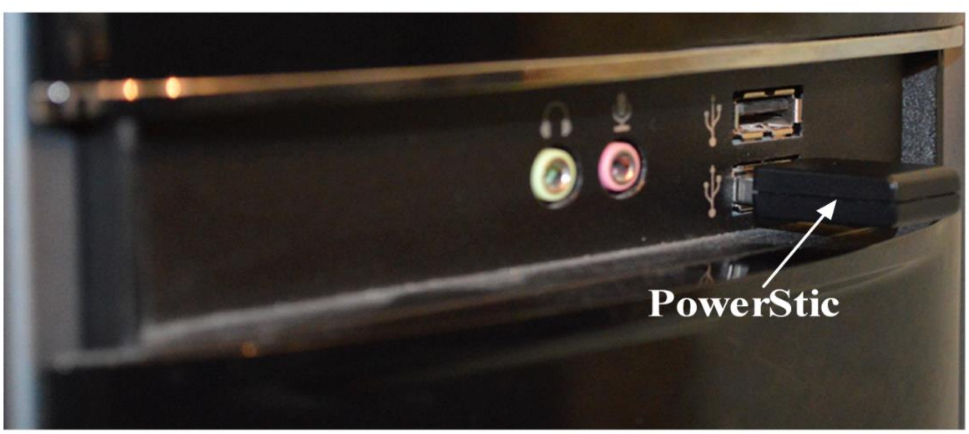
PowerStic Saves Millions per Year in DataCenter Operational Costs, Lowering Datacenter TCO

How much electrical energy is simply thrown away in Datacenters and Cloud Computing networks today? How much money is being lost due to this thrown away electrical energy in workstation/server client-server systems? What if you could recover this lost energy and reduce your utility costs, simply by plugging in a device into unused USB ports in your system? Sound impossible? Interested in learning more? Read on.

PowerStic inserted into a Supermicro X8STi Data Server USB Port

PowerStic inserted into a HP Proliant DL360P Data Server USB Port



PowerStic inserted into a HP Pavilion WorkStation USB Port

Figure 1: The PowerStic Recycling Waste Energy in Computer Systems

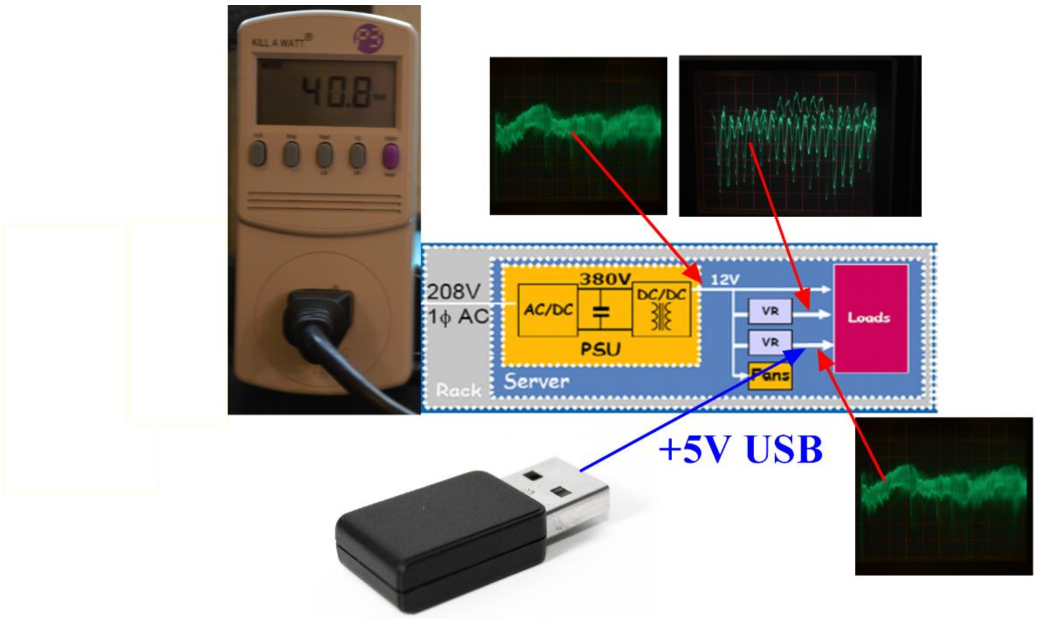
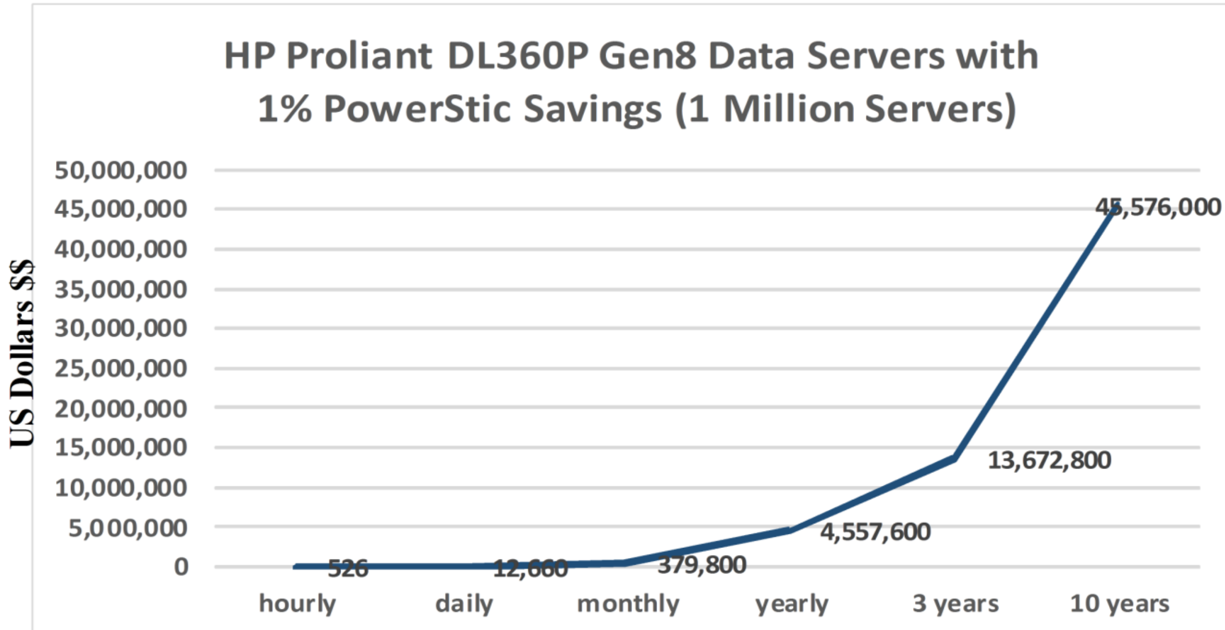


Figure 2: PowerStic Enhanced Workstation-Server System Model

In 2007, CurrentRF discovered a methodology for recovering the energy lost due to switching transients in digital and switching systems. Capitalizing on this discovery, the company was able to develop an IC, the CC-100 Power Optimizer, that recovers the energy lost due to these switching transients, and convert this energy back into usable power. Later, it was learned that modern system voltage regulators have very poor high frequency back to front isolation (S12 isolation), thus this high frequency energy created by logic and switching transitions in digital logic devices was found to couple to all parts of any digital system(see Figure 2 above).

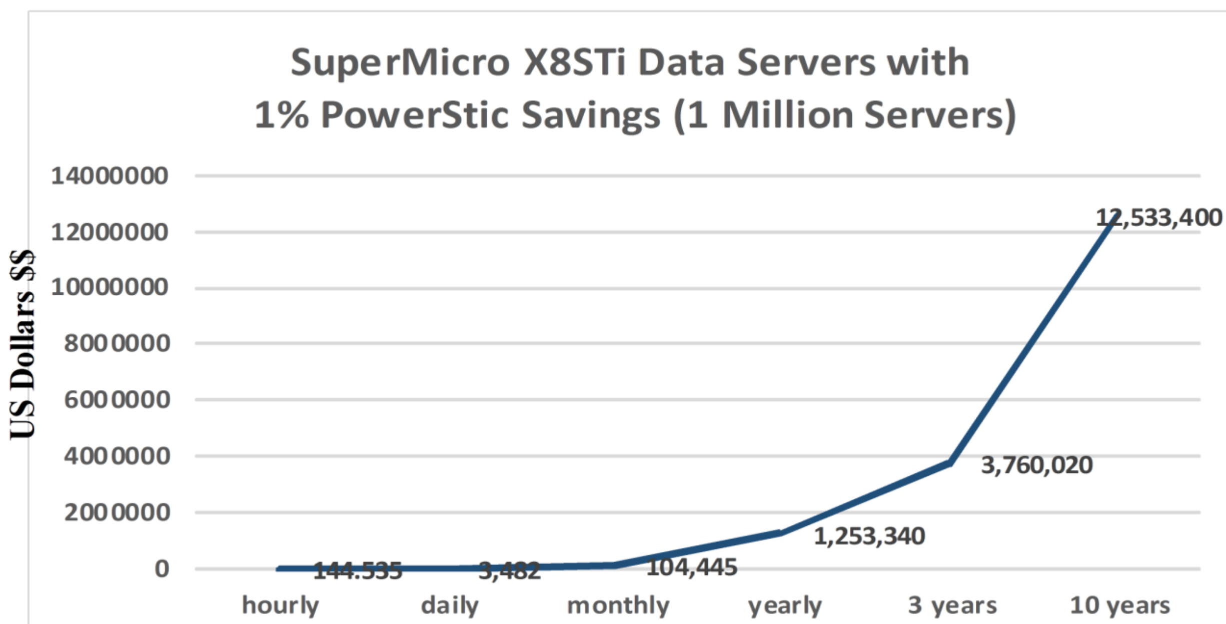
Using the techniques developed in the CC-100 IC engineering effort, and the CC-100 IC itself, the PowerStic device was created, enabling the capture and recycling of this regulator coupled, wasted energy present in all workstation, server, and networking computing systems.

At a **minimum**, how much energy and money can be saved using the PowerStic device in workstation, server, and networking computing systems? In Figure 3 and 4 below, based on testing results on HP Proliant DL360P Gen8 and SuperMicro X8STi data servers used in most data centers, the cost savings per year can range at a minimum, from 1 to 4 million dollars per year, in datacenters with 1 million active servers. The numbers scale with the number of active servers utilized.



All Cost Savings Based on 10.55 Cents per KiloWatt-Hour
(2014 US Average Commercial Utility Rates)

Figure 3: HP Proliant DL360P Gen8 Data Server Savings with Inserted PowerStic



All Cost Savings Based on 10.55 Cents per KiloWatt-Hour
(2014 US Average Commercial Utility Rates)

Figure 4: SuperMicro X8STi Data Server Savings with Inserted PowerStic

The numbers shown in Figures 3 and 4 above are the **minimum** amount of dollars that can be saved using the PowerStic devices in these server networks. A 1 to 4 dollar per server savings per year is not terribly impressive return, until one looks at large server farms such as Google, Microsoft, IBM, etc. (~1 million servers worldwide) and/or looks at the average and maximum possible power savings as shown in Figures 5 and 6 below.

Figures 5 and 6 below show not only the minimum dollars that can be saved with the PowerStic devices, but also the maximum and average revenue saved when the PowerStic devices are plugged into unused USB port on HP and SuperMiro servers. Tests have shown that the typically the PowerStic saves on average, 10% of the dynamic power dissipated in processing systems. This average ranges from 20% maximum to a 1 % minimum, depending totally on the data processing volume and the amount of I/O activity on the individual server.

The dollar savings, based on an average US commercial Utility rate of 10.55 cents per kilowatt-hour, shows an ROI point at $10.00 US Dollars for the HP Proliant DL360P Gen8 and SuperMicro X8STi data servers in Figures 5 and 6. The ROI point for the HP servers, shown in Figure 5, varies from about 1.5 months per server assuming high DSP activity, to roughly 3.5 months per server for average DSP activity, to 24 months with minimum DSP activity.

The same trend is seen with the SuperMicro X8STi server. The ROI point for the SuperMicro servers, shown in Figure 6, varies from about 3.5 months per server assuming high DSP activity, to roughly 10 months per server for average DSP activity, to 90 months with minimum DSP activity.

In all cases, once the ROI point has been reached, the purchase price of $9.99 in 100 piece and up volumes, which is the TCO for the PowerStic, PowerStic and system owners see decreased utility costs and lower overall TCO for the servers in their systems. This amounts to essentially “free” energy from the ROI point onward, in that the PowerStic enables the capturing and recycling of previously thrown away energy.

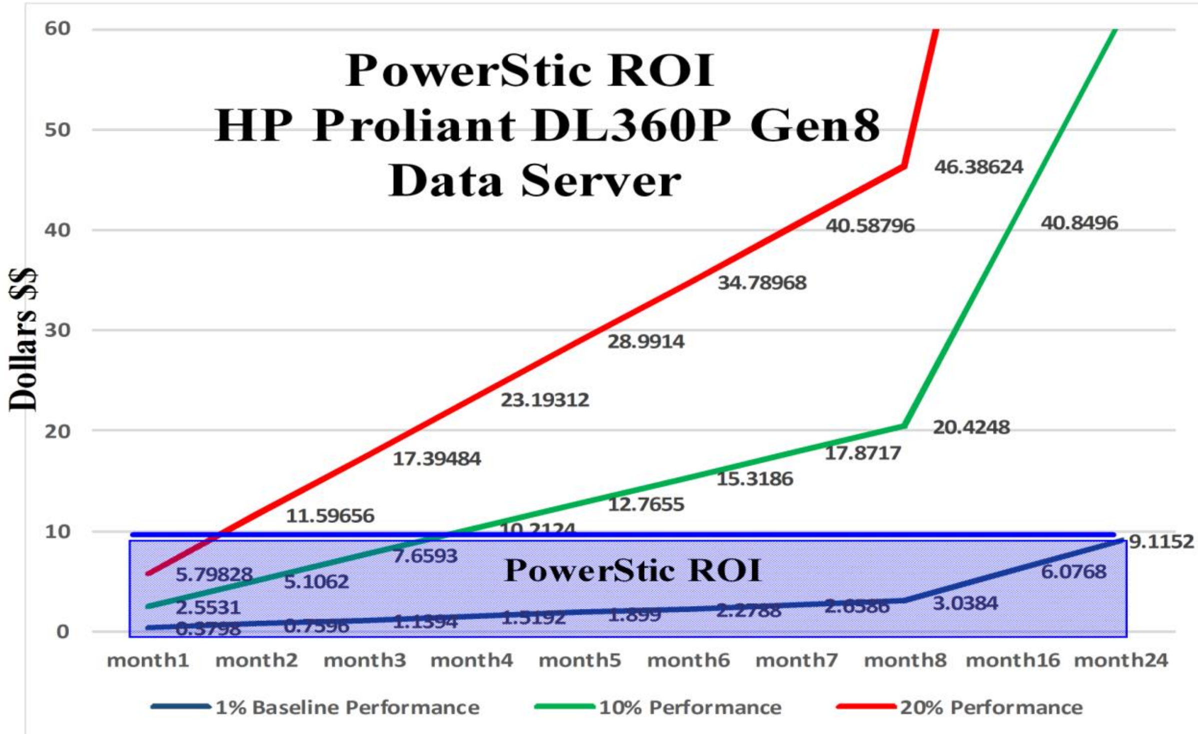


Figure 5: PowerStic ROI with a HP Proliant DL360P Gen8 Platform

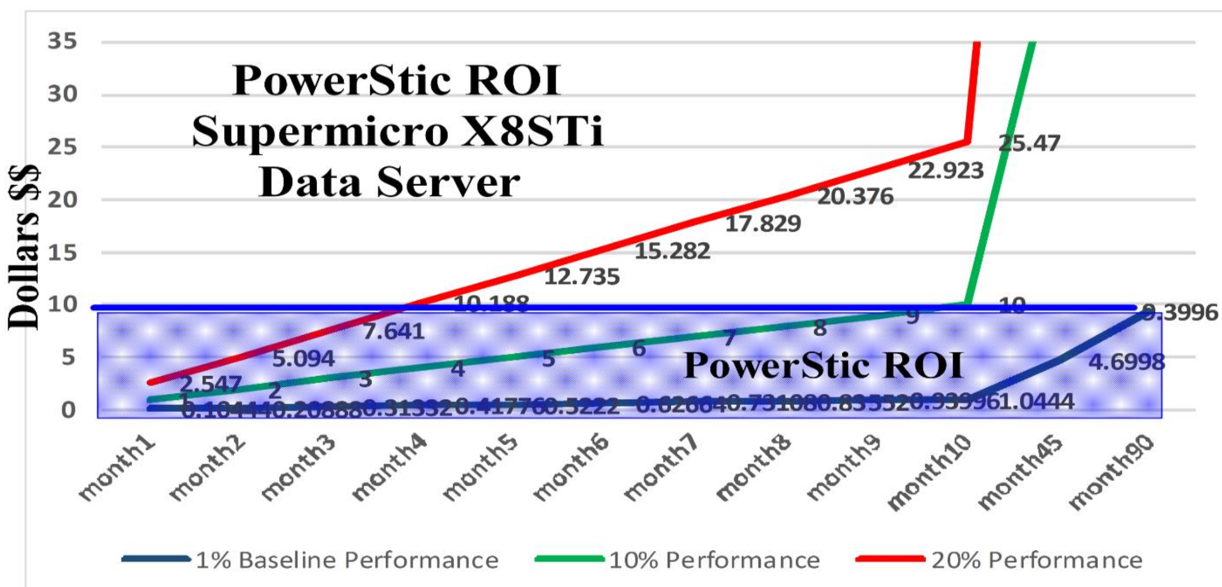


Figure 6: PowerStic ROI with a SuperMicro X8STi Platform

Figures 7 and 8 show the cost saving characteristics that are the result of average DSP volume and 10% PowerStic savings when PowerStics are used on HP and SuperMicro servers. Given 1 million servers, such as can be found in datacenters owned by Google, MicroSoft, IBM worldwide, one can expect to see annual utility cost savings in the 15 Million to 30 Million dollar range, given average DSP volume in and out of these 1 million server datacenters.

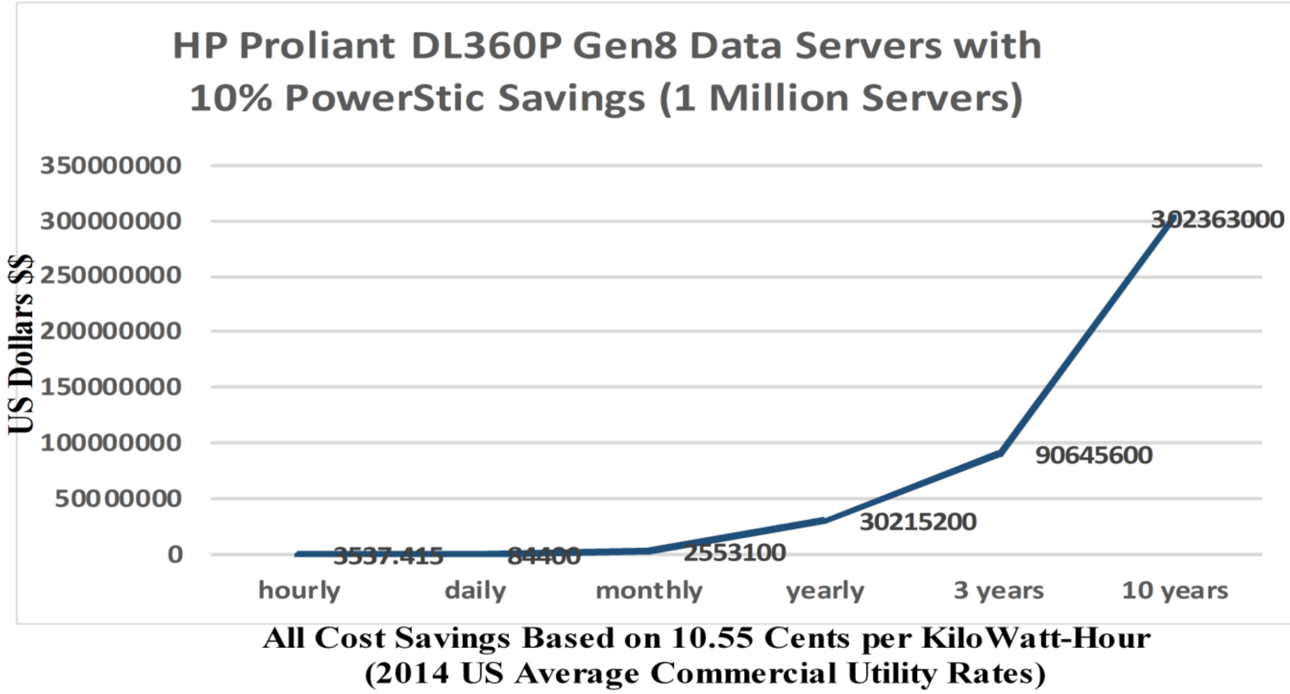


Figure 7: HP Proliant DL360P Gen8 Data Server Savings with Inserted PowerStic

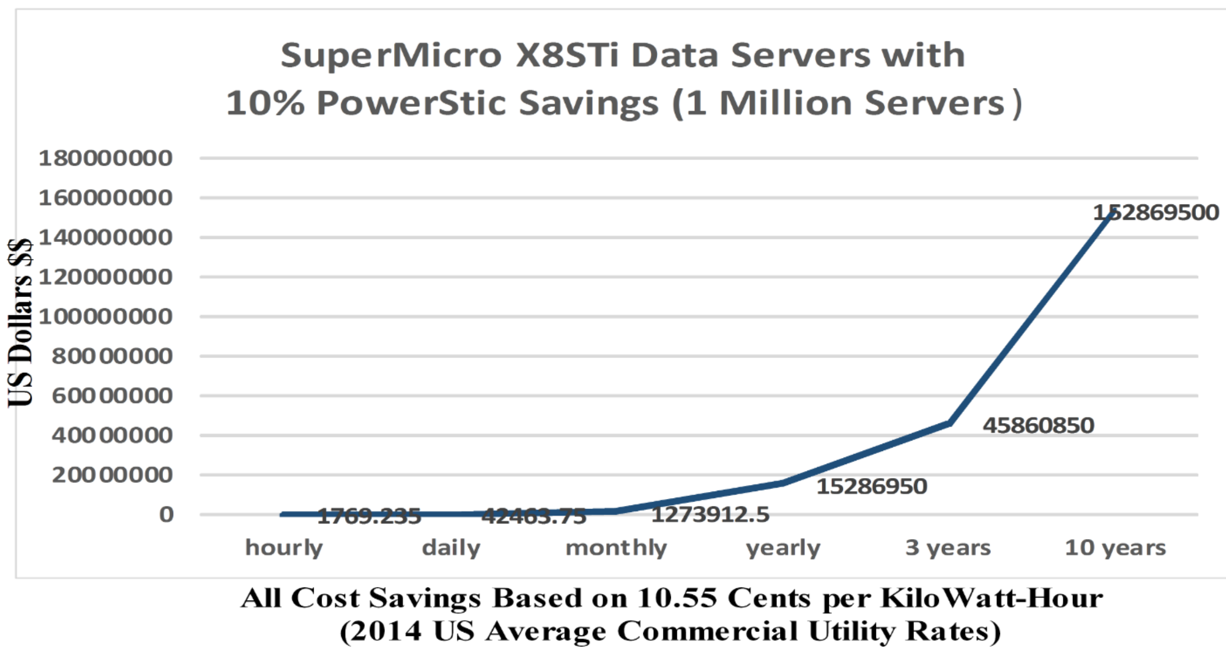


Figure 8: SuperMicro X8STi Data Server Savings with Inserted PowerStic

Figures 9 and 10 show the cost saving characteristics that are the result high DSP volume and 20% PowerStic savings when PowerStics are used on HP and SuperMicro servers in small, 100 server datacenters. Given 100 servers, one can expect to see annual utility cost savings in the $7000.00 to $3000.00 dollar range, given high DSP volume in and out of these datacenters. These utility cost savings seem small when compared to mega-datacenters of 1 million servers, however for cash strapped businesses, these savings are critical for annual profits and can be used for the purchase of additional servers, workstations, etc.

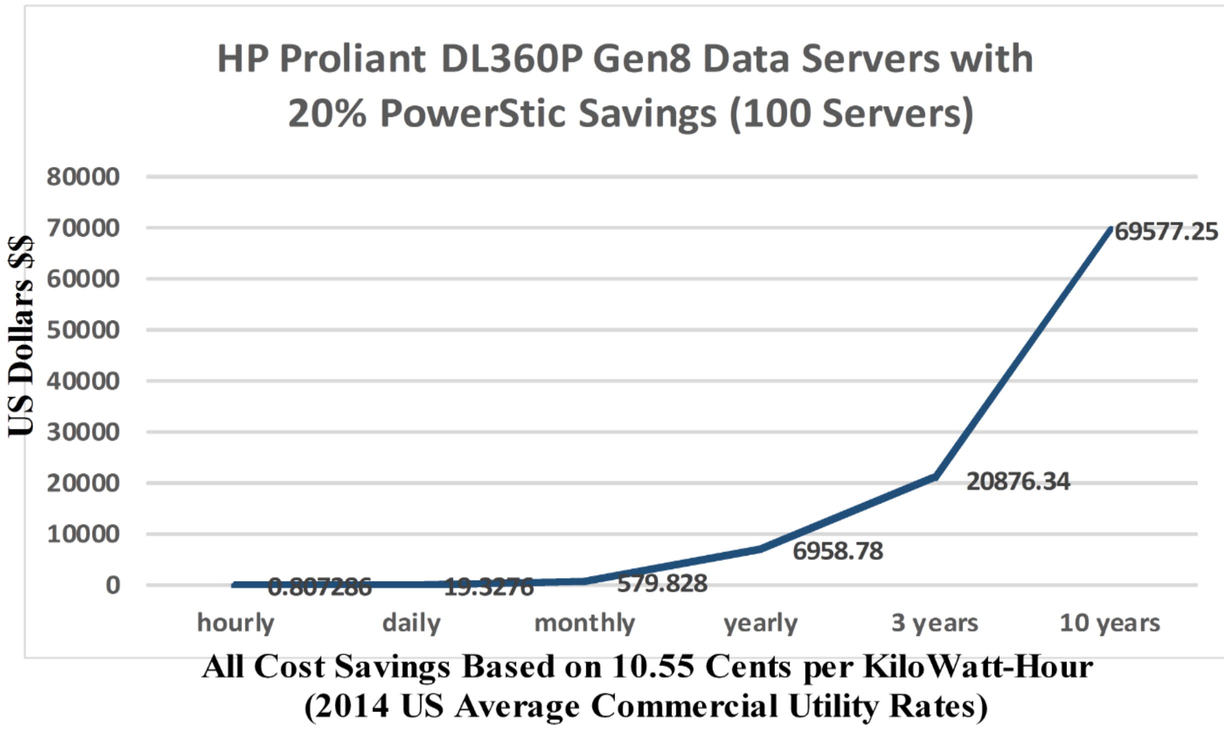
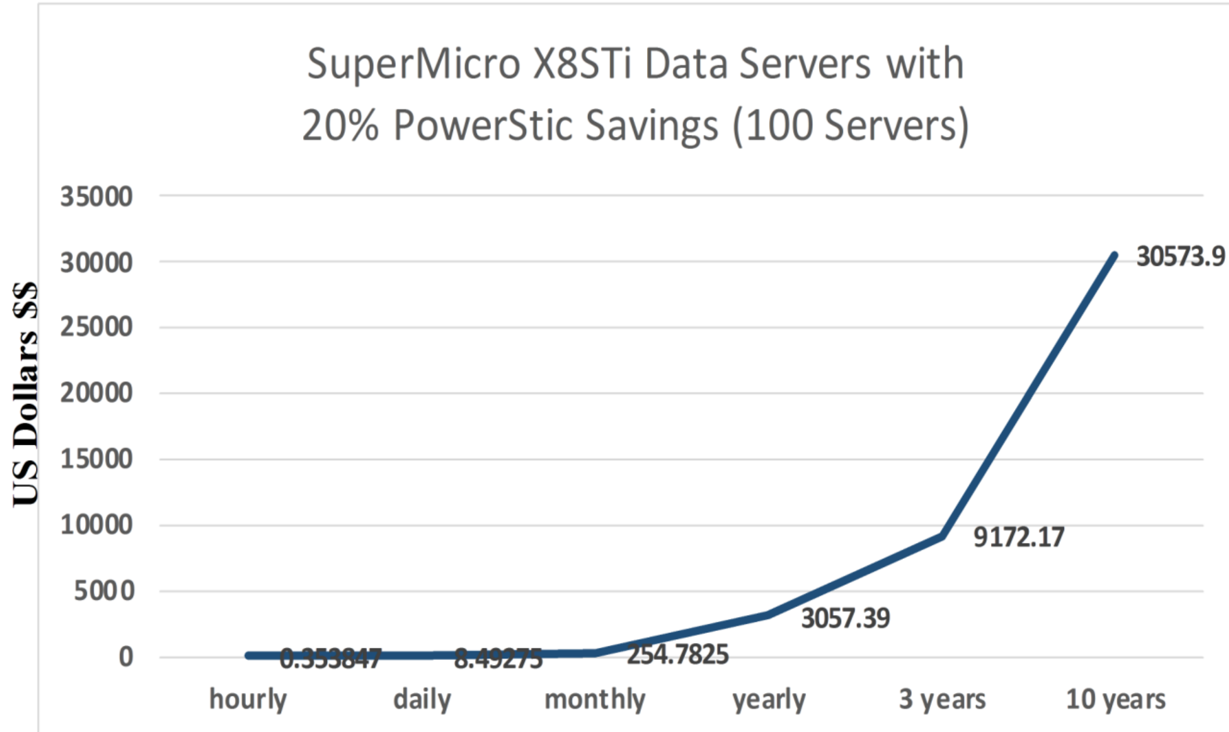


Figure 9: HP Proliant DL360P Gen8 Data Server Savings with Inserted PowerStic

Figure



All Cost Savings Based on 10.55 Cents per KiloWatt-Hour
(2014 US Average Commercial Utility Rates)

Figure 10: SuperMicro X8STi Data Server Savings with Inserted PowerStic

Cost Data Justification

Test Methodology

How were the PowerStic cost saving numbers presented above generated? Obviously, we have not tested the PowerStic in server farms and datacenters for a duration of 10 years. The testing paradigm utilized was stable enough to allow prediction of PowerStic performance far in excess of the actual time tested. This predictive methodology is widely used in the electronics industry, and is the basis of electronic burn-in/infant mortality stressing/testing as well as MTBF failure prediction.

Figure 11: PowerStic-Rack Server Power Reduction Test Set-up

A server rack in a temperature controlled server room, shown in Figure 11, was utilized for the PowerStic-Rack Server tests. As shown in Figure 11, a server was isolated and selected for the power reduction test, powered off, and a Kill-A-Watt power meter was inserted in series with the Server 120V power line. The Kill-A-Watt meter was then set to record Kilowatt-hours. The Kill-A-Watt meter records Kilowatt-hour usage in .01 or 1/100 Kilowatt-hour increments. The Kill-A-Watt meter automatically resets to zero each time the power is removed and applied to the meter. A stopwatch timer on an Apple cellphone was utilized to record the passage of time between the .01 Kill-A-Watt increments of the Kill-A-Watt meter.

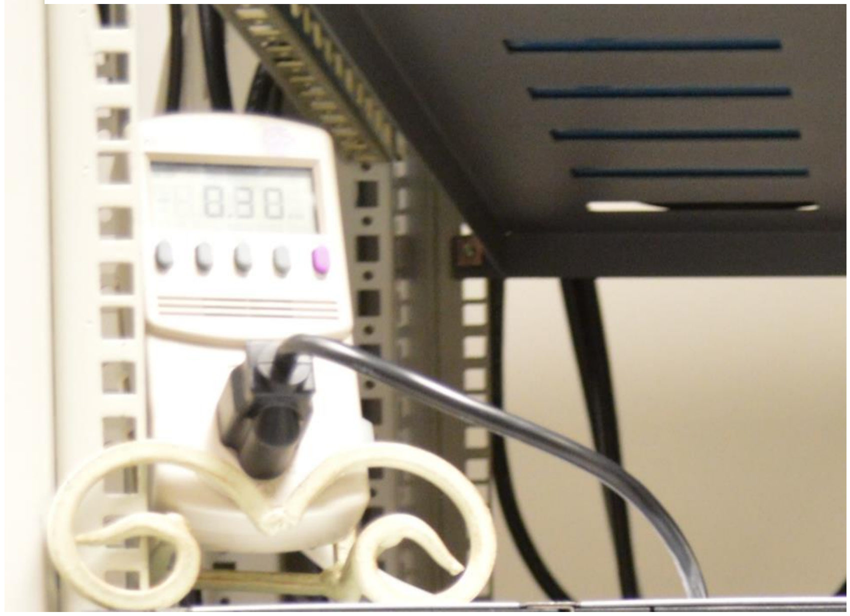
With the hardware configured and set, the Linux command shown below was issued for data loading onto the SSDs and HDDs in the selected server:

Linux command used to Exercise the processors, HDD's and SSD's for Server Tests

```
NICE N -20 DD IF=/DEV/0 OF=/DEV/NULL BS=1024K OF=/TEMP/filename
```

This command line was issued for each processor core/SSD and HDD pair in the system, enabling the processor to load dummy data into each SSD and HDD in the server under test. This action, with the server I/O not being utilized, created a minimal and stable DSP routine that would allow for minimal server operational variance(OS activity lulls and spikes), allowing PowerStic inserted and extracted **testing with minimal** system activity variance, run to run. The establishment of this routine was critical for server baseline activity measurements and confidence in long term extrapolation of server test results.

Figure 12: Kill-A-Watt Meter in the PowerStic-Rack Server Power Reduction Test Set-Up



Since it was impractical to power the server down at the end of each PowerStic inserted or extracted test, just to reset the Kill-A-Watt meter, it was decided to visually record the time between each .01 Kilowatt-hour increment on the Kill-A-Watt meter. The procedure was as follows:

With the PowerStic extracted from the USB port, using the Apple Cellphone timer, record the elapsed time of the .01 Kilowatt-hour increment on the Kill-A-Watt meter. Secondly, insert the PowerStic, as shown in Figure 13, and wait for the next .01 Kilowatt-hour increment of the Kill-A-Watt meter. Lastly, with the PowerStic inserted, at the .01 Kilowatt-hour increment, start the cell phone timer and record the time interval to the next .01 Kilowatt-hour increment on the Kill-A-Watt meter.

The above procedure was repeated until 6 to 8 extracted/inserted data sets were recorded as shown in Figures 14 through 17. The data shown in Figures 14 through 17 became the basis for the cost saving plots shown in Figures 3 through 6.

Figure 13: PowerStic Inserted into a SuperMicro X8STi Data Server

Figure 14 shows the raw data, the data spread, and the data averages for the PowerStic Extracted and Inserted test runs with the SuperMicro X8STi data server. Each PowerStic Extracted(**yellow**) and Inserted(**green**) run was conducted in a "back to back" manner, so as to minimize lull and spike behavior of the OS and temperature effects from contaminating PowerStic Extracted and Inserted test results. This methodology also allowed randomized data sets to be extracted from the ~2.4hour testing run, further assuring a true average of each SuperMicro X8STi Server condition, the PowerStic Extracted(average run time 214.66 s) and the PowerStic Inserted(average run time 216.43s) into the SuperMicro USB port.

The SuperMicro data truly shows a distinct difference, the PowerStic Extracted vs the PowerStic Inserted into a USB port. As one would expect, it takes longer for the Kill-A-Watt meter to increment .01 Kilowatt-hours if the system power draw is less, and a shorter time for a .01 Kilowatt-hour increment if the system power draw is higher. The PowerStic Extracted timing data is clearly smaller than the PowerStic Inserted data, and the distribution plots clearly show a bimodal and normal distribution, showing that the difference is due to PowerStic function on system power, thus confirming that even at a minimal operational level, the PowerStic saving power and money in servers where it is utilized.

PowerStic								
SuperMicro	Tests	Extracted	Inserted					
Kilowatt-hrs	Seconds	Kilowatt-hrs	Seconds	Kilowatt-hrs	Seconds	Kilowatt-hrs	Seconds	
0		0.1	0	0.2	0	0.3		
0.01		0.11	215	0.21	215	0.31	0	
0.02		0.12	0	0.22	0	0.32	214	
0.03		0.13	216	0.23	217	0.33	0	
0.04		0.14	0	0.24		0.34	216	Average Time Per
0.05		0.15	217	0.25		0.35		.01 Kilowatt-hour:
0.06		0.16	0	0.26		0.36	0	214.66s
0.07		0.17	217	0.27		0.37	214	Average Time Per
0.08	0	0.18	215	0.28	0	0.38	0	.01 Kilowatt-hour:
0.09	215	0.19		0.29	216	0.39	216	216.43s

PowerStic Testing--SuperMicro X8STi Data Server (~166Watts)

PowerStic Extracted								
Kilowatt-hrs	Seconds	Kilowatt-hrs	Seconds	Kilowatt-hrs	Seconds	Kilowatt-hrs	Seconds	
0		0.1	0	0.2	0	0.3		
0.01		0.11	215	0.21	215	0.31	0	Total Test Time:
0.02		0.12		0.22		0.32	214	2.385Hrs
0.03		0.13		0.23		0.33		
0.04		0.14		0.24		0.34		
0.05		0.15		0.25		0.35		Average Time Per
0.06		0.16		0.26		0.36	0	.01 Kilowatt-hour:
0.07		0.17	0	0.27		0.37	214	214.66s
0.08	0	0.18	215	0.28		0.38		
0.09	215	0.19		0.29		0.39		

PowerStic Inserted								
Kilowatt-hrs	Seconds	Kilowatt-hrs	Seconds	Kilowatt-hrs	Seconds	Kilowatt-hrs	Seconds	
0		0.1		0.2		0.3		
0.01		0.11		0.21		0.31		Total Test Time:
0.02		0.12	0	0.22	0	0.32		2.404Hrs
0.03		0.13	216	0.23	217	0.33	0	
0.04		0.14	0	0.24		0.34	216	
0.05		0.15	217	0.25		0.35		Average Time Per
0.06		0.16	0	0.26		0.36		.01 Kilowatt-hour:
0.07		0.17	217	0.27		0.37		216.43s
0.08		0.18		0.28	0	0.38	0	
0.09		0.19		0.29	216	0.39	216	

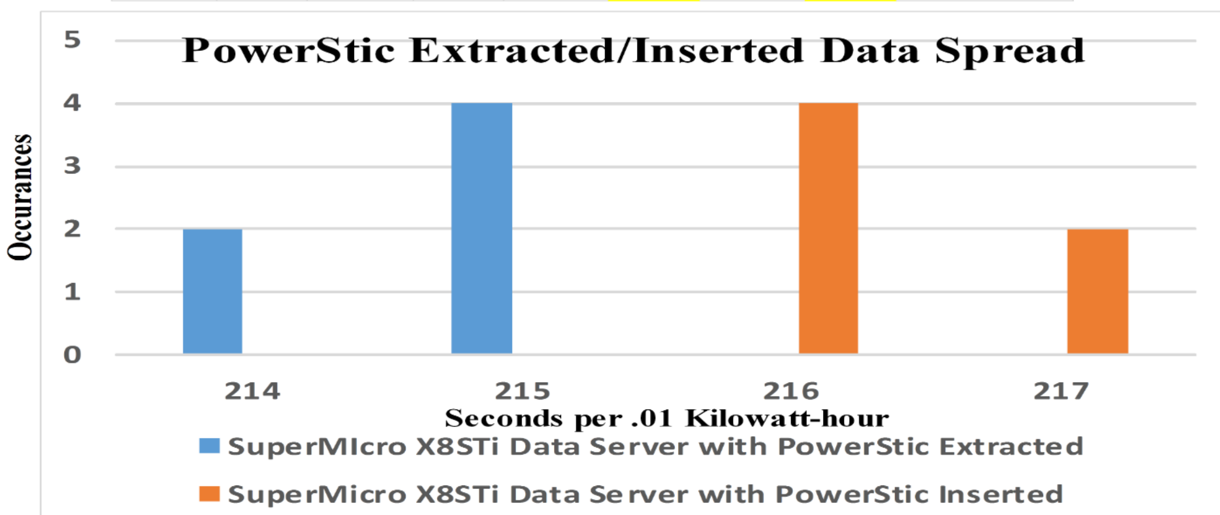


Figure 14: PowerStic-SuperMicro X8STi Power Saving Data and Analysis

Figure 15 shows PowerStic Extracted and Inserted mathematics, the minimum system and PowerStic activity, the delta in power demonstrated by the PowerStic device, as well as the system current saved by the device when inserted in the SuperMicro X8STi data server.

PowerStic Minimum Power Savings on SuperMicro X8STi Data Servers

PowerStic Extracted

$$\frac{214.66s}{3600s/hour} = .0596278hours \qquad \frac{10Watt-hours}{.0596278hours} = 167.707W$$

PowerStic Inserted

$$\frac{216.43s}{3600s/hour} = .0601194hours \qquad \frac{10Watt-hours}{.0601194hours} = 166.33554W$$

$$167.707W - 166.33554W = 1.3W$$

Power Delta

$$\frac{1.3W}{120V} \approx 10.8mA$$

Current Saved

Figure 15: PowerStic-SuperMicro X8STi Server Power Reduction Metrics

Figure 16 shows the raw data, the data spread, and the data averages for the PowerStic Extracted and Inserted test runs with the HP Proliant DL360P Gen 8 data server. As with the SuperMicro test runs, each PowerStic Extracted(**yellow**) and Inserted(**green**) run was conducted in a "back to back" manner, so as to minimize lull and spike behavior of the OS and temperature effects from contaminating PowerStic Extracted and Inserted test results. This methodology also allowed randomized data sets to be extracted from the ~1.4hour testing run, further assuring a true average of each HP Proliant DL360P Gen8 Server condition, the PowerStic Extracted(average run time 94.36 s) and the PowerStic Inserted(average run time 94.66s) into the HP USB port.

As with the SuperMicro data, the HP truly shows a distinct difference, the PowerStic Extracted vs the PowerStic Inserted into a USB port. As one would expect, it takes longer for the Kill-A-Watt meter to increment .01 Kilowatt-hours if the system power draw is less, and a shorter time for a .01 Kilowatt-hour increment if the system power draw is higher. The PowerStic Extracted timing data is clearly smaller than the PowerStic Inserted data, and the distribution plots showing a bimodal distribution, again showing that the difference is due to PowerStic function on system power, thus confirming that even at a minimal operational level, the PowerStic saving power and money in servers where it is utilized.

PowerStic												
HP Tests	Extracted	Inserted										
Kilowatt-hrs	Seconds	Kilowatt-hrs	Seconds	Kilowatt-hrs	Seconds	Kilowatt-hrs	Seconds	Kilowatt-hrs	Seconds	Kilowatt-hrs	Seconds	
0		0.1	95	0.2		0.3	0	0.4	94	0.5	94	
0.01		0.11	0	0.21	0	0.31	94	0.41		0.51	0	
0.02		0.12	94	0.22	95	0.32	94	0.42		0.52	95	
0.03		0.13		0.23	94	0.33	0	0.43		0.53	94	
0.04		0.14	0	0.24	0	0.34	96	0.44				Average Time Per
0.05	0	0.15	94	0.25	95	0.35	94	0.45	0			.01 Kilowatt-hour:
0.06	94	0.16	0	0.26	94	0.36		0.46	95			94.36s
0.07	0	0.17	95	0.27	0	0.37		0.47	94			Average Time Per
0.08	96	0.18		0.28	94	0.38	0	0.48	0			.01 Kilowatt-hour:
0.09	0	0.19		0.29	94	0.39	96	0.49	94			94.61s

PowerStic Testing--HP Proliant DL360P Gen8 Data Server (~380Watts)

PowerStic Extracted												
Kilowatt-hrs	Seconds	Kilowatt-hrs	Seconds	Kilowatt-hrs	Seconds	Kilowatt-hrs	Seconds	Kilowatt-hrs	Seconds	Kilowatt-hrs	Seconds	
0		0.1	95	0.2		0.3	0	0.4		0.5		
0.01		0.11		0.21		0.31	94	0.41		0.51	0	Total Test Time:
0.02		0.12		0.22		0.32	94	0.42		0.52	95	1.415 Hours
0.03		0.13		0.23		0.33		0.43		0.53	94	
0.04		0.14	0	0.24	0	0.34		0.44				
0.05	0	0.15	94	0.25	95	0.35		0.45	0			Average Time Per
0.06	94	0.16		0.26	94	0.36		0.46	95			.01 Kilowatt-hour:
0.07		0.17		0.27		0.37		0.47	94			94.36s
0.08		0.18		0.28		0.38		0.48				
0.09	0	0.19		0.29		0.39		0.49				

PowerStic Inserted												
Kilowatt-hrs	Seconds	Kilowatt-hrs	Seconds	Kilowatt-hrs	Seconds	Kilowatt-hrs	Seconds	Kilowatt-hrs	Seconds	Kilowatt-hrs	Seconds	
0		0.1		0.2		0.3		0.4	94	0.5	94	
0.01		0.11	0	0.21	0	0.31		0.41		0.51		Total Test Time:
0.02		0.12	94	0.22	95	0.32		0.42		0.52		1.419 Hours
0.03		0.13		0.23	94	0.33	0	0.43		0.53		
0.04		0.14		0.24		0.34	96	0.44				
0.05		0.15		0.25		0.35	94	0.45				Average Time Per
0.06		0.16	0	0.26		0.36		0.46				.01 Kilowatt-hour:
0.07	0	0.17	95	0.27	0	0.37		0.47				94.61s
0.08	96	0.18		0.28	94	0.38	0	0.48	0			
0.09		0.19		0.29	94	0.39	96	0.49	94			

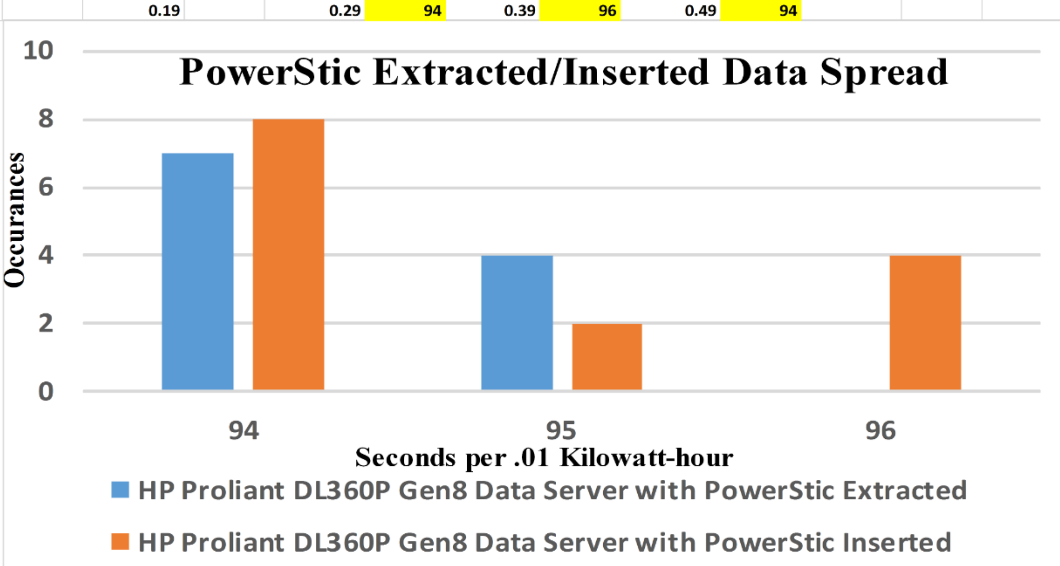


Figure 16: PowerStic-HP Proliant DL360P Gen8 Power Saving Data and Analysis

Figure 17 shows PowerStic Extracted and Inserted mathematics, minimum system and PowerStic activity, the delta in power demonstrated by the PowerStic device, as well as the system current saved by the device when inserted in the HP Proliant DL360P Gen8 data server.

PowerStic Minimum Power Savings on HP Proliant DL360P Gen8 Data Servers

PowerStic Extracted

$$\frac{94.36s}{3600s/hour} = .026211 hours \qquad \frac{10 Watt-hours}{.026211 hours} = 381.519W$$

PowerStic Inserted

$$\frac{94.610s}{3600s/hour} = .0262806 hours \qquad \frac{10 Watt-hours}{.0262806 hours} = 380.509W$$

$$381.519W - 380.509W = 1.01W$$

Power Delta

$$\frac{1.01W}{120V} = 8.4mA$$

Current Savings

Figure 17: PowerStic-HP Proliant DL360P Gen8 Server Power Reduction Metrics

Despite the power magnitude delta between these machines, the SuperMicro X8STi server (167W) and the HP Proliant DL360P Gen8 server (381W), the power saved with this minimal testing routine is about 1 Watt or an 8mA to 10mA current return. This current return result is similar to what CurrentRF has seen on it’s PowerStic demonstration board.

Figure 18: PowerStic Inserted into a HP Proliant DL360P Gen8 Data Server

Figures 14 through 17 above show minimal server power savings with the PowerStic device. Figures 18 and 19 show average (~10%) HP Proliant DL360P Gen8 power saving performance that is the result of PowerStic insertion. The current

PowerStic Average Power Savings on
HP Proliant DL360P Gen8 Data Servers

PowerStic Extracted $\frac{10.8A}{5Servers} = 2.16A * 120V = 259W$

PowerStic Inserted $\frac{9.62A}{5Servers} = 1.924A * 120V = 231W$

$259W - 231W = 28W$ **Power Delta**

$\frac{28W}{259W} * 100 \approx 11\%$ **Percentage Reduction**

$\frac{28W}{120V} = 233mA$ **Current Savings**

Figure 19: PowerStic-HP Proliant DL360P Gen8 Server Average Power Reduction Metrics

data shown in Figures 18 and 19 was generated by a total of 5 servers (1 of 5 PowerStics shown in Figure 18) that were power reduced with a single PowerStic per HP server. Generally, one PowerStic per server provides optimal server power savings. The average (~10%) power savings is the result of normal server activity and is the result of the average combination of minimal server activity shown in Figures 14 through 17, and known peak server activity shown in Figures 20 through 23 below. The data shown in Figures 18 and 19 is the basis of the cost savings plots shown in Figures 7 and 8.

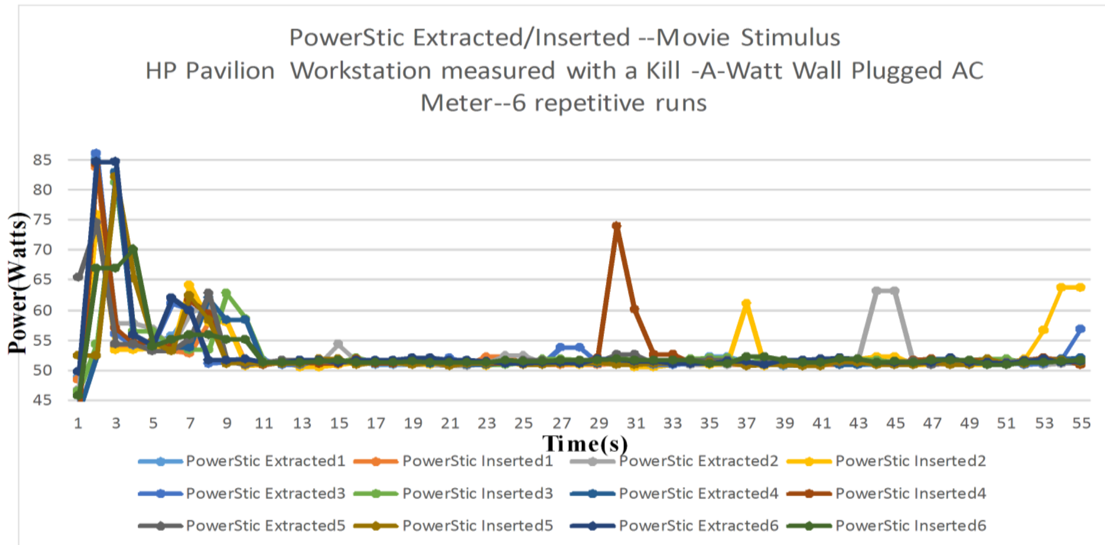


Figure 20: PowerStic Extracted/Inserted Video Data Runs(6 Runs)

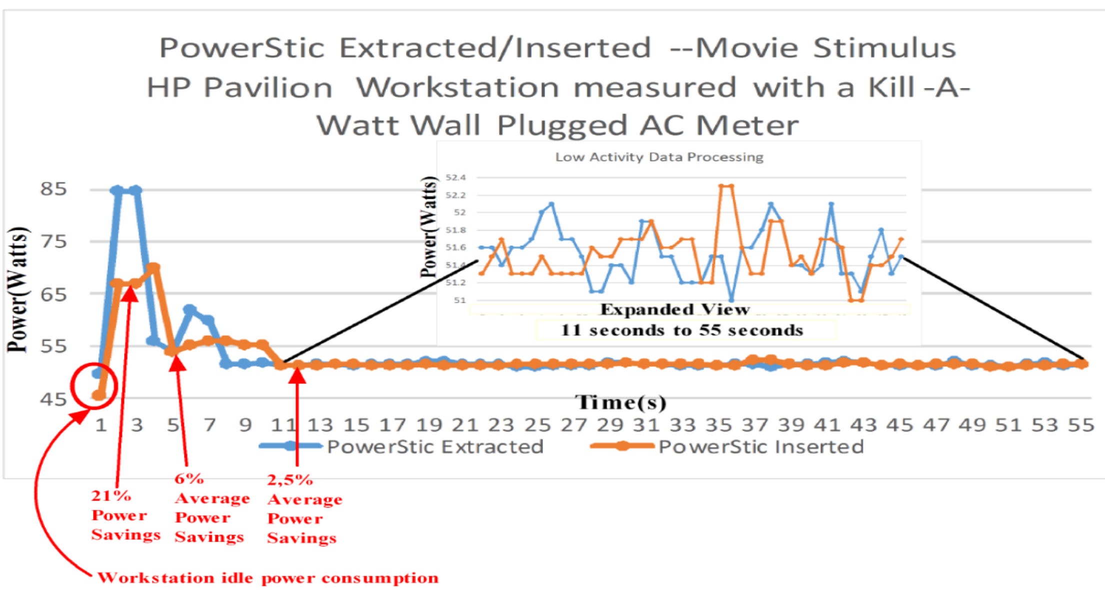


Figure 21: PowerStic Extracted/Inserted Video Data Run(Maximum Savings)

Figure 20 shows a series of 6 PowerStic Extracted and Inserted runs on a HP Pavilion workstation, running a video stimulus, launched from the desktop of an HP Pavilion workstation. The peak activity in the Figure 20 through 24 plots is the result of the graphics system on the HP Pavilion loading the video data from the HDD and/or SSD, setting up the viewing window for the video, etc., for the video playback. The reduced activity seen later in the video run is the actual data activity of the video itself which requires less power for execution.

PowerStic Maximum Recorded Power Savings on HP Pavilion Workstations

PowerStic Extracted =85W

PowerStic Inserted =67.15W

$$85W - 67.15W = 17.85W$$

Power Delta

$$\frac{17.85W}{85W} * 100 \approx 20\%$$

Percentage Reduction

$$\frac{17.85W}{120V} = 148.75mA$$

Current Savings

Figure 22: PowerStic-HP Pavilion Workstation Peak Power Reduction Metrics

The Figure 20 through 24 data plots show the variability encountered in typical systems. Figure 20 plot also shows the difficulty encountered in testing the PowerStic on systems running modern operating systems. During testing, the operating systems tend to do random operations that contaminate PowerStic testing runs. These random operations are normal and are "bookkeeping" for the computer system, but if one relies on a single runs for evaluating PowerStic performance, one may obtain false results.

PowerStic Average Recorded Power Savings on HP Pavilion Workstations

PowerStic Extracted =78W

PowerStic Inserted =70W

$$78W - 70W = 8W$$

Power Delta

$$\frac{8W}{78W} * 100 \approx 10\%$$

Percentage Reduction

$$\frac{8W}{120V} = 66.66mA$$

Current Savings

Figure 23: PowerStic-HP Pavilion Workstation Average Power Reduction Metrics

Figures 23 and 24 show the results of the average runs of the 6 PowerStic Extracted and Inserted runs shown in Figure 20. As expected, the random activity lulls and peaks shown in the Figure 20 plots are much reduced in the Figures 23 and 24 plots and show the true average PowerStic saving activity in the HP Pavilion system and correlate well to the HP Proliant DL360P Gen8 average activity data shown in Figures 18 and 19.

Figures 21 and 22 show the result of peak activity and PowerStic savings on the HP Pavilion workstation and are the basis of the 20% peak cost saving plots shown in Figures 9 and 10.

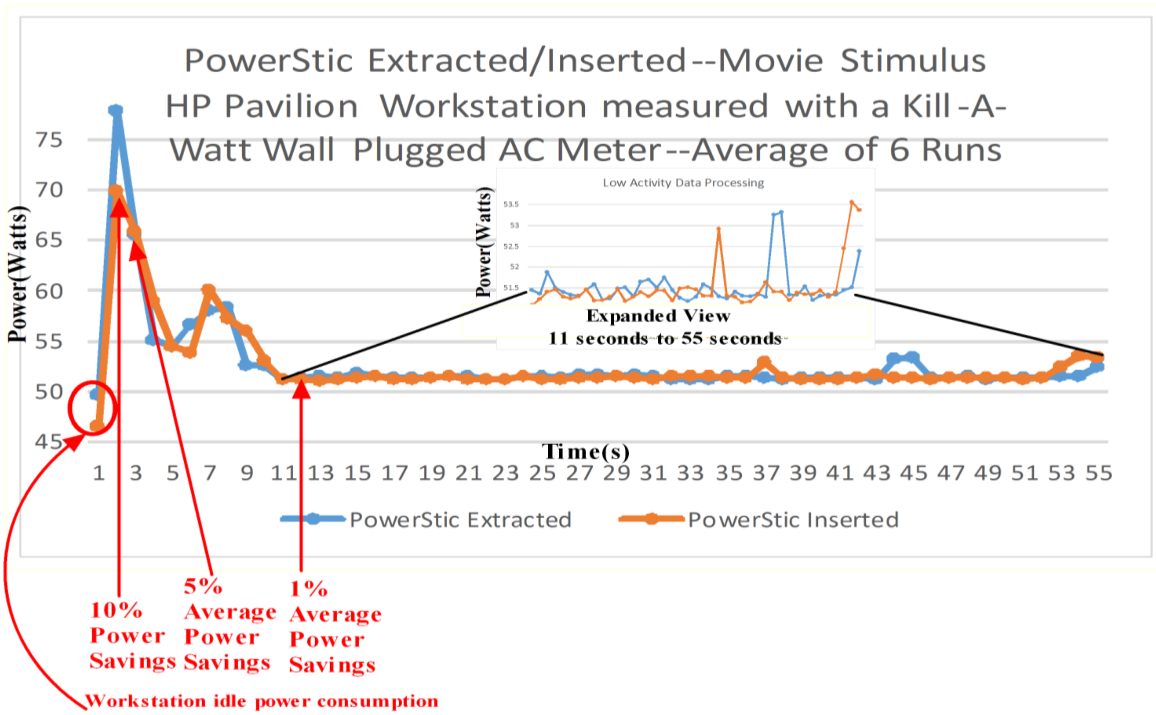


Figure 24: PowerStic Extracted/Inserted Video Data Run(Average Savings)

Conclusion

The PowerStic captures and recycles logic and switching circuit based, wasted transient energy present in all workstation, server, and networking computing systems. The device converts this energy back into usable power in these systems, simply by plugging the device into an empty USB port. No software support is needed for device operation. Generally, one PowerStic per server or workstation is all that is needed for effective system power savings.

The PowerStic saves enough electrical energy, on average, to pay for itself in a 3 to 10 month time frame, less ROI time needed if workstation or server activity is high. Beyond the initial cost of the device, there is zero TCO for the PowerStic, and the device will last, without failure, in systems, 30 years and beyond.

Estimates, based on real world testing, show, on average, the PowerStic saving anywhere from 15 to 30 million dollars a year in utility costs, beyond the ROI cost of the device, in data centers with 1 Million active servers.

The PowerStic, based on an unusual design technique of the CC-100 IC, is a breakthrough in Energy Harvesting, and is designed to be an easy retrofit into existing datacenters and Cloud Computing Networks.

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For PowerStic and CC-100 characterization information, data, demo and reference designs,
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http://www.CurrentRF.com.
Also, see the **MicroWave Journal** Article,
"Tapping into a New RF Energy Source found in Digital Processing Circuits.pdf" under the"**Power Optimizer**" pushbutton at **http://www.CurrentRF.com**