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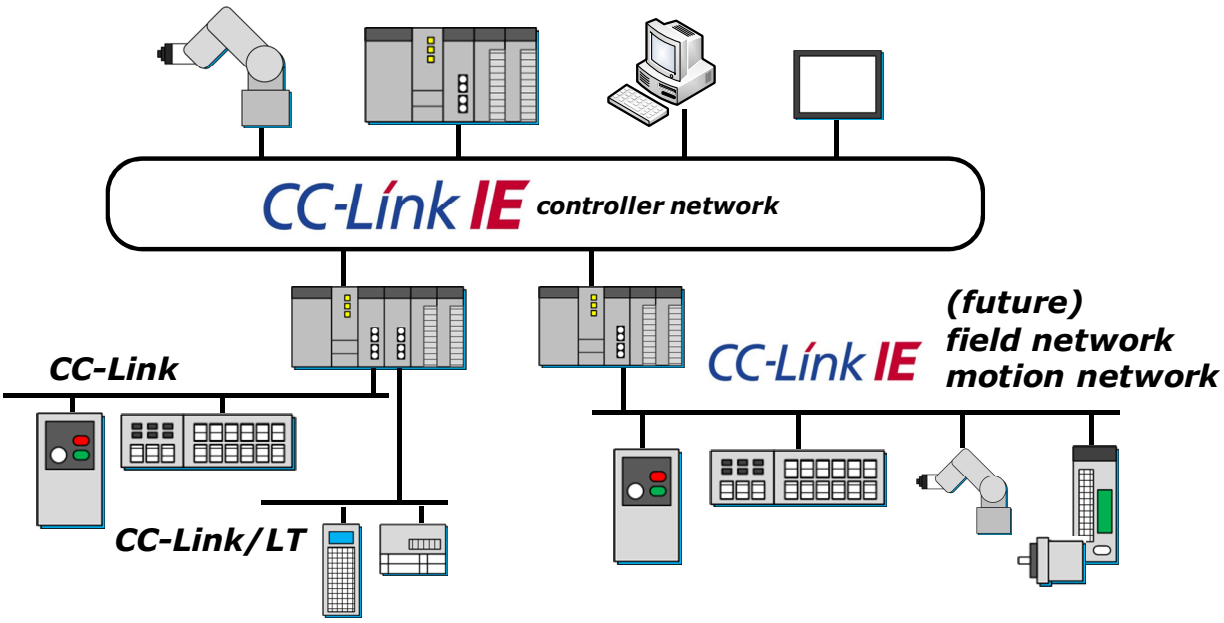
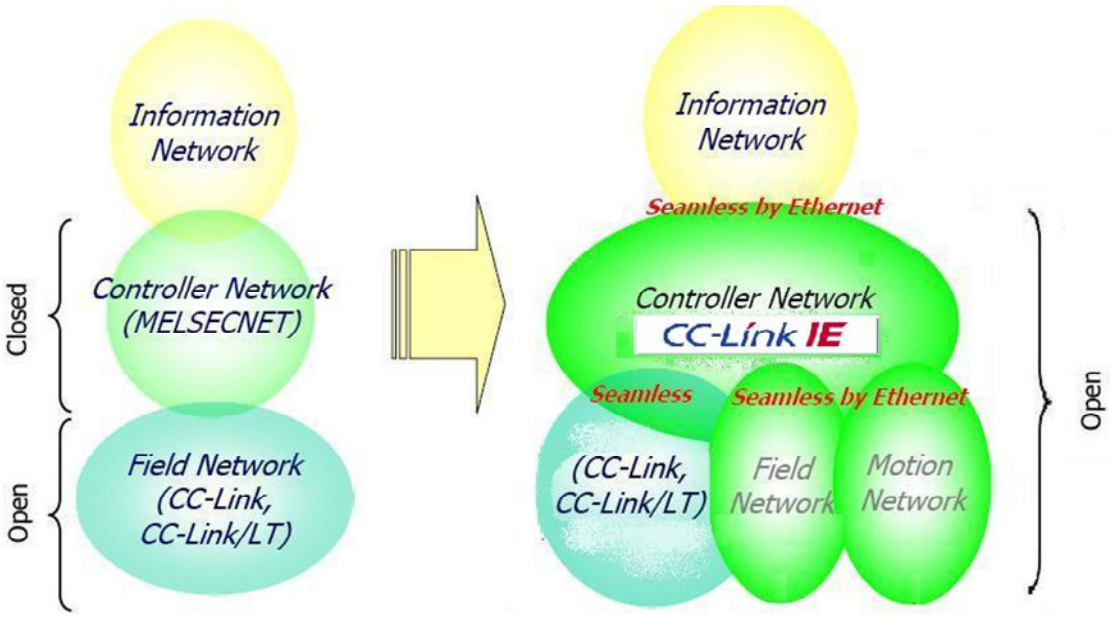
CC-Link IE: Gigabit Ethernet Performance for Today's Controller Networks

ARC Advisory Group



The CC-Link IE controller network is the first network to be released from the integrated "CC-Link IE" series



The CC-Link Partner Association Network Roadmap

Executive Overview

Mitsubishi Electric is a major global automation supplier. The company is strongest in the Japanese market, but has a large presence throughout Asia as well as globally in many industries. Mitsubishi is a full scope supplier able to provide all types of factory automation products from drives and servos to PLCs, CNCs, motion controls, robotics, and MES. The company has been growing its export business and has a corporate culture featuring a very powerful quality ethic. Mitsubishi enjoys the #1 or #2 market position in most of the markets where it competes.

Mitsubishi Electric has developed a new high performance controller network, named CC-Link IE. This 1 GB Ethernet-based network has been provided to the CC-Link Partner Association. CLPA will use this network as the first phase of its plan to provide open solutions encompassing the full range of industrial networks.

Unlike its major competitors, Mitsubishi is not aggressively pursuing services business as a means of growth. Mitsubishi prides itself on close and sustained relationships with manufacturing leaders in critical industries such as automotive and flat panel display systems. Rather than pursue services growth, Mitsubishi plans to grow as a product company, relying on its extremely close collaboration with OEMs, end users, and system integrators. Mitsubishi itself will focus instead on the development and improvement of its products. This product-oriented strategy allows Mitsubishi to avoid competition with its own channel partners.

Automation networks have trended toward ownership by multi-vendor consortiums and also towards using IT networks (especially Ethernet) as a source of technology. Mitsubishi has followed this model through its support of the CC-Link Partner Association (CLPA). The company donated technology to this consortium and is a founding member. The CLPA has promoted CC-Link technology and extended its scope to include sensor and safety networks. However until now the CLPA has dealt only with the lower-level sensor and device networks. Mitsubishi has maintained as proprietary its higher level controller network (MELSECNET), although the company provides a number of powerful tools for MES and enterprise integration based on Ethernet.

With the support of Mitsubishi, CC-Link has grown to become the leading fieldbus in Asia and one of the largest globally when measured by installed base. In 2007, the CLPA announced a new and powerful control level network, named CC-Link IE. This open-technology network, based on fiber optic 1GB Ethernet, will be managed by the CLPA along with the CC-Link

fieldbus. The performance and scalability advantages of this new network are now available to all CLPA members. CC-Link IE is a new high-performance control network for Mitsubishi's iQ Automation™ line and e-F@ctory Enterprise connectivity products, however the same technology is also available to all members of the CLPA. Both Mitsubishi and other CLPA products can now employ a standardized, open, high performance Ethernet control network that is based on shared rather than proprietary technology.

CC-Link IE includes a number of adaptive features that are essential for Ethernet networks in critical manufacturing applications. These include a real-time communication service that in CC-Link IE is based on a shared networked memory model. This design has valuable advantages in automation applications because it separates network provisioning from application design. CC-Link IE also employs no external Ethernet infrastructure.

This new network also marks a new direction for the CLPA. Formerly it had developed only sensor and device-level networks. Beginning with its release of CC-Link IE, the organization has announced a roadmap to further expand its scope to include all types of automation networks. CLPA will be developing additional high-performance networks in the future based on Ethernet for motion control and high performance fieldbus applications. This will significantly expand the scope of the CLPA, and also expand the value of its technology to CLPA members.

Mitsubishi in Automation

The open-technology of CC-Link IE should be considered in the context of Mitsubishi, the company that provided significant resources for its development. Mitsubishi Electric Corporation is a major global supplier of automation products and systems. Yet for an automation company so large, it is less well known in some regions than its local competitors. This relatively low profile comes in part because Mitsubishi is strongest in the Japanese and Asian market. Mitsubishi Electric enjoys significant market share in the growing markets of Asia as well as globally in many important automation equipment markets. This report provides a broad perspective of Mitsubishi Electric, and also explores how Mitsubishi is advancing its automation networking and developing the types of global collaboration that today's market demands.

Mitsubishi Electric is an industrial giant. Its most recent sales figure is over $30 Billion, and through subsidiaries and related companies it employs almost 100,000 people around the world. The company is organized around 9 major business units (see figure). While these units each have their own business area, they collaborate internally in their business processes. This provides an important advantage to Mitsubishi in the factory automation market, because the company has internal as well as external customers. As we shall see, Mitsubishi is both a demanding customer and a supplier when it comes to automation products. The tough demands of their own corporate quality and production programs have a hand in forming Mitsubishi automation products, which are used throughout their own manufacturing processes.

Mitsubishi Business Group	Group Products
Industrial Products	Factory Automation Systems Automotive Equipment
Information Systems	Information Systems, Network Services Electronic Systems Communication Systems Semiconductors
Machinery	Public Utility Systems Building Systems
Consumer	Home Products, Digital Media Equipment

Mitsubishi Electric Group Business Areas

Mitsubishi's Factory Automation Systems Group is a major unit within Mitsubishi Electric. The group represents roughly 10% of Mitsubishi Electric's employees and business volume. It has also experienced significant growth in its export business. Export sales by the group have doubled during the past 5 years, and represent an increasingly important segment of the group's overall business. For the group as a whole, exports are the critical driver of business growth.

Quality, Completeness, and Collaboration

Product quality is such a prevailing focus within Mitsubishi that it is deeply ingrained not only in production activities, but also in product design, development and commercialization. As an example of this quality culture, Mitsubishi performs root cause analysis of all product returns, and provides these reports to its customers. Needless to say, the company enjoys a

very low product return rate, despite the innovative design and manufacturing it employs.

Another unique aspect of the Mitsubishi Factory Automation group is its position as a complete supplier of automation products (see figure). The ability of a single source to supply not only controllers, but drives, motion control, power distribution, networks, HMIs, CNC, robots, and software places Mitsubishi in élite company within the factory automation market.

Factory Automation Business	Products
Industrial Automation	PLCs HMIs
Drive Controls	AC Servos Motion Controllers Inverters, Drives
Electrical Distribution	Mechatronic Products Motor Starters
Mechatronic Products	Numerical Controllers Electrical Discharge Machines Laser Processing Machines Robots

Mitsubishi Factory Automation Business Unit Products

Besides quality consciousness and a complete product line, Mitsubishi's strategies for success have another important aspect. Mitsubishi has long-established a highly collaborative relationship with many leading OEMs and end users in its markets. This begins with the company's in-house machine businesses, of course. Mitsubishi manufactures and markets well respected laser processing and EDM machines. But it also has long-standing relationships with leading OEMs and end users in many other areas. Many Japanese automotive and Asian flat panel display manufacturers are world leaders in their industries. These manufacturers represent an important resource that Mitsubishi uses to drive continuous improvements into its products. Company executives point to these sustained relationships as an important factor in Mitsubishi's ability to combine innovative design, high performance, and small size in many of its automation products, especially drives.

Collaboration extends to the company's product strategy as well. Unlike most automation companies its size, Mitsubishi does not work to capture large shares of the automation services business. In today's market, many automation suppliers are trying to capture as much of this business as they

can, which can bring them into competition with their own channel partners and customers. By contrast, Mitsubishi is focused on creating best-in-class products. This strategy is unusual for a company with such a broad range of automation products. Besides the fact that services can be a profitable business, other automation companies use their service business to gain deeper understanding of their customer's "pain points" and insight into improved products and solutions.

Yet Mitsubishi's strategy is to succeed as a products oriented business. Mitsubishi believes that its extensive in-house use of its own products combined with its deep collaboration with OEMs, end users, system integrators, and other partners provides the same level of insight and customer feedback that other companies obtain from service engagements. The company is confident in the superiority of its products. Adopting the strategy of a product company allows Mitsubishi to maintain a symbiotic and non-competitive relationship with its service partners.

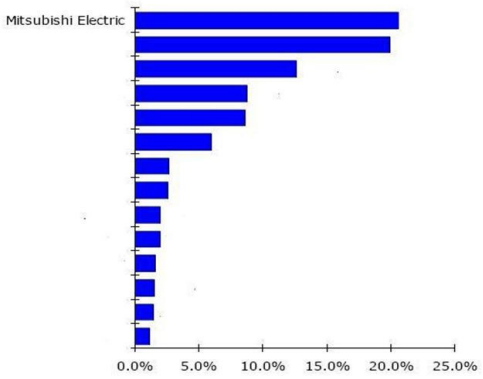
Mitsubishi Electric Provides a Wide Range of Automation Products

While this level of product-oriented strategy is unique among major automation suppliers, Mitsubishi products are not limited to drives or other products at the "edge" of production. The company's e-F@ctory enabled products are used to provide "vertical" integration and enterprise connectivity for all types of Mitsubishi automation systems and production equipment. And just like the automation products, e-F@ctory technologies are used extensively in Mitsubishi's own manufacturing operations. One of Mitsubishi's hidden strengths as a manufacturer of state-of-the-art products is that it must use its own technology to build its products. Mitsubishi's factory sites and manufacturing operations are proof points that Mitsubishi products can contribute to efficient and high quality manufacturing.

Proof of the pudding

Mitsubishi's market position provides evidence that their strategies for success bear fruit. The company has the #1 or #2 position in Japan and Asia in all the automation markets where it competes, and has leading positions in the global market as well. Mitsubishi has exceptional strength in smaller

PLCs and ships more PLC units than any other company in the world according to ARC's most recent market data (see figure). The company also has leading shares in supplying this equipment to many key vertical industries, including the automotive, flat panel display, electronics, semiconductor, food, beverage, and pharmaceutical industries.



PLC Worldwide Market Shares by Unit Shipment Volume

One further example shows the company's devotion to quality and openness. In order to facilitate customers who were moving from the Mitsubishi A Series PLCs to its latest Q Series automation platform, Mitsubishi developed detailed migration planning documents. This by itself is not unusual. Many automation suppliers do this. But Mitsubishi created a website and posted the complete set of migration planning documents on the Internet where any customer (or competitor) could see the details in full. In addition, Mitsubishi freely published an extensive set of software tools in support of migration.

Usually automation suppliers carefully guard access to such resources for strategic reasons. The details of an automation migration can be cumbersome. Sometimes the planning process for migration leaves some areas unspecified and relies on the expertise of the field service personnel. Suppliers usually don't want to publicize any difficulties in the process. Mitsubishi's approach was to carefully develop these plans and then publish them openly so that its customers could become familiar in advance all the steps in the migration process as well as the available resources, and then make a fully informed decision about the best time and sequence for their own migration to the new product line.

Business Drivers for New Network Adoption

New networks in manufacturing do not emerge simply because of available networking technology. There are underlying business drivers in today's manufacturing climate that favor the adoption of new and improved network technologies. A pair of examples will illustrate this well. First look at

the ultra-modern world of flat panel display manufacturing, one of the fastest growing and fasted changing manufacturing industries today. Second, examine changes in a far more mature and traditional manufacturing industry – automotive.

Fast Moving Flat Panel Manufacture

Flat panel displays have become dominant technologies not only in IT applications, but in home entertainment and communication. Part of their success comes from huge product improvements and cost reductions that have been achieved in recent years. Japanese manufacturers (Sony and Sharp are examples) have led this field.

Firms such as these have combined manufacturing disciplines from both Japan and the west to become powerhouse manufacturers in this huge and rapidly growing market. Japanese manufacturing methods have traditionally focused on techniques such as Kaizen, Kanban, and JIT that improve production using a "bottom-up" approach with an zealous focus on high product quality. European and North American methods have traditionally focused on overall process optimization and integration.

The traditional Japanese disciplines result in methods for reducing tact or cycle time, improving equipment utilization, and developing production equipment that can perform complex operations with very high precision.

The focus on high quality requires that extensive test and quality data be captured and retained for analysis. In flat panel manufacture, the size of a "mother glass" increases all the time, and the largest ones are now 3 meters square. It is important to process such large pieces with precision. But as larger units are produced and production ramps up, the quantity of recipe, test and quality data that must be processed simply explodes.

As flat panel glass size increases and production ramps up, the volume of test and quality information that needs to be managed simply explodes.

Finally, these production processes change frequently as improvements or new products are introduced. Manufacturers who want to stay competitive must be able to quickly adjust their factory production configurations in response to these changes. Startup, installation and engineering costs that are excessive cannot be tolerated because changes occur far too frequently. In summary, the requirements for effective utilization, precision, real-time coordination

among machine operations, and exploding data requirements dictate that manufacturing networks must be far more capable.

Automotive Assembly Requires Network Bandwidth

Automotive painting is another example of a process where increased competitive pressure has changed the requirements of manufacturing operations. The major trend has been to make production lines more flexible so that they can be used for the production of several different models. Adding this flexibility is a challenge in the most highly automated areas of automotive production, and painting is one of these. Paint operations include a large number of robots, which must perform reliably and precisely in a challenging physical environment full of chemical vapors, motion, high voltages, and electromechanical actuators.

Continuous diagnostic information from these actuators, valves, motors, and from moving parts of the field/motion network is critical in order to maintain high reliability, reduce down time, and operate the lines at capacity. In addition, flexible configurations are becoming ever more important. Additional robots and/or lines need to be accommodated quickly and easily without costing large amounts of lost production. Information pertaining to quality is also on the rise, and the painting process needs to be exceptionally well controlled in order to produce product of the highest quality.

These two examples show that regardless of how new or mature the application, manufacturers need greater agility, speed, and must process ever larger amounts of information from production operations. Automation networks act as the "nerves" carrying this vital information throughout a manufacturing operation. Expanding the capacity and agility of this factory "nervous system" is an important way to design for the needs of the future.

Trends in Industrial Automation Networks

Today networks have become critical and commonplace within industrial production equipment. No longer used strictly when wiring cost is a consideration, networks are now designed into production lines and individual machines and have become critical components of leading manufacturing

operations. As networks have become more commonplace, a number of long term trends have emerged (see figure). These trends generally have moved automation networks away from vendor-specific solutions and toward shared networking technologies (CC-Link, ODVA, Profinet, SERCOS, etc.) and toward networks that use IT network technologies, especially Ethernet.

From…	To…
Vendor-specified	Industry standard
Vendor Intellectual Property	Consortium Intellectual Property
Various types of OSI layers 1-2	Ethernet
Separate safety network	Converged automation network

Trends in Industrial Automation Networks

Yet networks that operate production machinery have distinct application requirements. Success on the factory floor may require greater physical ruggedness, higher reliability, controlled performance, and other features. In the case of the factory floor, automation networks have made adaptations to their IT roots in order to meet these needs. For example:

- Physical Ruggedness – Networks exposed to shock, vibration, or harsh environments will use devices, cables, and connectors that are more rugged than IT equipment.

- Reliability – Automation networks achieve high reliability by providing media redundancy and very rapid fault recovery. These types of adaptations are used only in "core" enterprise networks, but are common in critical production networks. Furthermore plant networks will rely much more on fiber optic links to provide added reliability because of their immunity to electromagnetic interference and their ability to span large distances.

- Controlled performance – The network performance in terms of throughput, latency, and jitter must be managed. This is done through a number of means. These include careful implementation of Ethernet-based networks, isolation from enterprise network traffic, quality of service mechanisms to prioritize traffic, and 'lightweight" communication protocols with less overhead than the TCP/IP protocol suite.

- Scalability – production networks may be required to span an entire factory or synchronize a whole production line. This is another driver for greater inclusion of fiber optics.

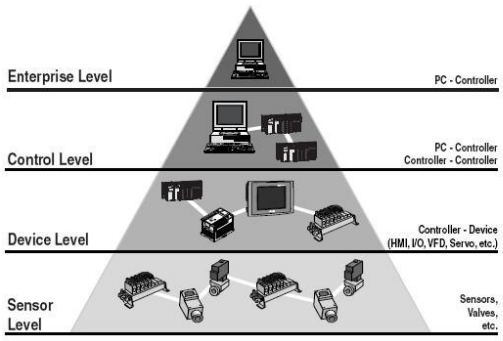
- Ease of Use – Automation networks need to be easy to design, provision, install, monitor, and troubleshoot. Daisy-chain style wiring is preferable to the star topology used for IT edge networks. Device or link failures should be isolated, identified and located without stopping the manufacturing operation. Redundant portions of the network must take over the services and mean time to repair should be low.

The results of these customer requirements are networks with distinct automation services and configurations. However these networks are increasingly built from commercial fiber optic and Ethernet technologies, with suitable adaptations for factory floor service. We see several different types of industrial adaptations of Ethernet, some of which use ASIC technology to provide a particular level of service. We also observe a set of network protocols designed specifically for industrial applications (examples are MODBUS, MODBUS TCP, CIP, Profinet, EtherCAT, etc.).

Mitsubishi's Automation Network Strategy

Mitsubishi has pursued a conventional strategy with respect to automation networks. At the sensor/device level they have adopted an open multi-vendor fieldbus strategy. The core of this strategy has been Mitsubishi's contributions and support of the CC-Link Partner Association (CLPA). Through the CLPA, the CC-Link fieldbus has become one of the most successful factory fieldbusses.

The next higher network level is sometimes called the controller level (see figure). In the past, Mitsubishi has employed a proprietary controller network, called MELSECNET. The controller network level performs peer-to-peer communications between PLCs and between PLCs, CNCs, robots, OITs and other controllers, PCs and servers. Its role is critical for integrating "islands of automation" into a single smooth-running production line. While this network must provide services to enterprise applications, its core function is to maintain a coordinated flow of information critical to the production process itself. Hence Mitsubishi's strategy



Automation Network Levels

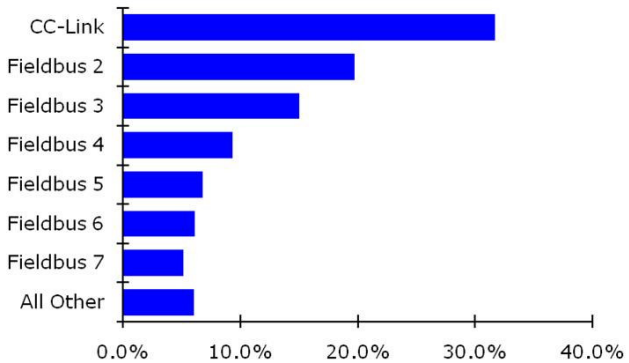
was to maintain tight control over the MELSECNET network. The MELSECNET network has been widely used in industries such as automotive, flat panel display, etc. as it is a high speed, high volume, reliable network for manufacturing lines. In particular network provisioning based on rameters simplifies MELSECNET setup.

Though MELSECNET has remained a proprietary network, Mitsubishi has provided integration with enterprise/Ethernet networks and applications. Mitsubishi provides a suite of tools that easily integrate shop floor information for enterprise applications via middleware tools, Ethernet communication modules, and e-F@ctory products. This allows enterprise and desktop applications to access factory floor information without compromising the critical functions of the MELSECNET network.

Device and Sensor Level Strategy

Sensor and device level networks, as noted earlier, have transitioned from networks that were defined by a single vendor to networks supported by an independent technology consortium. This form of organization has major advantages for all parties involved. The network specifications and the associated intellectual property are owned by the consortium rather than by any single member. The right to use the technology and the path of its future development are also managed by the members through the consortium rather than by a single firm. Also, the consortium develops testing programs and certifies products as compliant with the fieldbus specification.

This type of open partnership organization allows many diverse companies to share technology. Small and specialized companies can participate and use the consortium technology without making a major investment of their own. They can also be assured that their investment is not at risk from arbitrary decisions originating from a single large supplier. The consortium is responsible for any decisions that affect the technology, so no single supplier can change its direction at will.



Fieldbus Market Shares in Asia by Installed Node Count

Mitsubishi released control of the specifications for CC-Link in the year 2000. As a result, the CLPA was formed that year

with Mitsubishi and 5 other companies serving as Foundation Partners. The number of CLPA members and the number of CC-Link nodes has grown steadily since then. Today over 4.5 million CC-Link certified nodes have been shipped, and over 850 products from hundreds of manufacturers are certified as CC-Link compliant. CC-Link is now the leading fieldbus in Asia (see figure) when measured by installed base. CC-Link has also enjoyed success outside of Asia in large projects for automotive and material handling applications. This success places CC-Link in the top tier of global factory fieldbusses.

CC-Link features fast response time, large data transfer capabilities and a very high level of determinism. For instance, a network of 64 stations can be updated in approximately 4 ms. The CC-Link network is suited for large applications as well as distances up to 1.2 km, and further using repeaters. CC-Link features an easy-to-use memory mapped profile, enabling simple network configuration as well as various RAS (Reliability, Availability, and Serviceability) functions and diagnostic features. One of the key reasons why CC-Link is so widely used is its high degree of determinism, stable scan time, and high immunity to electromagnetic noise. In fact, all certified products must pass noise testing as part of CC-Link conformance testing.

CLPA has enhanced CC-Link technology by adding new capability in the forms of CC-Link/LT and CC-Link Safety. CC-Link/LT is a sensor level industrial automation field network providing efficient, integrated factory and process automation that reduces the installed cost of discrete wiring via innovative wiring without special tools. The LT designation (think of "light") can utilize a smaller I/O modularity for improved I/O network utilization. CC-Link Safety is a network with high reliability suitable for use in safety applications that require compliance with IEC61508 SIL3 and ISO13849-1 Category 4. Manufacturers are clamoring for safety networks in order to reduce the amount of wiring in safety systems.

In summary, Mitsubishi has already developed a series of automation network technologies. Most of these are open and some are proprietary. While Mitsubishi has maintained a proprietary network, it has also provided powerful tools allowing MES and enterprise applications to access that network.

CLPA Adds a 1 GB Ethernet Controller Network: CC-Link IE

In 2007 the CLPA introduced a new and far more powerful network, which is named CC-Link IE (IE for "industrial Ethernet"). CC-Link IE provides a high performance industrial Ethernet based controller network that can seamlessly communicate throughout the plant floor. The first step in CLPA's future roadmap is the release of this controller level network. This network was developed by Mitsubishi in conjunction with the CLPA Technical Task Force. Mitsubishi has transferred the rights to this network to the CLPA. This new network will be managed and products certified by the CLPA, similarly to CC-Link. CLPA certified products can now interact at the controller level as well as the sensor/device network level. Besides opening up this new level of integration to CLPA members, CC-Link IE will bring unprecedented levels of performance to automation applications.

Properties of CC-Link IE

CC-Link IE uses a fiber optic, 1GB Ethernet physical layer, standardized as IEEE 802.3z and popularly known as 1000BASE-SX. CC-Link IE uses an IEC 61754-20 LC standard connector. The use of 1 GB Ethernet at the controller level is unprecedented. Many IT Ethernet networks now use 1GB data rates at the backbone, but CC-Link IE will bring this new level of throughput to industrial plant-floor control networks.

Network Property	CC-Link IE Solution
Media	1000BASE-SX (IEEE 802.3z) Multi-mode fiber optic cable
Transmission speed	1 GB / Sec
Maximum distance between stations	550 m
Connector	IEC 61754-20 LC
Collision Avoidance	Token passing
Standard Network Topology	Loop
High Reliability Topology	Dual loop
Real-time communication Function	Networked shared memory (256 k bytes)
Secondary communication Function	Transient (non-real-time) Communication
Maximum stations per loop	120

Properties of the CC-Link IE Network

As an example of the change in performance, consider the situation where 32 stations are connected, and 2000 points are assigned to each station, CC-Link IE can provide 5ms cyclic communication. This is 14 times faster than MELSECNET/H, which is already a very fast network. In addition, CC-Link IE features a single 256 kb network shared memory model (for cyclic data) . As noted earlier, Asian manufacturers have requested this higher capacity in order to meet their rising needs for accurate, precise, and effective manufacturing as well as for reduced cycle and tact time.

1000BASE-SX is a fiber optic gigabit Ethernet standard that operates over multi-mode fiber. Many communication difficulties at manufacturing sites are caused by electromagnetic noise interference acting on the network cable. Adoption of fiber optic cables significantly reduces communication failures caused by such noise.

On top of this standardized IEEE physical layer, CC-Link IE builds a token passing datalink layer which supports a loop topology. This loop can have redundant media for high availability and can consist of up to 120 stations (see figure). CC-Link IE implements a real-time cyclic network communication service based on a shared networked memory model. This type of service is analogous to the services that were implemented on the older MELSECNET, but with far higher performance. Unlike MELSECNET, in CC-Link IE this communication service can be used by any CLPA supplier as a built-in part of the network.

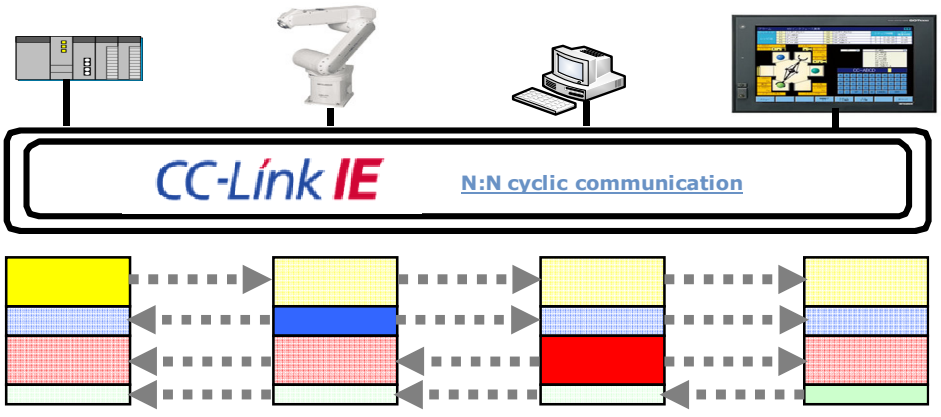
A Basic CC-Link IE Network

On a controller level network, simple integration and collaboration is a key factor. The role of a controller network is to exchange data among all controllers within a fixed cycle time. In order to achieve this, a controller network must provide N:N real-time communication. Implementing N:N real time communication can be highly complex when each controller must determine which controllers source and use particular data. Managing this communication configuration using a 1:1 based protocol is very complex. In order to resolve these issues, CC-Link IE uses the network shared memo-

ry architecture. This architecture enables each controller to know "what is happening in the network" with ease.

CC-Link IE cyclic (real-time) communication provides a transparent service to automation applications. The service is transparent because of this shared memory model. Applications can be designed without being aware of any networked communications, which are managed by the network independently. Applications do not know (or need to know) which data originates on the network, where data is sourced from, or where data must be delivered. The cyclic communication service handles these matters.

Because the cyclic communication is a built-in network service, it is only necessary to define a few parameters in order to start up the real-time communications. Also by adopting a token passing protocol, each controller passes the token and transmits the same data length. Since the data size is fixed, stable real-time network performance is assured. Another important property of the CC-Link IE network is that real-time communication takes precedence over transient communication by design. Thus any spike in transient communication will have no impact on the real-time communication service, which operates at a constant low latency cycle. Instead, the quality of service available via transient communication will vary if the offered load is higher than network capacity (and keep in mind that network capacity is 1 GB per second).



CC-Link IE Real-time Cyclic Communication

This is an important distinction between CC-Link IE and other industrial Ethernet protocols. Because of the shared memory model and N:N communication, not only high reliability but also easy configuration and set up is assured. Other industrial Ethernet protocols will require longer transmission cycles as the size of the network expands. In addition, the complexity

of network configuration increases. In CC-Link IE, system modifications such as the addition and deletion of machinery are greatly simplified as applications are unaware of network connections. These same types of re-configurations are a different story when using 1:1 communication protocols.

High availability is critical for reliable operation, especially for networks like CC-Link IE that can scale up to manage very large production systems. CC-Link IE exploits the capabilities of a loop network topology to deal with errors caused by broken cables or station failures. When operating with a dual cable, a built-in loopback function maintains CC-Link IE communication when a cable break occurs. The cyclic communication protocol is used to identify the segment where the break occurred, enabling a short mean time to repair. This behavior allows the real-time communication to occur without interruption for single failures. As the redundancy is built in, it is achieved without additional equipment thus reducing cost of high-availability configurations.

Network control switching is also a key feature for network stability. Even if one control station fails, another station will automatically take over the control of the network and maintain communication. Furthermore, if two stations fail simultaneously, the network will separate and one station will take control of each segment.

The transient communication service is also open and available to other applications. Transient communication will serve two purposes in CC-Link IE. It is used for intermittent automation communication (for example application download by an engineering tool) and will also be used for other protocols so that the network can operate with multiple protocols. The CLPA has announced a roadmap to implement TCP/IP as the first additional protocol using the transient communication service.

Finally, CC-Link IE features seamless communication. Not only can each station read/write to the device memory of all other stations on the network seamlessly, it will be able to communicate with existing CC-Link networks. This makes it possible to utilize existing assets, while being able to connect to future CLPA networks for field, motion, and safety. The user can perform programming and maintenance as if all stations are connected with a single/flat network regardless of physical configurations of the network.

End User Need	CC-Link IE Feature
Physical Ruggedness	Multi-mode fiber optics Redundant media
High Reliability	Immunity to EMF Uninterrupted service through cable, station failures Automatic identification of segment failures
Low Latency	Real-time communication with guaranteed QoS Low latency guaranteed by design No impact from intermittent services
Ease of Use	Daisy chain topology Network communications transparent to applications Automatic identification of network fault location Can encapsulate other protocols
Scalability	550 Meter segment length 1 GB network speed Each network supports more than 100 stations Networks can be joined to cover an entire plant

CC-Link IE Features Addressing End User Needs

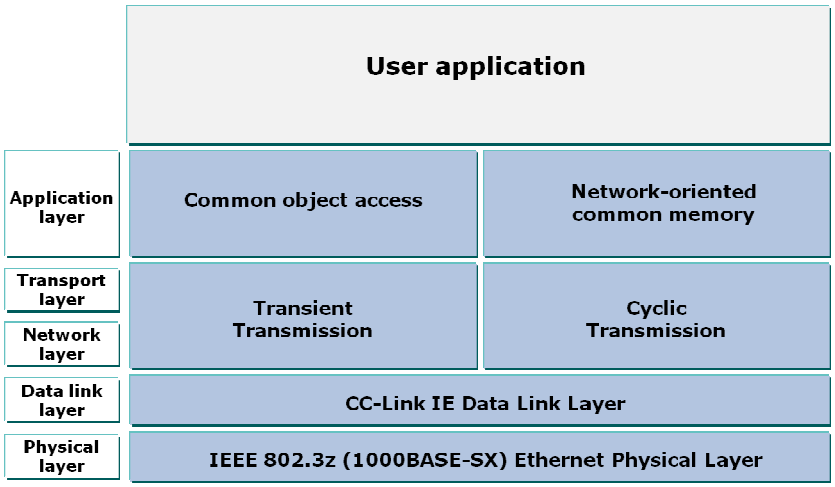
Earlier we noted that while industrial automation networks are now built using IT foundations, manufacturing automation requires adaptations in order to meet the application needs of the factory floor. CC-Link IE is designed to specifically address these requirements in a number of ways (see table). While clearly CC-Link IE is designed as a controller network critical for production, yet it employs the latest standards-based technologies deployed in the world of IT such as 1GB Ethernet. While CC-Link IE addresses the needs of the factory floor, how "open" is it? The question of openness is important to end users because the term implies that the network will have a long life and will be able to grow and improve over time rather than encounter some technological "dead end". So let's turn specifically to the question of openness.

CC-Link IE as an Open Controller Network

The fundamental property of openness is that a technology is standardized and also is not controlled or dictated by a single supplier. The CLPA is the organization that owns and manages CC-Link IE, and it is CLPA that has commercialized it and will certify compliance. Thus CC-Link IE will be

equivalent to any other automation network technology in this sense of openness.

Furthermore, the fundamental services that the network provides (real-time and transient communications) are both available for use by any party developing CC-Link IE products. The fact that all the key services have been shared is another indication that the technology is truly designed to support any number of products and suppliers. All CLPA member applications are free to use both the real-time and transient communication services on an equal basis. Any member can add their own applications on top of these services.



The CC-Link IE Protocol Stack

Furthermore, the CLPA has announced a similar strategy in terms of future CC-Link IE field and motion networks. As these networks adopt newer technology, CLPA plans to extend its Ethernet-based networks from the controller level (as it has now done with CC-Link IE) to the sensor/device network and into the domain of motion control networks. This indicates that CLPA will grow in scope. It will become an organization that encompasses the full range of automation networking in today's factory, rather than just fieldbus networks.

CC-Link IE has important differentiators from other controller network solutions. These include its end-to-end use of 1GB speed and fiber optics, its scalability in terms of network size, its transparent network communications, and its shared memory model of real-time cyclic communications. Of these, the shared memory concept is the most important differentiator. This shared memory model results in a very simple yet powerful and deterministic communication service that can be specified simply using just a few parameters. This service shields applications from knowledge or concern about networked communication and also provides a simple and accurate way to provision the controller network – something that many other technologies presently lack.

Another advantage of CC-Link IE is that it requires no external Ethernet infrastructure. In a controller network, this type of infrastructure is never strictly "external" because it is required to perform critical functions and may impact the overall equipment performance. What this means for CC-Link IE is fewer points of failure and no need for IT expertise. Instead of IT network expertise, a small set of parameters defines the application requirements. This brings high performance Ethernet networking within the automation domain, because the behavior of CC-Link IE is far more predictable than that of IT-based Ethernet networks.

Though based on 1 GB Ethernet, CC-Link IE requires neither an external Ethernet infrastructure nor IT expertise for support.

Yet while IT is not required to provision the CC-Link IE network, CC-Link IE networks can utilize the latest Ethernet technology that is the de-facto standard in the market. Off-the-shelf Ethernet cables and network analyzers can be used. Installation, set up, and troubleshooting times can be reduced by utilizing a variety of off-the-shelf components and tools. CC-Link IE offers an opportunity for Mitsubishi to upgrade the performance of its existing products by adapting them for CC-Link IE instead of MELSECNET. The new network will improve the performance of the principal Mitsubishi automation products as soon as they migrate to this new high performance network. For example:

- Existing products that use the CC-Link fieldbus continue to be supported as always, with their existing communication assured.
- The iQ Automation and Q Automation platform line is enhanced through the higher performance available from interfaces to CC-Link IE rather than MELSECNET.
- e-F@ctory applications can also benefit from improved performance, but because the existing APIs have been maintained, the higher performance will not require revisions to MES or other applications.

The CLPA roadmap to upgrade the technology of its fieldbus and motion control networks means that CLPA members (including Mitsubishi) will be able to benefit because their new products can leverage higher levels of performance, while at the same time address a broader range of automation applications.

Summary

The CLPA is now moving towards a full range of automation solutions based on the latest high-performance standards-based Ethernet networks. CLPA partners stand to benefit from this, especially the smaller firms who otherwise could not afford the research and development costs of this level of high technology. The CLPA roadmap, of which CC-Link IE is the newest component, will offer new opportunities for growth to all CLPA members, large or small.

The direction set by CC-Link IE also addresses the critical end user requirements for higher performance, more choice, and greater scalability. As CLPA grows, its technology solutions will increasingly offer a "one stop shop" encompassing all the automation requirements of manufacturers: control networking, fieldbus, sensor networks, and motion control. While the CLPA has traditionally focused only on the CC-Link factory fieldbus, this will not be the case in the future. Beginning with CC-Link IE, the CLPA is moving to address all the needs of modern factory automation.

Further information is available directly from the CLPA at www.cclinkamerica.org or by email at info@cclinkamerica.org.

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Acronym Reference: For a complete list of industry acronyms, refer to our web page at www.arcweb.com/Community/terms/terms.htm

API	Application Program Interface
APS	Advanced Planning & Scheduling
B2B	Business-to-Business
BPM	Business Process Management
CAGR	Compound Annual Growth Rate
CAS	Collaborative Automation System
CMM	Collaborative Manufacturing Management
CNC	Computer Numeric Control
CPG	Consumer Packaged Goods
CPAS	Collaborative Process Automation System
CPM	Collaborative Production Management
CRM	Customer Relationship Management
DCS	Distributed Control System
EAI	Enterprise Application Integration
EAM	Enterprise Asset Management
ERP	Enterprise Resource Planning
HMI	Human Machine Interface
IT	Information Technology
MIS	Management Information System
MRP	Materials Resource Planning
OpX	Operational Excellence
OEE	Operational Equipment Effectiveness
OIT	Operator Interface Terminal
OPC	OLE for Process Control
PAS	Process Automation System
PLC	Programmable Logic Controller
PLM	Product Lifecycle Management
RFID	Radio Frequency Identification
ROA	Return on Assets
RPM	Real-time Performance Management
SCM	Supply Chain Management
WMS	Warehouse Management System

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