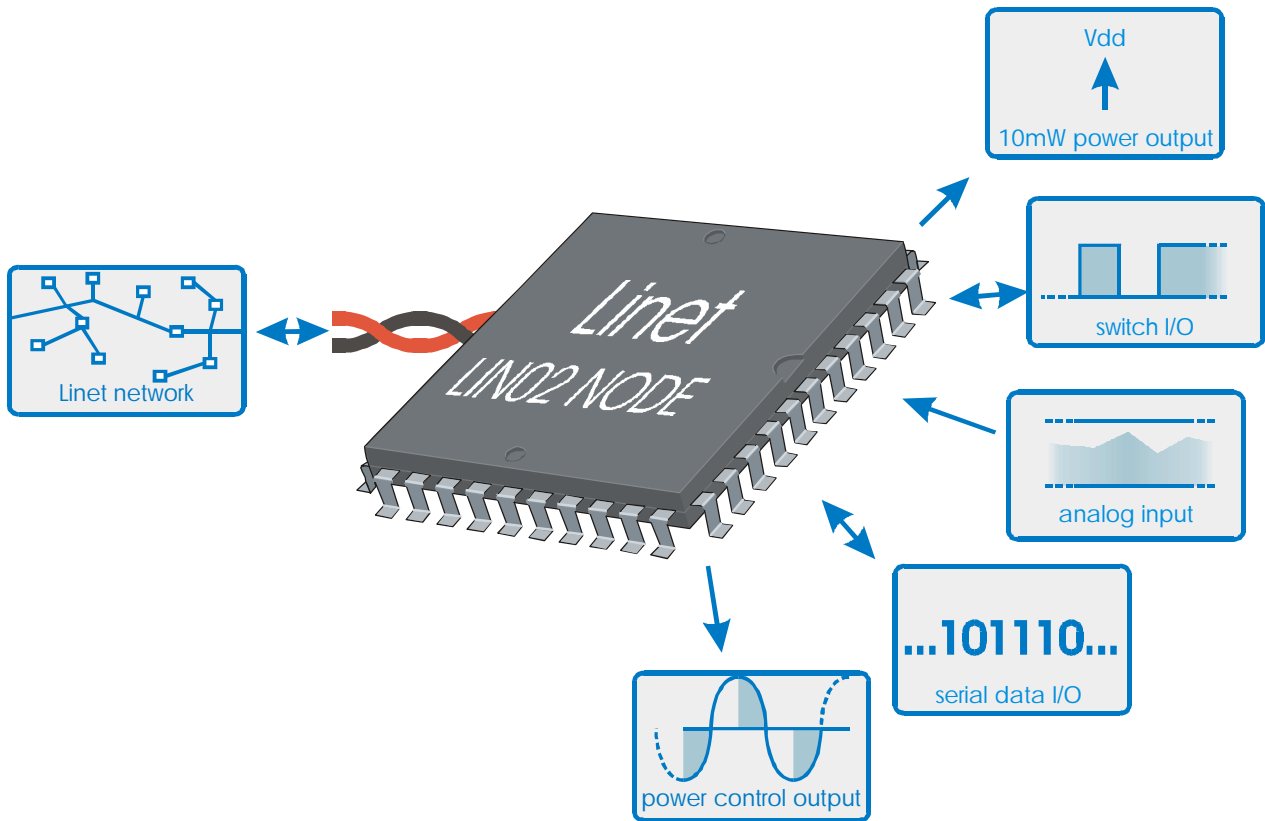


# LINET - LIGHT NETWORK SYSTEM



## GENERAL DESCRIPTION AND APPLICATION EXAMPLES

# LINET - Light Network System

## NETWORK SYSTEMS AND COMPONENTS FOR INDUSTRIAL APPLICATIONS

### GENERAL DESCRIPTION AND APPLICATION EXAMPLES

APRIL 1999

#### TABLE OF CONTENTS:

1. LINET - THE LIGHT NETWORK SYSTEM.....	3
2. LINET COMPONENTS AND CONFIGURATION EXAMPLES .....	5
3. CONFIGURING LINET NETWORK .....	10
4. LINET FACT SHEET .....	12
5. LINET APPLICATION EXAMPLES.....	13

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## 1. LINET - THE LIGHT NETWORK SYSTEM

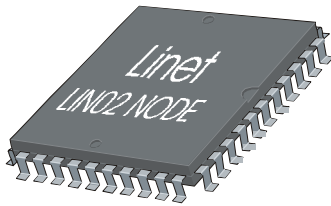
### WHAT IS LINET

Linnet is a local operational network. As such, it is intended to be used to control a network of electrically driven or controlled equipment and various types of data acquisition devices.

Linnet is a simple and easy solution for small-sized applications, where competing networks are technologically oversized. Despite its simplicity, Linnet has some unique features making it a robust and reliable solution in real-time industrial systems.

### THE LINET COMPONENTS

A Linnet network consists of a controller, network cable, and up to 200 nodes.



the node IC

The node in the Linnet system is a low cost single-chip network adapter. Instead of composing an applications program to the node, the system developer uses Linnet node's ready-made functions. The set of the functions are:

- switch input / output function,
- power control output function,
- serial data input / output function, and
- analog input.

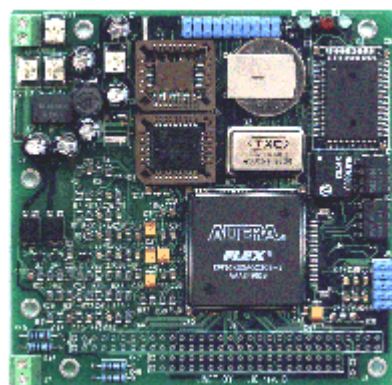
All nodes can perform all Linnet functions. However, only one function is active at a time in any given node.

The node is available as two versions: an IC or a hybrid. The IC is currently a TQFP48 packaged node, requiring a few external low-cost components to operate. It is intended to price and size sensitive OEM applications. The hybrid is a plug-and-play network card for embedded systems, being ideal to small production volumes or product development.

The network cable in Linnet system is single twisted pair cable. Both data and operating power required by the nodes are transmitted in the same, single pair. The cabling is totally topology and polarity free, and any terminating resistors are not used. This provides for maximum flexibility in designing, installing and modifying the network.



twisted pair



the controller

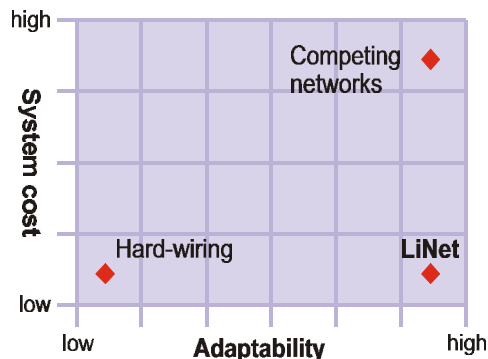
The controller is the centre of network communication during run-time. It also provides configuration services, eliminating need for any Linnet-specific configuration tools. The controller is shipped with software running the Linnet system and offering the basic set of network functions. When application specific extensions are required, they may be added to the controller software, or the controller may form a link to a computer or other host system. The controller is currently available as a PC/104 standard circuit board.

## FIVE KEY FEATURES

1. *Linnet is a low-cost solution.* This concerns not only the low-priced node chips. Due to easy system design and set-up, there are no start-up or other hidden costs in the Linet system.
2. *Linnet is easy to design, configure and administrate.* Protocol is 'embedded' in the system, so the complexity of the network is hidden from the user.
3. *Linnet operates reliably in noisy industrial applications.* Linnet uses unique signal handling procedure that ensures exceptionally high reliability.
4. *Linnet is a real-time system.* Linnet uses time division protocol. Each node has fixed signal delays and fixed data transmission capacity, which are independent from the system load or the total number of nodes in the network.
5. *Linnet is an open network.* Linnet has documented the node HW interface whereas competing systems document SW interface. The target is the same: devices from different manufacturers operate seamlessly in the same network.

## THE ADVANTAGES

Traditionally distributed control systems are built using either fixed, hard-wired control cabling or high-end operational network. The former is relatively easy to design, but adapts poorly in modifications or expansions required to the system during its lifetime. Use of the latter requires heavy investments in training, development tools and designing, and leads to complex solutions in simple applications. In fact, most of the competing networks are inherited from data networks, so drawbacks of those networks are inherited as well.

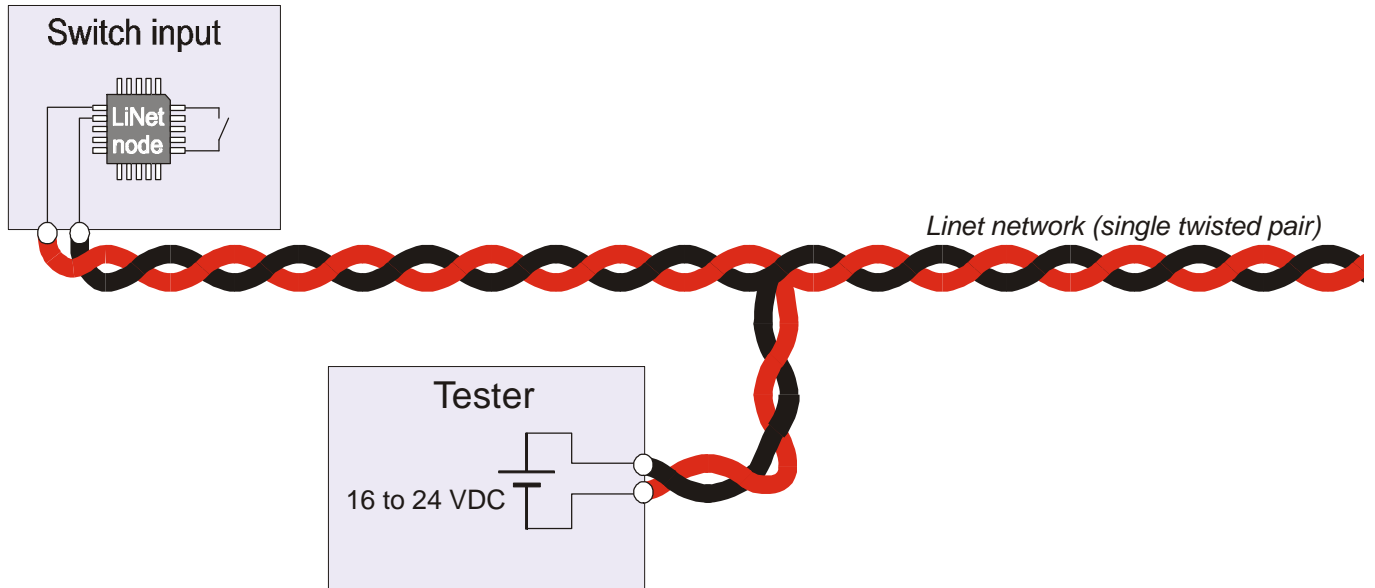


Linet was designed from scratch to meet the requirement for simple networking in simple application. Linet is absolutely the easiest network to design, configure and administrate. Linet users enjoy fast time-to-market, high reliability and low manufacturing cost for their product.

## LINET - THE COMPANY

Linet Oy is a privately held company committed in developing, producing and marketing components for the Linet light network system. Intensive product development has been going on from year 1995, when the company was founded. All members from the group of Linet system designers have long experience in electronics and embedded systems design. The experience of the group includes designing integrated industrial communications and telecommunications circuits for ABB, Nokia and other leading companies. The experience and know-how behind Linet is of the highest rank in its country.

## 2. LINET COMPONENTS AND CONFIGURATION EXAMPLES<sup>1</sup>



### INPUT SWITCH

The node has ready-made input to filtered, uniquely addressed switch input. To read the input, the switch is simply connected to the node.

The switch may perform as a lighting switch or brightness controller in home automation applications, as well as a limit switch or a photo switch input in industry automation etc.

### TESTER

As the network is being installed, electrician connects a battery, or any other DC voltage source, to the network. When a node senses DC voltage but no carrier, it goes into self-diagnostics mode. This way, the electrician can test each node right after it is installed and verify that the network and mains (when present) is connected properly, and that the node device is operating.

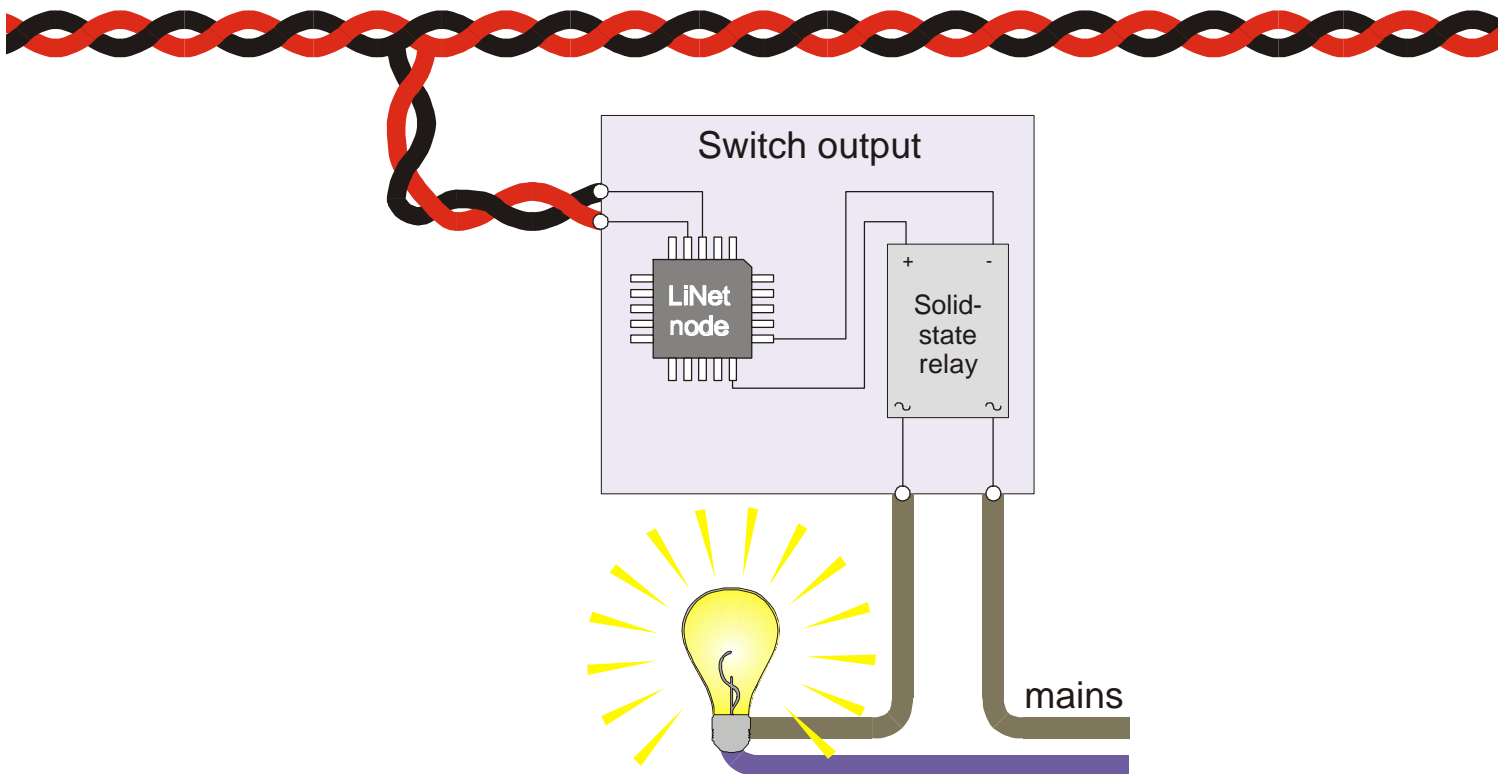
This same simple test method can be used in production of the node devices.

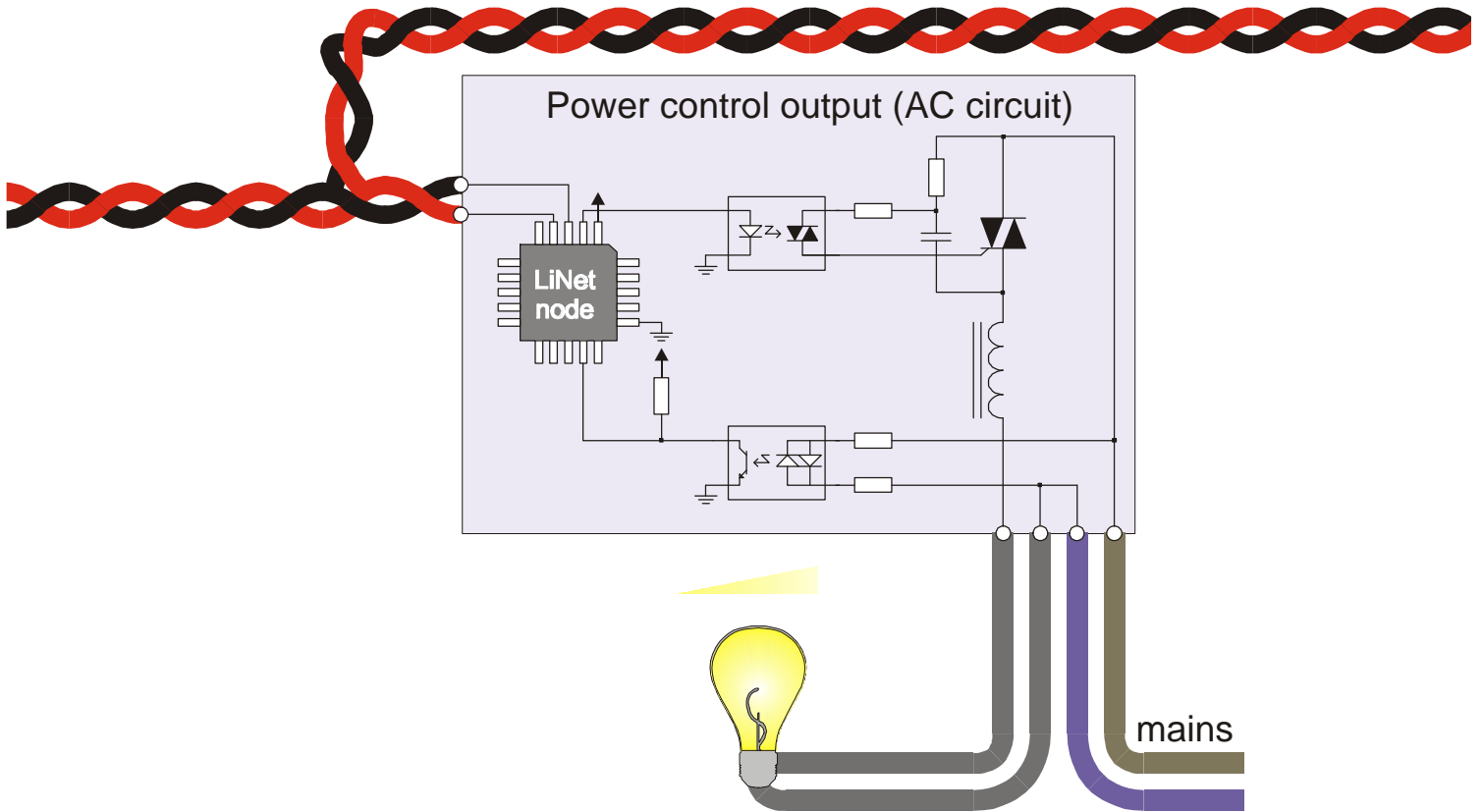
<sup>1</sup> Circuits in this chapter are to describe the use of the Linet node HW interface in various applications. The Linet node IC requires a few external components to operate. Because of clarity, they are not included. When the Linet node symbol is understood as the 'Linnet hybrid node', these circuits can be considered complete.

## SWITCH OUTPUT

To switch loads in the network on and off, the node is connected to a commercially available solid state relay. The node can drive any voltage or current, when the relay is selected according to the load ratings. The solid state relay can be also used to drive a contactor that requires high coil current.

The node's switch input is not tied to the output. In switch output applications, the input on the same node can be used to monitor system feedback signal.

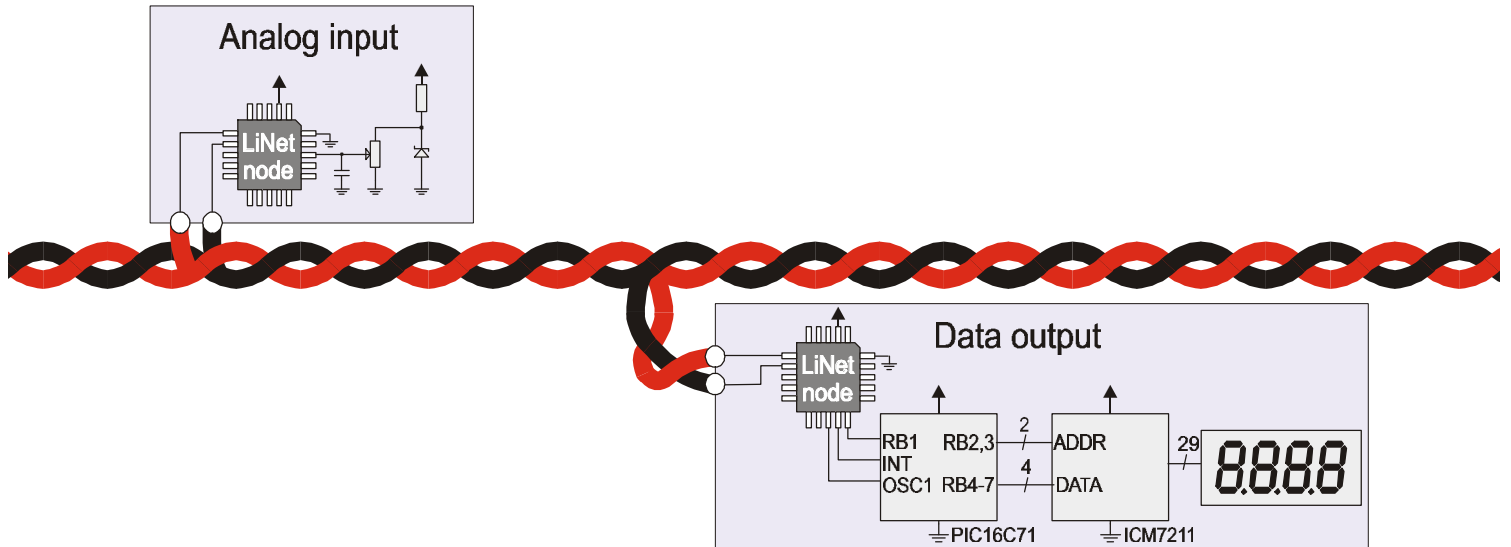




### POWER CONTROL OUTPUT

Linnet node has ready made functions to control power of a load - such as incandescent or halogen lamp, or pump or fan motor. AC loads are controlled using a typical phase angle controller circuit; DC loads are controlled using pulse width modulation.

The power of the load can be set by the Linet network controller, or by a pushbutton input switch. A short push on such input switch switches the load on and off, a long push adjusts the power.



## ANALOG INPUT

For maximum simplicity, the Linet node includes on-chip A/D-converter. To read analog measurement, like temperature or humidity information, the only design effort required is to scale the analog voltage to the on-chip converter input voltage range.

The A/D-converter result is a 12-bit integer, which is transmitted approximately 4 times per second. Note that because Linet is a synchronous system, there can be up to 200 analog input nodes in the network, all transmitting 4 readings per second simultaneously.<sup>2</sup>

The example circuit above uses a potentiometer as the analog voltage source.

## DATA OUTPUT

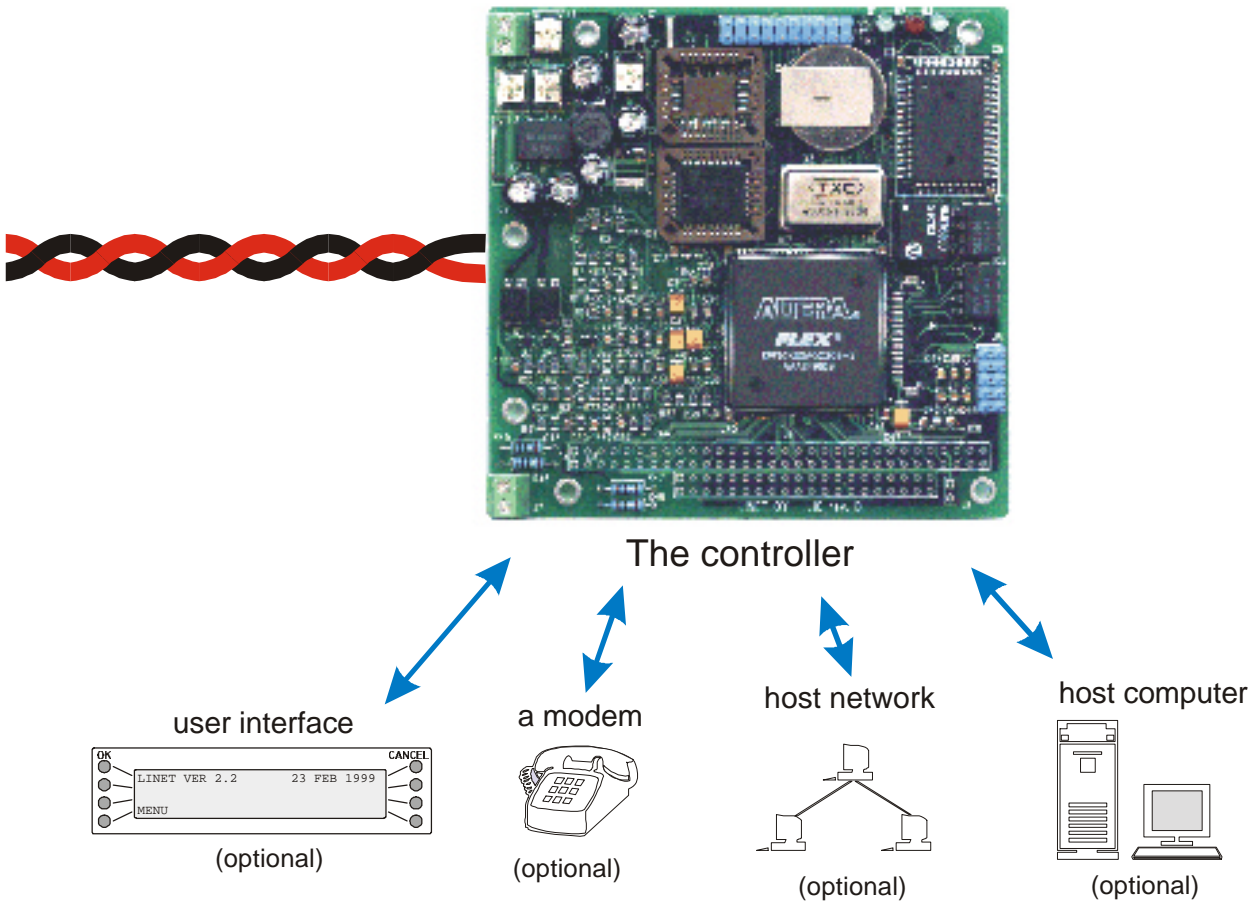
When the application requires distributed intelligence, the node is connected to a microcontroller. The application developer can choose any such processor he already is familiar with.

The node supplies serial data input, serial output and serial clock pins to send and receive synchronous, serial data at a constant rate. The node also supplies operating power to the microcontroller, so any external power supply is not needed.

In the above example, the device is a data display node. It is capable to display numeric information fetched by the controller, analog input node, or other kind of data node in the network.

<sup>2</sup> The transmission rate comes from the fixed full duplex capacity of 80 bits/sec per each node. As the maximum number of nodes in the network is 200 pcs, the system data rate is therefore 200\*80 bits/sec.





*THE CONTROLLER*

The controller supplies operating power and carrier signal to the Linet network. It runs the Linet operational system, which provides the basic network functions. When application specific additions are required, they may be written to the controller software.

The controller operates stand-alone, but it can also form a link to other systems, such as host computers, networks or modems. For this connectivity, the controller has a set of alternative interfaces: RS232/485 serial interface, PC/104 ('industrial-ISA') parallel interface, and extension bus interface.

The controller is also the tool to configure and administrate the network. To configure the network, either a user interface or a terminal (a PC running standard terminal application) is connected to the controller. When the configuration is done, the interface, or terminal, can be removed, and the controller will continue its operation stand-alone.

### 3. CONFIGURING LINET NETWORK

*NO TOOLS REQUIRED*

Configuring Linet network is very simple so it nearly removes the need for training. In home automation applications, for example, the tenant himself can operate his home control network. Any Linet-specific tools are not required either.

A couple of words from the node. All Linet nodes are similar, no matter what is their application, and there are no fixed machine addresses. Instead, each node contains 8 bits of EEPROM-memory to store their network address, which is an integer between 1 and 200. The node's address can therefore be configured by software, and modified later, when necessary. The node also keeps the address during power shutdown, or if the node is temporarily removed from the network.

*THE CONFIGURATION INTERFACE*

The Linet controller provides the necessary functions to configure a network. A user interface is required for configuring. It can be a PC or other computer running a terminal program, or alternatively a fixed interface consisting of a 4x20 character LCD display and 8 pushbuttons. Either of the interfaces is required only during configuration, and can be removed at run-time.

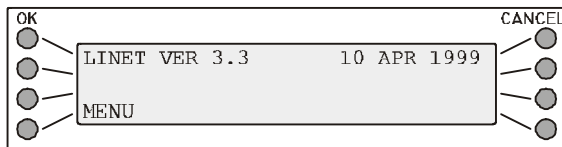


Illustration of the user interface layout.

*CONFIGURING A SWITCH ON/OFF APPLICATION*

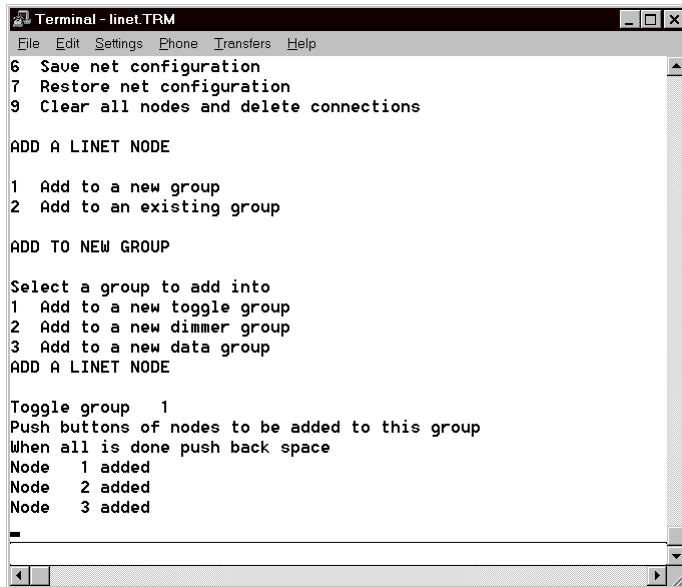
In a lighting application there is lighting fixture on the ceiling and lighting control pushbuttons at, say, both of the room's two entries. If these devices are desired to operate jointly, they are configured to be a *group*.

The operator first selects a command to make a new group. On the interface, he selects 'MENU' after which the interface enters a submenu, including functions as 'CONFIGURE NETWORK', 'VIEW NETWORK STATUS' and so on. The user selects 'CONFIGURE NETWORK' then 'ADD A LINET NODE', and finally 'ADD A NEW GROUP'. The function is selected by pressing the appropriate softkey on the user interface, or the corresponding number key on the terminal.

Now the controller prompts a list of available group types, which are toggle group, dimmer group and data group. At this moment, the operator tells the system the function of the group that is under construction. The user selects 'ADD A NEW TOGGLE GROUP', as it is a light switching application. (Triac dimmers and other power controllers would make a dimmer group. Sensors for temperature, humidity etc. use data group.)

Now the interface prompts the user to indicate the nodes to attach to the new toggle group. The user presses the light switch pushbutton in the room. If the node has not been previously configured, the controller automatically assigns a network address to the node. The controller uses the lowest unused address for this. At the same time, the controller adds the node to the logical toggle group.

After the first pushbutton, the user presses the next one and continues doing so until all the nodes that are intended to be in this group are indicated. When done, the user goes to the interface and returns to the root menu.



```
Terminal - linet.TRM
File Edit Settings Phone Transfers Help
6 Save net configuration
7 Restore net configuration
9 Clear all nodes and delete connections

ADD A LINET NODE
1 Add to a new group
2 Add to an existing group

ADD TO NEW GROUP
Select a group to add into
1 Add to a new toggle group
2 Add to a new dimmer group
3 Add to a new data group
ADD A LINET NODE

Toggle group 1
Push buttons of nodes to be added to this group
When all is done push back space
Node 1 added
Node 2 added
Node 3 added
```

A screenshot from the terminal interface during configuration.

That's all there is. In the toggle group, any of the pushbuttons in the group switch all lights in the same group.

#### NOTES ON THE CONFIGURATION

Adding more devices to the system - other toggle groups, dimmer and/or data groups - is analogous to the previous example. A full size network consisting of 200 nodes can take less than an hour to configure.

Same type of pushbutton node can be configured into both toggle and dimmer groups. In a dimmer application, a short push on the button switches the light and a long push adjusts its brightness. Note that the dimmer action is active on all nodes within the group, even on the pushbuttons, but there nothing is connected to the corresponding outputs.

A pushbutton on each node is required to configure the node. The tiny pushbutton on the hybrid can be used to this, as well as any external switch connected to the node's ON/OFF.IN pin (the external switch connected to that pin is in parallel with the onboard pushbutton on the hybrid node). Sometimes the device containing the node is installed into a location that is difficult to reach during configuration. To override this problem, the address can be configured to the node before it is installed, or the external pushbutton can be replaced with a light sensitive transistor, and the transistor can be pointed to with a laser-pen.

## 4. LINET FACT SHEET

### *THE NETWORK STRUCTURE*

- Single twisted pair cable network.
- Data and node operating power transmitted in the same cable.
- Totally topology and polarity free network.
- No terminating resistors required.
- Max. length of network cable 200 m.
- Max. 200 nodes in each network.

### *THE NODE*

- Ultra low power consumption (4 mW).
- 3mA current output capacity.
- Polarity free network connection.
- Integrated switch input/output function.
- Integrated power control output function.
- Integrated serial data input/output function.
- Internal A/D-converter (from LIN02 upward).
- Available as a low-cost IC or a hybrid.

### *THE CONTROLLER*

- Stand-alone network controller.
- Optionally forms a link to host computers or systems.
- RS232/485 serial interface.
- PC/104 ('industrial-ISA') interface.
- Extension bus interface.
- Available as a PC/104 circuit board.

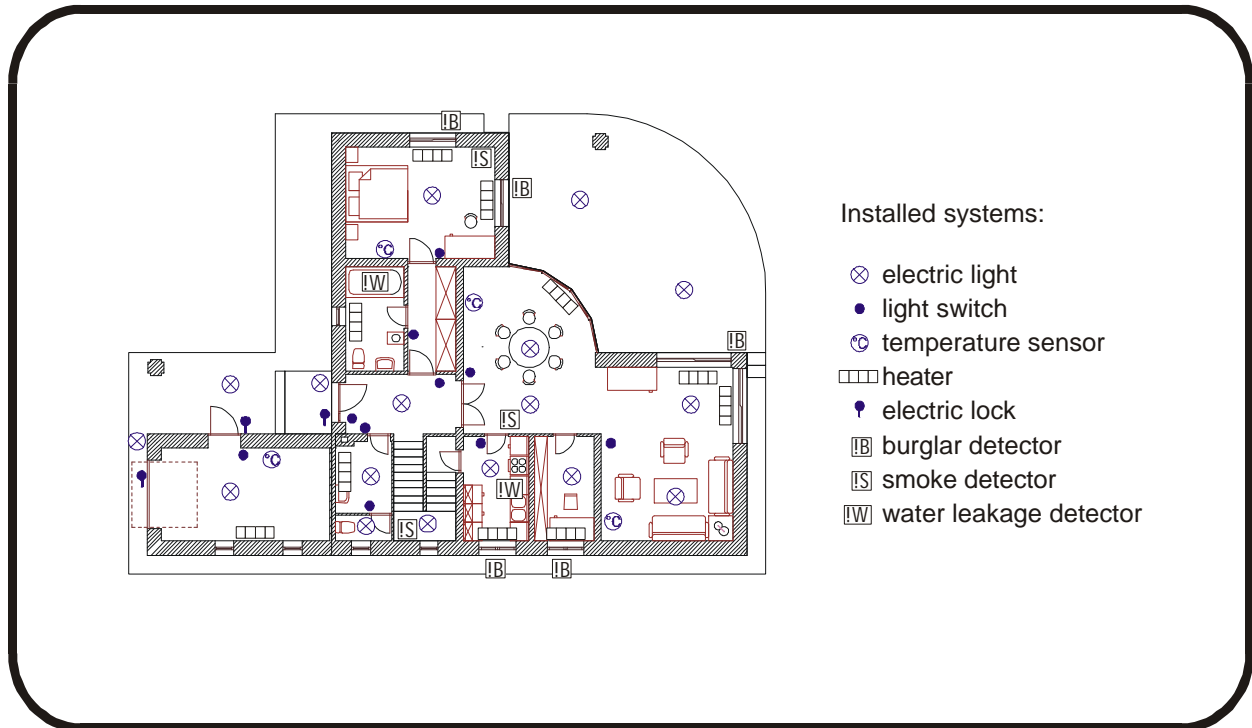
### *THE PROTOCOL*

- Time division protocol - no collisions.
- Fixed capacity that doesn't depend on system load.
- Fixed propagation delays.
- Low noise system - signalling based on 20kHz sine wave carrier.
- Protocol 'embedded' in the system.

### *BENEFITS FOR THE USER*

- Complexity hidden from the user.
- Easy system design, network configuration and administration.
- Fast time to market.
- No programming required during application manufacturing, installation or configuration.
- No Linet-specific development tools required.
- Open system - no obstacles for multi-vendor installations.

## 5. LINET APPLICATION EXAMPLES



### HOME AUTOMATION

#### *LINET IS A NEW OPPORTUNITY*

Use of automation in controlling electrical home appliances improves security and comfort, and reduces energy consumption. Today, many home automation systems are available as separate products that are hard-wired to the building. If many systems are installed, the total amount of cabling can be amazing. Such system is difficult, or impossible, to modify or expand.

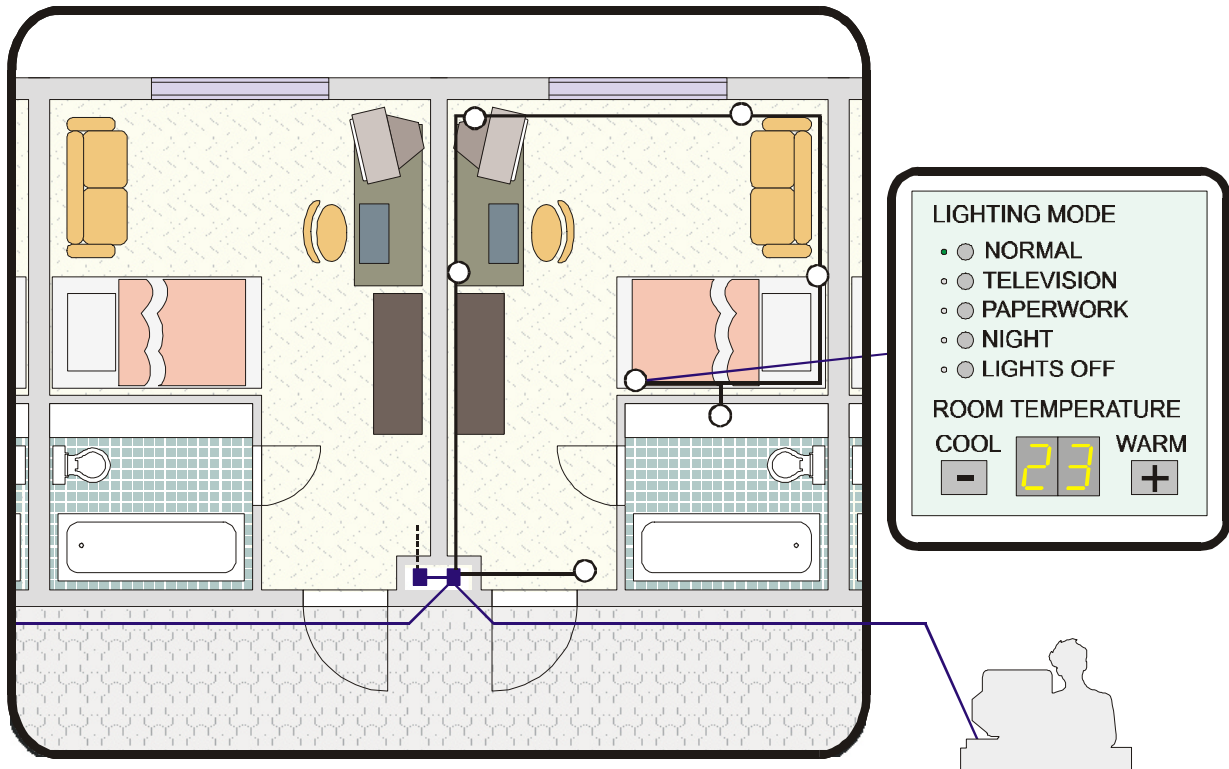
Linnet is an excellent base to expand the use of building automation into one family houses. It offers the functionality that meets the requirements in these applications where it's competitors are far too expensive and difficult to adopt.

#### *INTEROPERABILITY*

Linnet is a multi-vendor network by nature.

#### *EASY ADMINISTRATION*

Linnet is the easiest network to design, configure and administrate. Setting up and administrating Linnet system is so simple even the tenant himself can be the master of the network.



**AUTOMATION IN HOTEL ROOMS**

*LINET AND DATA NETWORK COMBINED*

Building automation in hotels improves comfort and security, and lowers energy consumption. A Linet network can control each room, so there is one Linet controller for each room. The controllers are linked together using Intranet, or other high capacity data network. This solution combines the easiness and low cost of the Linet and high capacity of the data network.

*ENERGY SAVINGS*

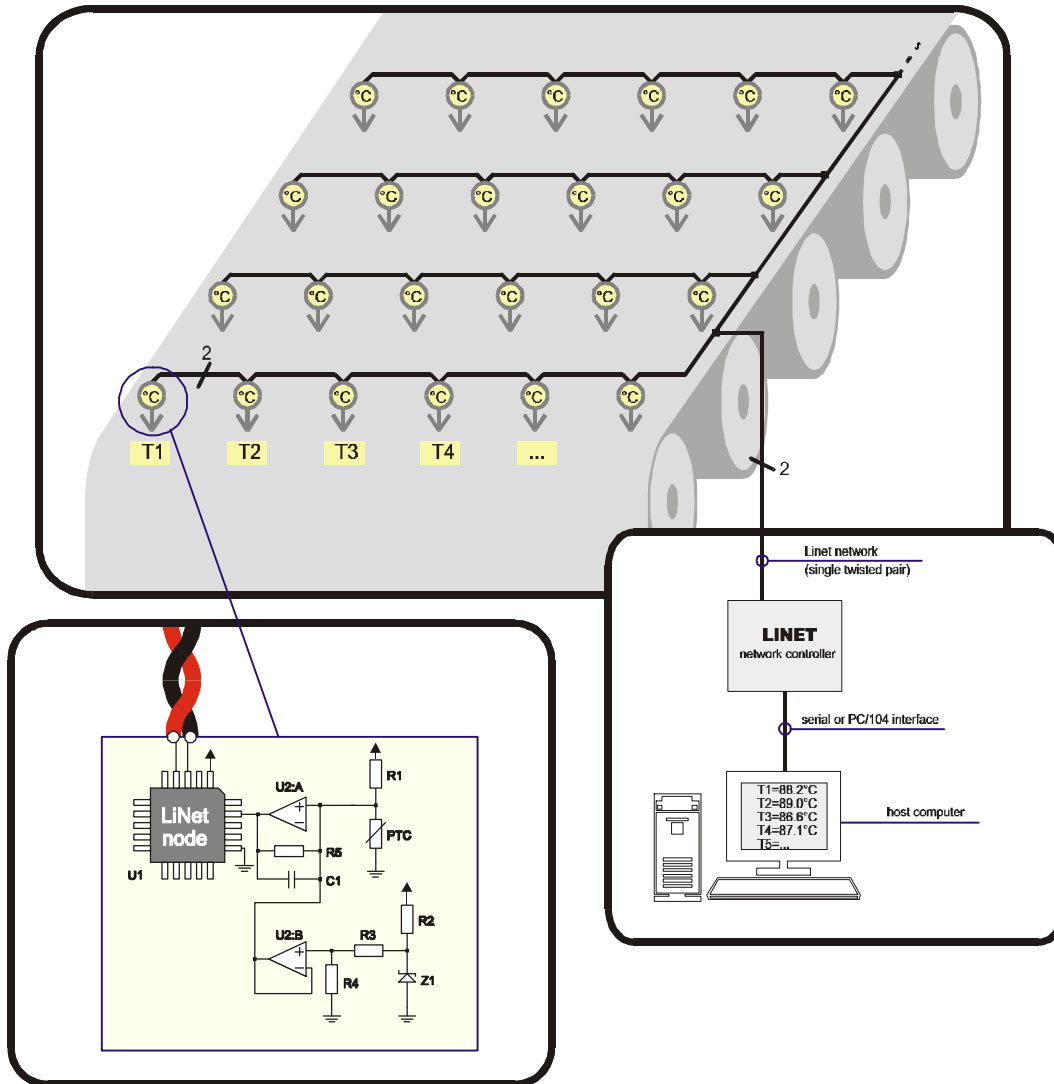
What happens when the guest leaves the room all lights and television switched on, and air conditioning set to maximum? In a controlled system, lighting and TV will automatically be shut down and power of air conditioning reduced. When the guest enters the room, the system will return to the original state.

*SECURITY AND ALARM SYSTEMS*

When the building is equipped with a control network, functions required by security and alarm systems are easy to implement. In case of a fire alarm, for instance, such system will switch all lights on, sound alarm, reduce ventilation, and alert fire service.

*IMPROVED COMFORT*

Lighting can be based on pre-set settings rather than switching discrete light. For example, a 'night' mode would mean just dim light in the corridors and toilets.



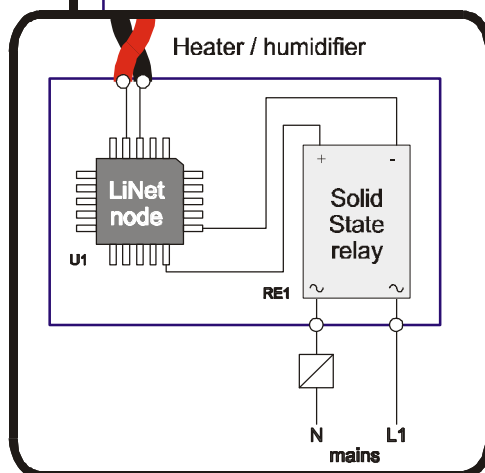
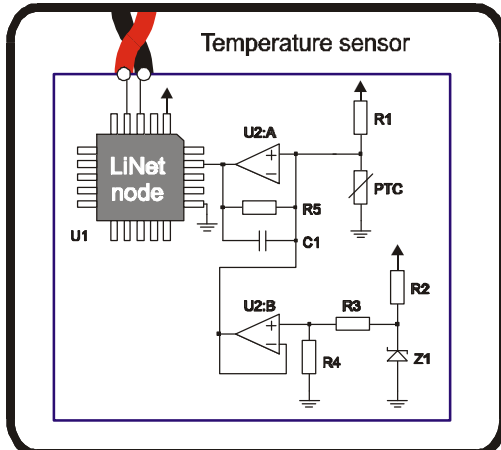
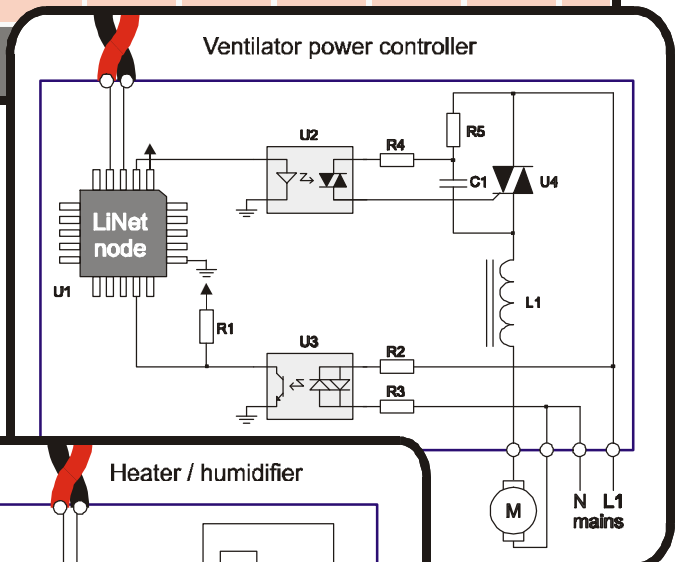
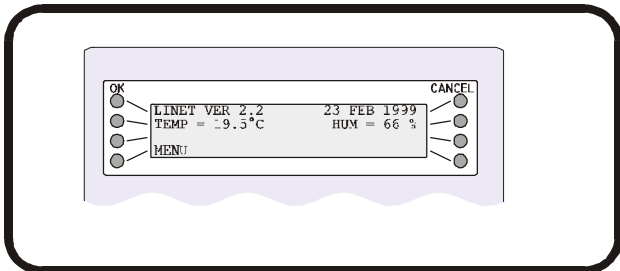
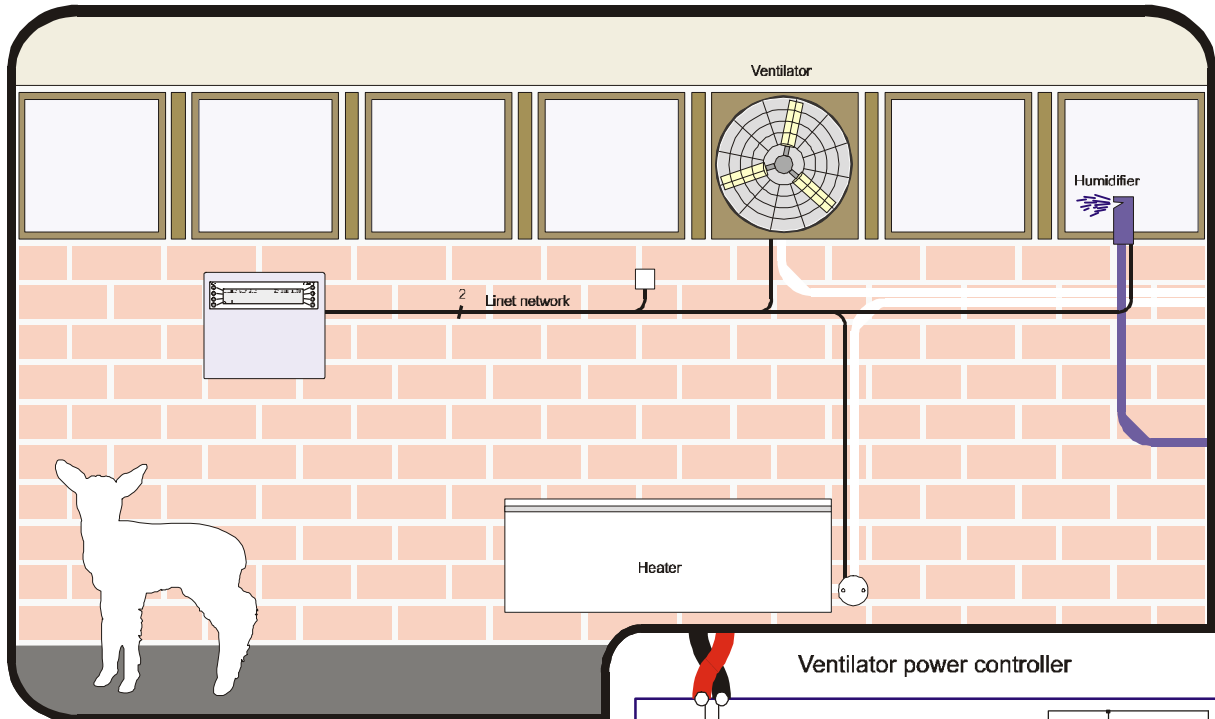
**TEMPERATURE MEASURING MATRIX**

*EFFECTIVENESS AND SIMPLICITY*

The Linet network first perfectly in many industrial automation applications. Data acquisition systems like sensor matrix, which is widely used in process industry, benefit in the synchronous time division protocol of the Linet network.

*APPLICATION FEATURES*

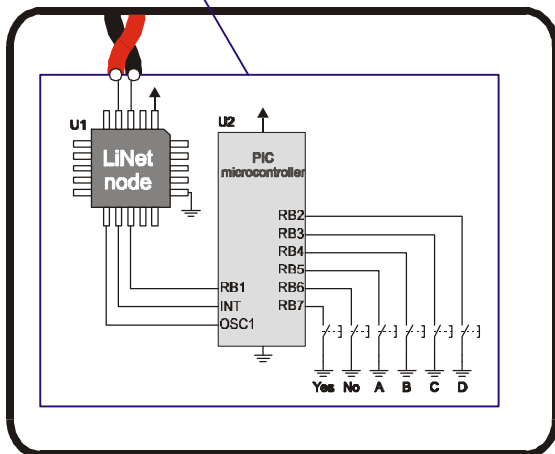
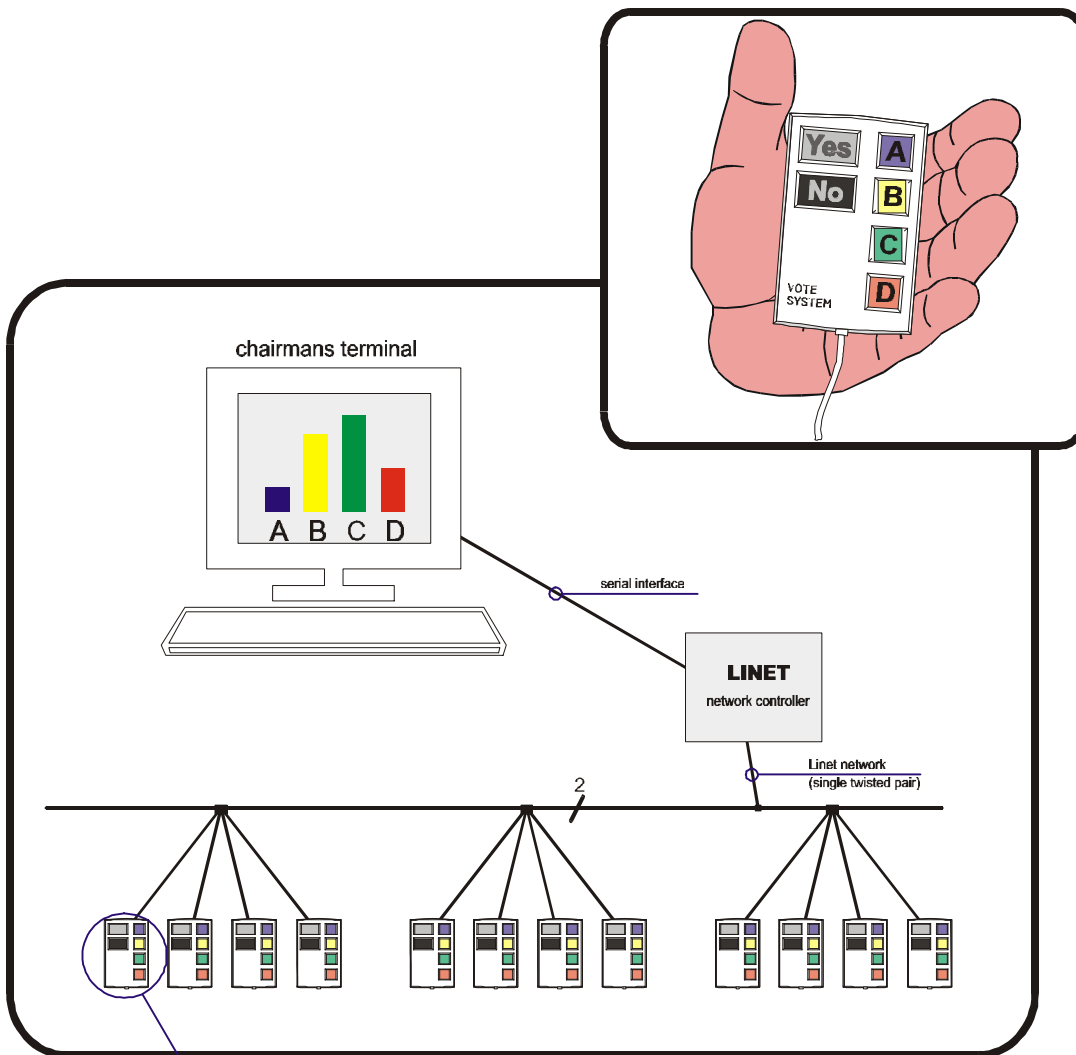
- 12-bit resolution using built-in A/D-converter.
- Simple and low cost node circuit.
- Simplest cabling - single twisted pair.
- Fully synchronous system.
- Four samples per second from each node, from up to 200 nodes simultaneously.



**SHED VENTILATION SYSTEM**

The Linet network can easily control fans, heaters, sensors and other appliance required in a ventilation system. The Linet controller is used as the ventilation system user interface. The required application specific functions are added as custom features to the controller software.





## VOTE SYSTEM

In the vote system, all participators have a response unit containing pushbuttons named 'yes', 'no', 'A' to 'D' etc. When voting has finished, chairman immediately sees the result from his terminal.

A vote system for up to 200 participators can easily be build using the Linet network as the basis.