



Building Automation with LCN

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Installation Bus

Modern buildings today are controlled by a network of sensors and actors. The controller(s) in the network receive information about the actual conditions of the building and the environment and regulate electrical devices to achieve a desired state. The network of controllers used in a building is called "Installation Bus". The term "Bus" is similar to the bus terminology in computer technology indicating common data line(s) where a number of I/O devices and controllers exchange information. The bus signals in buildings are either carried on a separate signal cable in addition to the power cable or they are incorporated into the power lines using signal modulation techniques. Wireless media can also be used to carry bus signals. However, due to the random interference problems, wireless technology is too unreliable to be used in large commercial and industrial building beyond non-critical applications such as in the remote control or to connect sensors.

The three most used installation buses worldwide are EIB, LonWorks and LCN. The EIB standard was originally developed by Siemens and later handed off to an industrial association that is chartered with the promotion of the compatibility between EIB devices developed by different manufacturers. LonWorks is a proprietary control network created by Echelon Corporation, a San Jose, California based, company. LCN is described in more details in this article. LCN differs mainly from EIB by having better cost/performance ratio and from LonWorks by being less complex for an enhanced feature set and therefore, also by lower costs.

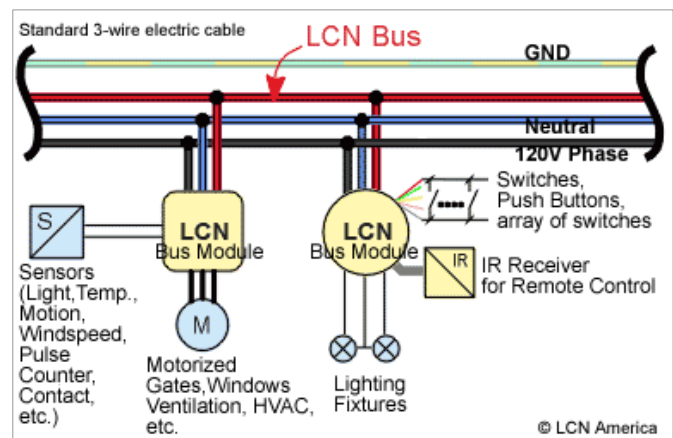
The LCN Installation Bus

Early 1992, the German company [ISSENDORFF Mikroelektronik GmbH](#) from Hanover started the development and marketing of a new building automation system based on a hard-wired network technology and named it LCN (Local Control Network). While other building control systems often use extra cables such as twisted pair or coaxial to run their control network, LCN took the approach of using an *extra wire* on the standard power cable as the physical bus. This approach offers two advantages: it simplifies the installation greatly (thus

lower the costs) and helps in converting conventional installations into bus based systems. Since then the LCN system has been installed in ten of thousands buildings worldwide.

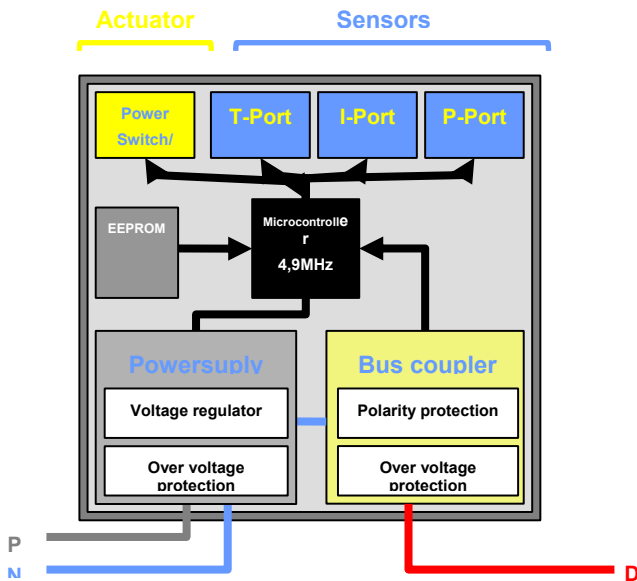
LCN is a multi-master installation bus, meaning that each controller can act as a master on the bus, e.g. it has full access to any sensor and actor in the network; the arbitration (negotiation for access) is done at the LCN protocol level. At first the goal was to develop LCN as a flexible control network that can grow from a single-room system into a multi-story building automation system without having to rewire the already installed area as well as without compromising the network reliability. Over the time, LCN has proven itself to scale economically and technically extremely well for building structures of *any* size, from very small to very large. The simple wiring method is only one of many outstanding features of LCN, in addition to a mesh network topology, a highly reliable network protocol, highly sophisticated software in each of the intelligent nodes; all help to differentiate LCN from the rest.

More details on how LCN works



To make it easy for electricians to install LCN, the system does not require extra cables beside the power cable. No special wire such as twisted pair or coaxial cable is required as needed in some other building automation systems. The only requirement is that the standard electric power cable has one extra wire that will be used as the

data wire to build up the network. Method of wiring also is the same as in the conventional installation: electrical power is distributed in the building to supply electrical energy to lights and lighting fixtures and other electrical devices such as motors, heater, air condition, motorized windows. LCN bus modules are installed either in the distribution boxes, wall switch boxes or at any point in the wiring. They are programmed to perform control tasks such as turning on/off devices or dimming lights based on certain interior or exterior conditions such as temperature, daylight and time of the day. Sensors for temperature, light, motion, rain, wind speed, etc. are plugged into the intelligent modules and are automatically configured by the software. Note that wall switches do not need to be wired to electrical devices and lighting fixtures as done in the conventional wiring method. Push buttons for manual control are also plugged into LCN bus modules and can be programmed to control any device anywhere in the building. This simplifies the wiring and reduces the amount of cable needed substantially.



The bus modules are equipped with a microprocessor and can work in stand-alone mode (e.g. without having to be connected to any other module). They have power outputs to drive electrical loads (dimnable as well as switching) and have sensor ports for a large variety of plug-and-play sensors. They also have input ports for push button switches, IR receiver, binary signal reader, etc. Power supply for the electronics is taken from the power line cable directly - no extra power supply unit is needed.

State-of-the-art electronic miniaturizations allow the standard module, the LCN-UPP, to be small to fit in the wall box behind the switch or receptacle mechanics. Once installed on the bus, each unit joins a control mesh network with other bus modules. The communication among these intelligent modules happens on the extra wire

of the power cable in the form of data packages, called “telegrams”. The telegrams are structured data that contain information such as the source, destination, command and status.

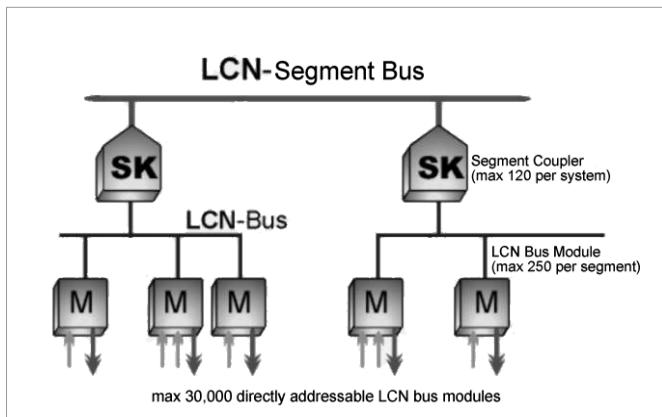
Source ID	Info	CRC	Target ID	Command	Param. 1	Param. 2
<i>Simplified Telegram</i>						

The LCN communication protocol is simple and fast yet sophisticated to allow prioritizing, grouping, broadcasting, etc. of telegrams. The whole network appears to function reliably as if it were a single control module with many inputs/outputs. Although the speed of the communication is 9600 baud, the effectiveness of the protocol allows real-time handling of more than 100 commands per second from one module to any other in the building. For example, pressing a button on the ground floor turns on the lights on the 30th floor within ten of milliseconds; practically there is no noticeable delay. The reliability of the system comes from the fact that the LCN communication protocol requires two-way communication between modules. Any command going from one module to the other requires an acknowledgment and a report of the execution status to be sent back. If failure occurred during the execution, the status report will also indicate its reason. This ensures the integrity of the control network and makes LCN a superior control network compared to others.

Expansion capability

The LCN installation can grow from a single module system to a system with a maximum of 30,000 addressable modules just by adding new modules to the power line. However, as one can imagine, the 30,000 bus modules cannot be put on one single bus line due to preservation of bus signals. The network is partitioned into smaller clusters called segments. Each segment accommodates 250 bus modules and has a max. physical line length of 1.5Km (about 1Mile). In small building structures, the whole network usually consists of one single segment, because one segment network is already a very large system, considering that only 1 to 2 modules are needed per room. A 3-bedroom house, for example, would typically need only about 5-10 units for most of the lighting and control tasks in and around the house. For high-rises or large complexes with several buildings, more units would be needed. In those cases, max. 120 segments with up to 250 modules can be coupled together using segment couplers resulting in a total number of 30,000 addressable modules in the network. The Main Tower, a 60 story building in Frankfurt, requires only around 1/3 of that maximum to provide its occupants total luxury, security and convenience using 100% LCN technology.

The LCN protocol identifies the source and destination



bus modules by their addresses (ID within its segment and segment address). Any of the 30,000 modules communicates directly with each other. By structuring the segments based on building topology - for example, each floor, or area, or building forms a segment - installers can keep the layout simple and easy to understand and maintain.

Sharing peripherals

In the LCN product lines, there are only few bus modules (they differ solely in the output power) complemented by a large number of peripherals consisting of sensors, load drives, adaptor, relays, converters, etc. The goal of LCN is to enable easy planning, because there are fewer choices to make for modules. However, the bus modules are packed with more functions than any modules from other systems. Additionally, the large number of peripheral provides many flexible ways to reach the optimal solution for each control problem, similar to using a large number of Lego blocks to build any desired object.

Peripherals on the LCN network can be shared over the network. For example, the outside temperature sensor is attached to one bus module nearby. If another bus module at the other end of the building needs to know the outside temperature, it just sends a query to the owner of the sensor and will receive the temperature information, just as if it had its own outside temperature sensor. Practically, this kind of sharing makes the whole installation appear to have more sensors and peripherals than it really does. The system works more effectively, in harmony, and can react better to both local and global events because, in many cases the bus modules acting on same source of information.

Easy programming

The LCN bus physically ties together all modules throughout the building. After the installation is done, the functions of the system are configured by a piece of programming software running on a PC called LCN-PRO. Most of the basic programming tasks are just of the point-

and-click type and none requires computer programming skills. The target audience of LCN-PRO is ordinarily trained electricians who handle all stages from planning, installing to programming the finished installation. The programming capabilities are simple to master yet flexible and sophisticated. For example, some of the switches and push buttons can just be configured to be programmed later by building occupants. Complex control scenes can be stored/recalled/changed easily. Once the system programming task is completed, the PC is no longer needed and the LCN network functions without maintenance. The complete building control program is kept on the PC as backup. If there is ever a need to replace a bus module, the program of the old module can be downloaded into the new module within seconds and all functions are restored.

The program on the modules is password protected, so that only authorized modification of the building functions is allowed.

Operation and Maintenance

In building automation systems with a central control unit, a failure at the controller will cause widespread problems throughout that also are very difficult to diagnose. In contrast, LCN system operates much more reliably thanks to the distributed control paradigm. Failure of any single bus module only leads to local problem and is easy to diagnose. To enhance reliability even further, overload/overheat conditions are automatically monitored and prevented by the firmware in the modules, long before any severe failure can occur. Because the products are vigorously tested and guaranteed for 45 years at operating temperature of 45 degree Celsius, module failure is rare.

Recovery from power failure

LCN bus modules are designed to bridge a power failure for up to 20 sec without losing track of what it was currently working on. This capability helps the LCN system to be resistant to problems caused by power line surges that plague other building control systems without extra equipment for protection. In the events of longer power failure, the whole LCN network is back to function after only few second after the power is restored.

Furthermore, LCN modules can distinguish between a long and a short power failure and execute the appropriate pre-programmed procedure in each case. For example, in a building with a backup power generator, LCN can be programmed to automatically turn off all unnecessary high load devices but keep all security and emergency functions intact, so that the building is still accessible yet overloading of the backup generator is avoided.

Network monitoring and security

Thank to the following core features in the LCN communication protocol, monitoring software and devices is aware of real-time building conditions at all time:

1. "Acknowledgement" upon receiving command by any module.
2. "Execution Status" is generated automatically by any module executing a command. These messages are broadcasted in the LCN-Bus.
3. "Status Commands" are automatically sent when a module detects a change in its (input/output) state.
4. "Error Messages" are generated upon conditions such as an overload on the power outputs or if a fuse has been blown or if the internal power supply has been overloaded by any reason.

All network telegrams can be monitored and logged using a PC that taps on the bus via the LCN-PC interface unit. The monitor program can also be configured to report alarm conditions via e-mail and/or SMS or other destinations on the Internet.

Conclusion

LCN is a cost effective and highly capable building control and automation system. Its cost effectiveness comes from the fact that the system is simple to design and install. Its payback time is short (within few years) thank to the energy usage control aspect of the system. LCN provides all required functions for a modern building: Comfort, Convenience, Lighting Control, Mechanical Control, Security, Monitor and Alarm. Last but not least, this investment significantly increases the market value of the property.

More information

<http://www.lcn-america.com>

Acknowledgment

LCN is a trademark of ISSENDORFF GmbH in Germany and other countries.

EIB stands for European Installation Bus and is a trademark of the European Installation Bus Association which has been merged into the Konnex Association (<http://www.konnex-knx.com/>)

LonWorks is a trademark of Echelon Corporation, San Jose, California, USA