GE
Grid Solutions

Multilin DMC490

Microgrid Controller & Generation Optimizer

GE's Multilin™ DMC490 is a powerful multi-function server and automation controller that has been specifically designed for the optimization and control of grid-connected and off-grid, or islanded, microgrids. Based on GE's proven substation automation hardware and Microgrid algorithms, the DMC490 optimizes the cost of operation and energy in the presence of a mix of renewable and non-renewable generator sources.

The Microgrid Control System supports applications such as interlocking, on-demand triggers, and automatic feeder transfers can be realized through an embedded IEC 61131-3 compliant user-based configurations. Users can configure the DMC490 to also support On-Demand Load Shedding applications through simple point maps and SCADA protocols. GE's Multilin C90Plus and the DMC490 work together to provide fast, dynamic loadshed capabilities.

The DMC490 uses a local or remote embedded HMI to enable Operators to visually identify the state of a microgrid control system while presenting information to SCADA/EMS or DMS systems through a fast and secure communication network.

Key Benefits

- Enables integration of renewable energy resources such as wind turbines or solar PV with conventional fossil based generators
- Optimizes the dispatch of distributed energy system resources to reduce the total cost of energy and cost of operating a microgrid system
- Maintains a secure and reliable supply of power for mission critical loads through coordination with GE's advanced automation controllers and protection devices to operate in 'islanded' mode
- Maximizes the use of renewable assets for reduced GHG emissions and environmental impact

Application Specific Solutions

- Off-the-grid remote communities: Opportunities to optimize operation of diesel-gas generators and integration with renewable energy resources
- Military bases: Ensures 'always-on' supply of power through coordination with GE's fast loadshed automation devices during unplanned interruptions of power from the main grid
- Mining communities: Opportunities to best utilize the available energy resources and help reduce diesel-gas consumption for community energy needs

Generation Optimization

- Provides substantial reduction in fuel costs by intelligent management of generating assets
- Maximizes the use of renewable generation by leveraging the available energy storage system

Holistic Energy System

- Integrates electrical and thermal energy assets such as CHP and boilers
- Maximizes overall system optimization and minimizes the total energy costs

Improved Return on Investment

- Enables integration of existing power system assets to the new infrastructure for an improved asset utilization
- Further reduces distribution system losses through the integration of Volt/VAR controls

Reliable Power

- Maintains uninterruptible power supply for mission critical infrastructure with ability to operate in 'islanded' mode
- Manages turn on/off operation of low priority controllable loads in case of generation deficit situation within the "islanded" microgrids

Microgrid Visualization

- Empowers local microgrid system operators to make informed decisions by providing system visualization
- Provides a SCADA man-machine interface to manage energy, loads, and operational modes in the Microgrid System

imagination at work

What is a Microgrid

A microgrid system is typically capable of operating in "islanded" (off-the grid) or grid-connected mode. Based on the grid connection "status" of a microgrid, it can be categorized as:

Permanently Islanded Microgrid

Permanently Islanded microgrid networks are stand alone networks that must produce all of the generation locally that will be consumed by the loads in the network. Islanded microgrid networks are quite often found in remote, northern or island communities where the high cost of importing fuel and the availability of renewable resources (wind, hydro) can make optimization of generation resources very desirable.

Grid-Tied Microgrid

Grid-tied microgrid networks are able to produce power within its distribution networks as well as import power from a utility source. University campuses and military facilities that have on-site generation for backup power can utilize their on-site generation to offset the costs of electricity when it is cheaper to produce electricity than to buy it.

The Multilin DMC490 with its Generation Optimizer is at the heart of the microgrid control system, surrounded by intelligent controllers, communications and other power system devices.

Microgrid Control System Components

The Microgrid Control System is based on a supervisory control architecture provided by the Multilin DMC490 Microgrid Controller and Generation Optimizer as well as the Multilin C90Plus Fast Loadshed Controller.

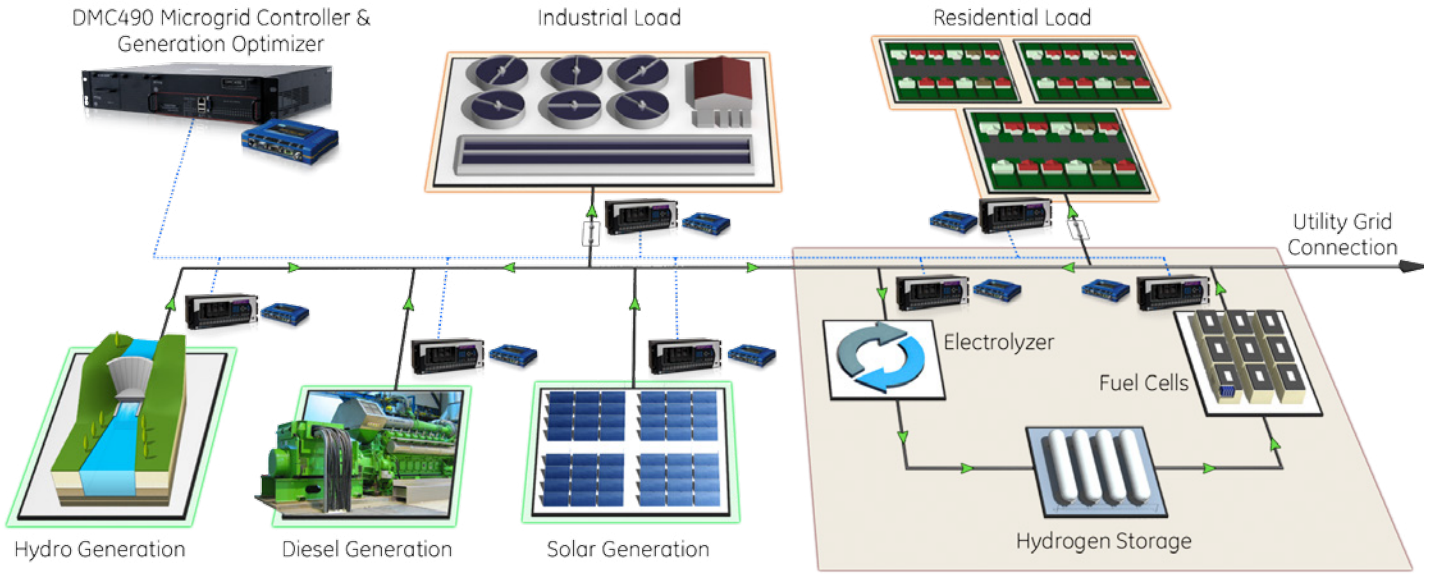
The core function of the DMC490 Generation Optimizer is its ability to monitor, track, and forecast load and generation resources within the microgrid. In order to facilitate this, the DMC490 is required to communicate with intelligent controllers distributed at key points across the microgrid.

DMC490 Generation Optimizer

The DMC490 Generation Optimizer is the central engine of an advanced microgrid control solution that provides management of DERs for the most economical power. A detailed functionality description of the DMC490 controller is provided in following sections.

Typical Microgrid Control System Architecture and Optimization Sequence

The DMC490 is the central supervisory controller of a microgrid control system that maximizes the use of the renewable DERs and provides set points for various energy resources to provide power for the load demand in the most economical method possible.



Communications Network

The DMC490 is able to measure load requirements and generation capacity at various locations across the microgrid network. As these load and generation centers are spread out geographically, a reliable and robust communications network should be deployed, such as GE's advanced wired and wireless communications solutions to ensure the DMC490 is able to monitor and control various assets within the network. Where economical to do so, an Ethernet network can be deployed at each critical measurement point. When the microgrid spans long distances or laying fiber optic cables is uneconomical, a secure, industrial wireless network can be deployed. The DMC490 minimizes the amount of information needed to be transmitted over the communications network by optimizing the data requirements at each load or generation location.

Intelligent Local Controllers

Each generating source and energy storage unit is monitored, and receives commands from the DMC490 by an intelligent controller located locally at DER locations. These controllers perform the real time measurements of the load or generating units and communicate back to the DMC490. These controllers also receive the commands from the DMC490 to initiate the turning on or off of the dispatchable generators and charging / discharging commands for storage devices.

These intelligent controllers are required to support built-in open communication protocols such as DNP3, Modbus, IEC 60870-5-101/103/104, SNMP, PRP, Generic ASCII protocols, and IEC 61850 protocols and have the appropriate control capability to interact with the generator or storage unit control systems.

Integration and Configuration Services

The MCS offering includes microgrid system feasibility studies, engineering, system design and modeling, DMC490 Generation Optimizer configuration, first level system integration services, system commissioning support and training. GE has a team of subject matter experts to help develop and build a microgrid project.

Microgrid Control System Features

GE's microgrid control solution provides a multitude of functionalities for permanently islanded (off-the-grid) and grid-connected microgrid systems.

Lowers Cost of Producing power

Through its ability to monitor and trend key load, the DMC490 is able to predict the load requirements within a microgrid for future periods through a smart dispatch mechanism. The smart dispatch send commands to dispatchable generators to meet these load requirements in the most economical method possible.

Maximizes Use of Green Power

When renewable generation (hydro, wind, solar) and methods of storing power (hydrogen, battery, pumped storage) are available, the DMC490 is able to maximize the use of DERs by enabling energy storage when it determines there is excess renewable power available or it is economically viable to do so. At a later time when there is not enough renewable generation to support the load, the DMC490 can dispatch this low cost stored energy to meet the load requirements in the most efficient manner possible.

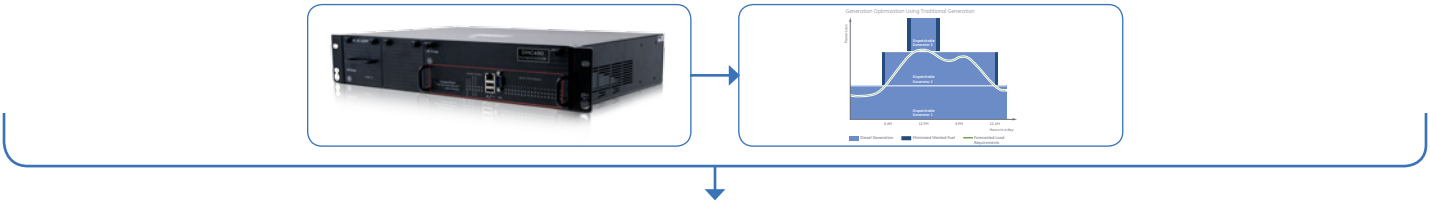
Load Forecasting

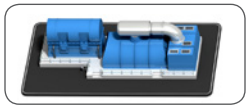
The capability of the DMC490 to forecast the future load requirements is key to providing the optimum generation to support the load. All loads are continuously tracked and used by the DMC490 to create a forecast for the load profile of the microgrid for the next 24 hours.

If the actual measured load usage differs from what the DMC490 forecasts for reasons such as a drop in temperature resulting in less load requirements, the DMC490 will continually adjust its forecast to make the best predictions for load requirements.

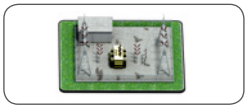
Typical Distributed Energy Resources (DERs) for Microgrid Systems

The DMC490 can integrate many different types of Distributed Energy Resources into its generation optimization control algorithms.

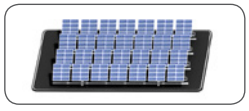




Dispatchable Distributed Energy Resources
- Diesel-gas Generators
- Fuel Cell Systems
- Batteries
- Combined Heat & Power (CHP)

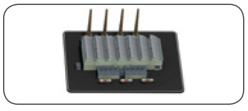


Isochronous Generation
- Diesel-gas Generators
- Fuel Cells
- Hydro Generators
- Utility Source



Renewable Generation
- Hydro Generators
- Wind Generators
- Solar Generators
- Bio-gas Based Generation
- Hydrogen Fuel Cell

Energy Storage
- Hydrogen Fuel Cells with Electrolyzer
- Batteries – Various Battery Technologies



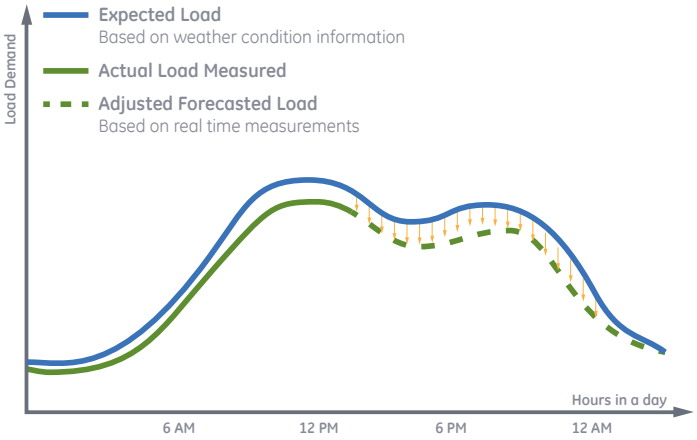
Loads
- Industrial
- Commercial
- Loadshed Control

If the local utility or campus has the ability to perform advanced load requirement forecasts that could be used instead of or to compliment the forecasts made by the DMC490, these forecasts can be uploaded into the DMC490 for use in its optimization calculations. Note that if the DMC490 measures that this external forecast is not matching the actual load profile, it will adjust the uploaded forecast to more accurately match what is being used in the microgrid.

Generation Forecasting

The distributed generators that are connected to the microgrid are currently monitored by the DMC490 and their output is constantly tracked. A forecast for the expected output of generation from renewable sources over the next prediction horizon (e.g. 24 hours) is then created to predict the contribution to the overall generation that will be supplied by these renewable sources.

Similar to the load forecast predictions, if the actual measured generation from available sources differs from what the DMC490 forecasts for reasons such as a drop in wind or an increase in clouds as compared to previous days, the DMC490 will continually adjust its forecast to make the best predictions for the contribution of renewable generation that will be available to support the required loads in the microgrid.



The DMC490 develops a 24 hour expected load profile for which it will provide the necessary generation within the system to support it. If the actual measured load is different than the forecasted load, the DMC490 will continually adjust the forecast to provide the appropriate generation.

Optimal Generation Dispatch

Using the load profile that was created based on historical power usage and adjustments made on real time monitoring, the DMC490 will optimize the use of the available generation to provide power in the most economical means possible.

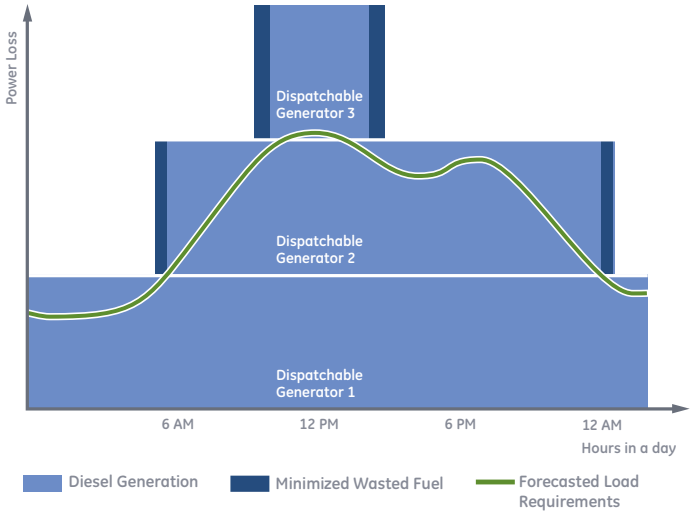
As a part of the configuration process of the DMC490, each generation source is given a cost value to run that generating source. Renewable generators such as wind or solar power will be given a lower cost than diesel or other fuel based generators. Using this information, along with the operating and efficiency characteristics of the generators, the DMC490 will give commands to the dispatchable generators and/or storage devices to best match the generation with the load requirements.

In order to use the minimal amount of fuel required to support the load, the DMC490 will turn on the dispatchable generators just before needed in order to minimize the idling time of the generators to provide the most cost effective method in supporting the load.

As a part of its generation optimization algorithms, the DMC490 takes into account the operational characteristics of the generators such as the start up time required and the minimal generation loading that is require to make it operate efficiently.

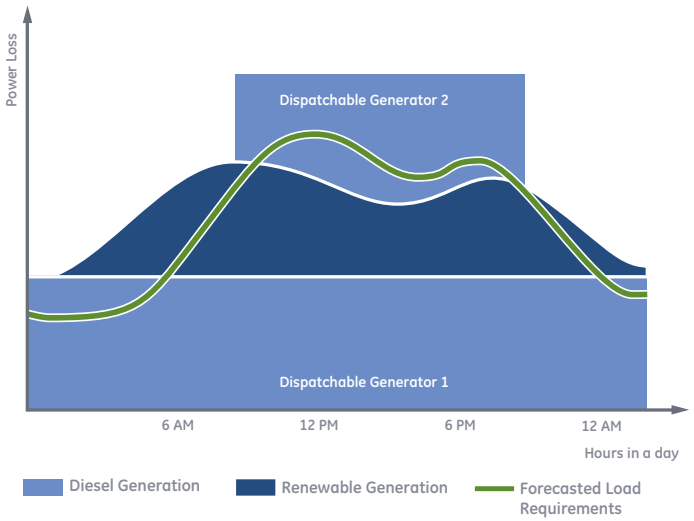
The DMC490 performs its generation optimization calculations and sends commands to the generators to maximize generator performance every 6 minutes. As changes in the load occurs between 6 minute optimization cycles, the DMC490 ensures that it took into account enough generation loading margin known as "Isochronous Generator Margin" or "Isoc Margin" to support the addition to the load.

Generation Optimization Using Traditional Generation



The DMC490 generation optimization algorithms intelligently start and stop the dispatchable generators at the optimal times to support the load and minimize the time the generators are running.

Generation Optimization with Integrated Renewable Generation



As it is not dispatchable, when renewable generation is integrated into the microgrid system, the DMC490 will dispatch available generation taking into account the contribution of renewable generation into the system.

Renewable Generation Integration

Using the forecasts made for the amount of renewable generation that will be available in the microgrid, the DMC490 is able to provide additional cost savings in the microgrid network. By taking into account the amount of renewable generation that will be available for future periods, the DMC490 will reduce the amount of dispatchable fossil fuel based generation running to meet the load requirements.

Since by its nature renewable generation is variable and can very quickly decrease in contribution to the system (wind slows or increased cloud cover), the DMC490 will incorporate an additional margin of standby generation (Isoc Margin) when renewable contribution is high to ensure there will always adequate generation available to support the load.

Isochronous Generation Control

The isochronous generators (or "isoc generator" are the generators in the microgrid that are used to stabilize the frequency of the system. Based on a pre-defined configuration, the DMC490 is able to identify which generators are the isoc generators as specified by preference of the system operators.

The types of generators that can be used as an isoc generator in the microgrid are defined below:

- Utility source
- Diesel-gas generator
- Hydro generator
- Fuel cell generator

Energy Storage Integration

When a method of storing energy is available, (hydrogen electrolyzer or batteries) renewable generation can be used to its maximum potential for providing cost savings. Energy storage is possible since low cost energy does not need to be used at the exact time that it is produced, therefore it can be used later when renewable sources may not be available.

Storing Energy

During periods of time where there is more renewable generation available than is required to support the load (such as spilling over the dam at night for hydro), or when there is additional generation margin due to lightly loaded generators, the DMC490 can initiate the hydrogen production or storage (battery or pumped storage) of "fuel".

Using cost information, the optimization algorithms in the DMC490 analyze the excess generation available and determine if it is economically beneficial to store energy at that time. The DMC490 will take into consideration the amount of time it takes the storage medium, to operate efficiently and how long it must run for prior to seeing benefits, before it initiates the storage process.

Using Stored Energy

When there is not enough renewable generation in the system to support the load requirements and there is sufficient stored energy available to support the loads, DMC490 will initiate the use of available stored energy and will help reducing the fossil fuel consumption to run the diesel generators to feed the loads. In this case, the stored energy resource will act as one of the dispatchable generators in the system.

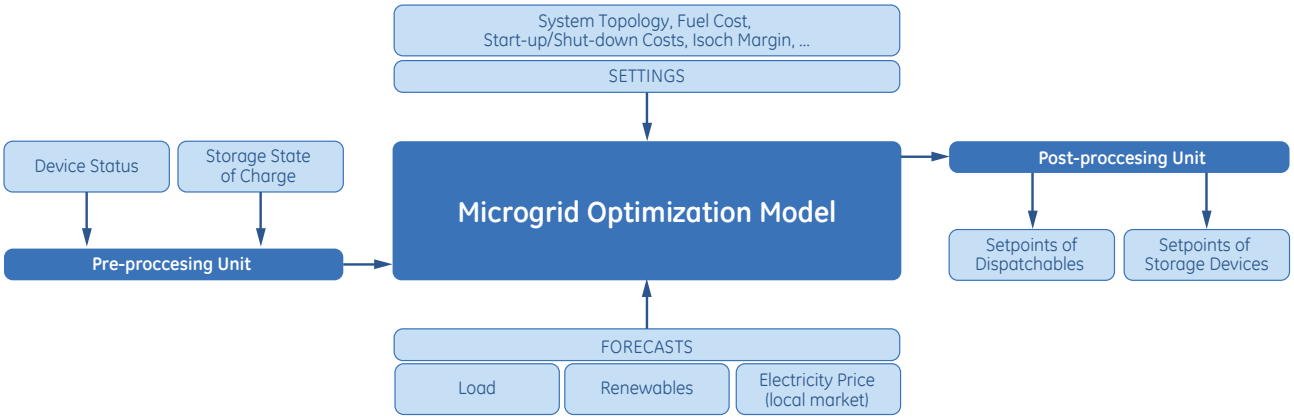
Generator Unit Commitment

This function of DMC490 enables users to force select the dispatchable generators to be committed for a certain minimum time over the forecasted horizon with a minimum delay. This function considers a portion of the energy storage outputs defined by a predetermined profile - which is calculated by microgrid optimization algorithms based on readings from storage device and the results of previous optimal dispatch.

This function also enables use of grid connection as a resource and determines the total share of power to be imported from the grid to be able to support the load demand.

The Unit Commitment function of the DMC490 feeds the Optimal Dispatch algorithm to commit certain generating assets considering system parameters and forecasted demand.

Generator Unit Commitment Integration



Automation Control

The DMC490 Generation Optimizer algorithms are able to make recommendations as to when to use the various dispatchable resources in the network. When appropriate, these commands can be sent directly to the local controllers that are connected to the generators.

When there are special requirements or operating conditions that need to first be considered before these commands can be sent to the local controllers, the DMC490 contains an advanced logic engine that can be used to customize the control of these resources. This logic engine includes many different types of logic operators including Boolean logic and mathematical operators.

For example, in cases where it is not possible to directly measure the hydrogen state of charge in a hydrogen based energy storage system, by using a mathematical equation value of hydrogen charge level it can be calculated locally using this powerful logic and math engine. DMC490 also supports IEC 61131 Logic capabilities to simplify the design of automation schemes.

DMC490 is able to manage load-generation balance with the control of the dispatchable loads with user defined load-shed logics.

Advanced Automation Applications

The DMC490 provides the computing platform necessary to automate substation procedures. Automation features include:

- HMI, One Line Viewer and Annunciator
- Mathematical Control Logic
- Analog Value Selection
- Accumulator Freeze
- Control Lockout
- Programmable Logic using IEC 61131
- Double Point Association
- Input Point Suppression
- Redundant I/O
- Alarm Management

Communications

Communication to Client or Server Devices

The DMC490 supports multiple simultaneous SCADA protocols such as DNP3, Modbus, IEC 60870-5 101,103, and IEC 61850 MMS to communicate with the devices connected to the Generation and Load Points and supports VLAN communications. The DMC490 optimizes the amount of information needed and uses low bandwidth so that the Microgrid optimization system can operate even where there is limited bandwidth between the control system and the local control devices. These supported protocols also enable the seamless integration of the DMC490 into SCADA, Energy Management Systems or DCS systems.

Information that can be made available to these systems include:

- Real time load being used
- Total renewable generation being provided
- Total stored energy being provided
- Amount of stored energy available for use
- Total dispatchable generation available

For grid-tied Microgrid systems, the DMC490 controller can act as a gateway device to communicate to upstream utility systems. It has extensive support for various time sync methodologies and will accept time sync signals from SNTP/NTP servers, IRIG-B and SCADA protocols. It can also distribute time sync information through built-in IRIG-B distribution interface, SCADA Protocols and/or through the RS232 serial communication ports directly.

Sequence of Events Record

The DMC490 provides a Sequence of Events Record that records all of the generation optimization decisions and logic operations performed by the DMC490. The Sequence of Events can be monitored locally or remotely through a web-based HMI.

Secure Remote Access

The Multilin DMC490 provides robust security environment, providing seamless integration with existing IT department policies. Role based Access Control, Secure Web Interface, Secure File Transfer, and extensive user activity logging provide a complete security toolkit required to achieve NERC-CIP compliance.

Non-operational Data

Using secure pass-through connections, users can extract valuable non-operational data such as digital fault records and event files. An Automated Record Retrieval Manager (ARRM) is also available to retrieve and store record files from devices connected to the DMC490. These records and historical log files can be archived and utilized for trending and analysis.

Pass-through/Terminal Server

A built-in terminal server emulator allows pass-through connections to be initiated to substation device (relay, meter, RTU or other device). Once the connection is established, the local event records can be uploaded from the substation devices and viewed remotely. Remote access can be secured with TLS or SSH.

Virtual Serial Ports

Virtual serial ports eliminate copper wire communications to feeder bays when a serial-only device is located in the bay. A small terminal server can be placed in the bay and connected to the Ethernet network, allowing all Multilin DMC490 serial client applications to connect directly to the serial device.

Role Based Access Control

Role Based Access Control is achieved using local or remote authentication such as LDAP, TACACS+, RADIUS. Hence, ensuring only authenticated and authorized users gain access to the system. When using LDAP or TACACS+, revoking user privileges, system wide, is as simple as updating the centralized user database.

The list of Network security protocols supported are as follows:

- LDAP
- RADIUS
- TACACS+
- TLS
- HTTPS
- SSH
- SCP
- Syslog
- SFTP
- CHAP

Syslog is used for tracking and reporting security events for auditing purposes

Built-in Firewall

Multilin DMC490 is equipped with a built-in firewall for enhanced cyber security. The DMC490's firewall is designed to drop unsolicited or invalid routed packages. The firewall is pre-configured to block outbound traffic on external interfaces and inbound traffic on both internal and external interfaces. The DMC490 automatically generates rules allowing inbound traffic on internal interfaces for all configured services. The rules are user configurable for inbound/outbound traffic customization.

Maximize the Distribution Network Efficiency (Grid Tied Networks)

The MCS system can also provide capability to minimize the distribution system losses and maximize network efficiency by leveraging the existing system assets such as Voltage regulators and capacitor banks. The Multilin DMC490 controller, as part of the MCS system, can host advanced algorithms for Volt/VAR controls for a distribution network.

It is possible to increase local distribution network efficiency by optimizing and flattening the voltage profile and by maximizing the reactive power injection into the local distribution network.

Microgrid Visualization and HMI

The DMC490 includes a user-friendly HMI for monitoring, control and visualization of a Microgrid network.

The DMC490 supports a web based HMI that is accessible using a standard Internet browser or through a VGA monitor and USB keyboard/mouse attached directly to the unit.

Users have access to all data points in the systems, alarm screens, communications status screens and dynamic one line diagrams, all through the secure web interface.

The web based HMI supports the following security features to ensure secure remote or local access:

- Configurable auto logout/login for Remote and Local HMI access
- Disabling of Remote HMI Non-Observer Privileges
- Login to specific custom screens for added security to sensitive displays

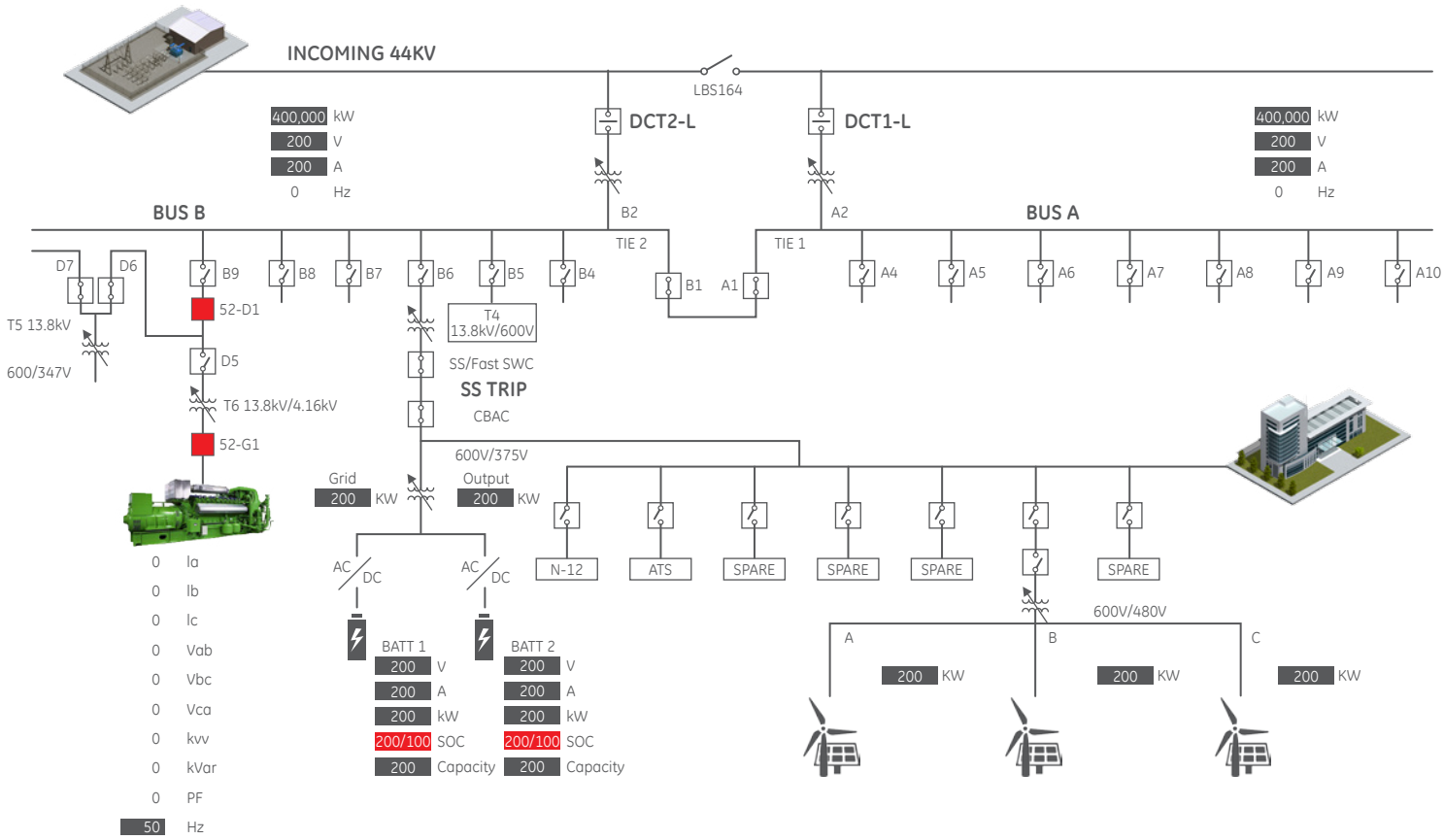
Microgrid Applications

The Microgrid Control system is used in various types of applications including Grid-tied and Off-Grid systems, Remote communities, Islands, Campus / University, Military, and industrial facilities.

As an example, permanently islanded remote and mining communities face a challenge to reduce total cost of energy, primarily driven by fossil fuel cost and high fuel transportation costs. Although, many of these remote communities may have some form of a renewable resource, such as run of a river hydro, small bio-gas plant, wind, or solar, unfortunately because of lack of smart control system infrastructure, they are primarily dependent upon fossil fuel based generation for their energy needs.

The Microgrid Control system can help many of these remote islanded communities by optimizing the operation of existing assets and also by helping integrating renewable energy resources into the existing network. Such capability not only helps these communities to reduce the total cost of energy, but can also help reduce the GHG emissions and resulting adverse environmental impacts.

Typical Microgrid Control Solution Single Line Diagram



A microgrid system architecture diagram for a typical remote community suitable for application of GE's Microgrid Control System

Order Code Item	DMC490	*	*	*	-	*	*	*	*	-	*	*	*	*	-	*	*	*	*	-	*	*	*	*	-	*	*	*	*	Description
CPU OPTIONS		M																												1.6 GHz CPU, 1.0 GB DDR RAM, SINGLE ETHERNET
		N																												1.6 GHz CPU, 1.0 GB DDR RAM, DUAL REDUNDANT ETHERNET
		P																												1.6 GHz CPU, 1.0 GB DDR RAM, SINGLE ETHERNET, 16GB CF
		Q																												1.6 GHz CPU, 1.0 GB DDR RAM, DUAL REDUNDANT ETHERNET, 16GB CF
POWER SUPPLY			A																											100-240 VAC (47-63 Hz), 100-300 VDC (10%)
			B																											20-55 VDC (10%)
POWER SUPPLY (Redundant)				U																										NONE
				A																										100-240 VAC (47-63 Hz), 100-300 VDC (10%)
				B																										20-55 VDC (10%)
SERIAL COMMUNICATION						U	U	U	U		U	U	U	U																NONE
						1	1	1	1		1	1	1	1																RS-232 IO Assy
						2	2	2	2		2	2	2	2																D400 RS-485 IO Assy
						3	3	3	3		3	3	3	3																D400 Glass Fiber Optic IO Assy
						4	4	4	4		4	4	4	4																D400 Plastic Fiber Optic IO Assy
IRIG-B INPUT CARD																U														NONE
																A														IRIG-B INPUT CARD
IRIG-B DISTR CARD																	U													NONE
																	B													IRIG-B Distribution Card
FIRST NETWORK SLOT																		1												ETHERNET 4 PORT 10/100 MB TP SWITCH
																		2												ETHERNET FIBER OPTIC (HOT STANDBY) 2 PORT 10/100 BASE-S
																		4												ETHERNET REDUNDANT TP + COM2
																		5												D400 100BASE-FX HOT STANDBY ETHERNET
SECOND NETWORK SLOT																			U											NONE
																			1											ETHERNET 4 PORT 10/100 MB TP SWITCH
																			2											ETHERNET FIBER OPTIC (HOT STANDBY) 2 PORT 10/100 BASE-SX
																			3											MODEM PORT (REQUIRES EXTERNAL MODEM)
																			4											ETHERNET REDUNDANT TP + COM2
																			5											D400 100BASE-FX HOT STANDBY ETHERNET
USB KVM, AUDIO																				U										NONE
																				A										USB KVM & Audio Card
D400 LOCAL HMI																					U									NOT REQUIRED
(ONE-LINE VIEWER)																					A									LOCAL HMI (BASIC)
D400 IEC 61850																						U								NOT REQUIRED
																						A								IEC61850 CLIENT APPLICATION
LOGICLINX																							U							NOT REQUIRED
EXECUTOR LICENSE																							A							D400 LOGICLINX EXECUTOR LICENSE
D400 Setup Software																								U						NOT REQUIRED
FIRMWARE IMAGE																									Q					FIRMWARE VERSION 5.30
MICROGRID LICENSE																										1				CONFIGURATOR LICENSE
																										3				CONFIGURATOR + RUNTIME LICENSE
AUTOMATED RECORD RETRIEVAL MANAGER																											U			NOT REQUIRED
																											A			AUTOMATED RECORD RETREIVAL MANAGER LICENSE

imagination at work

ecomagination™ Certified

GEGridSolutions.com

GE's Microgrid Control System is "ecomagination approved" by GE. This means it has been proven to deliver significant operational and environmental benefits to customers. Ecomagination is GE's way of creating new value for customers, investors and society by helping to solve energy and efficiency challenges.

GEA-31987(E)
English
170127