will reduce the performance of one of the HDDs or the SSD. Several configuration examples are given in the next section. Please refer to that section for more details.

It is also important to note that hardware based encryption solutions using Self Encryption Drives (SED) are not supported with Intel SRT. Today the infrastructure for SEDs only supports a single drive and does not support the caching device or RAIDed hard drives. In order to provide data encryption when in RAID mode or with Intel SRT you must use a software encryption solution that encrypts before the data is written to the storage subsystem.

Configuring SRT

Not all possible configurations of SRT caching with an SSD and a volume of RAIDed HDDs are shown below. Instead a few examples are given to give the user some indication of what is possible.

RAID enablement of SRT through BIOS setup

SRT is only supported on workstations with Intel's AHCI SATA controller with Rapid Storage Technology 10.5 or higher. In order to configure and use SRT the AHCI SATA controller must be configured in RAID mode through the BIOS. Correct setup can be verified by going into computer setup. During boot depressing the f10 key to enter setup.

As shown in Figure 5, choose the Storage tab and Storage Options menu. Verify that SATA Emulation is in RAID+AHCI.

Figure 5: BIOS Raid Configuration

SRT is configured in the Intel RST GUI. Enabling means acceleration will be turned on and either configured to Enhanced or Maximized, see Figure 6 for an example. As mentioned previously Enhanced mode uses the SSD as a write through cache which writes data to both the SSD and the cache. Maximized mode changes the caching algorithm to write back. A write back cache will write the cache device and only write the hard drive when space is needed in the cache.

Figure 6: Cache enabled in Enhanced Mode
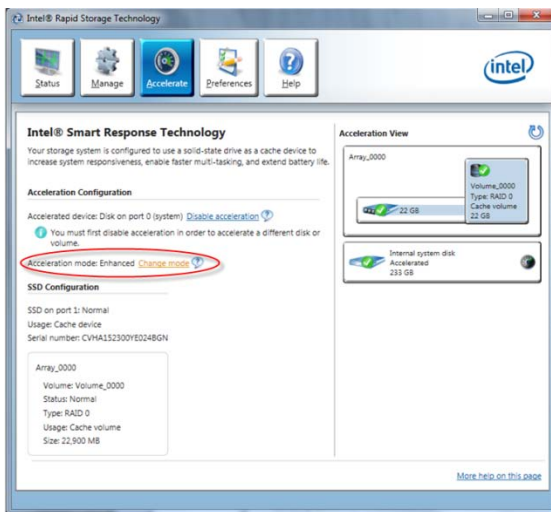
Adding a caching device.

The AHCI controller has to be configured to support RAID by changing the storage format in the BIOS if it is not already configured for RAID. The BIOS screen shown in the previous section shows an appropriately configured system.

Once Intel's AHCI controller is configured for RAID the caching device can be added and the SRT software installed.   Run the Intel Rapid Storage Technology Installer first to load the SRT software. Choose the installer: Start->All Programs->Intel->Intel Rapid Storage Technology Installer. On some systems the GUI can be installed directly from the control panel. This will force a reboot of the system. Once rebooted bring up the RST software. Go to: Start->All Programs->Intel->Intel Rapid Storage Technology.

With a caching device installed an acceleration tab will be available for configuration. This tab shown in Figure 7 is all that is required to turn the SSD into a cache. Choose Enable acceleration from the Accelerate section (note that this choice is also available from the status page).

Figure 7: Enabling the cache
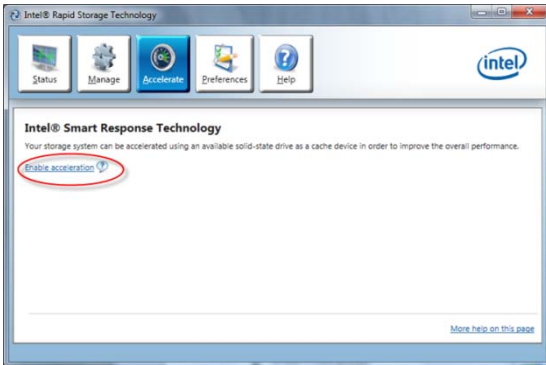
A dialog similar to Figure 8 gives the user some flexibility in how the SSD is configured when using it as a cache. The cache can be configured for either 18.6 GB or full capacity of the drive up to a maximum of 64 GB. A single hard disk drive or a single volume can be chosen to be accelerated. Lastly the acceleration mode can be selected by the user. The user can change mode at any time, if the user wishes to use the caching device as a standard storage device they must first disable acceleration, otherwise that caching device may not work normally.

Figure 8: Configuring caching
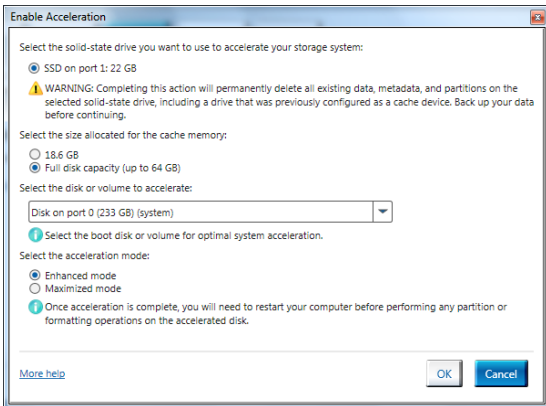
Adding RAID to an already configured caching solution

A single SSD can be used as a caching device for a single RAIDed volume in the HP Z220 Workstation. In order to configure this solution correctly the platform must first disable caching by selecting the disable acceleration button on the acceleration tab as shown in Figure 9.

Figure 9: Disabling the cache
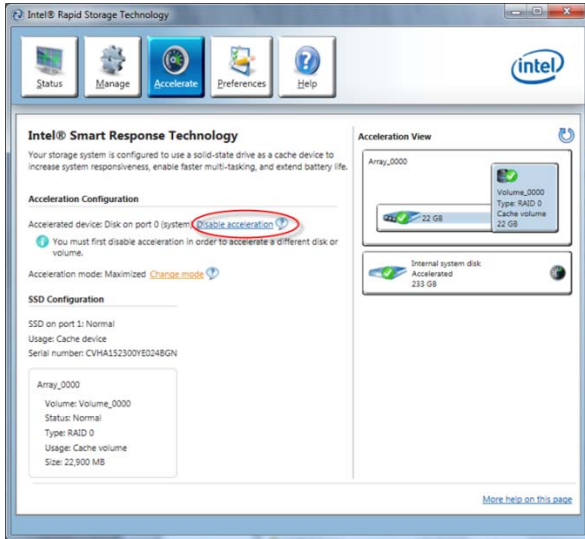
Once Acceleration is disabled a Create tab appears which allows creation of a RAIDed HDD array. Figure 10 shows how to select the volume type. Available volume types will vary based on the number of HDD available. In the example captured only two HDDs were RAIDed allowing only the RAID 0 (stripped for performance) or RAID 1 (replicated for redundancy). Make appropriate choices similar to the example dialog shown in Figure 11. This will configure the hard drives into a RAIDed volume.

Figure 10: Enabling and selecting RAID mode
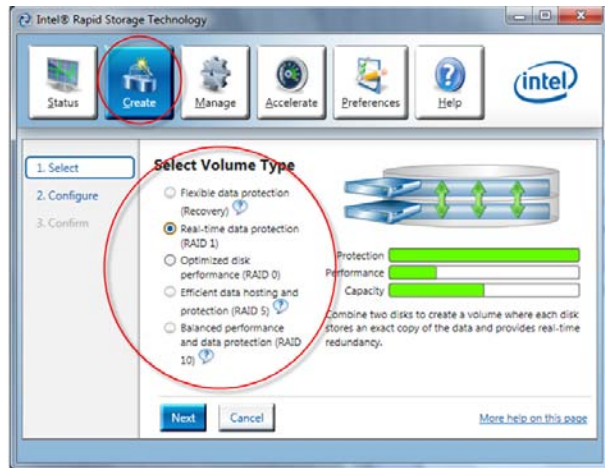
Figure 11: Configuring RAID
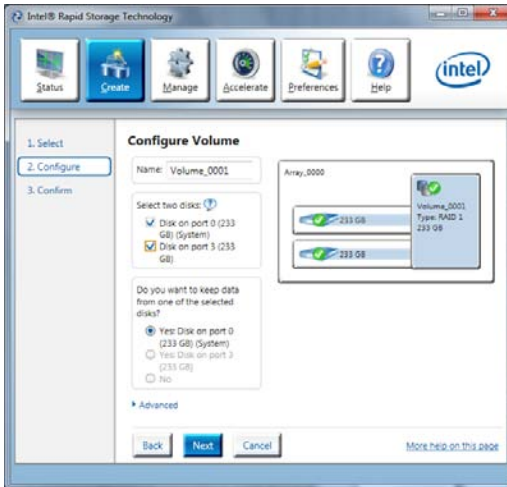
The RAIDed volume will be created, but migration takes time to complete since data will be moved to the new hard drive. You can watch the migration happen in the status window as shown in Figure 12. While the data is being transferred Acceleration mode is not available. Once completed the Acceleration tab is again available and the cache can be enabled. By clicking on Select Device the caching device can be re-enabled as shown in Figure 13 and Figure 14.
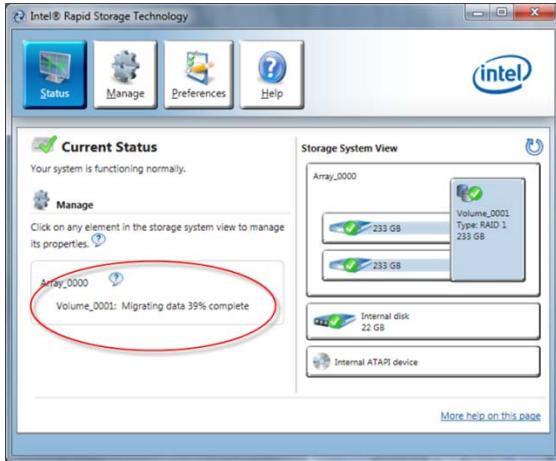
Figure 12: Migrating the data

Figure 13: Selecting caching device
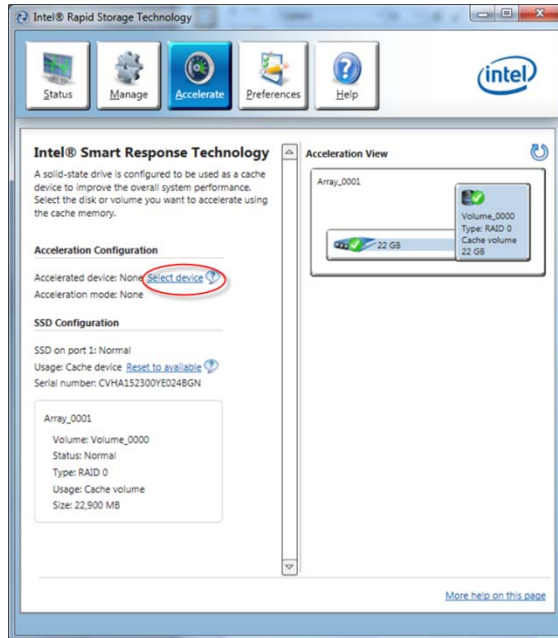
Figure 14: Cache configured with Raid
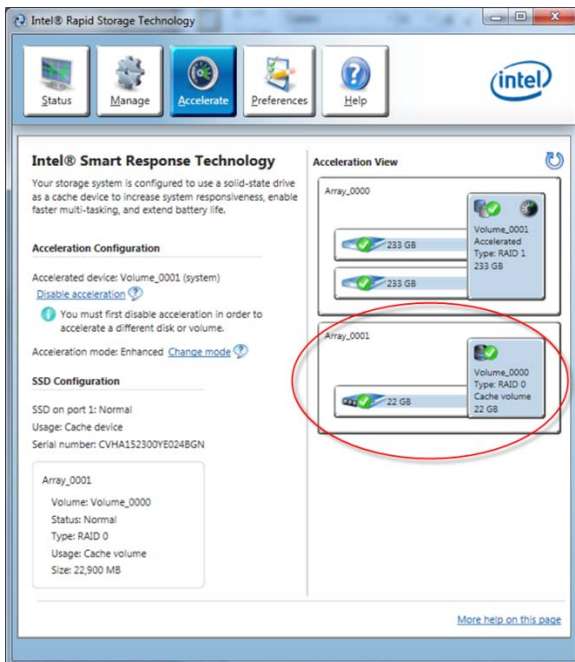
Intel Solid-State Drive Toolbox

Intel Solid-State Drive Toolbox can be used in conjunction with Intel SRT. All features of the toolbox may not be available, but drive wear, drive health, and many other attributes as well as tuning features are available. If an Intel caching device is used it is recommended that you download this toolbox from Intel's website at:
intel.com/support/go/ssdtoolbox/index.htm

Additional resources

hp.com/go/whitepapers

hp.com/go/Z220CMT_manuals

hp.com/go/Z220SFF_manuals

HP 8470w Manual

HP 8570w Manual

HP 8770W Manual