GE

Grid Solutions

G500 Substation Gateway

Firmware Release Notes

MIS-0109

Version 2.00 Revision 0

GE Information

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About this Document

Purpose

The purpose of this document is to outline features, capabilities and issues, known to exist within the G500 Substation Gateway at the time of release.

Intended Audience

This document is an external document intended for both GE Staff and Customers. It highlights the features and capabilities of the G500 firmware.

Additional Documentation

For further information about the G500, refer to the following documents:

- *G500 Software User's Manual (SWM0101)*
- *G500 Hardware Instruction Manual (994-0152)*
- *G500 Quick Start Guide (SWM0106)*

For the most current version of the above documentation, please download a copy from:
http://www.gegridsolutions.com/app/ViewFiles.aspx?prod=g500&type=3

1. Version 1.00 (27-March-2019)

1.1 Software Versions

The following defines the software versions required for interaction with the G500.

Package	Version	Notes
G500 Firmware	1.0.652	G500 Firmware Version.
DS Agile MCP Studio	1.0.0	Supported DS Agile MCP Studio Software.
G500 HMI Viewer	1.0.653	Supported G500 HMI 64-bit Software.

1.2 Predix Edge OS and Other Firmware Versions

The following defines the firmware versions supported for Predix Edge Linux OS, FPGA, CPLD, UEFI and BCOM FPGA in the G500 v1.0.652.

Package/Firmware	Version	Notes
Predix Edge OS	2.2.1	Supported GE's Secured Linux Operating System Version.
FPGA	1.02.00	Supported FPGA Version of Multi-Function Controller Platform (MCP)
CPLD	1.2.1	Supported CPLD Version of Multi-Function Controller Platform (MCP).
UEFI	VX5D0007.C01	Supported UEFI Version of Multi-Function Controller Platform (MCP).
BCOM FPGA	2.3.0	Supported COM's Module FPGA Version of Multi-Function Controller Platform (MCP).

1.3 Key Features

G500 is part of the Multi-Function Controller Platform (MCP).

G500 is designed to provide a reliable and accurate collection of data (metering, status, events and faults) from serial or LAN based intelligent substation devices to master applications such as SCADA, EMS, DMS or other enterprise applications. With its modern and robust cyber security features, the G500 is designed for smooth integration into NERC CIP and Cyber Security environments while consolidating functions such as ethernet communications, time synchronization, HMI and SCADA applications.

G500 supports the following key features as part of v1.00.

Advanced Gateway : G500 collects operational and non-operational data from substation protection, control, monitoring, RTU, and intelligent devices, pre-processes the data and moves it up to EMS and DMS SCADA systems providing centralized substation management.

Advanced Automation : G500 provides the computing platform necessary to automate substation procedures, such that intricate processes are carried out safely and efficiently by creating advanced custom automation programs using IEC 61131 compliant tools and perform basic math functions on data points using the built-in calculator tool.

Datalogging and Alarm Management : G500 supports logging of analog and binary events, including alarm management. Users have access to view and extract logged data via Runtime

HMI corresponding screens (Trending, SOE, Historical Data, Active Alarms).

Automated Records (files) Retrieval and Management (ARRM) : G500 supports automated extraction of data files from IEDs, such as digital fault recording (DFR) records, event files, device information files, etc. Acquired files can be securely pushed automatically to remote systems.

Secure Passthrough Remote Access and VPN : G500 allows users to securely access substation devices from remote locations through validated interactive sessions hosted by the G500.

User Authentication : G500 provides Role Based Access Control (RBAC) with Local Account Authentication.

Runtime HMI : G500 provides user interaction with Role Based Access Control via a portable Runtime HMI application that runs in the Local unit KVM interfaces, as well as Remote in Windows based computers. There is no requirement to install Java/JRE on the Windows computers.

Support for Predix Edge Connectivity : G500 uses GE's Hardened *Predix EDGE* Operating System (Linux Yocto based) and supports secured connectivity for enrolling the unit into Predix Edge Manager.

Predix Edge Manager is a GE hosted Cloud Application that provides asset / fleet management of enrolled devices.

Hardware Based PRP/Redundant LAN Support : G500 supports up to 3 hardware based independent PRP or Redundant LAN through the rear ethernet ports.

Hardware Based IEEE 1588 PTP Master-Slave Support : G500 supports hardware based PTP Master-Slave support on the rear ethernet ports.

Hardware Based IRIG-B Input Support : G500 supports hardware based IRIG-B input.
NOTE: G500 can be configured to use PTP as a primary time source with automatic fail back to IRIG-B IN (IRIG-B IN must be in UTC time zone in this release).

Hardware Asset Management Application (HAMA) : G500 supports monitoring of the hardware parameters, e.g. network modes, serial port settings, temperatures, real time utilizations of various resources, etc. and presenting of these to the G500 System Point Database by means of Analog/Digital/Accumulator/Text Points.

1.4 Capability and Capacity

The G500 performance test levels are presented in this section.

G500 Hardware under test: 4 core CPU/ 16GB RAM variant.

NOTE: In the combined tables, numbers in brackets are for the G500 variant with 2 core CPU/8GB RAM.

Requirement	Steady State Loading	Avalanche Loading
Loading Signal changes (continuously / sec)	AI - 10,000 (5,000) DI – 100	All points changing twice in 2 secs
Number of connected IEDs to G500	500 (250)	500 (250)
G500 total RTDB Point count	200,000 (100,000)	200,000 (100,000)
Points / IED	400	400

DI & AI	150x DI and 250x AI per IED	150x DI and 250x AI per IED
Each G500 Server has points (half for 2 core CPU/8GB RAM)	DI = 18750 i.e.=150*500/4 AI = 31250 i.e.=250*500/4	DI = 18750 i.e.=150*500/4 AI = 31250 i.e.=250*500/4
Remote G500 HMI connections	3 Simultaneous connections	3 Simultaneous connections
Local G500 HMI connections	1 connection (multiple displays)	1 connection (multiple displays)
Datalogger / Continuous reports	1000 (500) AI mapped / 100 (50) reports	1000 (500) AI mapped / 100 (50) reports
ARRM	5 sessions / IED	5 sessions / IED
Alarms	100 (50) / sec	100 / sec (for 2 seconds)

1.4.1 Stand Alone

G500 provides the following performance capabilities in Single (non-redundant) Mode.

1.4.1.1 Performance Test Levels

The performance of G500 is tested using the activity levels and disturbance scenarios presented next.

The master station response times are defined in Table 1.1: Standalone Performance test results.

Table 1.1: Standalone Performance test results

Activity	DNP	DNP	IEC 61850	IEC 61850
Hardware (CPU / RAM)	4 core / 16 GB	2 core / 8 GB	4 core / 16 GB	2 core / 8 GB
Loading Condition	Steady state	Steady state	Steady state	Steady state
Protocol – CLIENT / SERVER	DNP / DNP	DNP / DNP	IEC 61850 / DNP	IEC 61850 / DNP
RTDB Point count	200,000	100,000	200,000	100,000
Total RCB configured / Simulation per sec	NA	NA	6000 1000	3000 500
Number of IEDs	500 (250)	500 (250)	500 (250)	500 (250)
Points / IED (AI + DI + AO + DO)	[AI-250, 150-DI, 20-DO, 20-AO, 10-ACC]	150DI+250AI (Configured AO, DO no simulation)	150DI+250AI (Configured AO, DO no simulation)	150DI+250AI (Configured AO, DO no simulation)
Datalogger reports	100 (50) Periodic reports	100 (50) Periodic reports	100 (50) Periodic reports	100 (50) Periodic reports
Number of Master connections Point count / Server	8 DI – 9300, AI – 15500	4 DI – 4650, AI - 7750	8 DI – 9300, AI - 15500	4 DI – 4650, AI - 7750
Remote / Local HMI connections	1 Remote / 0 Local HMI	1 Remote / 0 Local HMI	1 Remote / 1 Local HMI	1 Remote / 0 Local HMI
CPU utilization – Avg, Min, Max (%) – values for 4 core CPU	60,50,92	80, 28, 95	56, 30, 95	46, 36, 75
Average Memory	2.4 GB	1.4 GB	3 GB	2 GB
Event latency in (msecs) Average, Min, Max	399,19,1.04sec	487,13,1.31	589, 5, 2200	330, 41, 652
Control latency in (msecs) Average, Min, Max	34,12,291	629,3,1.09	8, 6, 16	9, 3, 68

1.4.1.2 HMI Response time

Under heavy loading conditions, the G500 provides the HMI response times listed in Table 1.2: User Interface Response Time.

Table 1.2: User Interface Response Time

Activity	Normal	High
Screen Access (Point Summary)	< 2 s	< 2 s
Screen Access (One Line Viewer)	5 to 7 s	5 to 7 s
System Logs	< 2s	2s
Alarm ACK Delay (Single Alarm)	< 1 s	< 1 s
Alarm ACK Delay (20,000 Alarms)	< 2 s	< 7 s
DI/AI Update to Point Summary Screen	< 1 s	< 1 s
Datalogger	<2s	<2s

NOTE: Under heavy loading conditions, the control latency was measured by simulating one control every 5 seconds continuously from the Master station.

1.4.2 Hot Standby Redundancy

G500 provides the following performance capabilities in Hot Standby Redundancy Mode.

Configuration	DNP	IEC61850
Hardware (CPU /RAM)	4 core / 16 GB	4 core / 16 GB
Redundancy	Hot Standby	Hot Standby
Number of IEDs	500 (250)	500 (250)
Protocol – CLIENT / SERVER	DNP / DNP	IEC61850 / DNP
RTDB Point count	200,000 (100,000)	200,000 (100,000)
Points / IED (AI + DI + AO + DO)	150 DI, 250 AI	150 DI, 250 AI
Number of Master connections Point count / Server	8 (4) DI – 9300, AI – 15500 (DI – 4650, AI – 7750)	8 (4) DI – 9300, AI – 15500 (DI – 4650, AI – 7750)
Total RCB configured / Simulation per sec	NA	6000 (3000) 1000 (500)
Datalogger / Continuous reports	NA	NA
ARRM	Not configured	Not configured
Alarms	100 (50) /sec	100 (50) /sec
Remote / Local HMI connections	1 Remote / 0 Local HMI	1 Remote / 0 Local HMI
CPU utilization – Avg, Min, Max (%) – values for 4 core CPU	60,34,71	32,46,67
Average Memory	3.12 GB	4.3 GB
Event latency – Average, Min, Max (msec)	390,60,1sec	368,2.8,1sec
Control latency – Average, Min, Max (msec)	30,12,377	3,1,73

1.4.3 Warm Standby Redundancy

G500 provides the following performance capabilities in Warm Standby Redundancy Mode.

Protocol	DNP	IEC61850	IEC 104
Hardware CPU / RAM	4 core / 16 GB (2 core / 8 GB)	4 core / 16 GB (2 core / 8 GB)	4 core / 16 GB (2 core / 8 GB)
Redundancy Mode	Warm Standby	Warm Standby	Warm Standby
Number of IEDs	500 (250)	500 (250)	500 (250)
Protocol – CLIENT / SERVER	DNP / DNP	IEC61850 / DNP	IEC 104 / IEC 104
RTDB Point count	200,000 (100,000)	200,000 (100,000)	200,000 (100,000)
Points / IED (AI + DI + AO + DO)	150 DI, 250 AI	150 DI, 250 AI	150 DI, 250 AI
Number of Master connections Point count / Server	8 (4) DI – 9300, AI – 15500 (DI – 4650, AI – 7750)	8 (4) DI – 9300, AI – 15500 (DI – 4650, AI – 7750)	8 (4) DI – 9300, AI – 15500 (DI – 4650, AI – 7750)
Total RCB configured / Simulation per sec	NA	6000 (3000) 1000 (500)	NA
Datalogger reports	100 (50) Periodic reports	100 (50) Periodic reports	100 (50) continuous reports
ARRM	Not configured	Not configured	Not configured
Alarms	100 (50) /sec	100 (50) /sec	100 (50) /sec
Remote / Local HMI connections	1 Remote / 0 Local HMI	1 Remote / 0 Local HMI	1 Remote / 0 Local HMI
CPU utilization – Avg, Min, Max (%) – values for 4 core CPU	62,53,96	43,48,60	28,32,42
Average Memory	2.4 GB	3 GB	3.4 GB
Event latency – Average, Min, Max (msec)	437,26,1.06	683,323,1sec	221,107,380
Control latency – Average, Min, Max (msec)	44,11,240	3,1,85	30,10,331

NOTE: G500 Supports maximum of 4 simultaneous Runtime HMIs (Remote + Local) either in Standby or Redundancy Modes (Hot/Warm Redundancy).

1.5 Time Sync Accuracy (PTP/IRIG-B/NTP)

G500 supports Hardware based PTP/IRIG-B and Software based NTP Time Sync Accuracy.

1.5.1 PTP Accuracy

1.5.1.1 Test Steps:

Below are setup details used for measuring PTP IN Time sync accuracy:

- Total number of samples considered ~250,000.
- Accuracy found to be < +/- 1ms for 99.86% of samples.
- Measured the accuracy for every second at the G500 CPU or Kernel.

1.5.1.2 Test Results:

Time Sync Input	Accuracy % of samples within (+/- 1 msec)
PTP IN	99.86% (samples within +/-1 ms)

NOTES:

- Accuracy is measured in a scenario where the hardware /FPGA is fully loaded.
- If IEDs are getting time synced using any of the client communication protocols, then the above accuracy cannot be guaranteed at the IED.

1.5.2 IRIG-B Accuracy

1.5.2.1 Test Setup:

Below are setup details used for measuring IRIG-B IN Time sync accuracy:

- Total number of samples considered ~50,000.
- Accuracy found to be < +/- 1ms for 99.8% of samples.
- Measured the accuracy for every second at the G500 CPU or Kernel.

1.5.2.2 Test Results:

Time Sync Input	Accuracy % of samples within (+/- 1 msec)
IRIG-B IN	99.8% (samples within +/-1 ms)

NOTES:

- Accuracy is measured in a scenario where the hardware /FPGA is fully loaded.
- If IEDs are getting time synced using any of the client communication protocols, then the above accuracy cannot be guaranteed at the IED.

1.5.3 NTP IN Accuracy

1.5.3.1 Test Setup:

Below are setup details used for measuring NTP IN Time sync accuracy:

- Total number of samples considered ~50,000.
- Accuracy found to be < +/- 10ms for 99.97% of samples.
- Measured the accuracy for every second at the G500 CPU or Kernel.

1.5.3.2 Test Results:

Time Sync Input	Accuracy % of samples within (+/- 10 msec)
NTP IN	99.97% (samples within +/-10 ms)

NOTES: If IEDs are getting time synced using any of the client communication protocols, then the above accuracy cannot be guaranteed at the IED.

1.5.4 NTP OUT Accuracy

Below are setup details used for measuring NTP OUT Time sync accuracy:

- Total number of samples considered ~50,000.
- Accuracy found to be < +/- 1 ms for 99.9% of samples.
- Measured the accuracy for every second at the IED.

1.5.4.1 Test Results:

Time Sync Output	Accuracy % of samples within (+/- 1 msec)
NTP OUT	99.9% (samples within +/- 1ms)

NOTES: If IEDs are getting time synced using any of the client communication protocols, then the above accuracy cannot be guaranteed at the IED.

1.6 Application List

The following applications comprise the G500 v1.00 released firmware version and build 1.0.652.

Application	Support in Standalone/ Warm Standby	Support in Hot Standby
Runtime HMI	✓ Available	✓ Available
One Line Viewer	✓ Available	✓ Available
Config GUI / Schemas	✓ Available	✓ Available
System Library	✓ Available	✓ Available
C++ System Library	✓ Available	✓ Available
Connection Parser	✓ Available	✓ Available
Calculator	✓ Available	✓ Available
Hardware Asset Management Application (HAMA)	✓ Available	✗ Not Available
PTP/IRIG-B Time Sync	✓ Available	✓ Available
Modbus Client	✓ Available	✓ Available
Modbus-TCP/SSH Client	✓ Available * Not Available in Warm Standby	✗ Not Available
SEL® Binary Client	✓ Available	✗ Not Available
Analog Data Logger	✓ Available	✗ Not Available
Generic ASCII Client	✓ Available	✗ Not Available
Modbus Server	✓ Available	✗ Not Available
DNP 3.0 Server	✓ Available	✓ Available
DNP 3.0 Client	✓ Available	✓ Available
Digital Event Manager	✓ Available	✓ Available
Database Server	✓ Available	✓ Available
DNP 3.0 TCP/IP Transport Layer	✓ Available	✓ Available
DNP 3.0 Server Serial Transport Layer	✓ Available	✓ Available

Application	Support in Standalone/ Warm Standby	Support in Hot Standby
DNP 3.0 DIDO	✓ Available	✖ Not Available
IEC 60870-5-101/104 Server	✓ Available	✖ Not Available
IEC 60870-5-103 Client	✓ Available	✖ Not Available
IEC 61850 Client	✓ Available	✓ Available
IEC 60870-5-101/104 Client	✓ Available	✖ Not Available
Event Logger	✓ Available	✓ Available
Real-Time Database	✓ Available	✓ Available
LogicLinx IEC 61131-3 Soft Logic	✓ Available	✓ Available
Redundancy Manager	✓ Available	✓ Available
System Point Manager	✓ Available	✓ Available
Load Shedding and Curtailment	✓ Available	✖ Not Available
Control Lockout Manager	✓ Available	✓ Available
Software Watchdog	✓ Available	✓ Available
Configuration Manager	✓ Available	✓ Available
IP Changer	✓ Available	✓ Available
MD5SUM Builder	✓ Available	✓ Available
System Status Manager	✓ Available	✓ Available
Virtual Serial Ports	✓ Available	✓ Available
SNMP Client	✓ Available	✖ Not Available
Automated Record Retrieval Manager	✓ Available	✖ Not Available
Software Licensing Subsystem	✓ Available	✓ Available
Third-party components	✓ Available	✓ Available
Terminal Services	✓ Available	✓ Available
mcpcfg utility	✓ Available	✓ Available
E-mail Utility	✓ Available	✓ Available
IO Traffic Monitor	✓ Available	✓ Available
Firewall	✓ Available	✓ Available
Edge OS & Drivers	✓ Available	✓ Available
Secure Enterprise Connectivity	✓ Available	✓ Available
Genconn	✓ Available	✓ Available
HMI Access Manager	✓ Available	✓ Available
Sync Service Library	✓ Available	✓ Available
Sync Server Application	✓ Available	✓ Available
Analog Report Generator	✓ Available	✖ Not Available
OpenVPN	✓ Available	✓ Available

1.7 Known Issues

1.7.1 Cyber Security

GE Internal Reference #	Summary	Impact
B-12426	User Account Remote Authentication (LDAP-AD/CISCO-TACACS+)	Remote user authentication using these methods is not available in this release. Only Local Account Authentication is available, with roles: • **Observer** • **Operator** • **Supervisor** • **Administrator** • **Pass-through user**

1.7.2 Clients

GE Internal Reference #	Summary	Impact
D-05002	Cannot perform file transfer from GENASCII devices.	ARRM file retrieval from SEL 1xx/2xx relays (using GENASCII) is not possible.

1.7.3 Servers

GE Internal Reference #	Summary	Impact
B-11968	No support for events in NVRAM in DNP3 Server.	Events that have not been yet transmitted to Master (Clients) are lost if G500 is power cycled / restarted. However – the integrity polls will continue to provide accurate database representation.
B-11967	No support for events in NVRAM in IEC101/104 Server.	Events that have not been yet transmitted to Master (Clients) are lost if G500 is power cycled / restarted. However – the integrity polls will continue to provide accurate database representation.

1.7.4 Automation

GE Internal Reference #	Summary	Impact
D-05877	No warning message when storage space is reduced in datalogger configuration.	Currently datalogger application re-adjusts the storage space(increase/decrease) based on the newly allocated settings. In this case users might not be aware of the deletion of the records if the newly allocated storage space is smaller than the previous allocated one.
D-05033	Suppressed quality through Input Point Suppression (IPS) application is not reported to Masters.	DNP3 and IEC 101-104 Servers send Online Quality rather than the substituted/last reported quality when points are suppressed.
D-05462	Load shedding: Persistent storage of Zone Assignments is not working.	There is no persistency of zone assignments across power restarts when user sets the zones through Analog Setpoint commands.

GE Internal Reference #	Summary	Impact
B-11969	No support for events in NVRAM for DEM.	DEM is responsible for handling alarms. Events/Alarms that have not been yet committed to the SQL database are lost if G500 is power cycled / restarted. However – the integrity polls will continue to provide accurate database representation.
D-07025	Alarm/SOE Database corruption when abrupt G500 power failure happens & Events are simultaneously generated.	This is a remote case and if the database corruption happens the SQL server will not be started.

1.7.5 Configuration

GE Internal Reference #	Summary	Impact
D-06168	FPGA needs to be restarted for PTP/IRIGB configuration change.	No functional impact. PTP/IRIG-B configuration will not be applied without reboot of G500.

1.7.6 HMI

GE Internal Reference #	Summary	Impact
D-05802	Local HMI shows exception errors when screens are open and video resolution is changed lower than the current size of HMI frames.	Occurs only when screen resolutions are changed, and the Local HMI has windows opened with a larger size than the new set resolution. User must close the Local HMI and re-open again.
D-05463	Point groups: Points are missing after deleting an active group.	If a used point group is deleted from the systemwide configuration then points belonging to that group are not visible in the point group summary. However, if user changes the point group allocation from the corresponding instantiated client map file(s) then points will be visible in the point group summary.

1.7.7 Pass-through

GE Internal Reference #	Summary	Impact
D-07084	Cannot access hosts inside Internal Zone unless hosts have custom routing configured.	Only hosts in internal zone that allow configuration of custom routes can be accessed via VPN server from external zone.

1.7.8 System

GE Internal Reference #	Summary	Impact
D-05714	Update of only Edge OS is not supported.	If only Edge OS updates are required, the complete G500 firmware image needs to be updated.

GE Internal Reference #	Summary	Impact
D-06167	Full support for latest PTP power profiles: IEEE C37.238-2017 IEC61850-9-3 Ed.1 2016	Enhancement. G500 supports the following PTP profiles: IEEE 1588-2008 J4 Peer-to-Peer Profile IEEE C37.238-2011 Power System Profile (but this has been withdrawn) Limited IEC61850-9-3 Ed.1 2016 Power Utility Automation Profile

1.7.9 Hardware

GE Internal Reference #	Summary	Impact
D-06232	IRIG-B Out is invalid during start-up.	IRIG-B OUT signal produces a 1970-01-01 signal for brief periods of time during G500 start-up.
D-06165	SFP Hot Plug in / Plug out detection.	No functional impact. Points that represent the status of SFP IN/OUT will not be reflected until G500 is rebooted.
D-06458	Audio Output Port is not working.	User is unable to hear Alarm or any sounds from the Audio Output Port of G500.

2. Version 1.10 (14-February-2020)

2.1 Software Versions

The following table defines the software versions required for interaction with the G500.

Package	Version	Notes
G500 Firmware	1.1.457	G500 Firmware Version.
DS Agile MCP Studio	2.0.0.0.35611	Minimum Supported DS Agile MCP Studio Software.
G500 HMI Viewer	1.1.458	Supported G500 HMI 64-bit Software.

2.2 Predix Edge OS and Other Firmware Versions

The following table defines the package/firmware versions supported for Predix Edge Linux OS, FPGA, CPLD, UEFI and BCOM FPGA in the G500 v1.1.457.

Package/Firmware	Version	Notes
Predix Edge OS	2.2.1	Supported GE's Secured Linux Operating System Version.
FPGA	1.03.00	Supported FPGA Version of Multi-Function Controller Platform (MCP).
CPLD	1.2.2	Supported CPLD Version of Multi-Function Controller Platform (MCP).
UEFI	VX5D0007.C01	Supported UEFI Version of Multi-Function Controller Platform (MCP).
BCOM FPGA	2.3.0	Supported COM's Module FPGA Version of Multi-Function Controller Platform (MCP).

2.3 Key Functions and Changes

2.3.1 Enhancements

This G500 version adds the following new features compared to V1.00:

2.3.1.1 Cyber Security

GE Internal Reference #	Summary	Resolution
E-03212, E-03213	Remote Authentication & Emergency Access Support.	Added the support for Remote User Authentication support for LDAP-Active Directory/CISCO-TACACS+ Servers and Enhanced Emergency Access functionality.
R-01161	G500 LDAP connection check without PING command.	Added the support in LDAP Authentication to check the connectivity to the LDAP Server without using ICMP Echo/PING command.
B-12677	Enhanced Emergency Admin access	Created a new enhanced and more robust workflow for Emergency Access when Remote Authentication is not available.

B-13288/ B-13334	Cyber Security Enhancements.	Enhancements based on Cyber Security and Coverity Reports are included.

2.3.1.2 Clients

GE Internal Reference #	Summary	Resolution
B-12826	Modbus TCP/SSH Client Support for Warm/Hot Standby.	Added Warm & Hot Standby Redundancy Support for Modbus TCP/SSH Client application.
R-01137	DNP Data Link Retries in G500 to be more like D20.	Added support for DNP Data Link Retries enable/disable option for Direct Operate controls.

2.3.1.3 Server

GE Internal Reference #	Summary	Resolution
R-01185	IEC101/104 Server support for NG implementation.	Added support for different link address to Backup Serial port in IEC101 DPA.
E-03739	Configurable DNP DPA Abs/Rel time for Binary Input Change Events.	Added support for Binary Input Change Events in DNP3 DPA to report with either Absolute timestamp or Relative timestamp.

2.3.1.4 Automation

GE Internal Reference #	Summary	Resolution
E-03776	Increase in DTA Application Limits.	Added support to increase the Application Limits for the following Automation applications. *Calculator* ▪ Evaluation Expressions from 2,000 to 10,000 ▪ Digital Assignments from 2,000 to 10,000 *System Point Manager* ▪ Local groups from 256 to 1,000 ▪ Input Point Suppression groups from 256 to 10,000 ▪ Redundant IO groups from 256 to 10,000.
R-01186	Remote Control Lockout Group Enhancements.	Added support for manual group ownership in Remote Control Lockout functionality by explicitly acquiring the lock using a Group pseudo DO point.

2.3.1.5 HMI

GE Internal Reference #	Summary	Resolution
E-03446	Support for Setting GUI in addition to mcpcfg.	Added web-based Setting GUI in addition to command line mcpcfg for configuring G500 settings.

2.3.1.6 Passthrough/VPN

GE Internal Reference #	Summary	Resolution
R-01113	Improve GUI of VPN Server Routing and White Listing.	Enhancements are implemented in the VPN Server Routing List and White Listing drop-down options in GUI.

2.3.1.7 System

GE Internal Reference #	Summary	Resolution
B-13018	Secure Tunnel between Active & Standby G500s.	Added support for secure tunnel framework for data/command exchange between Active and Standby G500s in Hot & Warm Standby Redundancy modes.
B-12766	Hardware Asset Management Application (HAMA) Enhancements.	Added the support to show information/status of additional PCIe expansion cards (serial and D.20 when available).
B-12663	SOE and Alarm functions in HMI.	Enhanced speed and efficiency of SOE and Alarm functions.

2.3.1.8 Hardware

GE Internal Reference #	Summary	Resolution
B-12575	Hardware Based IRIG-B Output Support.	Added support for hardware based IRIG-B output to existing IRIG-B input.
R-01184	Added Fiber Optic Single Mode GB SFP as order option “L”.	Added support for Fiber Optic Single Mode GB SFP as order option “L” in the Ordering Guide.

2.3.1.9 Documentation

GE Internal Reference #	Summary	Resolution
R-01164	Add Note/description to Software Configuration Guide to clarify that Double Point functionality is only for Alarms.	Updated the Software Configuration Guide to clarify the support for Double Point Alarms as available only for Double Points in G500.
B-12696	Improve Documentation for Warm Standby Redundancy functionality.	Improved documentation for configuring Warm Standby Redundancy workflow in Software Configuration Guide.

2.3.2 Fixed defects

This version of G500 has the fixes for the following defects compared to V1.00:

2.3.2.1 Cyber Security

GE Internal Reference #	Summary	Resolution
D-08375	Unable to add VLAN Interfaces in OpenVPN Routing List.	Fixed the issue of showing up the VLAN interfaces in the OpenVPN Routing List.
D-08376	SSH/Ping to other Interfaces of G500 is not working from Remote PC through OpenVPN.	Fixed the issue in forwarding the Ping/SSH to the other interfaces from the Remote PC using OpenVPN in G500.
D-10000	Observer/Operator can obtain the secret signature.	Fixed the issue with permissions for Operator/Observer user to avoid obtaining the secret signature.

2.3.2.2 Clients

GE Internal Reference #	Summary	Resolution
D-09785	DNP DCA memory usage increase when 10 controls/sec are simulated continuously.	Fixed the memory leak issue in DNP Client when more than 10 controls/sec are simulated continuously.

2.3.2.3 Automation

GE Internal Reference #	Summary	Resolution
D-07611	Sync To operation from DSAS "Overrides" Sync Manager Users.	DSAS excludes the Sync Manager configuration and users while doing Sync To operation to the G500.
D-05603	ARRM TFTP File retrieval is not working with 8-Series relays.	Fixed the issue of supporting file retrieval from 8-series relays through TFTP.
D-08328	ARRM FTP functionality is not working while restoring the snapshot to G500.	Fixed the issues with the decryption of FTP Password in the ARRM configuration files while restoring the configuration from the other G500 device.
D-07603	ARRM cannot read files from SEL via FTP.	Fixed the issues with the decryption of FTP Passwords from SEL relays while reading the files through ARRM.
D-08361	ARRM Directory path not updated after save and commit changes.	Fixed an issue where ARRM Change in Directory Path in File set Template was not propagating correctly after configuration save and commit.
D-08080	Redundant IO doesn't start unless there is at least one AI mapped.	Fixed an issue where Redundant IO doesn't start unless there is at least one AI being mapped, now works without any AI mapped.

D-05877	No warning message when storage space is reduced in datalogger configuration.	If the new configured datalogger file size is smaller than the current datalogger file size, pop up a confirmation dialog with the warning msg shown below : "The new requested size for this report is smaller than the current size of the data in the report. This operation will delete old/new/all data in the report. Do you want to continue?" Only saving datalogger configure when user clicks the 'yes' button
D-07025	Alarm/SOE Database corruption when abrupt G500 power failure happens & Events are simultaneously generated.	After EdgeOS 2.2 upgrade timestamps off by random number of hours in MariaDB. By purging the database (apps automatically restarted), the issue was resolved.

2.3.2.4 Configuration

GE Internal Reference #	Summary	Resolution
D-08357	ARRM FTP/SFTP/TFTP default timeout increase to 10 sec.	Updated the default timeout for FTP/SFTP/TFTP from 2 secs to 10 secs.

2.3.2.5 HMI

GE Internal Reference #	Summary	Resolution
D-08521	G500 Buzzer should be disabled by default.	The default state of the G500 Buzzer after the firmware is installed is OFF.
D-09979	Manual forced accumulator values not supporting full range.	Fixed the issue with accumulators for not supporting max value of 2^63-1.
D-10185	Saving of Datalogger reports in Local HMI.	Fixed the issue in saving the datalogger reports in Local HMI.
D-10233	Local HMI allows admin and operator users to copy private keys to USB.	Fixed the issue in Local HMI File Explorer to copy the private keys to USB for all users.
D-05802	Local HMI shows exception errors when screens are open and video resolution is changed lower than the current size of HMI frames.	Fixed.

2.3.2.6 Pass-through

GE Internal Reference #	Summary	Resolution
D-07084	Cannot access hosts inside VPN Internal Zone unless hosts have custom routing configured.	Fixed.

2.3.2.7 System

GE Internal Reference #	Summary	Resolution
B-13055	Password Encryption/Decryption getting failed for Snapshot/Restore of one G500 to another G500.	Fixed the issue with failure of Password Encryption/Decryptions while using the Snapshot and Restore functionalities across the G500s.
D-09906	Missing SOEs during SOE Export.	Fixed the issue of missing of SOEs in the export file while DI events are being simulated and deletion is in progress.

2.3.2.8 Hardware

GE Internal Reference #	Summary	Resolution
D-06232	IRIG-B Out is invalid during start-up.	IRIG-B OUT signal produces a 1970-01-01 signal for brief periods of time during G500 start-up.
D-06458	Audio Output Port is not working.	Fixed the issues with audio output port of G500.

2.3.3 Known Issues

This G500 version has the following known issues:

2.3.3.1 Cyber Security

GE Internal Reference #	Summary	Impact
D-08565	Firewall rule settings are not reflecting in ICMP functionality.	If ICMP Echo setting is enabled in G500 and when Ping command from PC is issued to the G500, G500 responds to the ping request when G500 is booting. However, this issue comes only in a remote case and other TCP/SCADA connections are not impacted.

2.3.3.2 Clients

GE Internal Reference #	Summary	Impact
D-09916	SEL Binary Client application restarts when configured to communicate with SEL 351S relay.	SEL Binary Client fails to communicate to the SEL 351S relay when the relay is connected through G500's Virtual Serial Ports.
D-05002	ARRM file retrieval from SEL 1xx/2xx relays (using GENASCII) is not possible.	ARRM file retrieval from SEL 1xx/2xx relays (using GENASCII) is not possible.

2.3.3.3 Servers

GE Internal Reference #	Description
B-11967	No support for events in NVRAM in IEC101/104 Server. Events that have not been yet transmitted to Master (Clients) are lost if G500 is power cycled / restarted. However – the integrity polls will continue to provide accurate database representation.
B-11968	No support for events in NVRAM in DNP3 Server. Events that have not been yet transmitted to Master (Clients) are lost if G500 is power cycled / restarted. However – the integrity polls will continue to provide accurate database representation.

2.3.3.4 Automation

GE Internal Reference #	Summary	Impact
D-05033	Suppressed quality through Input Point Suppression (IPS) application is not reported to Masters.	DNP3 and IEC 101-104 Servers send Online Quality rather than the substituted/last reported quality when points are suppressed.
D-05462	Load shedding: Persistent storage of Zone Assignments is not working.	There is no persistency of zone assignments across power restarts when user sets the zones through Analog Setpoint commands.
B-11969	No support for events in NVRAM for DEM.	DEM is responsible for handling alarms. Events/Alarms that have not been yet committed to the SQL database are lost if G500 is power cycled / restarted. However – the integrity polls will continue to provide accurate database representation.

2.3.3.5 Configuration/Settings

GE Internal Reference #	Summary	Impact
D-10345	mcpcfg settings must be reconfigured while upgrading the G500 from v1.0 to v1.1.	As part of upgrading the G500 from v1.0 to v1.1, the configuration settings must be reconfigured using mcpcfg or settings GUI after upgrading to v1.1.
D-10346	PTP-1588 IN and IRIG-B IN cannot be enabled at the same time in G500 v1.1.	G500 v1.1 does not support both PTP IN and IRIG-B IN to be enabled at the same time. Also, by default these Time Sync Input sources are disabled and user can enable either of them using mcpcfg or settings GUI.
D-06168	FPGA needs to be restarted for PTP/IRIGB configuration change.	No functional impact. PTP/IRIG-B configuration will not be applied without reboot of G500.

2.3.3.6 HMI

GE Internal Reference #	Summary	Impact
D-09695	Operator User in Active G500 gets Observer Group privileges sometimes after multiple switch-over or fail-overs in Hot or Warm Standby Redundancy.	Runtime HMI needs to be logged out and logged in if this case happens.
D-09915	G500 HMI "Internal Access Error" after SEL DCA is configured and then crashes.	Runtime HMI cannot be logged in and it displays “Internal Access” error even after rebooting the G500. However, once SEL Binary Client Configuration is deleted from the configuration then this issue will not be observed.
D-09944	Internationalization: Settings and messages in the Powerbar in Runtime HMI are not changing to specified language.	No Functional Impact. However, the messages/settings in the Powerbar in Runtime HMI continue to be seen in English.
D-10324	“The configuration has been modified. Unsaved changes will be discarded. Do you want to discard the changes?" this message is getting displayed even though any changes made are already committed. This applies to the Access tab in the local HMI viewer.	No Functional Impact. However, the message creates inconvenience to the user.
D-10325	After saving the changes in the Access tab of the local HMI viewer and navigating to other tab without committing the changes, then Local HMI viewer is not accessible.	Impact: Loss of access to the Local HMI viewer. However, can be recovered by committing or discarding the changes from DSAS.
D-05463	Point groups: Points are missing after deleting an active group.	If a used point group is deleted from the systemwide configuration then points belonging to that group are not visible in the point group summary. However, if user changes the point group allocation from the corresponding instantiated client map file(s) then points will be visible in the point group summary.

2.3.3.7 Pass-through

None

2.3.3.8 System

GE Internal Reference #	Summary	Impact
E-03371	No method to restore a G500 after all admin local logons lost/forgotten.	G500 cannot be logged in using SSH/HMI/ Front Serial Port. However, users can use the Single Image installer through USB and restore the Factory Default firmware and the configuration.

D-08036	Avoid not applicable errors displayed during G500 bootup process.	No Functional Impact. However, during reboot of G500, some not applicable error messages are displayed on the console connected to the display port.
D-10254	Double Quote (" ") are not allowed to use in the password field for FTP in Sync Manager.	Double quotes (" ") cannot be used in password field of FTP in the Sync Manager configuration.
D-05714	Update of only Edge OS is not supported.	If only Edge OS updates are required, the complete G500 firmware image needs to be updated.
D-06167	Full support for latest PTP power profiles: IEEE C37.238-2017 IEC61850-9-3 Ed.1 2016	Enhancement. G500 supports the following PTP profiles: IEEE 1588-2008 J4 Peer-to-Peer Profile IEEE C37.238-2011 Power System Profile (but this has been withdrawn) Limited IEC61850-9-3 Ed.1 2016 Power Utility Automation Profile

2.3.3.9 Documentation

GE Internal Reference #	Summary	Impact
D-09783	G500 sync to UTC-(UTC_OFFSET) instead of UTC after fall back from PTP to IRIG-B - a reboot is required to fix the offset problem.	Dynamic failover at runtime between PTP and IRIG-B will not happen. Documentation does not capture this.
D-10131	Missing information about syslog file in the G500 SW Configuration Guide.	No Functional Impact. However, the examples that show the format of rsyslog file output are not available in the Software Configuration Guide.

2.3.3.10 Hardware

GE Internal Reference #	Summary	Impact
D-06165	SFP Hot Plug in / Plug out detection.	No functional impact. Points that represent the status of SFP IN/OUT will not be reflected until G500 is rebooted.

2.4 Capability and Capacity

The G500 v1.10 meets below performance test level requirements of G500 v1.00.

NOTES:

- G500 Hardware under test: 4 core CPU/ 16GB RAM variant.
- In the below table, numbers inside the brackets are for the G500 variant with 2 core CPU/8GB RAM.

Requirement	Steady State Loading	Avalanche Loading
Loading Signal changes (continuously / sec)	AI - 10,000 (5,000) DI – 100	All points changing twice in 2 secs

Number of connected IEDs to G500	500 (250)	500 (250)
G500 total RTDB Point count	200,000 (100,000)	200,000 (100,000)
Points / IED DI & AI	400 150x DI and 250x AI per IED	400 150x DI and 250x AI per IED
Each G500 Server has points (half for 2 core CPU/8GB RAM)	DI = 18750 i.e.=150*500/4 AI = 31250 i.e.=250*500/4	DI = 18750 i.e.=150*500/4 AI = 31250 i.e.=250*500/4
Remote G500 HMI connections	3 Simultaneous connections	3 Simultaneous connections
Local G500 HMI connections	1 connection (multiple displays)	1 connection (multiple displays)
Datalogger / Continuous reports	1000 (500) AI mapped / 100 (50) reports	1000 (500) AI mapped / 100 (50) reports
ARRM	5 sessions / IED	5 sessions / IED
Alarms	100 (50) / sec	100 / sec (for 2 seconds)

2.4.1 Stand Alone

G500 provides the following performance capabilities in Single (non-redundant) Mode.

2.4.1.1 Performance Test Levels

The performance of G500 is tested using the activity levels and disturbance scenarios presented next.

The master station response times are defined in Table 2.1: Standalone Performance test results.

Table 2.1: Standalone Performance test results

Activity	DNP	DNP	IEC 61850	IEC 61850
Hardware (CPU / RAM)	4 core / 16 GB	2 core / 8 GB	4 core / 16 GB	2 core / 8 GB
Loading Condition	Steady state	Steady state	Steady state	Steady state
Protocol – CLIENT / SERVER	DNP / DNP	DNP / DNP	IEC 61850 / DNP	IEC 61850 / DNP
RTDB Point count	200,000	100,000	200,000	100,000
Total RCB configured / Simulation per sec	NA	NA	6000 1000	3000 500
Number of IEDs	500 (250)	500 (250)	500 (250)	500 (250)
Points / IED (AI + DI + AO + DO)	[AI-250, 150-DI, 20-DO, 20-AO, 10-ACC]	150DI+250AI (Configured AO, DO no simulation)	150DI+250AI (Configured AO, DO no simulation)	150DI+250AI (Configured AO, DO no simulation)
Datalogger reports	100 (50) Periodic reports	100 (50) Periodic reports	100 (50) Periodic reports	100 (50) Periodic reports

Number of Master connections Point count / Server	8 DI – 9300, AI – 15500	4 DI – 4650, AI - 7750	8 DI – 9300, AI - 15500	4 DI – 4650, AI - 7750
Remote / Local HMI connections	1 Remote / 0 Local HMI	1 Remote / 0 Local HMI	1 Remote / 1 Local HMI	1 Remote / 0 Local HMI
CPU utilization – Avg, Min, Max (%) – values for 4 core CPU	60,50,92	80, 28, 95	56, 30, 95	46, 36, 75
Average Memory	2.4 GB	1.4 GB	3 GB	2 GB
Event latency in (msecs) Average, Min, Max	399,19,1.04sec	487,13,1.31	589, 5, 2200	330, 41, 652
Control latency in (msecs) Average, Min, Max	34,12,291	629,3,1.09	8, 6, 16	9, 3, 68

2.4.1.2 HMI Response time

Under heavy loading conditions, the G500 provides the HMI response times listed in Table 2.2: User Interface Response Time.

Table 2.2: User Interface Response Time

Activity	Normal	High
Screen Access (Point Summary)	< 2 s	< 2 s
Screen Access (One Line Viewer)	5 to 7 s	5 to 7 s
System Logs	< 2s	2s
Alarm ACK Delay (Single Alarm)	< 1 s	< 1 s
Alarm ACK Delay (20,000 Alarms)	< 2 s	< 7 s
DI/AI Update to Point Summary Screen	< 1 s	< 1 s

NOTE: Under heavy loading conditions, the control latency was measured by simulating one control in every 5 seconds continuously from the Master station.

2.4.2 Hot Standby Redundancy

G500 provides the following performance capabilities in Hot Standby Redundancy Mode.

Configuration	DNP	IEC61850
Hardware (CPU /RAM)	4 core / 16 GB	4 core / 16 GB
Redundancy	Hot Standby	Hot Standby
Number of IEDs	500 (250)	500 (250)
Protocol – CLIENT / SERVER	DNP / DNP	IEC61850 / DNP
RTDB Point count	200,000 (100,000)	200,000 (100,000)
Points / IED (AI + DI + AO + DO)	150 DI, 250 AI	150 DI, 250 AI
Number of Master connections Point count / Server	8 (4) DI – 9300, AI – 15500 (DI – 4650, AI – 7750)	8 (4) DI – 9300, AI – 15500 (DI – 4650, AI – 7750)

Total RCB configured / Simulation per sec	NA	6000 (3000) 1000 (500)
Datalogger / Continuous reports	NA	NA
ARRM	Not configured	Not configured
Alarms	100 (50) /sec	100 (50) /sec
Remote / Local HMI connections	1 Remote / 0 Local HMI	1 Remote / 0 Local HMI
CPU utilization – Avg, Min, Max (%) – values for 4 core CPU	60,34,71	32,46,67
Average Memory	3.12 GB	4.3 GB
Event latency – Average, Min, Max (msec)	390,60,1sec	368,2.8,1sec
Control latency – Average, Min, Max (msec)	30,12,377	3,1,73

2.4.3 Warm Standby Redundancy

G500 provides the following performance capabilities in Warm Standby Redundancy Mode.

Protocol	**DNP**	**IEC61850**	**IEC 104**
Hardware CPU / RAM	4 core / 16 GB (2 core / 8 GB)	4 core / 16 GB (2 core / 8 GB)	4 core / 16 GB (2 core / 8 GB)
Redundancy Mode	Warm Standby	Warm Standby	Warm Standby
Number of IEDs	500 (250)	500 (250)	500 (250)
Protocol – CLIENT / SERVER	DNP / DNP	IEC61850 / DNP	IEC 104 / IEC 104
RTDB Point count	200,000 (100,000)	200,000 (100,000)	200,000 (100,000)
Points / IED (AI + DI + AO + DO)	150 DI, 250 AI	150 DI, 250 AI	150 DI, 250 AI
Number of Master connections Point count / Server	8 (4) DI – 9300, AI – 15500 (DI – 4650, AI – 7750)	8 (4) DI – 9300, AI – 15500 (DI – 4650, AI – 7750)	8 (4) DI – 9300, AI – 15500 (DI – 4650, AI – 7750)
Total RCB configured / Simulation per sec	NA	6000 (3000) 1000 (500)	NA
Datalogger reports	100 (50) Periodic reports	100 (50) Periodic reports	100 (50) continuous reports
ARRM	Not configured	Not configured	Not configured
Alarms	100 (50) /sec	100 (50) /sec	100 (50) /sec
Remote / Local HMI connections	1 Remote / 0 Local HMI	1 Remote / 0 Local HMI	1 Remote / 0 Local HMI
CPU utilization – Avg, Min, Max (%) – values for 4 core CPU	62,53,96	43,48,60	28,32,42
Average Memory	2.4 GB	3 GB	3.4 GB
Event latency – Average, Min, Max (msec)	437,26,1.06	683,323,1sec	221,107,380

Control latency – Average, Min, Max (msec)	44,11,240	3,1,85	30,10,331

NOTE: G500 Supports maximum of 4 simultaneous Runtime HMIs (Remote + Local) either in Standby or Redundancy Modes (Hot/Warm Redundancy).

2.5 Time Sync Accuracy (PTP/IRIG-B/NTP)

G500 supports Hardware based PTP/IRIG-B and Software based NTP Time Sync Accuracy.

The current version does not support runtime dynamic failover across different time sources.

Time Sync Input	Accuracy
PTP IN	100% samples within +/-121 microseconds
IRIG-B IN	100% samples within +/-100 microseconds
NTP IN	99.97% samples within +/-10 ms
NTP OUT	99.9% samples within +/- 1ms

NOTES:

- PTP and IRIG-B time accuracy is measured in a scenario where the hardware /FPGA is fully loaded and applies to G500 only.
- If IEDs are getting time synced using any of the client communication protocols (e.g. DNP3), then the above accuracy cannot be guaranteed at the IED.

2.6 Application List

The following applications comprise the G500 v1.10 released firmware version and build 1.1.457.

Application	Support in Standalone/ Warm Standby	Support in Hot Standby
Runtime HMI	✓ Available	✓ Available
One Line Viewer	✓ Available	✓ Available
Config GUI / Schemas	✓ Available	✓ Available
System Library	✓ Available	✓ Available
C++ System Library	✓ Available	✓ Available
Connection Parser	✓ Available	✓ Available
Calculator	✓ Available	✓ Available
Hardware Asset Management Application (HAMA)	✓ Available	✖ Not available
PTP/IRIG-B Time Sync	✓ Available	✓ Available
Modbus Client	✓ Available	✓ Available
Modbus-TCP/SSH Client	✓ Available	✓ Available
SEL® Binary Client	✓ Available	✖ Not Available
Analog Data Logger	✓ Available	✖ Not Available
Generic ASCII Client	✓ Available	✖ Not Available
Modbus Server	✓ Available	✖ Not Available
DNP 3.0 Server	✓ Available	✓ Available

Application	Support in Standalone/ Warm Standby	Support in Hot Standby
DNP 3.0 Client	✓ Available	✓ Available
Digital Event Manager	✓ Available	✓ Available
Database Server	✓ Available	✓ Available
DNP 3.0 TCP/IP Transport Layer	✓ Available	✓ Available
DNP 3.0 Server Serial Transport Layer	✓ Available	✓ Available
DNP 3.0 DIDO	✓ Available	✖ Not Available
IEC 60870-5-101/104 Server	✓ Available	✖ Not Available
IEC 60870-5-103 Client	✓ Available	✖ Not Available
IEC 61850 Client	✓ Available	✓ Available
IEC 60870-5-101/104 Client	✓ Available	✖ Not Available
Event Logger	✓ Available	✓ Available
Real-Time Database	✓ Available	✓ Available
LogicLinx IEC 61131-3 Soft Logic	✓ Available	✓ Available
Redundancy Manager	✓ Available	✓ Available
System Point Manager	✓ Available	✓ Available
Load Shedding and Curtailment	✓ Available	✖ Not Available
Control Lockout Manager	✓ Available	✓ Available
Software Watchdog	✓ Available	✓ Available
Configuration Manager	✓ Available	✓ Available
IP Changer	✓ Available	✓ Available
MD5SUM Builder	✓ Available	✓ Available
System Status Manager	✓ Available	✓ Available
Virtual Serial Ports	✓ Available	✓ Available
SNMP Client	✓ Available	✖ Not Available
Automated Record Retrieval Manager	✓ Available	✖ Not Available
Software Licensing Subsystem	✓ Available	✓ Available
Third-party components	✓ Available	✓ Available
Terminal Services	✓ Available	✓ Available
mcpcfg utility	✓ Available	✓ Available
E-mail Utility	✓ Available	✓ Available
IO Traffic Monitor	✓ Available	✓ Available
Firewall	✓ Available	✓ Available
Edge OS & Drivers	✓ Available	✓ Available
Secure Enterprise Connectivity	✓ Available	✓ Available
Genconn	✓ Available	✓ Available
HMI Access Manager	✓ Available	✓ Available

Application	Support in Standalone/ Warm Standby	Support in Hot Standby
Sync Service Library	✓ Available	✓ Available
Sync Server Application	✓ Available	✓ Available
Analog Report Generator	✓ Available	✖ Not Available
OpenVPN	✓ Available	✓ Available

3. Version 2.00 (27-May-2020)

3.1 Software Versions

The following table defines the software versions required for interaction with the G500.

Package	Version	Notes
G500 Firmware	2.0.159	G500 Firmware Version.
DS Agile MCP Studio	2.1.0	Minimum Supported DS Agile MCP Studio Software.
G500 HMI Viewer	2.0.159	Supported G500 HMI 64-bit Software.

3.2 Predix Edge OS and Other Firmware Versions

The following table defines the package/firmware versions supported for Predix Edge Linux OS, FPGA, CPLD, UEFI and BCOM FPGA in the G500 v2.0.0.

Package/Firmware	Version	Notes
Predix Edge OS	2.2.1	Supported GE's Secured Linux Operating System Version.
FPGA	1.03.00	Supported FPGA Version of Multi-Function Controller Platform (MCP).
CPLD	1.2.2	Supported CPLD Version of Multi-Function Controller Platform (MCP).
UEFI	VX5D0007.C01	Supported UEFI Version of Multi-Function Controller Platform (MCP).
BCOM FPGA	2.3.0	Supported COM's Module FPGA Version of Multi-Function Controller Platform (MCP).

3.3 Key Functions and Changes

3.3.1 Enhancements

This G500 version adds the following new features compared to previous versions:

3.3.1.1 Cyber Security

GE Internal Reference #	Description
B-13463	Updated NERC CIP5 Response Bulletin for v2.0.
D-10339	Cyber Security Enhancements (SSL, SSH, Session cookies, Session negotiation, Firewall, Password Encryption, Cyphers, LDAP).
D-10398	TACACS+ shared secret is no longer visible in the Runtime HMI.
D-07660	The G500 SED is now shipped with a default SED password (set in UEFI).

3.3.1.2 Clients

GE Internal Reference #	Description
E-03038	Added D.20 client (single instance) support to connect to D.20 IO peripherals.

3.3.1.3 Servers

None

3.3.1.4 Automation

None

3.3.1.5 Configuration/Settings

GE Internal Reference #	Description
E-03397	Allow import of full D.20 DCA configuration (IO peripherals and communication) from B003 (D2x) to G500.
B-13469	Added support to restore snapshots when Remote Authentication mode is enabled. After restore operation is completed, the device is in Local Authentication Mode. All Remote Authentication configuration parameters are retained after snapshot restoration and the user would need to reselect the Authentication mode to Remote (LDAP/TACACS+) from the Runtime HMI.
B-13418	Snapshots and configuration archives which contain internally configured passwords for IED, ARRM, Synch Manager, LDAP, TACAS+ are now portable across different G500 units of same or newer version (in previous versions this was possible only on the exact same unit).
B-13498	Added Encrypted MCPCloneSnapshot type. These may also be used for Firmware Upgrade operations.
B-13500	In redundant units, the serial port settings are configured separately in unit A and B and are not synchronized across to accommodate different serial port allocation between units A and B (required mainly for RS485 loops).
D-10254	Allow Double Quotes ("") when configuring passwords for FTP in Sync Manager.
D-09947	Ability to Save Changes of LDAP Server Settings without activating it (unit remains in Local Authentication mode).
B-13075	Added support for selecting the colors used to indicate errors in configuration. See Systemwide > GUI > Conditional Formatting.

3.3.1.6 HMI

GE Internal Reference #	Description
E-03784	In redundant devices: improved user experience and robustness for Local HMI during failover.
D-10576	Added support to view the existing emergency access code and forcing to generate a new emergency access code if needed.
D-10554	D.20 Traffic is not available to be visualized in Runtime HMI (this is an enforced rule, not a defect).
D-10577	When "mcpemergency" utility on local HMI is used to generate the emergency access code, is now possible to copy the code and paste it to the login prompt. Previously this had to be entered manually (the code is long and prone to make mistakes).

3.3.1.7 Pass-through

None

3.3.1.8 System

GE Internal Reference #	Description
E-03629	Implemented Firmware Upgrade workflow using generic USB storage. External USB size must be between 8 – 32 GB in this release.
E-03371	Implemented a procedure to allow users to restore a G500 to Factory Default ("clean") configuration when all admin local logons have been lost (use USB storage method).

3.3.1.9 Documentation

GE Internal Reference #	Description
B-13504	Updated supported variants of Modbus Clients (Modbus RTU, Modbus TCP and Modbus TCP/SSH) and their support in warm and hot redundancy modes in the SWM0101 (Software Configuration Guide).
B-13513	Created Remote Authentication manuals for LDAP AD, Open LDAP, 389 DS.

3.3.1.10 Hardware

GE Internal Reference #	Description
E-03001	Added D.20 HDLC PCIe module as optional module, installable in PCIe slot 3. For additional details, please refer to "994-0152 G500 Substation Gateway Instruction Manual V200 R0".

3.3.2 Fixed defects

This version of G500 has the fixes for the following defects compared to V1.10:

3.3.2.1 Cyber Security

GE Internal Reference #	Description
D-10539	Passthrough and Terminal Server Ports were shown in the Firewall Rules despite not being enabled in Connections configuration. White List rules in the Firewall configuration are now created only for enabled Passthrough/Terminal Server connections.

3.3.2.2 Clients

GE Internal Reference #	Description
D-09916	SEL Binary Client was restarting abruptly when detected Double Precision Scaling Factors in a SEL relay (for e.g. SEL-351S). Now it logs a message into the diagnostic log and exits gracefully.
D-10226	An SNMP Disabled IED was enabled automatically after receiving a trap.

3.3.2.3 Server

GE Internal Reference #	Description
D-10392	AI and ACC parameters were not reported to DNP master based on the threshold settings in the DNP3 Server Mapfile.
D-07837	Modbus Server application failed to connect with message "killing modbusdpa application".

3.3.2.4 Automation

None

3.3.2.5 Configuration/Settings

GE Internal Reference #	Description
D-10318	FTP in sync manager could not be configured from the Settings GUI.
D-10488	LDAP Remote Authentication configured settings (but not yet activated because "Enable" checkbox was not selected in the Settings tab) were not saved/persisted across reboots of G500.

3.3.2.6 HMI

GE Internal Reference #	Description
D-10378	HMI was occasionally displaying “Unsupported Value of Security Type”.
D-10574	Local HMI could not login sometimes using Emergency Access code during start up of G500.
D-09944	Internationalization: Settings and messages in the Powerbar in Runtime HMI were not changing to specified language.
D-10324	Fixed the message “The configuration has been modified. Unsaved changes will be discarded. Do you want to discard the changes?" that was displayed even though any changes made are already committed. This applies to the Access tab in the local HMI viewer.
D-10325	After saving the changes in the Access tab of the local HMI viewer and navigating to other tab without committing the changes, then Local HMI viewer was not accessible.

3.3.2.7 Pass-through

None

3.3.2.8 System

GE Internal Reference #	Description
D-10081	Accumulator values were not synchronized between Active and Standby in Warm Standby Redundancy.
D-10373	Local HMI login prompt and Emergency access terminal were not available if LDAP server was not available during reboot.
D-10462	Pairing of redundancy failed after factory default settings was performed.
D-10479	The prompt "=> " was not returned during Secure Passthrough (SSH, Telnet, SSL/TLS) with SEL BIN.
D-10504	Multiple SSH sessions were not accessible in an LDAP enabled device.
D-10562	Datalogger Periodic Reports trending stopped/paused during long runs.

D-10563	SBO Controls were sometimes not accepted by RTDB if Control In Progress DTA was configured for the same DO Points or if control rate was >3 seconds in continuous/performance test scenarios.
D-10600	Active G500 was taking an additional ~1minute time to start when Standby G500 was powered off during startup.

3.3.2.9 Documentation

GE Internal Reference #	Description
D-09783	Only one-time source can be enabled at a time (PTP / IRIG-B); captured this in Software Configuration Guide.
D-10131	Added the format and details about Remote Syslogs of G500 in G500 Software Configuration Guide (SWM0101).

3.3.2.10 Hardware

None

3.3.3 Known Issues

This G500 version has the following known issues:

3.3.3.1 Cyber Security

GE Internal Reference #	Description
B-13652	Patches can be manually installed into the G500 from shell admin session without being signed. Workaround: Any patches issued by GE shall have to be validated using external means.
D-08565	If ICMP Echo setting is enabled in G500 and when Ping command from PC is issued to the G500, G500 responds to the ping request only when G500 is booting. However, this issue comes only in a remote case and other TCP/SCADA connections are not impacted.

3.3.3.2 Clients

GE Internal Reference #	Description
E-04038	D.20 Client is supported only in non redundant systems in this release.
B-13475	SEL Binary Client doesn't support Double Precision Scaling Factors.
D-09915	SEL IEDs with this configuration type are not supported (e.g. SEL-351S).
D-05002	ARRM file retrieval from SEL 1xx/2xx relays (using GENASCII) is not possible.

3.3.3.3 Servers

GE Internal Reference #	Description
B-11967	No support for events in NVRAM in IEC101/104 Server. Events that have not been yet transmitted to Master (Clients) are lost if G500 is power cycled / restarted. However – the integrity polls will continue to provide accurate database representation.

B-11968	No support for events in NVRAM in DNP3 Server. Events that have not been yet transmitted to Master (Clients) are lost if G500 is power cycled / restarted. However – the integrity polls will continue to provide accurate database representation.

3.3.3.4 Automation

GE Internal Reference #	Description
D-05033	Suppressed quality through Input Point Suppression (IPS) application is not reported to Masters. DNP3 and IEC 101-104 Servers send Online Quality rather than the substituted/last reported quality when points are suppressed.
D-05462	Load shedding: There is no persistency of zone assignments across power restarts when user sets the zones through Analog Setpoint commands.
B-11969	DEM is responsible for handling alarms. Events/Alarms that have not been yet committed to the SQL database are lost if G500 is power cycled / restarted. However – the integrity polls will continue to provide accurate database representation.

3.3.3.5 Configuration/Settings

GE Internal Reference #	Description
D-10343	Sync Manager Settings are not retained during upgrade from V1.0 to V1.1. User needs to re-enter these manually. Will not fix.
D-10345	mcpcfg settings must be reconfigured after upgrading G500 from 1.0 to 1.1. Will not fix.
D-10502	NOT A DEFECT. If client applications are configured in non redundant mode and later the device properties are switched to a redundant mode where some applications are not enabled - their respective points are still available to be mapped, but at runtime will be offline. This is to retain the mappings in case the user decides to switch later back to single mode and the client applications are active again, as previously configured.
D-10388	TACACS+ remote authentication can be enabled and activated even if the TACACS+ Server is not available in that moment. This will conduct to a device that can only be accessed using Emergency Access process, as long as TACACS+ server is not available.
D-06168	FPGA needs to be restarted for PTP/IRIGB configuration change. No functional impact. PTP/IRIG-B configuration will not be applied without reboot of G500.
D-10825	Online Editor / SNMP Agent Browser is not able to retrieve OID data if gathering data from target device takes more than 60 seconds. Workaround: configure the SNMP client offline, using OID from the end device (e.g. using a 3rd party MIB browser).

3.3.3.6 HMI

GE Internal Reference #	Description
D-10229	Gateway -A /-B designation is missing from local HMI banner sometimes
D-09695	Operator User in Active G500 gets Observer Group privileges sometimes after multiple switch-over or fail-overs in Hot or Warm Standby Redundancy. Runtime HMI needs to be logged out and logged in if this case happens.

D-05463	If a used point group is deleted from the systemwide configuration then points belonging to that group are not visible in the point group summary. However, if user changes the point group allocation from the corresponding instantiated client map file(s) then points will be visible in the point group summary.

3.3.3.7 Pass-through

None

3.3.3.8 System

GE Internal Reference #	Description
E-04130	The USB FLASH drive used for the Firmware Upgrade must be FAT32 format. As a result of this, only USB FLASH drives of maximum 32 GB can be used. The minimum size, imposed by storage requirements, is 8 GB.
E-03041 D-10346	Input time source selection (PTP / IRIG-B / NTP) does not support dynamic failover between time sources at runtime. Only the configured time source is active at a time.
D-10781	In redundant G500, if both units are (re)started at same time, the indications code and config out of sync are incorrect. Workaround: start one G500 at a time (wait for the first one to start) or restart one of the units while the other one runs.
D-10763	Communications stops on D.20 link in rare cases and doesn't recover. Current workaround: when stop condition is detected, the system will be automatically rebooted. If the system reboots to recover from this condition, the following message will be logged to the system event log: MsgID=70; INFO; Description=Last Reset Cause; Misc=Last reset caused by WDT_CARRIER.D20
D-10227	Email does not send messages when an alarm is activated.
D-08036	During start of G500, some not applicable error messages are displayed on the console connected to the display port. No Functional Impact.
D-05714	Update of only Edge OS is not supported. If only Edge OS updates are required, the complete G500 firmware image needs to be updated.
D-06167	Full support for latest PTP power profiles: IEEE C37.238-2017 IEC61850-9-3 Ed.1 2016 Enhancement: G500 supports the following PTP profiles: IEEE 1588-2008 J4 Peer-to-Peer Profile IEEE C37.238-2011 Power System Profile (but this has been withdrawn) Limited IEC61850-9-3 Ed.1 2016 Power Utility Automation Profile

3.3.3.9 Documentation

None

3.3.3.10 Hardware

GE Internal Reference #	Description
D-06165	No functional impact. SFP Hot Plug in / Plug out detection. Points that represent the status of SFP IN/OUT will not be reflected until G500 is rebooted.

3.4 Capability and Capacity

This G500 version supports the following application limits.

Application	Feature	Configuration Limits
Digital Event Manager	**Alarms**	
	Max Number of Alarm Groups	256
	Max number of members in an Alarm Group	1000
Calculator	**Expression Type:**	
	Evaluations	10000
	Timers	1000
	Analog Assignments	2000
	Digital Assignments	10000
	Quality Conversions	1000
	Type Conversions	1000
	Averages	1000
	Output to Input Conversions	1000
Load Shed DTA	**Number of Feeders and Zones**	
	Max Zones	50
	Max Feeders	100
Analog Reports DTA	Max Analog Reports	100
System Point Manager	Accumulator Freeze	100
	Analog Value Selection	100
	Control Lockout	
	• Remote Groups	8
	• Local Groups	1000
	Double Points	1000
	Input Point Suppression	10000
	Control in Progress	256
	Redundant I/O	10000
Analog Data Logger	Continuous Reports	1000
	Periodic Reports	1000
	Out of Range Reports	1000
VPN Server	Number of VPN Clients	8

SCADA – No. of Client or Server connections (Serial/Network/D.20)		
	Serial IEDs	
	DNP Multidrop	80
	DNP Multidrop (Modem)	80
	Generic ASCII	80
	SEL Binary IED	80
	IEC 60870-5-101 Multidrop	80
	IEC60870-5-103 Multidrop	80
	Modbus Multidrop	80
	D.20	1
	Network IEDs	
	DNP3 TCP	500
	Modbus TCP/Modbus TCP-SSH	500
	IEC60870-5 104	500
	IEC61850	500
	SNMP	1
	VPN Server	1
	Serial Masters	
	DNP3 Serial Master	8
	IEC 60870-5-101 Master	8
	Modbus Serial Master	8
	Network Masters	
	DNP3 Network Master	8
	IEC 60870-5-104 Master	8
	Modbus TCP Master	8
SCADA - No. of IEDs or Master station LRUs in each connection		
	Serial /Network IEDs	
	IEC60870-5-103 Multidrop	255
	DNP3 Multidrop/Network	10
	Modbus Multidrop/TCP	20
	IEC60870-5 101 Multidrop	1000
	IEC60870-5 104	10
	SNMP Client	100
	GenASCII Client	120
	IEC61850 Client	60

	SEL Binary Client	1
	D.20 Client	120
	Serial /Network Masters	
	DNP3 Serial Master	32
	Modbus Serial Master	32
	IEC60870-1 101 Master	32
	DNP3 TCP Master	1
	Modbus TCP Master	1
	IEC60870-1 104 Master	1
SCADA - No. of points configured in each IED/Peripheral mapfile		
	DNP3 Multi-Drop/Network IEDs	1000
	Modbus Multi-Drop/Network IEDs	1000
	GenASCII IED	1000
	SNMP IED	1000
	IEC60870-1 103 Multi-Drop	1000
	IEC60870-1 101/104 Multi-Drop	
	• Bitstream	32
	• Double Command	1000
	• Integrate Total	1000
	• Measurand	1000
	• Packed Single Point	16
	• Regulating Step Command	1000
	• Set Point Command	1000
	• Single Point	1000
	• Step Position	1000
	SEL Binary IED	
	• Fast Meter Analog Input	32
	• Demand Analog Input	32
	• Peak Demand Analog Input	32
	• SER Digital Input	1000
	D.20 Peripheral Client	
	D.20 S Card	64 Digital Inputs, or 32 Double Point Inputs, or 64 Transition Counters, or 32 Form C Counters
	D.20 A Card	32 Analog Inputs
	D.20 K Card	32 Digital Outputs

	D.20 C Card	C0	16 Digital Inputs 8 Digital Outputs
		C1	16 Digital Inputs 8 Digital Outputs 16 Analog Inputs
		C2	16 Digital Inputs 8 Digital Outputs 8 Analog Inputs 8 Analog Outputs
SCADA - No. of points mapped into server mapfile			
	DNP3 Serial/TCP Master		DI -10000 AI -15000 DO -5000 ACC – 3000
	Modbus Serial/TCP Master		DI -10000 AI -15000 DO -5000 ACC -3000
	IEC60870-1 101/104 Master		DI -10000 AI -15000 DO -5000 ACC - 3000

This G500 version meets the following performance test levels (same as G500 v1.10).

NOTES:

- G500 Hardware under test: 4 core CPU/ 16GB RAM variant.
- In the following table(s), numbers inside the brackets are for the G500 variant with 2 core CPU/8GB RAM.

Requirement	Steady State Loading	Avalanche Loading
Loading Signal changes (continuously / sec)	AI - 10,000 (5,000) DI – 100	All points changing twice in 2 secs
Number of connected IEDs to G500	500 (250)	500 (250)
G500 total RTDB Point count	200,000 (100,000)	200,000 (100,000)
Points / IED DI & AI	400 150x DI and 250x AI per IED	400 150x DI and 250x AI per IED
Each G500 Server has points (half for 2 core CPU/8GB RAM)	DI = 18750 i.e.=150*500/4 AI = 31250 i.e.=250*500/4	DI = 18750 i.e.=150*500/4 AI = 31250 i.e.=250*500/4
Remote G500 HMI connections	3 Simultaneous connections	3 Simultaneous connections

Local G500 HMI connections	1 connection (multiple displays)	1 connection (multiple displays)
Datalogger / Continuous reports	1000 (500) AI mapped / 100 (50) reports	1000 (500) AI mapped / 100 (50) reports
ARRM	5 sessions / IED	5 sessions / IED
Alarms	100 (50) / sec	100 / sec (for 2 seconds)

3.4.1 Stand Alone

This G500 version provides the following performance capabilities in Single (non-redundant) Mode.

3.4.1.1 Performance Test Levels

The performance of G500 is tested using the activity levels and disturbance scenarios presented next.

The master station response times are defined in Table 3.1: Standalone Performance test results.

Table 3.1: Standalone Performance test results

Activity	DNP	DNP	IEC 61850	IEC 61850
Hardware (CPU / RAM)	4 core / 16 GB	2 core / 8 GB	4 core / 16 GB	2 core / 8 GB
Loading Condition	Steady state	Steady state	Steady state	Steady state
Protocol – CLIENT / SERVER	DNP / DNP	DNP / DNP	IEC 61850 / DNP	IEC 61850 / DNP
RTDB Point count	200,000	100,000	200,000	100,000
Total RCB configured / Simulation per sec	NA	NA	6000 1000	3000 500
Number of IEDs	500 (250)	500 (250)	500 (250)	500 (250)
Points / IED (AI + DI + AO + DO)	[AI-250, 150-DI, 20-DO, 20-AO, 10-ACC]	150DI+250AI (Configured AO, DO no simulation)	150DI+250AI (Configured AO, DO no simulation)	150DI+250AI (Configured AO, DO no simulation)
Datalogger reports	100 (50) Periodic reports	100 (50) Periodic reports	100 (50) Periodic reports	100 (50) Periodic reports
Number of Master connections Point count / Server	8 DI – 9300, AI – 15500	4 DI – 4650, AI - 7750	8 DI – 9300, AI - 15500	4 DI – 4650, AI - 7750
Remote / Local HMI connections	1 Remote / 0 Local HMI	1 Remote / 0 Local HMI	1 Remote / 1 Local HMI	1 Remote / 0 Local HMI
CPU utilization – Avg, Min, Max (%) – values for 4 core CPU	60,46,97	80, 28, 95	56, 30, 95	46, 36, 75
Average Memory	2.9 GB	1.4 GB	3 GB	2 GB
Event latency in (msecs) Average, Min, Max	398,19,1.04sec	487,13,1.31	589, 5, 2200	330, 41, 652
Control latency in (msecs) Average, Min, Max	30,12,291	629,3,1.09	8, 6, 16	9, 3, 68

3.4.1.2 HMI Response time

Under heavy loading conditions, the G500 provides the HMI response times listed in Table 3.2: User Interface Response Time.

Table 3.2: User Interface Response Time

Activity	Normal	High
Screen Access (Point Summary)	< 2 s	< 2 s
Screen Access (One Line Viewer)	5 to 7 s	5 to 7 s
System Logs	< 2s	2s
Alarm ACK Delay (Single Alarm)	< 1 s	< 1 s
Alarm ACK Delay (20,000 Alarms)	< 2 s	< 7 s
DI/AI Update to Point Summary Screen	< 1 s	< 1 s

NOTE: Under heavy loading conditions, the control latency was measured by simulating one control in every 5 seconds continuously from the Master station.

3.4.1.3 D.20 HDLC Performance Test levels

The performance of G500 with D.20 HDLC card is tested with different scenarios listed in Table 3.3.

Table 3.3: D.20 HDLC Performance test results

Activity	Multi-Protocol	Multi-Protocol
Hardware (CPU / RAM)	2 core / 8 GB	4 core / 16 GB
Loading Condition	Steady state	Steady state
Protocol – CLIENT / SERVER	DNP, IEC 103, IEC 104, Modbus, IEC 61850 / DNP, Modbus, IEC 104	DNP / DNP
RTDB Point count	8244	200,000
Total RCB configured / Simulation per sec	NA	NA
Number of IEDs	101x D.20 peripherals + 42 other protocol IEDs	101x D.20 peripherals + 400 DNP IEDs
Points / IED (AI + DI + AO + DO)	Total = AI (1935) + DI (5056) + AO (154) + DO (993) + ACC (106)	[AI-250, 150-DI, 20-DO, 20-AO, 10-ACC]
Datalogger reports	NA	100
Number of Master connections Point count / Server	7	8 DI – 9300, AI – 15500
Remote / Local HMI connections	1 Remote / 0 Local HMI	1 Remote / 0 Local HMI
CPU utilization – Avg (%)	35.8	58.20
Average Memory	2.4 GB	2.52 GB
Event latency in (msecs)	696, 51, 1.97 sec	-

Average, Min, Max		
Control latency in (msecs) Average, Min, Max	72, 49, 254	-

3.4.2 Hot Standby Redundancy

This G500 version provides the following performance capabilities in Hot Standby Redundancy Mode.

Configuration	DNP	IEC61850
Hardware (CPU /RAM)	4 core / 16 GB (2 core / 8 GB)	4 core / 16 GB (2 core / 8 GB)
Redundancy	Hot Standby	Hot Standby
Number of IEDs	500 (250)	500 (250)
Protocol – CLIENT / SERVER	DNP / DNP	IEC61850 / DNP
RTDB Point count	200,000 (100,000)	200,000 (100,000)
Points / IED (AI + DI + AO + DO)	150 DI, 250 AI	150 DI, 250 AI
Number of Master connections Point count / Server	8 (4) DI – 9300, AI – 15500 (DI – 4650, AI – 7750)	8 (4) DI – 9300, AI – 15500 (DI – 4650, AI – 7750)
Total RCB configured / Simulation per sec	NA	6000 (3000) 1000 (500)
Datalogger / Continuous reports	NA	NA
ARRM	Not configured	Not configured
Alarms	100 (50) /sec	100 (50) /sec
Remote / Local HMI connections	1 Remote / 0 Local HMI	1 Remote / 0 Local HMI
CPU utilization – Avg, Min, Max (%) – values for 4 core CPU	60,34,71	32,46,67
Average Memory	3.12 GB	4.3 GB
Event latency – Average, Min, Max (msec)	390,60,1sec	368,2.8,1sec
Control latency – Average, Min, Max (msec)	30,12,377	3,1,73

3.4.3 Warm Standby Redundancy

This G500 version provides the following performance capabilities in Warm Standby Redundancy Mode.

Protocol	DNP	IEC61850	IEC 104
Hardware CPU / RAM	4 core / 16 GB (2 core / 8 GB)	4 core / 16 GB (2 core / 8 GB)	4 core / 16 GB (2 core / 8 GB)
Redundancy Mode	Warm Standby	Warm Standby	Warm Standby
Number of IEDs	500 (250)	500 (250)	500 (250)
Protocol – CLIENT / SERVER	DNP / DNP	IEC61850 / DNP	IEC 104 / IEC 104

RTDB Point count	200,000 (100,000)	200,000 (100,000)	200,000 (100,000)
Points / IED (AI + DI + AO + DO)	150 DI, 250 AI	150 DI, 250 AI	150 DI, 250 AI
Number of Master connections Point count / Server	8 (4) DI – 9300, AI – 15500 (DI – 4650, AI – 7750)	8 (4) DI – 9300, AI – 15500 (DI – 4650, AI – 7750)	8 (4) DI – 9300, AI – 15500 (DI – 4650, AI – 7750)
Total RCB configured / Simulation per sec	NA	6000 (3000) 1000 (500)	NA
Datalogger reports	100 (50) Periodic reports	100 (50) Periodic reports	100 (50) continuous reports
ARRM	Not configured	Not configured	Not configured
Alarms	100 (50) /sec	100 (50) /sec	100 (50) /sec
Remote / Local HMI connections	1 Remote / 0 Local HMI	1 Remote / 0 Local HMI	1 Remote / 0 Local HMI
CPU utilization – Avg, Min, Max (%) – values for 4 core CPU	62,53,96	43,48,60	28,32,42
Average Memory	2.4 GB	3 GB	3.4 GB
Event latency – Average, Min, Max (msec)	437,26,1.06	683,323,1sec	221,107,380
Control latency – Average, Min, Max (msec)	44,11,240	3,1,85	30,10,331

NOTE: G500 Supports maximum of 4 simultaneous Runtime HMIs (Remote + Local) either in Standby or Redundancy Modes (Hot/Warm Redundancy).

3.5 Time Sync Accuracy (PTP/IRIG-B/NTP)

This G500 version supports Hardware based PTP/IRIG-B and Software based NTP Time Sync Accuracy.

This version does not support runtime dynamic failover across different time sources.

Time Sync Input	Accuracy
PTP IN	100% samples within +/-121 microseconds
IRIG-B IN	100% samples within +/-100 microseconds
NTP IN	99.97% samples within +/-10 ms
NTP OUT	99.9% samples within +/- 1ms

NOTES:

- PTP and IRIG-B time accuracy is measured in a scenario where the hardware /FPGA is fully loaded and applies to G500 only.
- If IEDs are getting time synced using any of the client communication protocols (e.g. DNP3), then the above accuracy cannot be guaranteed at the IED.

3.6 Application List

This G500 version has the following applications available depending on configured redundancy mode.

Application	Support in Standalone	Support in Warm Standby	Support in Hot Standby
Runtime HMI	✓ Available	✓ Available	✓ Available
One Line Viewer	✓ Available	✓ Available	✓ Available
Config GUI / Schemas	✓ Available	✓ Available	✓ Available
System Library	✓ Available	✓ Available	✓ Available
C++ System Library	✓ Available	✓ Available	✓ Available
Connection Parser	✓ Available	✓ Available	✓ Available
Calculator	✓ Available	✓ Available	✓ Available
Hardware Asset Management Application (HAMA)	✓ Available	✓ Available	✖ Not available
PTP/IRIG-B Time Sync	✓ Available	✓ Available	✓ Available
D.20 Client	✓ Available	✖ Not available	✖ Not available
Modbus RTU/Multi-drop Client	✓ Available	✓ Available	✓ Available
Modbus - TCP Client	✓ Available	✓ Available	✓ Available
Modbus - TCP/SSH Client	✓ Available	✓ Available	✓ Available
SEL® Binary Client	✓ Available	✓ Available	✖ Not Available
Analog Data Logger	✓ Available	✓ Available	✖ Not Available
Generic ASCII Client	✓ Available	✓ Available	✖ Not Available
Modbus Server	✓ Available	✓ Available	✖ Not Available
DNP 3.0 Server	✓ Available	✓ Available	✓ Available
DNP 3.0 Client	✓ Available	✓ Available	✓ Available
Digital Event Manager	✓ Available	✓ Available	✓ Available
Database Server	✓ Available	✓ Available	✓ Available
DNP 3.0 TCP/IP Transport Layer	✓ Available	✓ Available	✓ Available
DNP 3.0 Server Serial Transport Layer	✓ Available	✓ Available	✓ Available
DNP 3.0 DIDO	✓ Available	✓ Available	✖ Not Available
IEC 60870-5-101/104 Server	✓ Available	✓ Available	✖ Not Available
IEC 60870-5-103 Client	✓ Available	✓ Available	✖ Not Available
IEC 61850 Client	✓ Available	✓ Available	✓ Available
IEC 60870-5-101/104 Client	✓ Available	✓ Available	✖ Not Available
Event Logger	✓ Available	✓ Available	✓ Available
Real-Time Database	✓ Available	✓ Available	✓ Available
LogicLinx IEC 61131-3 Soft Logic	✓ Available	✓ Available	✓ Available
Redundancy Manager	✓ Available	✓ Available	✓ Available
System Point Manager	✓ Available	✓ Available	✓ Available
Load Shedding and Curtailment	✓ Available	✓ Available	✖ Not Available
Control Lockout Manager	✓ Available	✓ Available	✓ Available

Application	Support in Standalone	Support in Warm Standby	Support in Hot Standby
Software Watchdog	✓ Available	✓ Available	✓ Available
Configuration Manager	✓ Available	✓ Available	✓ Available
IP Changer	✓ Available	✓ Available	✓ Available
MD5SUM Builder	✓ Available	✓ Available	✓ Available
System Status Manager	✓ Available	✓ Available	✓ Available
Virtual Serial Ports	✓ Available	✓ Available	✓ Available
SNMP Client	✓ Available	✓ Available	✗ Not Available
Automated Record Retrieval Manager	✓ Available	✓ Available	✗ Not Available
Software Licensing Subsystem	✓ Available	✓ Available	✓ Available
Third-party components	✓ Available	✓ Available	✓ Available
Terminal Services	✓ Available	✓ Available	✓ Available
mcpcfg utility	✓ Available	✓ Available	✓ Available
E-mail Utility	✓ Available	✓ Available	✓ Available
IO Traffic Monitor	✓ Available	✓ Available	✓ Available
Firewall	✓ Available	✓ Available	✓ Available
Edge OS & Drivers	✓ Available	✓ Available	✓ Available
Secure Enterprise Connectivity	✓ Available	✓ Available	✓ Available
Genconn	✓ Available	✓ Available	✓ Available
HMI Access Manager	✓ Available	✓ Available	✓ Available
Sync Service Library	✓ Available	✓ Available	✓ Available
Sync Server Application	✓ Available	✓ Available	✓ Available
Analog Report Generator	✓ Available	✓ Available	✗ Not Available
OpenVPN	✓ Available	✓ Available	✓ Available

<end of this section>

MODIFICATION RECORD

VERSION	REV.	DATE	AUTHOR	CHANGE DESCRIPTION
1.00	0	27th February, 2019	P. Smitha	Created for G500 Firmware Version 1.00.
	1	31st May, 2019	Gayatri Prasad. K	Updated for Defect D-06458: Audio Output Port is not working.
1.10	0	06th March, 2020	Bogdan Popescu Gayatri Prasad. K	Updated for G500 Firmware Version 1.10.
2.00	0	27th May, 2020	Bogdan Popescu Gayatri Prasad. K	Updated for G500 Firmware Version 2.00. Updated and removed feature requests from known issues and document sub-sections throughout for consistency.