Quarch Technology





Quarch Power Modules vs Current Probes

July 2016

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Introduction

Storage device power measurement

Power consumption is an important factor when designing or purchasing storage devices. Yet it can be hard to measure, especially on an individual device.

Traditional methods using an oscilloscope and current probes can be effective but are expensive, hard to implement, and physically large.

Quarch Programmable Power Modules are an easy-to-use solution that gets accurate results quickly.

This document compares these two methods for characterising storage device power consumption.

Test equipment

Quarch Programmable Power Modules (PPMs)

Quarch PPMs supply and measure power.
This makes them very flexible tools for engineers, both during development and testing of devices.

The PPMs can be controlled over USB, Ethernet, and Serial, with a free GUI or using scripting.

Data can be streamed indefinitely to a PC or stored on-board for shorter durations. Output voltages are programmable for margining and power up/down tests.

Test equipment

Oscilloscope and current probes

A Tektronix DPO 3032 oscilloscope and TCP0030 current probes are compared with the Quarch XLC power module in the following tests.

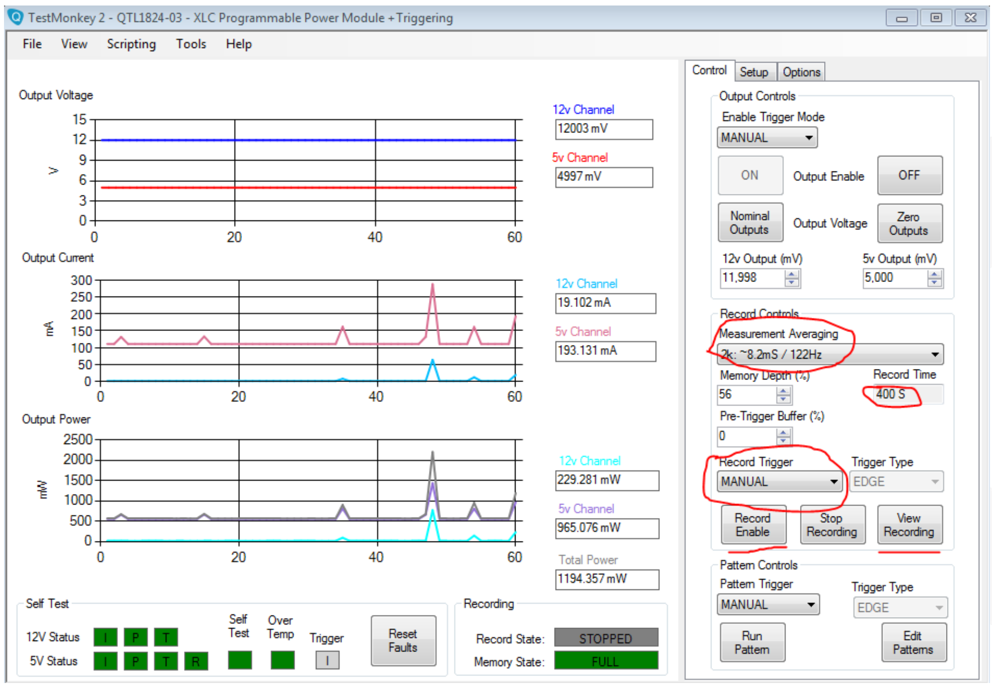
This represents a standard mid-range oscilloscope and the most suitable commonly-used current probes. Total cost is approximately three times that of a Quarch XLC PPM.

The example tests use a Quarch PPM to power an SFF SSD. A comparison of ease of use and results quality is given in the tests description.

Comparison example #1

Ready idle power – Quarch setup

The aim is to measure average power use over 400 seconds with the drive idle.



The PPM always samples at 250kS/s. The TestMonkey 2 GUI is used to set up the PPM to average 2048 samples to make each recorded value and to record each averaged value for 400 seconds starting when the Record Enable button is pressed.

When recording is complete, TestMonkey 2 is used to view the power consumption statistics.

Comparison example #1

Ready idle power – scope setup

The current probes have their Degauss/AutoZero set and are clamped round wires going to the drive.

Vertical offset is set as low as possible without causing negative clipping; vertical scale is set as large as possible without causing positive clipping. This gives the best vertical resolution the 8-bit ADC of the scope can provide.

The horizontal scale is set to 40s to give 400s over the ten divisions. This leaves the scope sampling at 12.5kS/s, given its memory depth of 5M points.

Triggering is set to run once when the Force Trig button is pressed.

Comparison example #1

Ready idle power – Quarch results

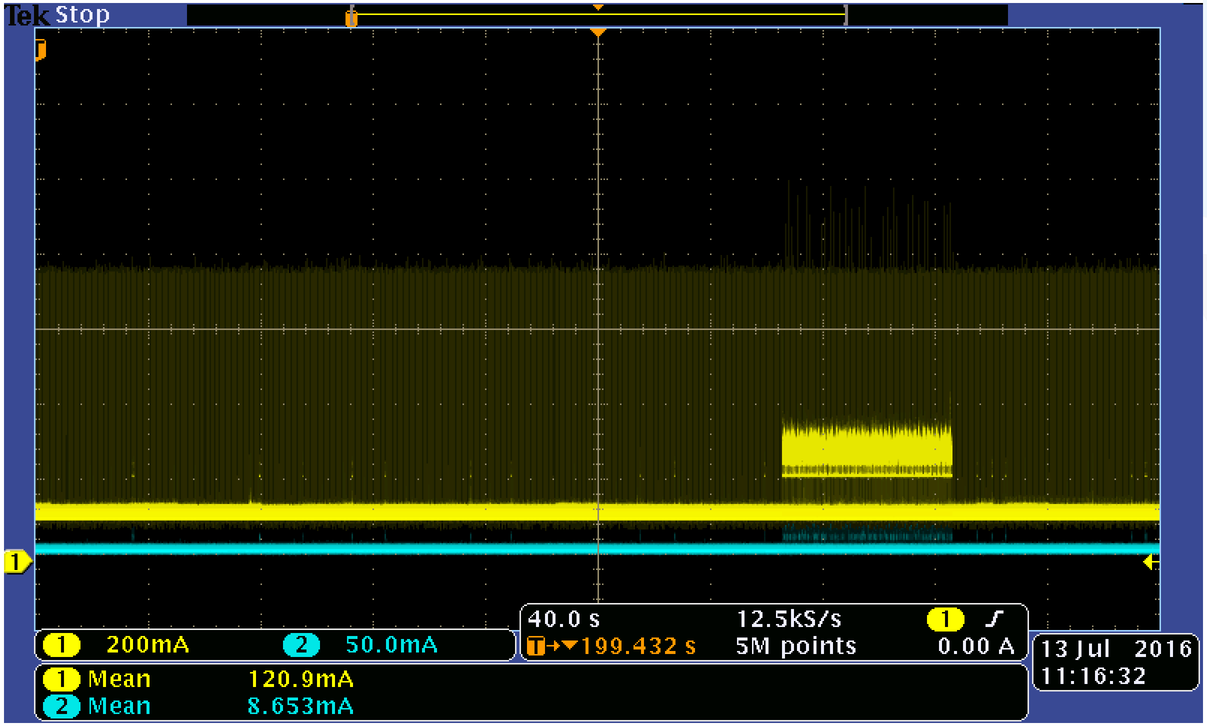
Recorded Data

Chart | Raw Data | Statistics

Statistic	Value	Unit
VOLTAGE		
5v Voltage Output	-	
Max Voltage	4999	mV
Min Voltage	4993	mV
Average Voltage	4998.916	mV
12v Voltage Output	-	
Max Voltage	12008	mV
Min Voltage	12000	mV
Average Voltage	12002.046	mV
CURRENT		
5v Current Output	-	
Max Current	328.583	mA
Min Current	110.247	mA
Average Current	114.908	mA
RMS Current	117.033	mA
12v Current Output	-	
Max Current	90.146	mA
Min Current	1.143	mA
Average Current	2.184	mA
RMS Current	6.99	mA
POWER		
5v Power Output	-	
Max Power	1640.615	mW
Min Power	551.125	mW
Average Power	574	mW
12v Power Output	-	
Max Power	1081.752	mW
Min Power	13.718	mW
Average Power	26.217	mW
Total Power Output	-	
Max Power	2612.365	mW
Min Power	565.612	mW
Average Power	600.621	mW

Comparison example #1

Ready idle power – scope results



DPO3032 - 11:20:48 13/07/2016

Comparison example #1

Ready idle power – conclusion

The PPM is easy to set up and the results easy to obtain, including waveforms, raw data, and statistics.

The scope was more complicated to set up, both in cabling and setting up the measurements. A lot of care is needed to get appropriate settings.

The scope only provides current measurements. To get accurate power measurements, additional channels and probes could be used to measure voltage, but cabling then becomes even more cumbersome.

For both 5V and 12V channels, the scope reads approximately 6mA higher than the PPM. The question of which is most accurate is considered next.

Comparison example #1

Ready idle power – conclusion

The previous setup was repeated but with the drive removed from the system so that 0A was expected on both channels.

The PPM recorded 0.007mA and 0.004mA average current from 5V and 12V.

The scope recorded 9.964mA and 7.429mA average current from 5V and 12V.

It is hard to remove this offset without manually adjusting raw data after recordings. Doing this brings the scope and PPM into reasonable alignment.

It is much easier to get an accurate reading with the Quarch setup.

Comparison example #2

Measuring startup current – setup

A customer has a requirement to measure the mean and RMS current for 20s, beginning 2s before drive startup. The solution is to be scripted in Python.

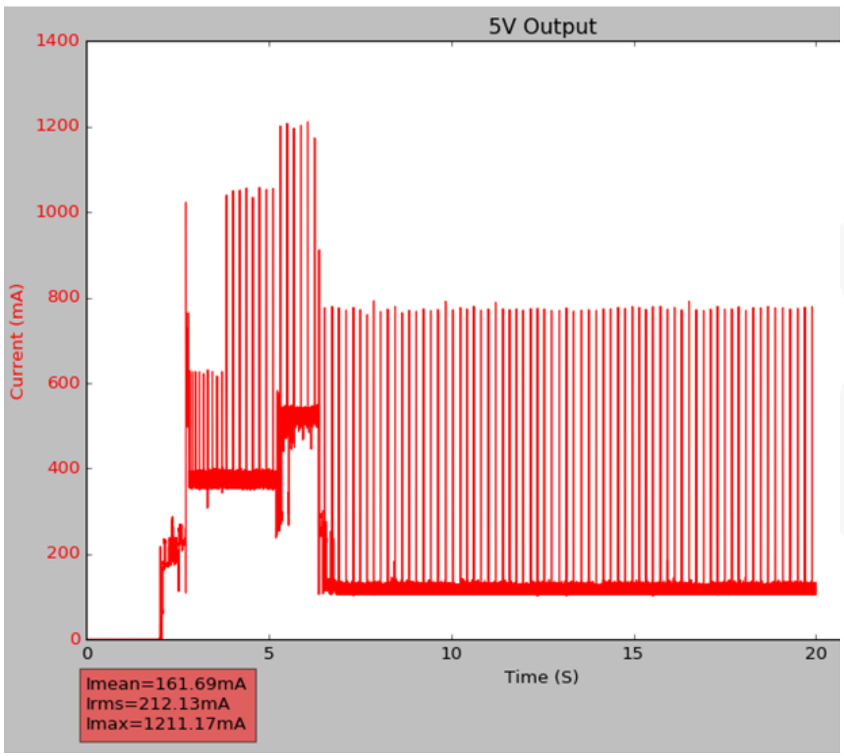
A Python script based on a standard Quarch example is modified to set the PPM averaging to zero volts output. It then starts the PPM recording – streaming data back to the PC – and after 2s sets the output voltages to 5V and 12V. After 20s, recording stops and the script calculates mean and RMS values.

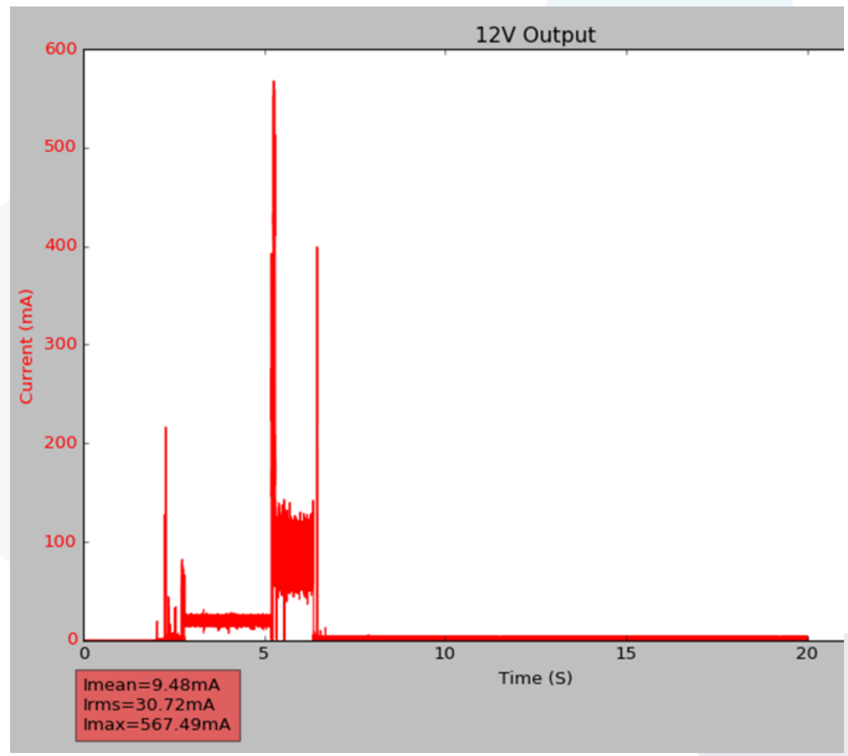
The scope is set up with the same probe and vertical configuration as for the idle measurements. The horizontal scale is set so that 20s of measurements are taken. With a 5 million points scope, this gives 250kS/s. This is the same as the PPM but each recorded point on the PPM is an average of 32 samples taken at 250kS/s.

Comparison example #2

Measuring startup current – Quarch results

Results are stored in CSV format and also displayed as below.

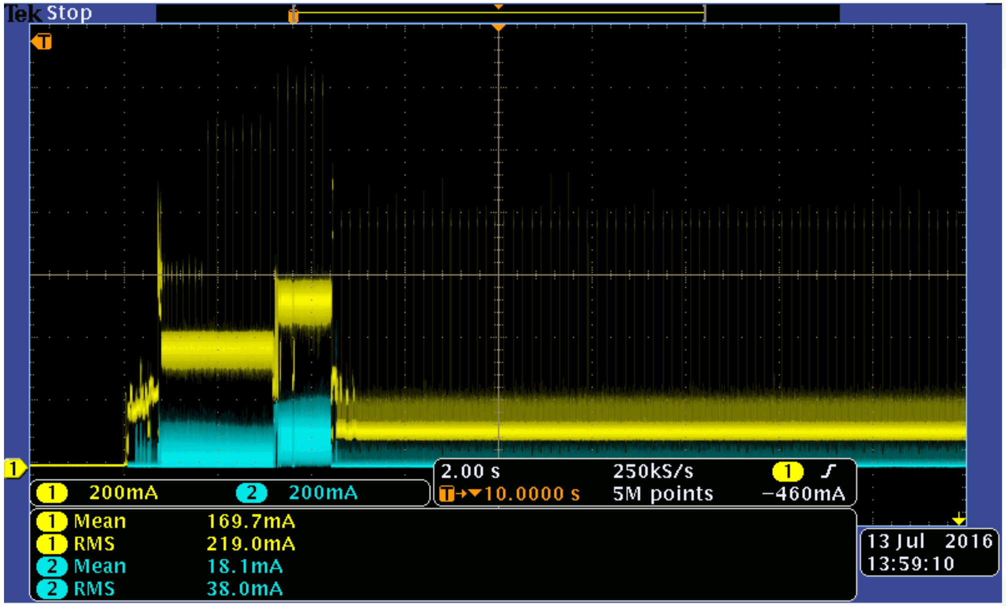




Comparison example #2

Measuring startup current – scope results

The Python script is set to trigger the scope at the same time as the PPM which gives the screenshot below.



DPO3032 - 14:03:24 13/07/2016

Comparison example #2

Measuring startup current – conclusion

When viewing startup current, a reasonably fast sample rate is desired. If a long duration is also required, this challenges both the scope and PPM.

The PPM can stream data to a PC indefinitely when averaging 32 samples and above for each stored measurement. A lower averaging rate captures spikes better but produces a data rate too high to transfer indefinitely. The scope can use a higher sampling, limited by the probes' 120MHz bandwidth, but only for short periods of time. If several seconds of data are required, performance is close to equal. If several minutes of data are required, the PPM outperforms most scopes.

In practice, the PPM and scope both have a sampling rate which is suitable for measuring drive startup current in most applications.

Low power measurements

The TCP0030 probe has a sensitivity of 1mA which requires using a 1mV/div vertical setting on the scope. In applications which require a higher dynamic range, a higher vertical setting is required, giving worse sensitivity.

TCP0030 Probe accuracy is listed as +/-3%.

The Quarch XLC PPM has a native ADC resolution of approximately 24uA up to 100mA and 3mA from 100mA to 3A.

The Quarch XLC PPM specifies accuracy of +/-(2uA + 2%) from 100uA to 1mA and +/-(2mA + 1%) from 1 to 3000 mA.

The low current measurement capability of the Quarch XLC PPM makes it an excellent tool for measuring standby power in many situations where an oscilloscope and current probes would be inappropriate.

Long durations

Oscilloscopes excel at measuring fast-changing signals (although the use of magnetic current probes limit bandwidth to around 120MHz) but are not so good at measuring for hours or even days.

The Quarch PPMs are designed to make it easy to run tests for long periods of time and continuously record power use. This can be very useful when running a drive workload simulation which may last for several hours or longer.

Using scripting, an engineer can integrate the power module with external tests and record the power used during the different parts of the test.

The Quarch PPM is becoming the standard tool used during disk drive benchmarking by reviewers – including Tom's IT PRO, Myce and The SSD Review.

Bandwidth considerations

Bandwidth, sampling rate and memory depth all affect the usefulness of the measuring setup when trying to observe fast-changing signals.

The current probes have a bandwidth of 120MHz. The scope has a maximum sample rate of 2.5GS/s and a memory depth of 5 million points.

The PPM has an input amplifier bandwidth of 10MHz, a sample rate of 250kHz and an on-board memory depth of 83560 samples.

On paper, the scope has an advantage. In practice, the PPM specifications exceed the requirements for nearly all power measurements on storage devices. The PPM will give the same results as carefully setup probes and scope – but in an easier, faster and more reliable fashion.

Next, we compare the PPM with a scope sampling at 2.5GS/s.

Bandwidth considerations

The PPM vs a scope sampling at 2.5GS/s

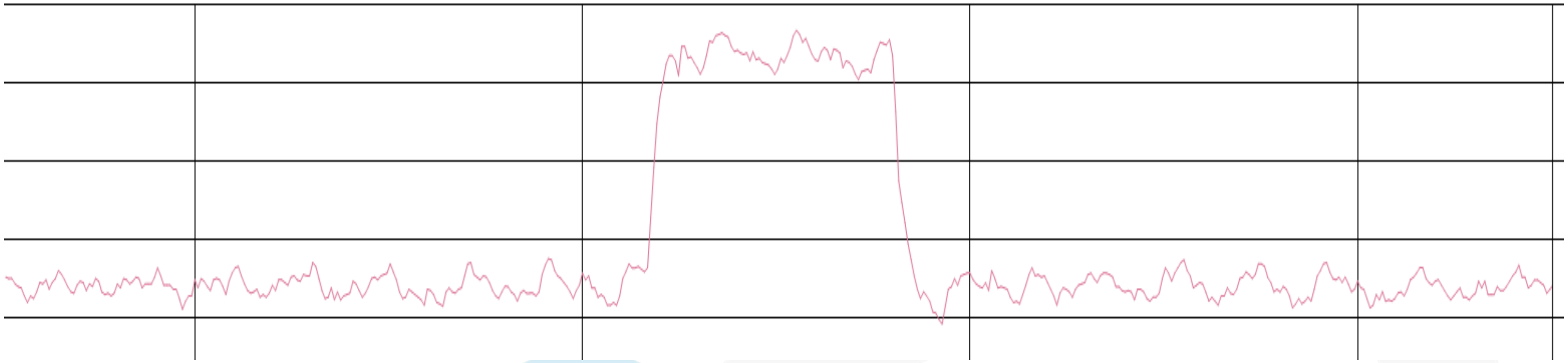
A drive was set to constant sequential reads. The XLC PPM was used, with averaging set to one, and then triggered to record when the current rose above 550mA. This gives 340mS of data. A 2ms window centred on a current spike was selected and is compared to a current spike acquired on the scope.

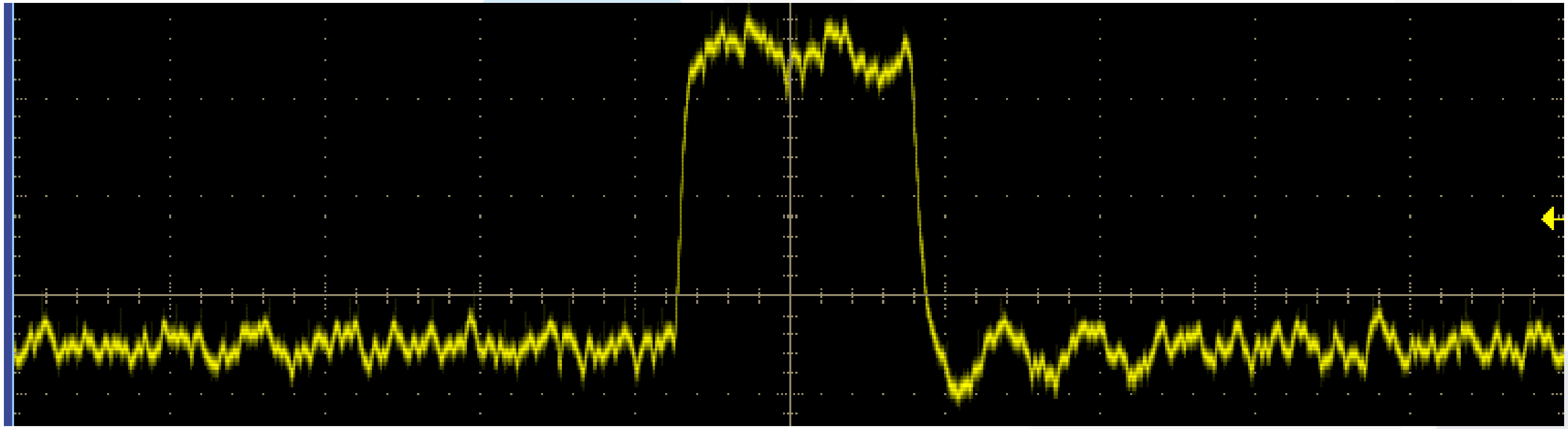
The results are compared visually on the next page. The PPM trace very closely resembles the scope's.

One measurement likely to be affected by sample rate is the maximum value recorded, i.e. the biggest spike captured during the recording. Over ten recordings, the PPM was found to have a maximum of 937mA and the scope 963mA. This is a pretty close agreement and it is unknown which device is recording the most accurate reading.

Bandwidth considerations

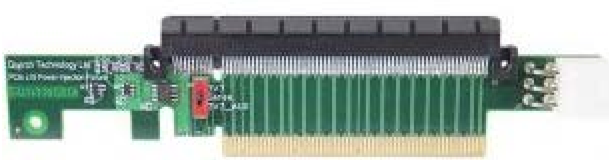
The PPM vs a scope sampling at 2.5GS/s





Injection fixtures

Quarch have a range of injection fixtures making it easy to use a PPM with 2.5″ drives, PCIe cards and M.2 devices. This removes the hassle of clamping current probes in awkward places.



Multiple modules

Quarch HD PPM

- Fits in a 1U rack.
- Available individually or with six power modules as shown.
- Measures power consumption of multiple devices simultaneously – in a cost effective and practical way.
- Ethernet interface provides easy control of all the modules.

Conclusions

Oscilloscopes excel at measuring fast signals but aren’t specifically designed for measuring the currents relevant to storage devices. Setup is complicated and it is difficult to obtain accurate results or record for long durations of time.

Quarch PPMs address these problems and additionally supply power – enabling a range of extra tests. Injection fixtures and USB, Serial and Ethernet control with dedicated software make running tests simple and cost effective.

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