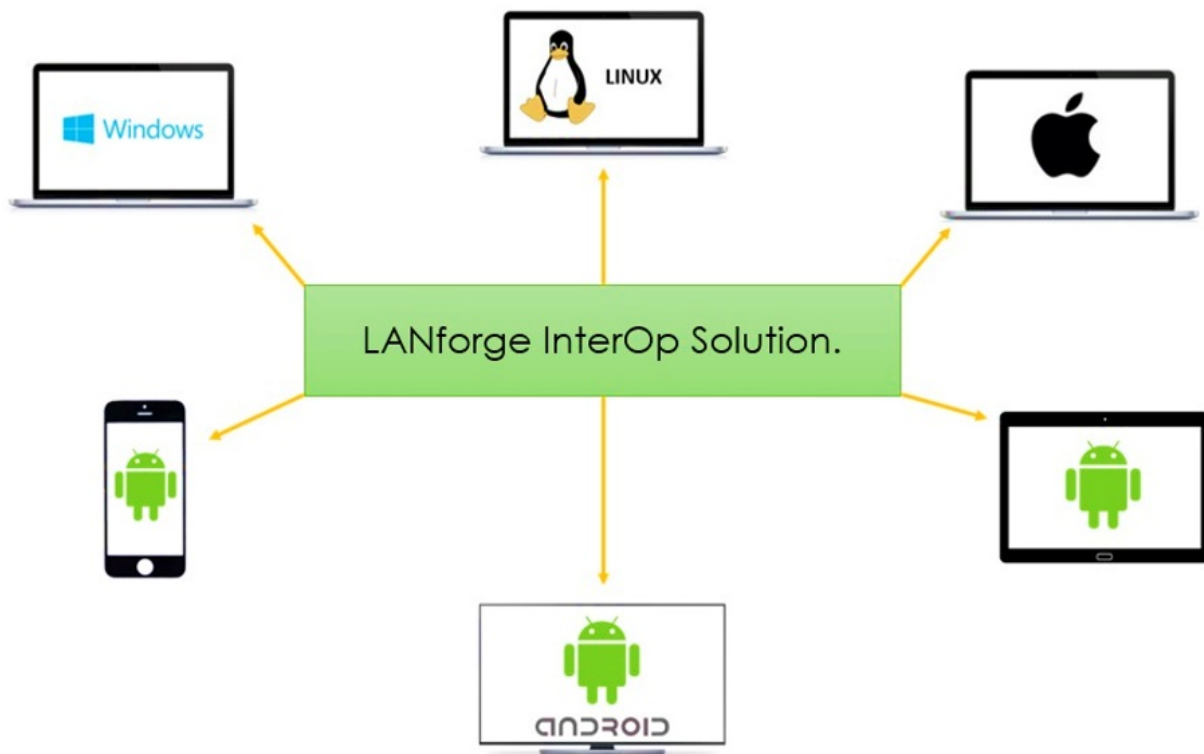


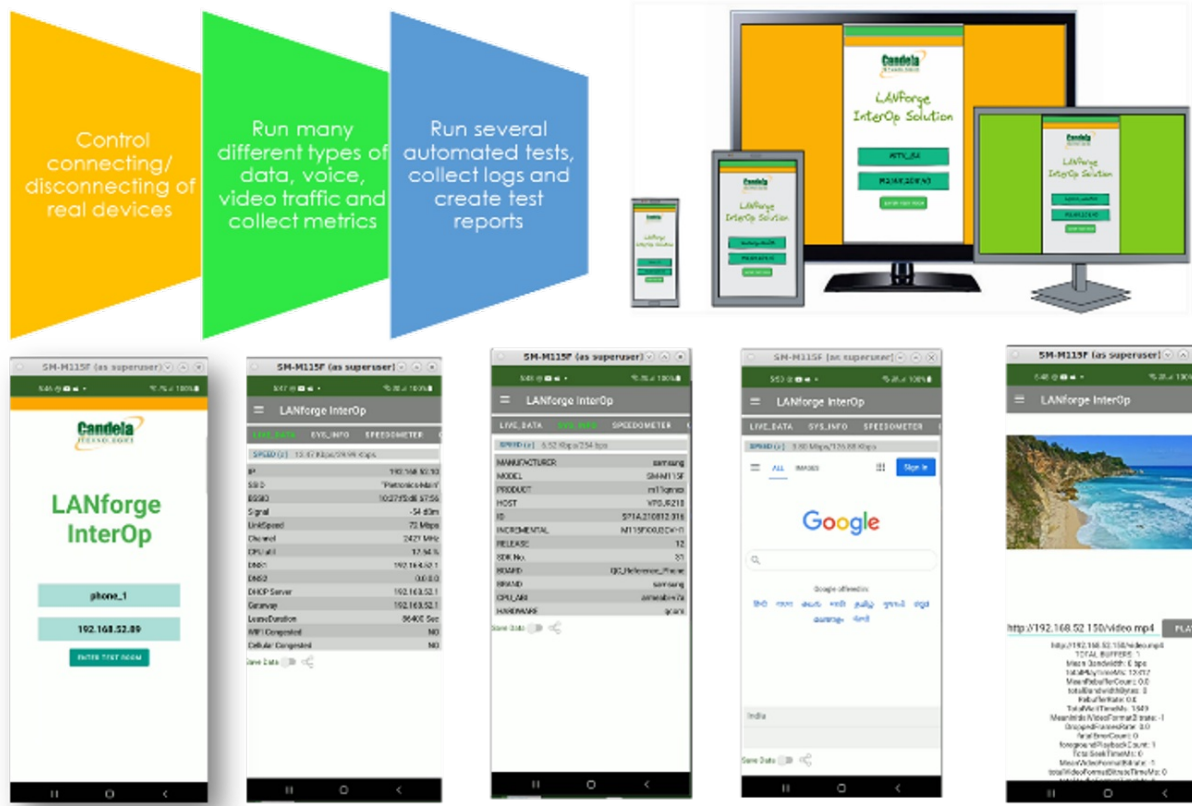
LANforge InterOp: WiFi Testing with Real Clients

For many years, WiFi access points' performance, scale, and functional testing in the lab had two different methodologies. One method was to benchmark the performance of the AP in completely isolated and conducted environments using RF chambers, emulated WiFi clients, and traffic generator tools. This method provided the most amount of the test coverage, determinism, and repeatability in testing, but it missed the key element of realism.

The second method relied on setting up a test lab in large walk-in screen room with lots of real devices and real application traffic. This method solved the realism problem, but at the cost of lack of proper automation and objective statistics on real application performance.

Candela LANforge InterOp solution attempts to bring the best of both worlds and provide a test solution that can scale and bring the realism, but at the same time provide automation and objective measurements of WiFi performance with real applications.



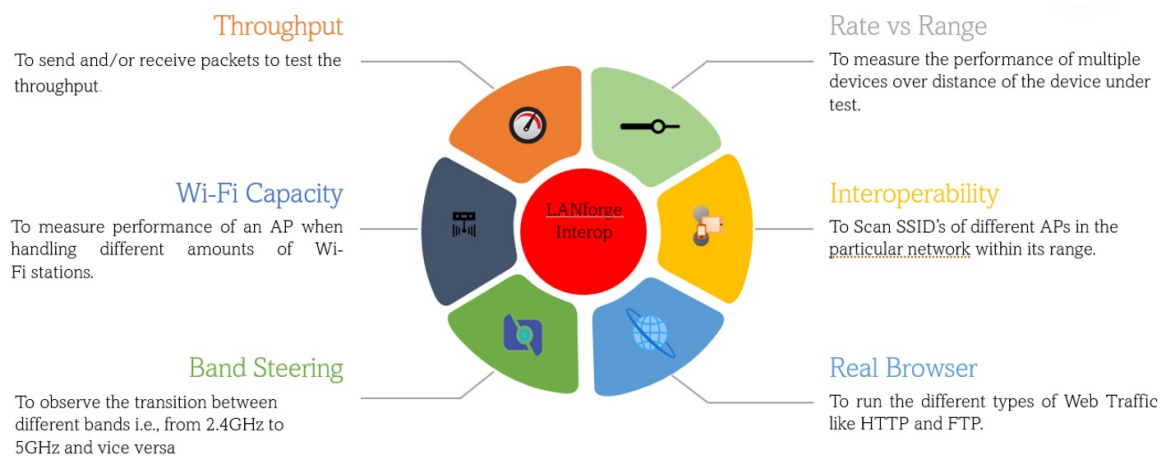


The LANforge InterOp product involves a set of completely automated testcases to test Access Points with real devices and real applications and measure and report KPIs.

Users install a lightweight LANforge InterOp software application on the end user devices and this software allows the test server to control these devices and run various tests. The endpoint application is made available on various standard and non-standard operation systems.

LANforge InterOp Features

- Realtime WiFi statistics display.
- Multiple device management and traffic generation.
- Ease of log fetching when faced with an issue.



LANforge InterOp Use Cases

RF Chambers:



- Control real devices in small numbers and run tests in RF chambers
- Tests normally run with a combination of virtual and real devices
- All real and virtual devices controlled from the same GUI or automation scripts.

Walk-In RF Screen Rooms:



- Setup large walk in screen rooms with 100+ real devices.
- Control all devices from a single test dashboard.

- ## Fully Automated Real Device Wi-Fi Testing

The floor plan illustrates the layout of a mobile phone store. The store is divided into several sections. The top section contains TCL TVs, Samsung A7, Samsung V11, and TCL TVs. The middle section contains Honor 9 Lite, Samsung g M11, Mi 4A, Noki a, Redmi Note 5A, 10 OR, Mi 5 Pro, and TCL TV. The bottom section contains Sony X, Sony X2, Vivo Y69, Lenovo Vibe P1, Redmi Note 7s, One Plus 5, Realme 3 Pro, Samsung g J6, Samsung g J2, Samsung g J6, and Redmi TV. The store also features a central area with Agent 1 and a right side with a Controller and various phone models including Samsung M1, Samsung g M2, Samsung A37, Samsung e 3s, Google Pixel, and Realme M2.

- Coverage Test House
Capacity Test House

- ## Real Campus Network Testing

LANforge Interop software allows both inband and out of band control of real devices from the LANforge server. All real devices can be connected via USB or Ethernet to the LANforge server for out of band controls and inband controls can be achieved through the WiFi test interface.



Real application testing includes video streaming, web conferencing, web browsing and more. Testing be conducted on real devices without internet access as many different types of voice, video and data clips can be installed prior to test execution on the LANforge server. The tests can be run between the server and the real devices with only the AP under test in between.

A wide variety of tests (as listed below) can be run:

- WiFi Capacity test
- Dataplane test
- Ping test
- Video streaming test

- Web page test
- HTTP file download test
- Long-term stability test
- Mixed traffic test

From the tests, key performance metrics such as throughput, packet loss, jitter, voice quality, video quality, webpage load times and more are measured in real time. From this data, charts and detailed test reports (in PDF, HTML, CSV and other formats) can be created.

Location	Mobile Brand	Mobile Hardware Version	RSSI	Data-rate	mcs	NSS	Tput(TCP UL)	Tput(TCP DL)	Tput (UDP UL)	Tput (UDP DL)
A1	Samsung	samsung SM-A750F r10 s	-42	150 mbps	7	1	5.0154	5.0207	0	3.67369
A2	Vivo	vivo vivo1901 r11 sdk: 30	-53	433 mbps	9	1	4.92747	4.19683	0	3.69628
A3	Poco	Xiaomi POCO F1 r10 sdk: 29	-43	866 mbps	11	2	0	5.04254	0	3.11878
A4	Redmi	Xiaomi Redmi Note 6 Pro	-36	433 mbps	9	1	4.84598	5.03162	0	3.47002
A5	Nokia	HMD Global Nokia 6.1 Plus	-56	433 mbps	9	1	0	4.98358	0	4.70051
A6	Redmi	Xiaomi Redmi Note 6 Pro r...	-37	433 mbps	9	1	5.11024	3.51065	0.60118	3.34019
B1	Oppe	OPPO CPH1727 r7.1.1 sdk:...	-35	135 mbps	7	1	5.01391	0.88431	4.59081	3.40636
B2	Poco	Xiaomi POCO F1 r10 sdk: 29	-41	866 mbps	11	2	4.84398	0.22391	0.98559	4.43137
B3	Vivo	vivo vivo1901 r11 sdk: 30	-43	433 mbps	9	1	5.34082	3.07372	0	3.66152
B4	Realme	OPPO CPH1859 r9 sdk: 28	-38	433 mbps	9	1	5.01295	5.00443	0	4.85163
B5	Redmi	Xiaomi M2010J19S r11 sd...	-39	433 mbps	9	1	5.01863	4.24777	0	4.06829
B6	Redmi	Xiaomi Redmi Note 7s r10...	-40	433 mbps	9	1	4.40368	4.21623	0	4.79155
C1	Realme	OPPO CPH1859 r9 sdk: 28	-36	433 mbps	9	1	5.01202	5.00509	0	4.70221
C2	Samsung	Samsung SM-M315F r12 s...	-48	433 mbps	9	1	4.84562	3.53704	0	4.83137
C3	Realme	realme RMX2002 r11 sdk:...	-48	433 mbps	9	1	5.0142	3.93721	4.90208	3.39926
C4	Oppe	OPPO CPH1931 r10 sdk: 29	-47	433 mbps	9	1	5.01202	4.1955	0.29795	4.29218
D1	Oppe	OPPO CPH1873 r9 sdk: 28	-31	433 mbps	9	1	0	0.02509	0.44708	3.27709
D2	Poco	Xiaomi POCO F1 r10 sdk: 29	-35	866 mbps	11	2	0.42767	3.66548	0.26701	4.27888
D3	Vivo	vivo vivo1818 r11 sdk: 30	-34	433 mbps	9	1	1.24667	1.62147	0.43978	2.84298
D4	Redmi	Xiaomi Redmi Note 5 r8.1...	-40	150 mbps	7	1	0	3.52703	0	3.02501
D5	Samsung	samsung SM-A605C r10 s...	-31	150 mbps	7	1	0	1.49416	0	2.32057
D6	Lenovo	Lenovo Lenovo 13011 r9...	-38	866 mbps	11	2	5.80689	2.9208	0.67145	3.52645
D7	Oneplus	OnePlus ONEPLUS A6000...	-36	866 mbps	11	2	0	5.01457	0.17277	0
E1	Poco	Xiaomi M2004J19P r10 sd...	-32	433 mbps	9	1	5.01123	0.91448	0	3.90604
E2	Vivo	vivo vivo1904 r11 sdk: 30	-41	433 mbps	9	1	4.86991	1.56763	0	3.87309
E3	Vivo	vivo V2052 r11 sdk: 30	-42	150 mbps	7	1	0	3.75214	0	2.52742
E4	Redmi	Xiaomi Redmi Note 5 Pro r...	-43	433 mbps	9	1	0	3.38757	0.79737	3.47815
E5	Redmi	Xiaomi Redmi Note 7 r10 ...	-37	433 mbps	9	1	0.16261	4.58639	0	0
F1	Poco	Xiaomi M2010J19C r11 sd...	-38	433 mbps	9	1	3.27155	1.25879	0	4.60552
F2	Samsung	samsung SM-M215F r12 s...	-39	433 mbps	9	1	0.00387	2.9204	0	4.99855
F3	Vivo	vivo vivo1609 r6.0 sdk: 23	-42	135 mbps	7	1	2.40674	2.53435	3.7146	2.73557
F4	Redmi	Xiaomi Redmi Note 5 Pro r...	-35	433 mbps	9	1	5.01107	4.41632	1.26806	3.3156
G1	Redmi	Xiaomi Redmi Note 7 r10 ...	-41	433 mbps	9	1	0	0.70583	0.7814	4.73207
G2	Redmi	Xiaomi Redmi Note 4 r7.0 ...	-41	150 mbps	7	1	0	0.3271	0	3.33271
G3	Redmi	Xiaomi Redmi Note 7 Pro r...	-48	433 mbps	9	1	5.01169	4.11564	0	4.32383
G4	Realme	realme RMX1971 r11 sdk:...	-31	433 mbps	9	1	1.31636	4.15094	0.95056	4.05955
G5	Redmi	Xiaomi Redmi Note 4 r7.0 ...	-39	150 mbps	7	1	5.01219	0.81354	0	2.69692
G6	Vivo	vivo vivo1907 r12 sdk: 31	-39	433 mbps	9	1	5.01328	4	5.02217	3.86855
G7	Realme	OPPO RMX1801 r10 sdk: 29	-41	433 mbps	9	1	2.57502	4.92946	4.09662	3.23142
H1	Nexus	Huawei Nexus 6P r8.1.0 s...	-42	866 mbps	11	2	5.18093	4.97976	0	2.97206
H2	Redmi	Xiaomi MI A1 r7.1.2 sdk: 25	-40	433 mbps	9	1	1.7163	4.95124	0	3.31487
H3	Oppe	OPPO CPH2083 r9 sdk: 28	-43	433 mbps	9	1	4.8476	4.27494	4.38822	4.10056
H4	Poco	Xiaomi M2010J19C r11 sd...	-37	433 mbps	9	1	2.48487	0.00838	0	4.72524
H5	Nazro	realme RMX3171 r11 sdk:...	-37	433 mbps	9	1	2.24902	5.02416	4.99435	3.59461
H7	Redmi	Xiaomi M2004J19C r10 sd...	-43	433 mbps	9	1	5.18048	3.13969	0	3.79337
H8	Realme	realme RMX1925 r10 sdk:...	-30	433 mbps	9	1	0.29812	2.43235	0.32984	4.05673
H9	Redmi	Xiaomi Redmi Note 7 Pro r...	-37	433 mbps	9	1	1.2141	3.64535	3.15414	3.92927

WE-CAN Real Client Scan

2022-11-08-11-42:28

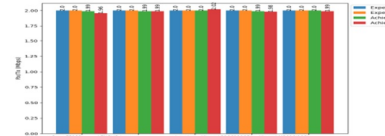


Lanforge Interop Wi-Fi Capacity Test report for Wi-Fi Client

2022-11-08-13-34-14



Device Name	Signal	Connected SSID	Security	Channel	Mode	Rx Rate (Mbps)	Tx Rate (Mbps)	Band	Direction	Traffic
Station HQ0101195	-74	NETGEAR3	WPA2	6	20/20	300	300	40	Upstream and Downstream	UP, Pkts



Objective:

The scan test in the WE-CAN APP is designed to scan the SSID of the different Access Points in the particular network within its range so as the connected clients in the LANforge WE-CAN server should scan the given SSID within its range.

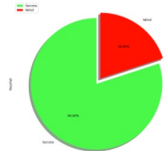
Testing Data (User Input)

Server IP	Target SSID	Security	Mode
192.168.208.40	NETGEAR3	WPA2	20

Phone Scan Table

Phone Name	User Name	MAC Address	Resource ID	Signal Strength	Phone Mode	Passed/Failed
Sony F122	sony_apella	84c7e2d3e337	10	-84.0	AUTO 20	Success
LENOVO	lenovoibm	e032f995c79ec	11	-13.0	AUTO 20	Success
vivo vivo	vivoHQ0	2074564b149b	12	-13.0	802.11 bgn	Success
Xiaomi 21041198	device_2	2d94e7237a61	13	-17.0	802.11 bgn	Success
Xiaomi HQ0101195	device_1	8c0fca78c3ab	14	NA	802.11 bgn	Failed

Pie Chart of Success and Failure



LANforge Interop Port Reset Test

2022-11-16-16:11:31



Test Setup Information

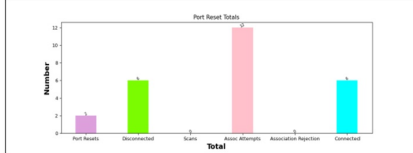
Device under test	QUT Name	Netgear
SSID	NETGEAR77-2G	
Test Duration	0:13:05	

Objective

The LANforge Interop port reset test allows user to test all of real Wi-Fi stations and connect them the AP under test and then disconnect and reconnect a random number of stations of random intervals. The objective of this test is to verify a heterogeneous public venue capacity where a number of stations arrive, connect and depart in quick succession. A successful test result would be that AP remains stable over the duration of the test and that stations can continue to reconnect to the AP.

Port Reset Total Graph

The below graph provides overall information regarding the test count where port reset total result provided as test input. Disconnected-H is the total number of disconnects happened for all clients during the test when WPA was disabled. Scanned-H is the total number of scanning state achieved by all clients during the test when network is enabled back again. Association attempt-H is the total number of association attempt (successful state) achieved by all client after the WPA is enabled back again in full test. Connected-H is the total number of connection (successful state) achieved by all clients during the test when WPA is enabled back again. Here test client used is 3 and number of result provided is 2.



Per Client Graph for client 450b13c

The below graph provides information regarding per station behaviour for every test count where port reset total result provided as test input. Disconnected-H is the total number of disconnects happened for a client during every test when WPA was disabled. Scanned-H is the total number of scanning state achieved by a client during the test when network is enabled back again. Association attempt-H is the total number of association attempt (successful state) achieved by a client after the WPA is enabled back again in full test. Connected-H is the total number of connection (successful state) achieved by a client during the test when WPA is enabled back again.

Objective:

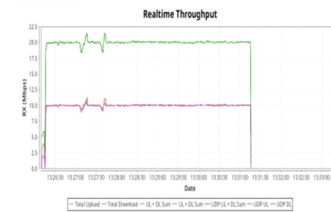
The LANforge Interop Wi-Fi Capacity Test is designed to measure the performance of an Access Point when handling different types of test clients. The test allows the user to increase the number of stations to test defined steps for each test duration and measure the per station and overall throughput, signal and mode rates for the AP. The expected behaviour for the AP is to be able to handle several stations under the limitation of the AP's speed and mode rate or stations get a fair amount of upstream and downstream throughput. An AP that cannot use test for a significant period of throughput decreases its mode stations on access.

Real-Time UDP Throughput Chart

Below chart shows the increased and sustained throughput for station increments x-1 time for UDP Pkts.

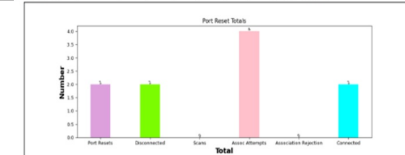
No. of stations(20 & 50)	Traffic rate	Total connected clients	Failed clients
30 - stations x 3 - 30			
50 - stations x 2	Total Upstream - Downstream, Total Downstream - Upstream	5	NA

Real Time Chart



Individual Device Performance Chart:

Device Name	Signal	Connected SSID	Security	Channel	Mode	Rx Rate (Mbps)	Tx Rate (Mbps)	Band	Direction	Traffic
Sony F122	-84	NETGEAR3	WPA2	4	20	72	0	20	Upstream and Downstream	UDP, Pkts



Real Client (WPA2/WPA3) Reset Observations

The below table shows actual behaviour of real devices for every test value

Real Count	Association attempt	Disconnected	Scanning	Association rejection	Connected
1	2	0	0	0	1
2	2	1	0	0	1

Real Client Detail Info

The below table shows detail information of real clients

S.No	name	device	user-name	mode	release
1	1.450b13c	Station	device_2	802.11 bgn	11
2	1.39a0b13c	Station	device_1	802.11 bgn	11
3	1.8f8a0b13c	Station	device_2	802.11 bgn	11

Test basic input information

LANforge ip	192.168.208.230
LANforge port	8080
ssid	NETGEAR77-2G
band	20
test count	2
time interval between every test(sec)	60
No. of Clients	3
Test Time	
Contact	support@candelatech.com

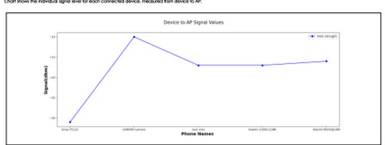
Generated by Candela Technologies LANforge network testing tool

<https://www.candelatech.com>

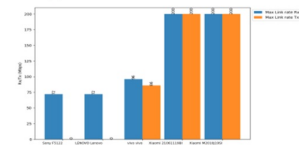


Signal Strength reported by the clients:

Chart shows the individual signal strength for each connected device measured from device to AP



Link Rates (Rx)



LANforge InterOp Rate vs Range

2022-11-08-13-24-10



Objective

InterOp measures the performance of each real client over a certain distance of the DUT. Distance is simulated using programmable Network and throughput test tool of each station (WPA2, WPA3). The test measures the performance over distance of the device under test. The test uses the user to plot SSID counts both upstream and downstream for different types of traffic, and different station types.

AP Name	NETGEAR3
Number of Real Stations	3
SSID	NETGEAR77-2G
Password	Password@123
Station Type	Station
Test Duration	0:00:21

InterOp download throughput for 3 real clients using TCP traffic

Below graph represents overall download throughput for different association levels



Table for Graph

Association Level	Download Throughput (Mbps)
1.0M	10.00
2.0M	10.00
4.0M	10.00
8.0M	10.00
16.0M	10.00
32.0M	10.00
64.0M	10.00
128.0M	10.00
256.0M	10.00
512.0M	10.00
1024.0M	10.00

Lead Times and Support:

Please contact support@candelatech.com if you need any assistance.

Lead Times: Four to six weeks.

TaaS/Onsite Support: Customers with only occasional test needs can use our Test as a Service option. Candela engineers can do the testing for you in our fully equipped test lab and provide a detailed test report with recommendations.

For more information, please contact sales@candelatech.com or give us a call at: 1-360-380-1618

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