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2. INTRODUCTION

IP-LINK is intended to be use with SATELLINE radio modems to form a wireless TCP/IP network. IP-LINK is connected to the Ethernet and to the radio modem. IP-LINK sends data from Ethernet to the radio modem and from the radio modem to the Ethernet. At least two IP-LINK units and radio modems are needed for communication.

IP-LINK is based on the Linux operating system. The operating system and memory is on chip, so there are no moving parts in the device and therefore it has a very high reliability.

A random radio protocol helps to avoid collisions in the radio modem network.
Data on the radio modem network can be encrypted to ensure privacy and can be compressed to achieve higher transfer speed.

3. TECHNICAL SPECIFICATIONS

Front side connectors.

Front side connectors (from left to right)

1. RJ45 10/100 M Ethernet connector. Use CAT5 UTP cable.
2. D9 console connector. This is used for changing the settings of the IP-LINK. A null modem cable must be used and settings 9600 baud, 8 data bits, none parity and 1 stop bit.
3. Radio modem configuration PROG switch. This button sets the radio modem to the PROG mode; enables to change the radio modem settings from the console connector. Power is not lost from the IP-LINK. For normal operation the switch should be down.
4. Reset button. Press shortly to boot the device. This also affects to the D15 connector in the back side. If the reset button is pressed for 10 seconds all the settings and password are set to the default.
5. Power connector. Use 9-30 V DC. This is also the power applied to the D15 connector in the back side.

IP-LINK D9 MALE CONNECTOR

PIN 5 SGND
PIN 9 NC
PIN 4 NC
PIN 8 NC
PIN 3 TD, out
PIN 7 NC
PIN 2 RD, in
PIN 6 NC
PIN 1 NC
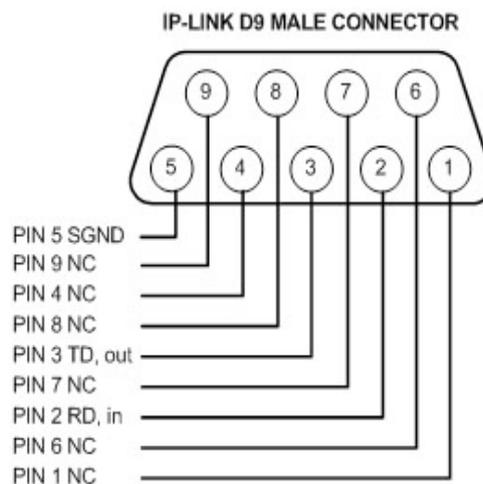
D9 console connector.

Back side connector D15
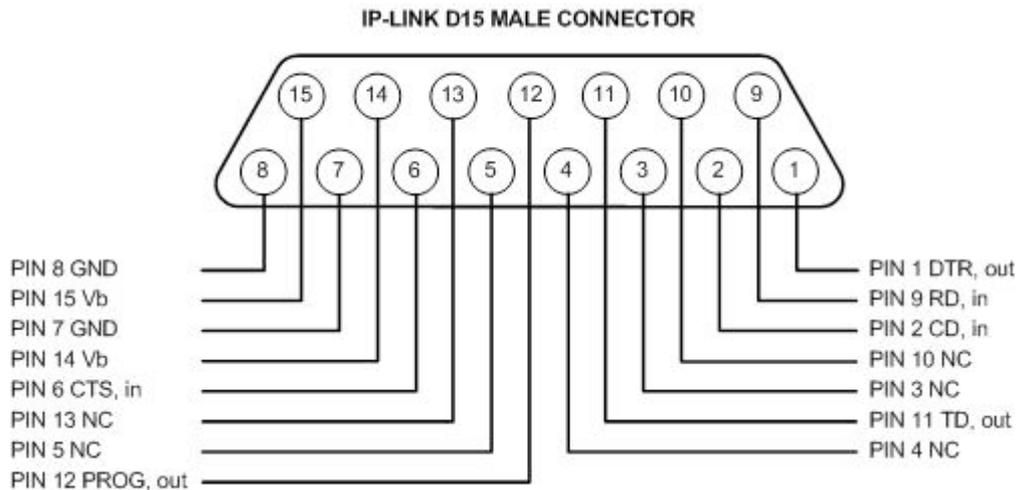
D15 radio modem connector.

Backside connector is used to connect the radio modem to the IP-LINK. Please turn off power from IP-LINK when installing radio modem to avoid short-circuiting D15 power and data signals. The DTR signal controls the radio modem power and it is not ON until the IP-LINK has finished booting.

LED indicators
At start-up when power is connected the first five LEDs are ON (RED) for a moment.
POWER – when power is ON, the LED is RED
STATUS 1 – when the device is booted and is ready to operate the LED is BLINKING (RED)
STATUS 2 – when the radio modem programming switch is ON, the LED is RED
TD – when the device sends data to the radio modem D15 connector the LED is ON (RED)
RD – when the device receives data from the radio modem D15 connector the LED is ON (RED)
ETH LINK – when the Ethernet cable is connected to the RJ45 connector the LED is ON (RED)
ETH ACTIVITY – when the device sends or receives data to / from the Ethernet the LED is ON (RED)

STATUS 1 and STATUS 2 ON at the same time - the radio modem programming switch is ON

5

Technical characteristics:

General Specifications

Operating Voltage	9-30 VDC
Operating temperature	-20 - +50 °C
Current Consumption	300mA @ 12V DC + the radio modem power consumption
Size	115 x 90 x 30 mm
Weight	120 g

Connectors

- Power	screw connectors
- Radio modem	D15 male
- Console	D9 male
- Ethernet	10/100 M RJ-45
- Reset button	
- Radio modem PROG switch	

Boot up time	45 seconds

Supported protocols	HTTP, IP, TCP, UDP, FTP, ICMP, ARP, DNS, TFTP

Accessories
YC0271 CRS-TSU (2 m D15m / D15f extension cable between IP-LINK and radio modem)
ME0210, DIN-rail mounting plate

Radio modem compatibility	SATELLINE-3AS with 3.xx software

4. INSTALLATION

Install IP-LINK in a shielded place, not directly outside. The operating temperature should be inside the limits -20 … +50 °C. Take in to account the effect of the sun light heating and condensation of the installation cabin. Recommendable maximum cable length for console cable is 10 meters. The maximum length of the Ethernet cable depends on the network; usually 100 meters at maximum. The cable between IP-LINK and radio modem can be up to 10 meters.

Bottom side with the installation plates.

The bottom side with DIN rail installation part vertically.

The bottom side with DIN rail installation part horizontally.

NOTE! Use only 3 x 6 mm screws! Otherwise the hardware inside might be damaged.

The IP-LINK should be connected to a radio modem with D15f - D15m extension cable CRS-TSU.

5. PROPERTIES

5.1 TCP/IP NETWORK MODEL
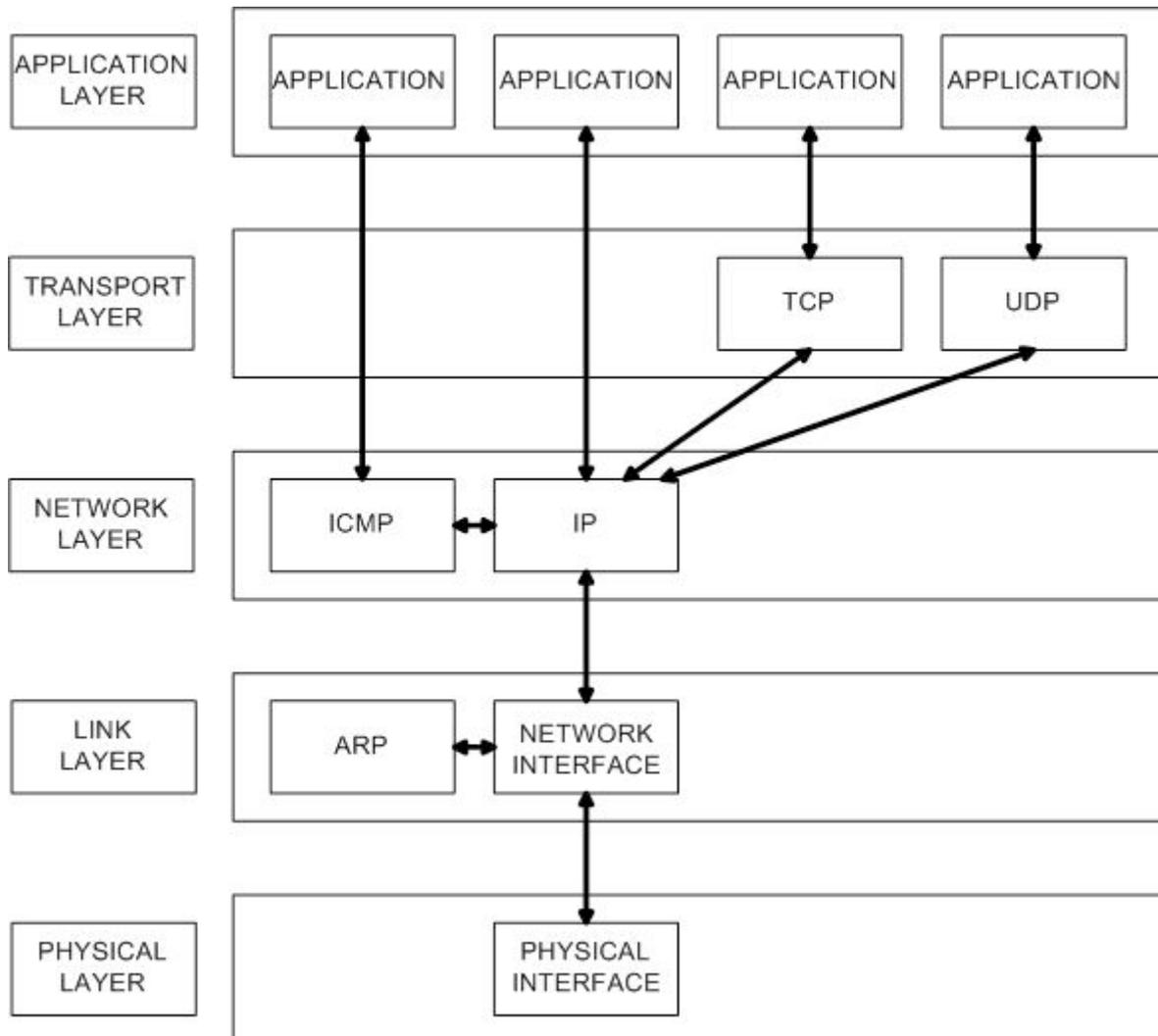
TCP/IP network model

The application can use different lower layer protocols for communication. Most common applications are WWW with HTTP (Hyper Text Transfer Protocol), file transfer with FTP (File Transfer Protocol), DNS (Domain Name Service) and Ping with ICMP (Internet Control Message Protocol). HTTP and FTP are application layer protocols. The protocols are divided to multiple layers; a change in one protocol layer does not necessitate a change in the application. Also applications on different physical networks can communicate with each other. For example Internet browsing from dial-up connection uses the same application (browser) as Internet browsing from LAN (Local Area Network).

5.2 <u>TCP AND UDP</u>

TCP (Transport Control Protocol) is a reliable protocol, which opens connection and has acknowledgements to ensure the data transmission with retransmissions, if needed. If the retransmissions are needed, those are sent after a retransmission timeout. The retransmission timeout value depends on the network, baud rate and response time. In narrow band radio network the retransmission timeout can be several seconds. The data is transferred in segments that have a variable size. The maximum size is limited by MSS (Maximum Segment Size) setting. TCP adds a header to the transmitted data.

UDP (User Datagram Protocol) is an unreliable protocol. UDP does not have retransmissions. UDP is mostly used for audio and video broadcasting where the missing data is not critical. TCP and UDP open the connection to an IP address and a port address, this combination is called socket. The port address is usually not shown in customer applications. For example web browsers open the connection by default to port 80, which is used for HTTP (Hyper Text Transfer Port). The ports are divided into three ranges: the Well Known Ports (0-1023), the Registered Ports (1024-49151) and the Dynamic and/or Private ports (49152-65535). The port numbers are only needed to know if the firewall is configured to limit access to the unwanted ports.

Port number	Description
20	FTP
21	FTP
22	SSH / Secure Telnet
23	Telnet
25	SMTP
43	Whois
53	DNS
68	DHCP
79	Finger
80	HTTP
109	POP2
110	POP3
119	NNTP

Commonly used ports. The full list is available at www.iana.org/assignments/port-numbers

5.2.1 <u>IP</u>

IP (Internet Protocol) is used to route packets. The IP-LINK operates at this layer. The IP address should be unique for every network interface in the same network. The IP address is a logical address but also a physical address, MAC, is needed. TCP and UDP packets are capsulated in IP packets, which means that an IP header is added to TCP and UDP packets.

The IP addresses are classified to classes from A to E. IP addresses inside the company networks are normally using the classes from A to C. The classification can be seen in the below table.

Class	First address	Last address
A-class private	10.0.0.1	10.255.255.254
B-class private	172.16.0.1	172.31.255.254
C-class private	192.168.0.1	192.168.255.254

Private IP address ranges.

Note that the addresses ending to ".0" or ".255" can not be used in the network interfaces, because those are reserved for broadcasting. IP address 127.0.0.1 is internal loop back - address for the operating system.

IP addresses are 32 bits wide. The IP addresses are presented in dotted decimal format so it would be easier to read. For example the binary format IP address 11000000 10101000 00000000 00000001 is 192.168.0.1 in dotted decimal format.

If the network interface would forward every packet in the network to the operating system, it would take a lot of unnecessary time. Therefore IP addresses have an IP mask. If the IP address is valid after masking it the packet is forwarded to the operating system, otherwise it is discarded. With IP masks it is also possible to make logically separate networks in the same physical network. The IP mask is 32 bits wide, as is the IP address. For example network interface 192.168.0.1 receives a packet from the network interface 192.168.0.254. The mask for 192.168.0.1 is set to 255.255.255.0. The sender IP address and receiver mask are combined with an AND-operation.

Sender IP address 11000000 10101000 00000000 11111110 (192.168.0.254)
Receiver mask   11111111 11111111 11111111 00000000 (255.255.255.0)
AND result   11000000 10101000 00000000 00000000 (192.168.0.0)

The AND result is in dotted decimal format 192.168.0.0. Because it is the same network where the receiver is the network interface forwards the packet to the operating system.

If the packet is sent from address 192.168.8.254 the result is as follows:
Sender IP address 11000000 10101000 00001000 11111110 (192.168.8.254)
Receiver mask   11111111 11111111 11111111 00000000 (255.255.255.0)
AND result   11000000 10101000 00001000 00000000 (192.168.8.0)
The result is not in the same network as the receiver so the packet is discarded.

To simplify the IP address and mask notation, the mask can be presented as a number of significant bits (ones). This is called the CIDR notation. Mask 255.255.255.0 can be presented as "/24" after the IP address in CIDR notation. The following table has some of the masks in different notations.

IP network	Mask in dotted decimal	IP address and mask in CIDR notation	Maximum amount of devices in network
10.0.0.0	255.0.0.0	10.0.0.0/8	16777214
172.16.0.0	255.255.0.0	172.16.0.0/16	65534
192.168.0.0	255.255.255.0	192.168.0.0/24	254
192.168.0.0	255.255.255.128	192.168.0.0/25	126
192.168.0.0	255.255.255.192	192.168.0.0/26	62
192.168.0.0	255.255.255.224	192.168.0.0/27	30
192.168.0.0	255.255.255.240	192.168.0.0/28	14
192.168.0.0	255.255.255.248	192.168.0.0/29	6
192.168.0.0	255.255.255.252	192.168.0.0/30	2

Different masks with different notations.

The mask must be contiguous so no binary zeros are allowed between binary ones. Therefore one field can only have values 255, 254, 252, 248, 240, 224, 192, 128 or 0.

Note that some network device manufacturers use inversed masks. They count the significant bits from the end of the mask. In these cases 255.255.255.0 would be 0.0.0.8 and "/24" would be "/8".

The IP broadcast address is used to send packets to every device in the same network. The IP broadcast address ends to ".255". The IP broadcast address must not be used as an IP address for the device.

5.2.2 ICMP

ICMP (Internet Control Message Protocol) is the protocol for different IP layers to talk to each other. ICMP is mostly used to inform error situations, like destination network unreachable. Also the Ping program uses ICMP directly from the application layer.

Type	Name
0	Echo reply
3	Destination unreachable
5	Redirect
8	Echo request
11	Time exceeded
12	Parameter problem

The most common ICMP types. The full list is available at www.iana.org/assignments/icmp-parameters

5.2.3 MAC ADDRESS AND ARP

IP address, the logical address, alone is not enough addressing information for the communication; also a physical address is needed. In Ethernet the physical address is also called MAC address (Medium Access Control). The IP address can be changed but the MAC address is always fixed and individual for the network interface.

The MAC address is 48 bits long and it is usually presented in two formats; MM:MM:MM:SS:SS:SS (e.g Linux) or MM-MM-MM-SS-SS-SS (e.g Windows). The first half is the unique code for the manufacturer and the second half is the serial number. For example MAC address 00:A0:C9:12:34:56 indicates that the manufacturer is Intel Corporation (00A0C9) and the rest is the network interfaces serial number.
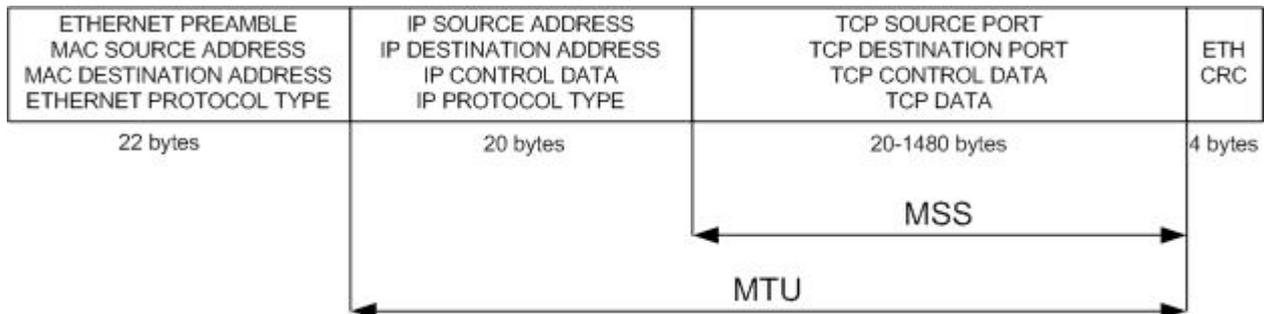
ARP (Address Resolution Protocol) is used at the link layer to find out the correlation between the IP and physical MAC address. IP-LINK has Proxy ARP in the radio and in the Ethernet interface. IP-LINK answers to the ARP requests, addressed to the device behind IP-LINK, by using Proxy ARP technique. By "faking" its identity, the IP-LINK takes the packets and routes them to the "real" destination. The difference to the normal networking setup is that if no one answers to the ARP query the packet is sent to the default gateway. When IP-LINK and the radio network are added to an existing network no changes are needed to the customer devices for the default gateway settings.

5.2.4 DHCP

DHCP (Dynamic Host Configuration Protocol) is used in the networks where the server runs DHCP service. When booting up, the workstation asks the IP settings from the DHCP server. The

communication is based on MAC addresses since workstation does not yet have IP address. IP-LINK does not support DHCP as a service or a client. The routes are defined static and cannot be updated dynamically. With IP-LINK static IP-addresses must be used. However, the DHCP can be used in the main network and for the user devices in it.

5.2.5 Ethernet TCP/IP frame

ETHERNET PREAMBLE MAC SOURCE ADDRESS MAC DESTINATION ADDRESS ETHERNET PROTOCOL TYPE	IP SOURCE ADDRESS IP DESTINATION ADDRESS IP CONTROL DATA IP PROTOCOL TYPE	TCP SOURCE PORT TCP DESTINATION PORT TCP CONTROL DATA TCP DATA	ETH CRC
22 bytes	20 bytes	20-1480 bytes	4 bytes

MSS

MTU

A simplified presentation of a typical Ethernet TCP/IP packet.

The Ethernet packet capsulation has two parts; a header and a CRC tailer. First in Ethernet header is preamble which is used to synchronize the Ethernet network interface receivers. The preamble is 8 bytes and in some literature not included in the length. Without the preamble the Ethernet capsulation is 18 bytes (header + tailer). MAC source and destination addresses are needed so the Ethernet network interfaces can send and receive data without broadcasting the data to everybody. The Ethernet is a broadcast medium but the MAC addresses make it possible to discard data that is not for the receiver.

The IP and TCP capsulation have only a header. The header is usually 20 bytes. The TCP header has the port addresses and other data needed for reliable transmission, e.g. sequence numbers and acknowledgements. After this is the actual user data. It always takes at least 66 bytes to transfer data with TCP/IP in Ethernet. The data can be at maximum 1460 bytes in one packet.

The size of the packet in the Ethernet or in other transfer medium can be limited with MTU (Maximum Transfer Unit) value. With a larger value the throughput is better: the response times are better with smaller packets especially in slow networks. The TCP is reliable protocol so it always opens the connection before transmitting any data. The opening of the connection takes one packet from the client to ask the other end (server) to open the connection and one packet from the server to accept the connection. TCP transfers the data in variable size segments, which are limited by the MSS (Maximum Segment Size) value. TCP acknowledges the data by segments. One MTU may hold multiple segments. The multiple segments are in the data part of the TCP packet and have a common header.

5.3 <u>SETTINGS FOR IP-LINK</u>

The settings for the IP-LINK can be changed from the console menu. The menu is accessible from the serial port with a null modem cable or from the network with Telnet.
The menu selections must end to an "ENTER".
The terminal software should have local echo disabled and use only CR-character (Carriage Return, 0x0D) as "ENTER".
After the changes have been made, they have to be applied before the changes take place.
Please note that the applying does not save the changes, the saving must be done separately.

```
--------------------------------------------------------------------------------
Satel IP-LINK Configuration
--------------------------------------------------------------------------------
1)    Ethernet Interface Settings
2)    Radio Modem Serial Settings
3)    Radio Interface Settings
4)    Show All Current Interfaces
5)    Routes
6)    ARP Cache
7)    Firewall
8)    Other Settings
N)    Domain Names
T)    Tests
A)    System information

D)    Load Default Configuration
L)    Stored Configurations
R)    Apply Changes without Saving
E)    Save Changes
X)    Logout
B)    Boot


IP-LINK>
```

5.4 ETHERNET INTERFACE SETTINGS

```
---------------------------------------------------------
Ethernet Interface Settings

1)     Ethernet IP Address                192.168.0.1
2)     Ethernet Network Mask              255.255.255.0
3)     Ethernet Broadcast Address         192.168.0.255
4)     Maximum Packet Size (MTU)          1500
5)     MAC Address                        00:06:70:00:00:01
6)     Ethernet Proxy ARP                 ON
7)     Show Statistics
```

1) Ethernet IP address
- Sets the Ethernet network interface IP address of the IP-LINK.

2) Ethernet Network Mask
- Sets the Ethernet network interface mask.

3) Ethernet Broadcast Address
- Sets the Ethernet network interface IP broadcast address.

4) Maximum Packet Size (MTU)
- Sets the maximum packet size (MTU) in Ethernet.

5) MAC address
- MAC address of the network interface. Not possible to change.

6) Ethernet Proxy ARP
- Sets the Proxy ARP ON or OFF.

7) Show Statistics
- Shows the statistics of the Ethernet interface.

5.5 <u>RADIO MODEM SERIAL SETTINGS</u>

```
------------------------------------------------------------
Radio Modem Serial Settings:

1)    Speed                              19200 bps
2)    Parity                             None
3)    Flow Control                       HW(CTS/RTS)

```

1) Speed
- Changes the speed of the serial interface to the radio modem. Note that the speed must be the same in the radio modem. It is recommended to use the same speed than the radio modem air transfer speed.

2) Parity
- Change the parity of the serial interface to the radio modem. The parity must also be changed from the radio modem.

3) Flow Control
- Change the flow control of the serial interface to the radio modem. Possibilities are none or hardware handshake.

5.6 RADIO NETWORK SETTINGS

IP-LINK has a special radio network interface. It is made to look like an Ethernet network for the Kernel but is in reality asynchronous serial RS-232 connection. When IP-LINK routes packets from the Ethernet interface to the radio modem interface the radio network framing is added to the packet. No changes to the IP capsulation and to the data inside it (TCP, UDP or other) are made. The radio modem adds the radio modem capsulation, which is dependant on the radio modem type used.
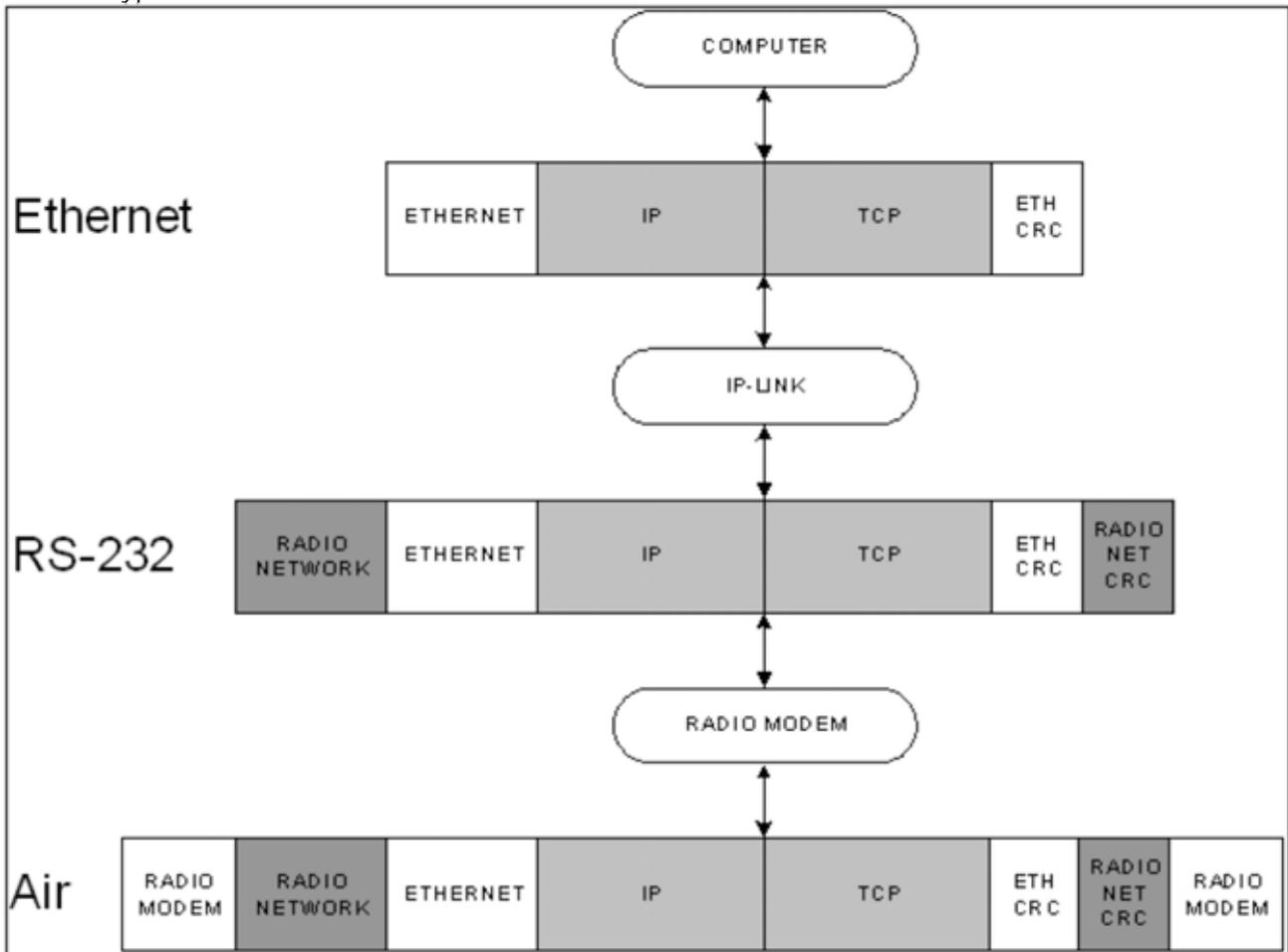
An example of the different capsulations between the devices with TCP/IP packet. IP and TCP data is not changed between any devices. The radio modem does not change the IP-LINKs radio network capsulation.

5.6.1 Radio interface IP settings

The IP-LINK has following radio interface settings. The settings affect to the IP settings of the radio interface.

```
---------------------------------------------------------------
Radio Interface Settings

1)    Radio IP Address                        10.10.10.1
2)    Radio Network Mask                      255.255.255.0
3)    Radio Broadcast Address                 10.10.10.255
4)    Maximum Packet Size (MTU)               1500
5)    Radio Proxy ARP                         ON
6)    Min Time Between Packets                10
7)    Max Random Factor for Time              4
8)    Packet Retry Limit                      500
A)    Use CD Signal for TX Control            ON
B)    Radio Network Compression               ON/500/1.1
C)    Radio Network Encryption                ON
D)    Show Statistics
```

1) Radio Interface IP Address
- Sets the radio modem interface IP address.

2) Radio Interface Network Mask
- Sets the radio modem interface IP mask.

3) Radio Interface Broadcast Address
- Sets the radio modem interface IP broadcast address.

4) Maximum Packet Size (MTU)
- Sets the maximum length (MTU) of the sent radio packets. Usually packets in the Ethernet network are 1500 bytes. This setting controls the fragmentation of the packets to the radio interface. For example the setting can be 800 bytes, so one 1500 packet from the Ethernet is fragmented to two packets for the radio. The received packets from the radio can be larger than this value.

5) Radio Proxy ARP
- Changes radio proxy ARP ON or OFF.

5.6.2 Radio interface protocol settings

The IP-LINK has a transmission protocol for the radio interface. The packets from the Ethernet network are capsulated inside a radio network framing, which is similar to the Ethernet framing. When a radio modem transmits data, first the radio modem transmitters PA (Power Amplifier) is started. The power is increased gradually (i.e. ramped up) in narrow band radio modems to

avoid interference to the other channels. When the PA is fully powered, the carrier signal is strong enough to be noticed by other radio modems. When the radio modem notice the signal stronger than the threshold the carrier signal is activated in the D15 connector. This takes about 5 ms with SATELLINE-3AS radio modem.

When the PA is fully powered, a synchronization sequence is added to the carrier. The last byte of the synchronization sequence is a synchronization byte. The receiving radio modem cannot know before the synchronization byte, if the signal is a beginning of a transmission or noise. When the receiving radio modem receives the synchronization byte, it knows it has been locked to the transmission and data will follow. The time before synchronization byte is about 20 ms with SATELLINE-3AS radio modem; there is a 20 ms time of uncertainty when collisions can happen with the SATELLINE-3AS and RX priority setting. When the carrier signal is monitored, the time of uncertainty is only 5 ms.

If two or more radio modems transmit at the same time, the transmissions can collide in the air and nothing can be received. A transmitting radio modem cannot detect a collision. It is important to try to avoid collisions since the transmission delay is longer and transmission speed is lower with the radio modems than in Ethernet.

In case when two radio modems start to transmit at the same time with different length packets, neither one will know that the collision takes place. The other radio modem with a short transmission stops transmitting first and starts to listen. The radio modem has missed the synchronization so it will not know whether the signal in the air is noise or a valid transmission. The SATELLINE-3AS RX priority setting only avoids transmitting if the radio modem has received the synchronization byte. In this case it would not help; the radio modem transmits and again a collision happens. This situation can be avoided if the carrier signal is monitored. IP-LINK has a setting for monitoring the carrier signal (CD, Carrier Detect).

The usage of the carrier monitoring may block the transmissions completely if there is a noise in the radio channel, therefore the radio modem threshold levels (RSSI, Received Signal Strength Indicator) must be set carefully in the radio modem. The radio modem does not try to receive transmission if the RSSI value is less than the set threshold. In SATELLINE -3AS radio modem the CD LED indicates the RSSI value. If the LED is RED the radio modem is transmitting. If the LED is GREEN, the radio modem is receiving. If the LED is ORANGE, the radio modem is receiving noise above threshold. Note that the CD is always ORANGE before the synchronization byte is received. With short data packets the transition from ORANGE to GREEN might be undetected visually.

Packets can be sent with a constant delay between every packet or with a random delay between the packets. If the radio modem CD signal is active or CTS (Clear To Send) signal is inactive, the IP-LINK waits and tries again. The amount of retries is limited by the packet retry limit. If the packet cannot be sent within the retry limit, it is dropped. The constant delay is set by setting the "Max Random Factor for Time" to a value "1".

6) Min Time Between Packets
- Sets the minimum time between the radio packets in 10 milliseconds resolution. This is the delay that is multiplied with "Max Random Factor for Time".

7) Max Random Factor for Time
- Sets the random mode maximum coefficient. For example, with Max Factor of 3 values 1, 2 and 3 are possible. With Min Time 10 ms the results are 10, 20 or 30 ms in random order.

8) Packet Retry Limit
- Sets the maximum amount of transmission attempts before the packet is discarded. This is not packet retransmission.

A) Use CD signal for TX control
- Sets ON or OFF D15 connectors CD signal monitoring.

5.6.3 Radio network compression

IP-LINK can compress the data sent to the radio network. This is useful if the data transferred is mostly text. Compressed images (JPG, GIF, PNG) cannot be re-compressed. The optimum setting depends on the applications used. The compression setting does not need to be ON in every IP-LINK. The IP-LINK receives compressed data if the compression setting is OFF.

B) Radio Network Compression
- Changes the radio network compression parameters. The parameters are Compression ON or OFF, minimum packet size and minimum compression rate. If the packet is smaller than the minimum packet size setting it is not tried to be compress. If the packet is compressed but the result is less than the compression rate, the packet is sent uncompressed. The compression rate 1 is not compressed. Value less than 1 means the packet is bigger after compression and value above 1 means the packet is compressed.

5.6.4 Radio network encryption

The radio network packets can be encrypted. The encryption is 64-bit shared key based. The setting (ON/OFF) and the key must be the same in all the IP-LINK devices. The key is eight values between 00-7F, for example "1A, 1C, 34, 7F, 69, 2D, 5, 40"

C) Radio Network Encryption
- Changes the radio network encryption parameters. The encryption is ON or OFF and the encryption key is in hexadecimal values.

5.6.5 Radio interface statistics

D) Show Statistics

Opens a new submenu. The radio network interface has similar statistics as the Ethernet network interface. The statistics can be used to analyze the performance and fine tune the settings. The statistics displayed have the IP settings and statistics for received (RX) and sent (TX) packets.

```
-----------------------------------------------------------------------
Interface Statistics for satel0:

satel0    Link encap:Ethernet  HWaddr 00:06:70:00:00:01
          inet addr:10.10.10.1  Bcast:10.10.10.255  Mask:255.255.255.0
          UP BROADCAST RUNNING MULTICAST  MTU:800  Metric:1
          RX packets:10158 errors:4 dropped:0 overruns:0 frame:4
          TX packets:10420 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:3
R)    Reset Statistics
D)    Show Real Time Packet Status
```

RX:

Packets – number of valid packets

Errors – total number of errors excluding dropped packets

Dropped – packets that have received dropped due to different encryption settings

Overruns – not in use

Frame – number of packets that have had error in the radio network framing

TX:

Packets – total amount of packets transmitted to the radio network

Errors – total number of errors

Dropped – packets that have been dropped from the transmission packet buffer (txqueue)

Overruns – not in use

Carrier – packet has been discarded after the retry limit

Collisions – not in use

Txqueuelen – this is the length of the transmission packet buffer

The submenu selection "D) Show Real Time Packet Status " shows the following real time diagnostics:

```
----  Showing Real Time Packet Status. Exit with ESC
Type  Size   Compr. Size Rate  Delay Retry Error
TX    54                       360   18
RX    814
RX    42
TX    54                       580   29
TX    531    393         1.3   20    0
RX    190
TX    54                       20    0
```

21

Type - the packet direction TX or RX.

Size - the size of the packet.

Compr. Size - the compressed size of the packet if the compression is used at the receiving or at the transmitting IP-LINK.

Rate - the compression ratio. A value bigger than 1 means the compression has made the packet smaller.

Delay - the total delay on the transmission. For example if the carrier signal has been ON and one or several delays are needed. In this example the "Min Time" has been 20 ms.

Retry - the number of retries when the packet has been tried to send.

Error - the explanation of a possible error.

The error types are:

Transmission:

DRP - dropped. Internal buffers are full and the packet has been dropped.

RET - retry. Maximum retry limit exceeded.

CTS - CTS signal has prevented the transmission to the radio modem and the packet is dropped.

Reception:

FRM - framing error. Error in the packet or not a full packet.

LEN - length. Erroneous packet length.

CRC - checksum. Error in the packet.

CRY - encryption. The received packet has been encrypted but the encryption is not ON in this device.

MAC- MAC address error. The received packet was not for this device. In two device systems the encryption key may be wrong. In a system with multiple devices this was a packet to another device and is a normal situation.

5.7 <u>ROUTING</u>

IP-LINK makes the routing decisions based on the route settings. The routes are added manually to the routing table and are static. The correct route is tried to find in mask based order and the first matching route is used. If no routes match, the packet is sent to the default gateway, if defined. The routes must be defined to both directions. If there is a route to only one direction the TCP connection cannot be opened and the PING program for testing does not work. So, the routes must be defined in both ends.

```
---------------------------------------------------------------------------
Kernel IP routing table
Destination  Gateway          Genmask          Flags  Metric  Ref  Use  Iface
192.168.0.0  *                255.255.255.0    U      0       0    0    eth0
10.10.10.0   *                255.255.255.0    U      0       0    0    sat0
127.0.0.0    *                255.0.0.0        U      0       0    0    lo
default      192.168.0.254    0.0.0.0          UG     0       0    0    eth0
```
The routing table.

From the routing table we can see that the Ethernet interface is in the 192.168.0.0/24 network and the radio network interface is in the 10.0.0.0/24 network. But the Ethernet interface IP address is not seen. The local loop back interface is in 127.0.0.0/8 network. The loop back interface is virtual and has the IP address 127.0.0.1. There is no need to change the loop back interface settings. The loop back interface is used if packets need to be dropped, in that case the packets are routed to loop back interface.

When the IP-LINK receives a packet from the network interface (Ethernet or radio) the destination address is compared to the mask in the first line. The comparison is made with AND operation. If the comparison result is the same as the destination, the packet is sent to the interface specified in the "Iface" section. If the destination in the first line does not match, the next line is tried until a match is found. If none of the routes match, the packet is sent to the default gateway. From the gateway the packet is routed to other networks. In the example above the default gateway (192.168.0.254) is in the Ethernet network. The default gateway in IP-LINK can also be radio interface of another IP-LINK. For the customer device the IP-LINK is usually the default gateway. In customer device the Ethernet address of the IP-LINK should be used in the gateway setting.

The "Flags" field parameter "U" means that the interface is usable. If the network cable is physically removed, it cannot be seen in the routing table. "G" in "Flags" field means that gateway is used with this route.
The "Metrics" and "Ref" fields are not used in IP-LINK.
"Iface" is the interface where to the packet is routed. It is not looked where the packet comes from. "Eth0" is Ethernet interface, "sat0" is radio interface and "lo" is loop back interface.

Example 1.
The Kernel receives packet with the destination address 192.168.0.7. The mask in the first line is tried. ANDing 192.168.0.7 with 255.255.255.0 gives a result 192.168.0.0. This is the same network as the destination so the packet is sent to Ethernet interface.

Example 2.
The IP-LINK receives a packet with the destination address 193.94.124.253. The ANDing with the mask in the first line gives a result 193.94.124.0. This is not the same network than the "Destination" in the first line. The second line is tried. ANDing with mask 255.0.0.0 gives a result of 193.0.0.0. This either has the same network as the "Destination" in the second line. The ANDing is now made with the third line mask 255.0.0.0. The result is 193.0.0.0 that is not the same network than 127.0.0.0. The fourth line has the default gateway so the packet is sent to the default gateway 192.168.0.254 in the Ethernet interface.

It is not possible to define multiple routes to the same destination. Only one route is possible. Usually the routes are defined to the networks, but it is possible to define routes to single devices also. In that case the mask is 255.255.255.255.
Route specific gateways can also be defined in the section "Gateway". The "Gateway" is only used in the defined route. The route specific gateway is different than the default gateway.
The routes can also be rejecting routes. In these cases the matching packet will be dropped.
On the last line of the routing table is the default gateway line.

```
default        192.168.0.254    0.0.0.0          UG    0      0    0    eth0
```

If this line is not seen the default gateway is in a network that is unreachable. The default gateway setting should be corrected to a destination that is reachable.

5.8 ARP CACHE TABLE

The routing does not change the IP destination address of the packet. The packets are sent to the receiver with a MAC address, which can be changed by network interface. The network interface uses ARP to find out the MAC address for the destination IP address. For example if the IP-LINK sends a packet to the network interface, the network interface must know the MAC address. If it does not know it, it sends an ARP query to ask, "What is the MAC address for this IP address?"

The ARP query is sent as an ARP broadcast with address FF:FF:FF:FF (all binary ones). All the network interfaces in the physical network will receive the message and the one having that IP address sends an ARP response "I have this IP address and my MAC address is this". Now the original sender can send the packet with right MAC address.

MAC addresses are saved temporarily in the network devices dynamic ARP cache. The MAC addresses are kept usually few minutes. Then the MAC address is removed and a new ARP query must be made. The ARP queries are also made in the middle of the data transfer. This enables the changing of the IP address in one device without restarting all the devices in the network. In narrow band radio network where the MAC addresses do not change often, the ARP queries take some bandwidth. The MAC addresses can be defined to be static.

```
-------------------------------------------------------------------------------
ARP Cache Table

Address            HWtype       HWaddress           Flags        Mask         Iface
192.168.1.9        ether    00:C0:9F:08:E5:5A       C                         eth0
192.168.7.8        <incomplete>                                               sat0
192.168.1.3        ether    00:C0:9F:08:E5:6F       CM                        eth0
```

ARP cache table entries. The MAC address of 192.168.7.8 has been asked but without a response. The MAC address of 192.168.1.3 has been added manually (M flag).

5.9 FIREWALL

The IP-LINK has a firewall that can be used to limit the traffic and to stop unauthorised traffic. The firewall rules can be configured based on the IP addresses, ports and/or protocols.

Firewall should be used in following cases:
1. It is not possible to separate user devices behind the radio network to a different sub network to limit the traffic. This may be the case if the radio network is added afterwards to the system and changes to the existing system addressing are impossible.
For example the main network IP address range is fixed and can not be expanded. If all the traffic from existing network goes to the radio network, the radio network will be filled with unnecessary traffic.
2. The traffic to and from radio network needs to be restricted for security reasons.

The best way to configure firewall is to allow only the traffic needed and deny everything else. If there is a need to connect remotely to the system that IP address should be allowed.

The firewall is based on rules. For every packet the rules are checked in order until the matching one is found. If no rule matches to the packet the default policy, accepting or silently dropping the packet, is applied. Usually the packet is silently dropped. Silent dropping means that the sender of the packet is not informed of this action. Without silent dropping the IP-LINK lets the sender know about possible errors with ICMP. Silent dropping increases security; without any answer the malicious port scanner can not know if there is a network device in the IP address. On the other hand, silent dropping makes debugging harder if the settings and the firewall rules are not correct.

```
-------------------------------------------------------------------------------
Firewall

1)     Firewall Enabled                        OFF
2)     Show All Rules
3)     Edit or Delete Rules
4)     Add a Rule
5)     Default Policy                          Accept the Packet
6)     S-NAT                                   OFF
```

1) Firewall enbled
- Set the firewall ON or OFF
2) Show all rules
- Shows all the defined rules
3) Edit or delete routes
- Edit or delete existing firewall rules
4) Add a Rule
- Add a new rule to the firewall
5) Default policy
- The default policy applied to the packet that does not match any rules. The default policy can be "Accept the Packet" or "Drop silently"
6) S-NAT

- Set NAT (Network Address Translation) ON or OFF. To set S-NAT ON also the firewall must be ON. S-NAT changes the source IP address from the packets going to the Ethernet interface to this device's IP address.

A new rule to the firewall is added with the menu option 4. The added rule must first be set to a correct order.

```
Insert rule before (ESC = Back, ENTER = First):
```

Pressing ENTER sets the rule to be first.

The firewall rule has following parts:

```
--------------------------------------------------------------------------------
Edit Rule

1)      Rule Number                             2
2)      Source IP Address                       Any
3)      Source IP Mask                          Any
4)      Source Port or ICMP type                Any
5)      Destination IP Address                  Any
6)      Destination IP Mask                     Any
7)      Destination Port                        Any
8)      Protocol                                Any
9)      Incoming Interface                      Any
P)      Policy                                  Accept the packet

C)      Check Rule
N)      Next Rule
B)      Previous Rule
R)      Go to Rule
A)      Create a New Rule
D)      Delete Rule
```

1) Rule Number
- The order this rule is applied if previous rules do not match.
2) Source IP Address
- The source IP address the rule is applied to.
3) Source IP Mask
- The source IP address(es) the rule is applied to.
4) Source Port or ICMP type
- The source port or ICMP type of the packet the rule is applied. The ICMP types are listed in the section ICMP.
5) Destination IP Address
- The destination IP address the rule is applied to.
6) Destination IP Mask
- The destination IP address the rule is applied to.
7) Destination Port
- The destination port the rule is applied.
8) Protocol
- The protocol the rule is applied; TCP, UDP, or ICMP.
9) Interface
- The incoming network interface the rule is applied to; Ethernet or radio network.

P) Policy

- The action taken if the rule matches, accept the packet, reject by ICMP or drop silently. Reject by ICMP means that the server sends to the sender by ICMP "destination unreachable" packet that the packet is discarded.

5.10 DNS

DNS (Domain Name System) is used to bind the IP addresses to hostnames. DNS is not part of the TCP/IP networking stack, but on the application layer. With DNS it is possible to use web browser with plain text names instead of writing the IP address. For example, it is possible to write "http://www.satel.fi" or "http://193.94.124.252" to the web browser address bar. Before a web browser opens a HTTP-connection it sends a query to the DNS -server "What is the IP address of the domain www.satel.fi ?". The DNS-server answers and after that the web browser can open the HTTP-connection with IP address. The HTTP-connection is opened with TCP/IP.

NOTE! IP-LINK does not have DNS service.

```
--------------------------------------------------------------------------------
Domain names

1)    Local Host Name                         IP-LINK
2)    Static Mappings
```

1) Local Host Name
- Set the host name for the device. Also shown in the command prompt.
1) Static Mappings
- Set a static host name for a another device. Not in use.

6. CONFIGURING THE IP-LINK

Before configuring the IP-LINK, a system plan with IP addresses must be done. IP-LINK has two IP addresses, one for the Ethernet interface and one for the radio modem interface. The radio modem interface IP addresses should be in a separate sub network than the ones in the Ethernet. It is recommended to use separate sub network for the user devices (computers, PLCs) behind the IP-LINK units.

Inside the companies the IP addresses are usually in 192.168.0.0 network and are not shown to the Internet side. A gateway between Internet and local network performs a Network Address Translation (NAT); the local network IP addresses are changed to Internet side IP addresses when packets are sent outside to the Internet and vice versa.

6.2 CONFIGURING A SYSTEM WITH TWO USER DEVICES

Configuration with two user devices, IP-LINKs and radio modems. In this example the user devices have two separate network address spaces.
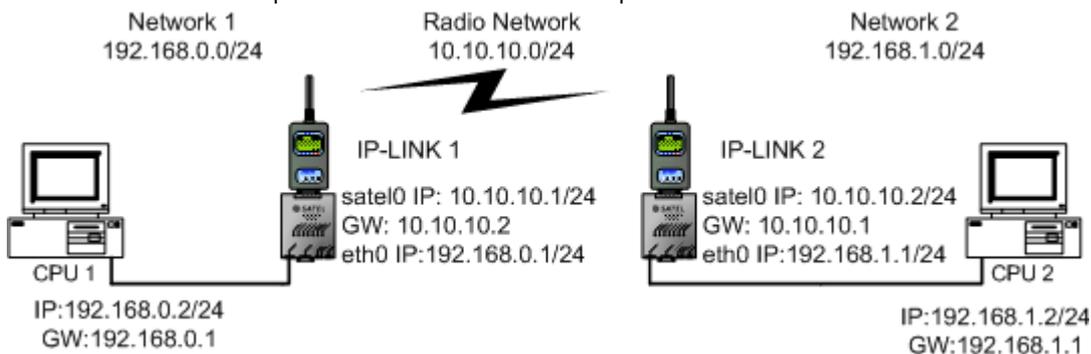
In the previous configuration the CPU1 and CPU2 are in the separate networks. This makes IP-LINK routing setup and the system expansion easier later.

5.2.5 Changing the settings via console

Connect a radio modem to the IP-LINK. Do not turn power ON while installing and removing the radio modem to avoid short-circuiting the D15 power and data lines. Connect D9 null modem cable to the IP-LINK and to the computer where the changes will be made. The serial cable between the computer and SATELLINE radio modem is usually straight. With IP-LINK the straight serial cable is not needed.

Use a terminal program in the computer with settings baud rate 9600, 8 data bits, 1 stop bit, none parity and no hardware handshaking. Turn power ON in IP-LINK. The IP-LINK booting should be seen at the terminal.

```
PPCBoot 1.1.5 (May 14 2003 - 15:56:37)
Viola Systems Arctic Board
Adapted by richard@uclinux.net

CPU:      MOTOROLA Coldfire MCF5272
Board:    Viola Systems Oy Arctic Board
          http://www.violasystems.com/
DRAM:     32 MB
FLASH:    8 MB
In:       serial
Out:      serial
Err:      serial
Net:      00:06:70:01:00:97
Press any key for PPCBoot Maintenance Menu:
```

Do NOT press any key. Wait for three seconds and let the device continue booting. The PPCBoot in IP-LINK is equivalent of the computer BIOS. There is no need to change any settings in PPCBoot. All the necessary settings can be changed from the menu. Let the IP-LINK continue booting and wait before the menu or login prompt appears. The booting takes 45 seconds.

5.2.5 Changing the settings via Telnet

By default the Telnet is enabled in IP-LINK. It is possible to open Telnet connection to port 23 or SSH Telnet connection to port 22. The booting cannot be seen with Telnet. Telnet connection is opened from the command prompt by typing "telnet 192.168.0.1". 192.168.0.1 is the default address of the IP-LINK. If the IP-LINK Ethernet IP address has been changed the Telnet connection must be opened to the new Ethernet address.

5.2.5 Changing the IP-LINK 1 settings

```
IP-LINK login:
```
The IP-LINK login prompt.

The boot is complete when the menu or the login prompt shows up. The IP-LINK is fully operational without logging in. If you don't see any text at all, check that the cable is null modem cable. The signals can be checked with a multimeter or check the cable with a PC that has two serial ports. Open two terminal connections between the serial ports where the null modem cable is connected, you should be able to type in another terminal and see it in the other terminal.

Enter the default login "root" and press ENTER.

```
IP-LINK login:root
```
The default login .

31

```
Satel IP-LINK Configuration
----------------------------------------------------------------
1)    Ethernet Interface Settings
2)    Radio Modem Serial Settings
3)    Radio Interface Settings
4)    Show All Current Interfaces
5)    Routes
6)    ARP Cache
7)    Firewall
8)    Other Settings
N)    Domain Names
T)    Tests
A)    System information

D)    Load Default Settings
L)    Stored Configurations
R)    Apply Changes without Saving
E)    Save Changes
X)    Logout
B)    Boot
```

The IP-LINK main menu.

All the commands in the menu must end to "ENTER", also the "ESC" (used for backing up).

By typing "8" and pressing "ENTER" next menu will be shown:

```
----------------------------------------------------------------
Other Settings

1)    Password
2)    Telnet Server                                 ON/23
3)    SSH Server                                    ON/22
4)    Memory
5)    Running Processes
6)    Run Command
7)    Uptime                                        0 d 0 h
8)    Switch to Command Line
```

The password can be set by the selection 1. The username (login) is always "root".
We do NOT recommend using "root", "admin", "admin123" or any other too easy password.
Pressing "ESC" and "ENTER" does the re-entering to the "Other settings". If the Telnet and SSH are not needed they should be disabled. This is done by the selections 2 and 3.

By typing "1" and pressing "ENTER" at the main menu next menu will be shown.

```
--------------------------------------------------------------------------
Ethernet Interface Settings

1)    Ethernet IP Address                    192.168.0.1
2)    Ethernet Network Mask                  255.255.255.0
3)    Ethernet Broadcast Address             192.168.0.255
4)    Maximum Packet Size (MTU)              1500
5)    MAC Address                            00:06:70:00:00:01
6)    Ethernet Proxy ARP                     ON
7)    Show Statistics
```

Change the settings to the values above. The MAC address cannot be changed.

Backing up to the main menu is done by pressing "ESC" and "ENTER".
On the main menu pressing "2" and "ENTER" the following menu will be shown:

```
--------------------------------------------------------------------------------
Radio Modem Serial Settings

1)      Speed                               19200 bps
2)      Parity                              None
3)      Flow Control                        HW (CTS/RTS)
```

These are the serial settings for the radio modem serial interface of IP-LINK, not for the console or the radio modem. The radio modem serial settings must be the same in the radio modem too. Backing up to the main menu is done by pressing "ESC" and "ENTER".

On the main menu by pressing "3" and "ENTER" the following menu will be shown:

```
--------------------------------------------------------------------------------
Radio Interface Settings

1)      Radio IP Address                    10.10.10.1
2)      Radio Network Mask                  255.255.255.0
3)      Radio Broadcast Address             10.10.10.255
4)      Maximum Packet Size (MTU)           1500
5)      Radio Proxy ARP                     ON
6)      Min Time Between Packets            10
7)      Max Random Factor for Time          6
8)      Packet Retry Limit                  500
A)      Use CD Signal for TX Control        ON
B)      Radio Network Compression           ON/500/1.1
C)      Radio Network Encryption            ON
D)      Show Statistics
```

After changing the settings above, the backing up to the main menu is done by pressing "ESC" and "ENTER".

By pressing "5" and "ENTER" in the main menu the following menu will be shown:

```
------------------------------------------------------------
Routes

1)      Show All Routes
2)      Show User Defined Routes
3)      Edit or Delete User Defined Routes
4)      Define a Route
5)      Default Gateway                     192.168.0.254
```

By pressing "5" and " ENTER" the following menu will be shown:

```
--------------------------------------------------------------------------------
Default Gateway

1)      Default Gateway                     10.10.10.2
2)      Interface                           Radio
```

Change the settings to be as the values above.
Press "ESC" and "ENTER" to return to the "Routes" menu. Press "4" and "ENTER" to define the route.

The settings must be set as in the following menu.

```
Select the following choices:

Route Type (Route to a Network):
1)    Route to a Single Host
2)    Route to a Network

ESC)  Back

IP-LINK>2

Route Destination IP Address ():192.168.1.0

Route Netmask(Net Only) [ENTER = None] (<none>):255.255.255.0

Rejecting Route? (No, this route is a normal route):
1)    No, this route is a normal route
2)    Yes, this route is a rejecting route

ESC)  Back

IP-LINK>1

Route Interface (0):
1)    Ethernet
2)    Radio

ESC)  Back

IP-LINK>2

Route Gateway [ENTER = None] (<none>): PRESS ENTER HERE

---- Edit Route:

1)    Route Order Number                    2
2)    IP Address                            192.168.1.0
3)    Type                                  Route to a Network
4)    Netmask                               255.255.255.0
5)    Reject?                               No, this route is a normal route
6)    Device                                Radio
7)    Gateway                               <none>

C)    Check Route
N)    Next Route
B)    Previous Route
R)    Go to Route
A)    Create a New Route
D)    Delete Route
```

By selecting "C" the IP-LINK checks the route and gives the following message:

```
Route OK. Based on this route, packets to the network 192.168.1.0/255.255.255.0
will be forwarded to the Radio interface
```

Returning to the routing menu is done by pressing "ESC" and "ENTER" and then to the main menu by pressing "ESC" and "ENTER".

Now all the needed settings are done and it is time to apply the changes.
If the IP-LINK settings are changed remotely it is recommended to try the new settings without saving them. If the settings are wrong and saved, the remote connection to the IP-LINK can be lost. In this case the IP-LINK can just be booted by the local personnel without any configuration expertise. The settings can be applied from the main menu with "R" and "ENTER" (Apply Changes without Saving).

When the settings work correctly they need to be saved permanently, otherwise after the next boot the settings are set back to the previous settings.
Settings are saved from the main menu by pressing "E" and "ENTER" (Save Changes).

After the applying, the IP settings can be shown by pressing "4" and "ENTER".

```
---------------------------------------------------------------------------
Interface Statistics:
eth0      Link encap:Ethernet  HWaddr 00:60:70:00:00:01
          inet addr:192.168.0.1  Bcast:192.168.0.255  Mask:255.255.255.0
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:100
          Base address:0x840

lo        Link encap:Local Loopback
          inet addr:127.0.0.1  Mask:255.0.0.0
          UP LOOPBACK RUNNING  MTU:16436  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:0

satel0    Link encap:Ethernet  HWaddr 00:60:70:00:00:01
          inet addr:10.10.10.1  Bcast:10.10.10.255  Mask:255.255.255.0
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:3
```

The IP settings look as above. Backing up to the main menu is done by pressing "ESC" and "ENTER".

To check the routes, press "5" and "ENTER" (Routes) and "1" and "ENTER" (Show All Routes).

```
---- Routing status

Kernel IP routing table
Destination     Gateway         Genmask         Flags Metric Ref Use Iface
192.168.1.0     *               255.255.255.0   U     0      0   0   satel0
192.168.0.0     *               255.255.255.0   U     0      0   0   eth0
10.10.10.0      *               255.255.255.0   U     0      0   0   satel0
127.0.0.0       *               255.0.0.0       U     0      0   0   lo
default         10.10.10.2      0.0.0.0         UG    0      0   0   satel0
```

The routes look as above. Go back to main menu by pressing "ESC" and "ENTER".
NOTE! The changes will not be shown and they will not be active until they have been applied.

5.2.5 The computer settings for CPU 1

Make the changes to the CPU 1 IP settings. If the CPU 1 has a Windows operating system, the settings look as follows. NOTE! The "Client for Microsoft Networks" and "File and Printer Sharing for Microsoft Networks" do not need be checked, because these items do not work well with low speed connections.
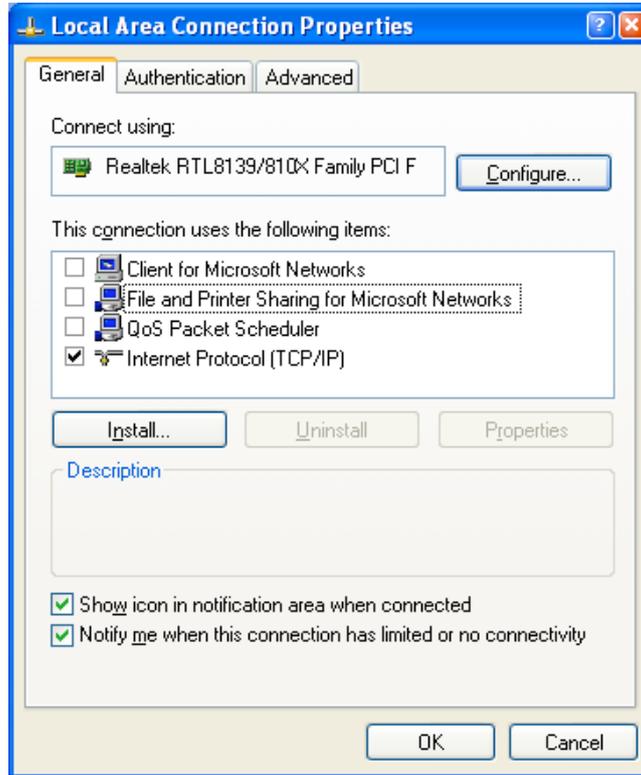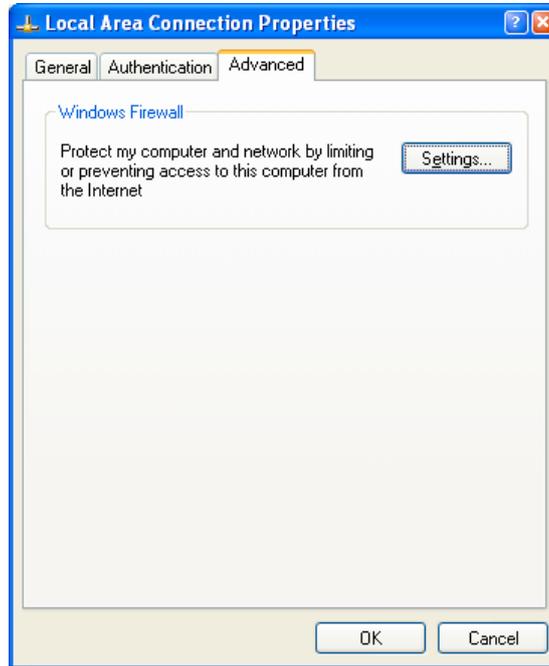

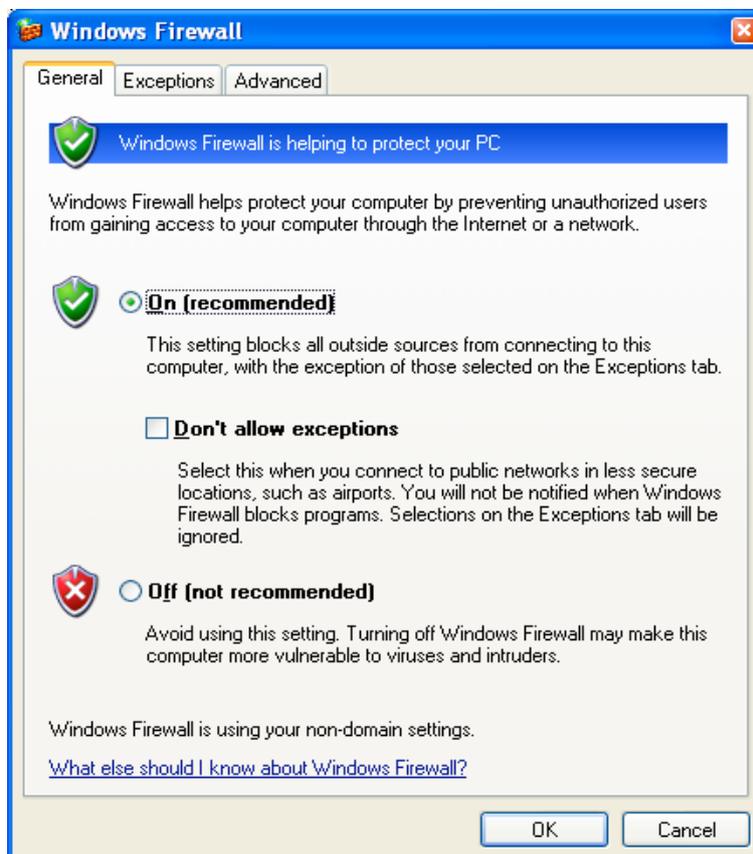The TCP/IP settings are set as follows.
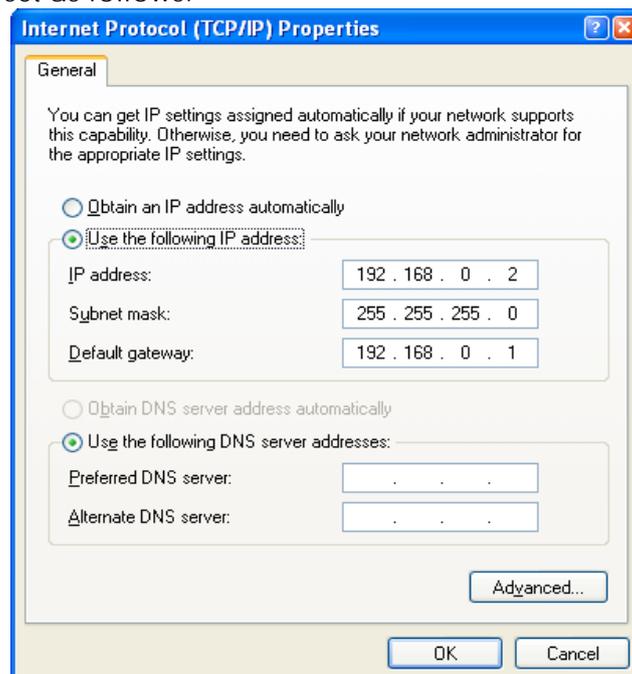
The CPU 1 IP address is 192.168.0.2 and the default gateway for CPU 1 is IP-LINK 1. The DNS is not used, so it is not needed to set. Click "OK".

With Windows XP service pack 2 the "Advanced" -tab from the "Local Area Connection Properties" must be selected.

The Windows Firewall can be entered by clicking the "Settings".

Select "Advanced" tab.
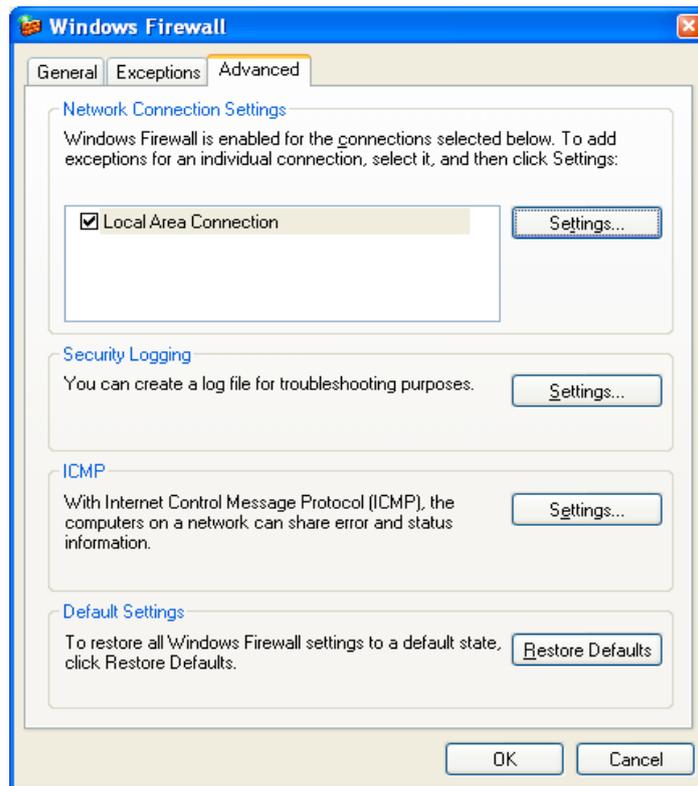
Click "Settings…" from the "Network Connection Settings"
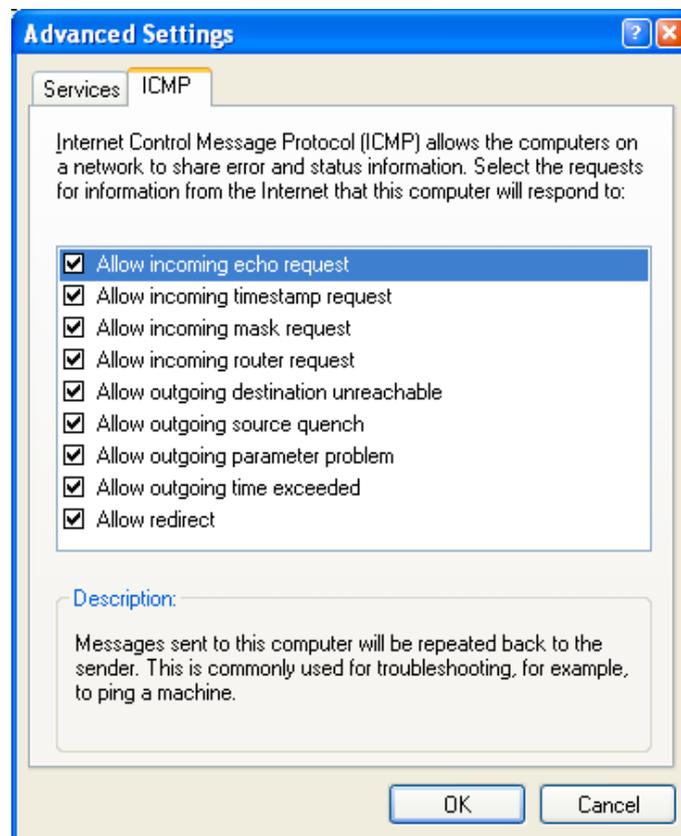
From the "Advanced Settings" window select "ICMP" tab. Check all the boxes and click "OK".

Connect the crossover network cable between CPU 1 and IP-LINK. The crossover network cables are usually marked with red connectors.

The IP settings can also be seen from the command prompt with "ipconfig" command.
To open command prompt select "Start"-> "Run" and type "cmd"+ "ENTER". In command prompt type "ipconfig"+"ENTER".
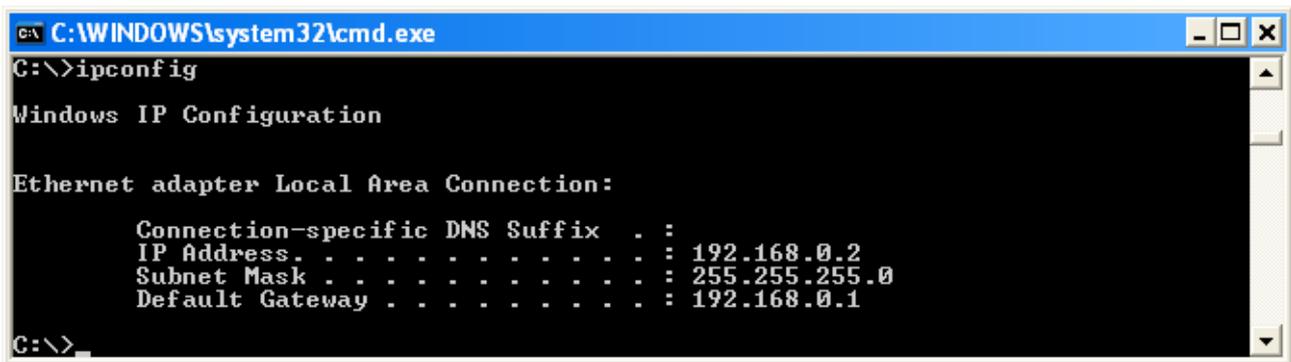
```
C:\WINDOWS\system32\cmd.exe                                    _ □ ×
C:\>ipconfig

Windows IP Configuration


Ethernet adapter Local Area Connection:

        Connection-specific DNS Suffix  . :
        IP Address. . . . . . . . . . . : 192.168.0.2
        Subnet Mask . . . . . . . . . . : 255.255.255.0
        Default Gateway . . . . . . . . : 192.168.0.1

C:\>
```

Now the connection between CPU 1 and IP-LINK 1 can be tested with Ping program. The Ping sends ICMP query packets to the destination and the destination responses to the queries. This two-way test gives a good picture if the settings and routing works. Firewall in the computer or in the IP-LINK may block ICMP messages. Check the firewall settings if the Ping does not work.

Type, "ping 192.168.0.1"+"ENTER" to the CPU 1 command prompt. The response is as follows.
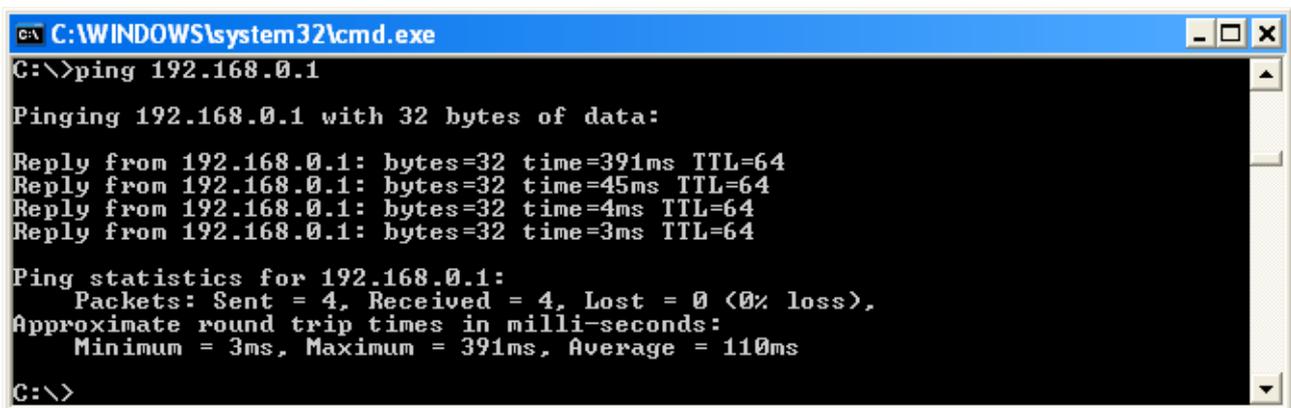
```
C:\WINDOWS\system32\cmd.exe                                    _ □ ×
C:\>ping 192.168.0.1

Pinging 192.168.0.1 with 32 bytes of data:

Reply from 192.168.0.1: bytes=32 time=391ms TTL=64
Reply from 192.168.0.1: bytes=32 time=45ms TTL=64
Reply from 192.168.0.1: bytes=32 time=4ms TTL=64
Reply from 192.168.0.1: bytes=32 time=3ms TTL=64

Ping statistics for 192.168.0.1:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 3ms, Maximum = 391ms, Average = 110ms

C:\>
```

Note the response times. Before the first Ping message the CPU 1 must find out IP-LINK 1 MAC address. The ARP procedure makes the first round trip time longer. The average response time on Ethernet is normally less than 10 ms.

The IP-LINK 1 radio network interface is pinged as follows.

The Ping response times from the radio interface are as fast as in the Ethernet interface. The Ping does not go over the radio network.

The Ping should also work from the IP-LINK to the CPU 1. Type "T" and "ENTER" in the main menu. The "Tests:" menu opens. The Ping test can be selected by typing "1" and ENTER. The "Ping address" (PING destination address) must be changed to be 192.168.0.2 as in the following picture.

```
-------------------------------------------------------------
Tests:

1)    Ping Test

ESC)  Back

IP-LINK>1

---- Ping Test:

1)    Ping Address                          0.0.0.0
2)    Ping Count                            4
3)    Ping Packet Size                      32
4)    Ping Timeout[sec]                     5

R)    Run Test

ESC)  Back

IP-LINK>1

Ping Target IP Address (0.0.0.0):192.168.0.2

---- Ping Test:

1)    Ping Address                          192.168.0.2
2)    Ping Count                            4
3)    Ping Packet Size                      32
4)    Ping Timeout[sec]                     5

R)    Run Test
```

Then press "R" + "ENTER" and the result looks as follows:

```
---- Running test (ping -c 4 -s 32 -i 5 192.168.0.2)...

PING 192.168.0.2 (192.168.0.2): 32 data bytes
40 bytes from 192.168.0.2: icmp_seq=0 ttl=128 time=8.1 ms
40 bytes from 192.168.0.2: icmp_seq=1 ttl=128 time=8.1 ms
40 bytes from 192.168.0.2: icmp_seq=2 ttl=128 time=4.0 ms
40 bytes from 192.168.0.2: icmp_seq=3 ttl=128 time=8.3 ms


--- 192.168.0.2 ping statistics ---
4 packets transmitted, 4 packets received, 0% packet loss
round-trip min/avg/max = 4.0/7.1/8.3 ms
```

Windows XP service pack 2 firewall by default allows Ping from the computer but not to the computer. Check the computer firewall, IP address and subnet mask settings if you cannot Ping from the IP-LINK.

The default time to wait for the Ping response (Ping timeout) is in IP-LINK 5 seconds. This is needed when the pinging is done over the radio network. If the timeout is too short the Ping will show no response. This must be taken in to account when pinging over the radio network. In Windows the Ping timeout can be set with "-w" option. For example "ping –w 5000 192.168.1.2" waits 5 seconds for each reply.

5.2.5 Changing the IP-LINK 2 settings

The settings for the IP-LINK 2 should be set as follows:

```
--------------------------------------------------------------------------------
Interface Statistics:
eth0      Link encap:Ethernet  HWaddr 00:60:70:00:00:02
          inet addr:192.168.1.1  Bcast:192.168.1.255  Mask:255.255.255.0
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:100
          Base address:0x840

lo        Link encap:Local Loopback
          inet addr:127.0.0.1  Mask:255.0.0.0
          UP LOOPBACK RUNNING  MTU:16436  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:0

satel0    Link encap:Ethernet  HWaddr 00:60:70:00:00:02
          inet addr:10.10.10.2  Bcast:10.10.10.255  Mask:255.255.255.0
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:3
```

Interface settings in IP-LINK 2.

```
---- Routing status

Kernel IP routing table
Destination     Gateway         Genmask         Flags Metric Ref Use Iface
192.168.1.0     *               255.255.255.0   U     0      0   0   eth0
192.168.0.0     *               255.255.255.0   U     0      0   0   satel0
10.10.10.0      *               255.255.255.0   U     0      0   0   satel0
127.0.0.0       *               255.0.0.0       U     0      0   0   lo
default         10.10.10.1      0.0.0.0         UG    0      0   0   satel0
```
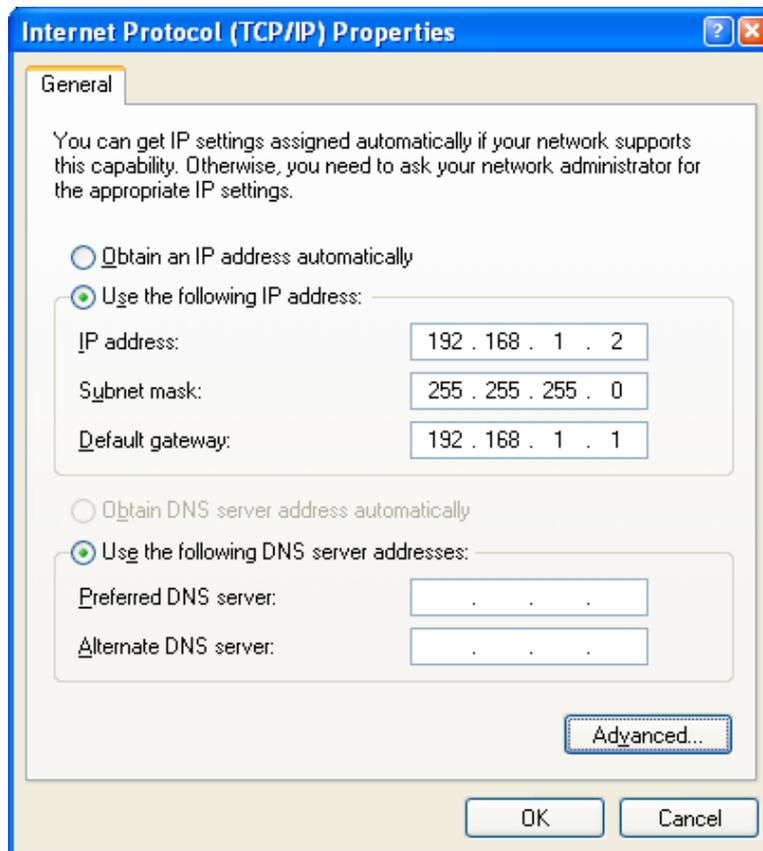
Routes in IP-LINK 2.

The IP-LINK 2 needs to have a route to network 192.168.0.0/24 added.

5.2.5 The computer settings for CPU 2

The settings for the CPU 2 are as follows.

Connect crossover network cable between CPU 2 and IP-LINK 2. Test the Ping from the CPU 2 to IP-LINK 2.

5.2.5 The radio modem settings

Shut the IP-LINK down by disconnecting the power. Connect the radio modems. Connect the power to the IP-LINKs. The IP-LINKs start the booting and the radio modems get ON when the booting is finished. Wait until the IP-LINK boots to the login prompt and then switch the IP-LINK PROG switch to ON (up) position. Now the radio modem menu appears.

Check that the radio modem settings are equal, especially the frequency. RX/TX addresses must be OFF and RX priority ON in the radio modems. Switch the IP-LINK PROG switch to OFF (down) position. Press "ENTER" and the IP-LINK login prompt appears.

Now the pinging over the radio modems can be done.

The IP-LINK 2 Ethernet interface can be pinged from CPU 1.
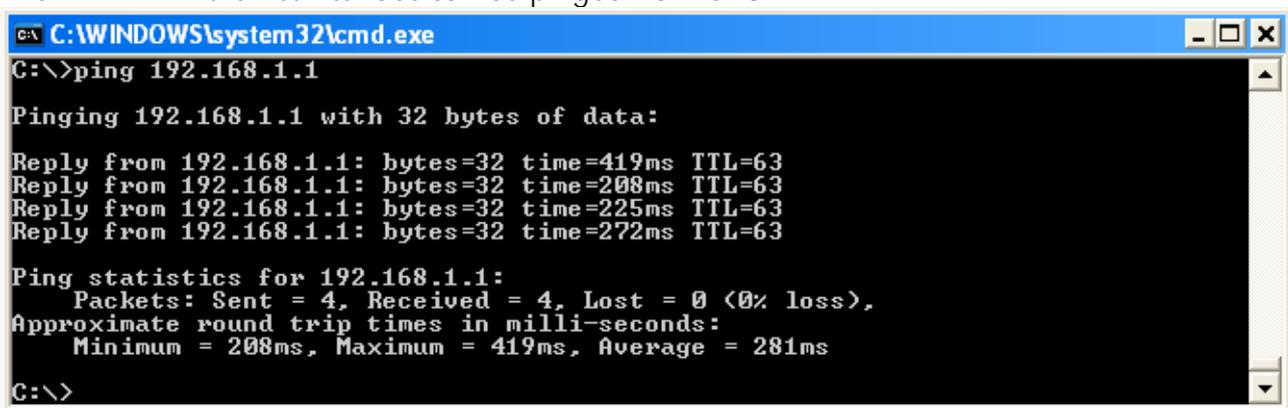
```
C:\WINDOWS\system32\cmd.exe

C:\>ping 192.168.1.1

Pinging 192.168.1.1 with 32 bytes of data:

Reply from 192.168.1.1: bytes=32 time=419ms TTL=63
Reply from 192.168.1.1: bytes=32 time=208ms TTL=63
Reply from 192.168.1.1: bytes=32 time=225ms TTL=63
Reply from 192.168.1.1: bytes=32 time=272ms TTL=63

Ping statistics for 192.168.1.1:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 208ms, Maximum = 419ms, Average = 281ms

C:\>
```
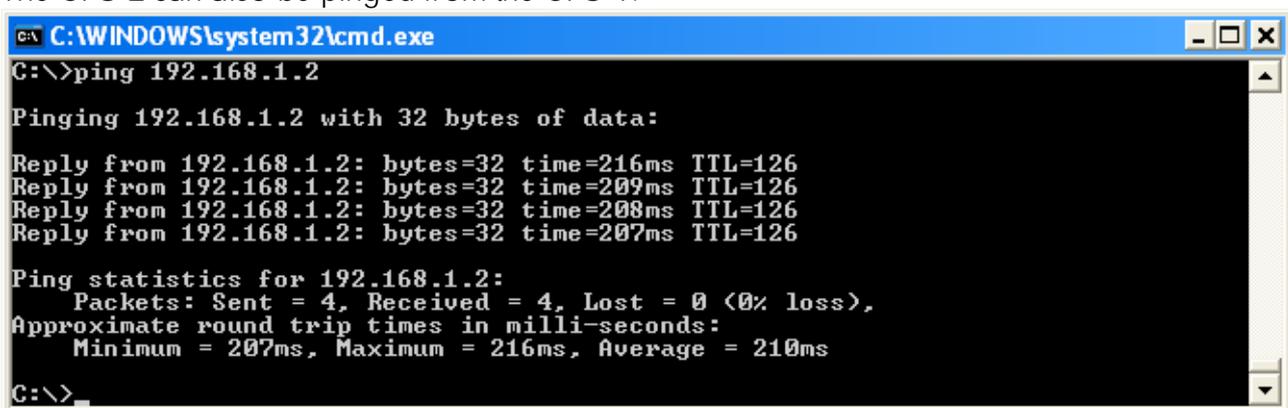
Notice the long first round trip delay.

The CPU 2 can also be pinged from the CPU 1.

```
C:\WINDOWS\system32\cmd.exe

C:\>ping 192.168.1.2

Pinging 192.168.1.2 with 32 bytes of data:

Reply from 192.168.1.2: bytes=32 time=216ms TTL=126
Reply from 192.168.1.2: bytes=32 time=209ms TTL=126
Reply from 192.168.1.2: bytes=32 time=208ms TTL=126
Reply from 192.168.1.2: bytes=32 time=207ms TTL=126

Ping statistics for 192.168.1.2:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 207ms, Maximum = 216ms, Average = 210ms

C:\>
```
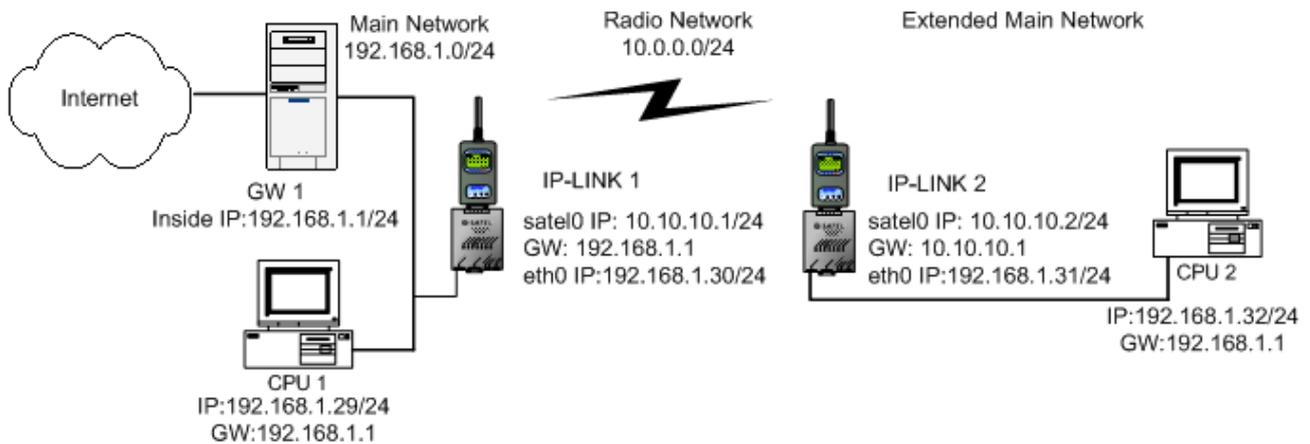
6.3 UNDERLINE(CONFIGURING A SYSTEM WITH EXTERNAL GATEWAY)

In the example above the user device CPU 2 is in the same address space as the main network. The routes to the single hosts must be defined into the IP-LINKs. NOTE! The routes must always be defined to both directions.

```
-------------------------------------------------------------------------------
Interface Statistics:
eth0      Link encap:Ethernet  HWaddr 00:06:70:00:00:01
          inet addr:192.168.1.30  Bcast:192.168.1.255  Mask:255.255.255.0
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:11302 errors:0 dropped:0 overruns:0 frame:0
          TX packets:4579 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:100
          Base address:0x840

lo        Link encap:Local Loopback
          inet addr:127.0.0.1  Mask:255.0.0.0
          UP LOOPBACK RUNNING  MTU:16436  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:0

satel0    Link encap:Ethernet  HWaddr 00:06:70:00:00:01
          inet addr:10.10.10.1  Bcast:10.10.10.255  Mask:255.255.255.0
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:4483 errors:0 dropped:0 overruns:0 frame:0
          TX packets:4211 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:3
```

Interface statistics of IP-LINK 1.

```
-------------------------------------------------------------------------------
Kernel IP routing table
Destination     Gateway         Genmask         Flags Metric Ref    Use Iface
192.168.1.32    *               255.255.255.255 UH    0      0        0 satel0
192.168.1.31    *               255.255.255.255 UH    0      0        0 satel0
192.168.1.0     *               255.255.255.0   U     0      0        0 eth0
10.10.10.0      *               255.255.255.0   U     0      0        0 satel0
127.0.0.0       *               255.0.0.0       U     0      0        0 lo
default         192.168.1.1     0.0.0.0         UG    0      0        0 eth0
```

Routing table of IP-LINK 1. Note the first two routes to single hosts.

```
-------------------------------------------------------------------------------
Interface Statistics:
eth0      Link encap:Ethernet  HWaddr 00:06:70:00:00:02
          inet addr:192.168.1.31  Bcast:192.168.1.255  Mask:255.255.255.0
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:4726 errors:0 dropped:0 overruns:0 frame:0
          TX packets:4464 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:100
          Base address:0x840

lo        Link encap:Local Loopback
          inet addr:127.0.0.1  Mask:255.0.0.0
          UP LOOPBACK RUNNING  MTU:16436  Metric:1
          RX packets:12 errors:0 dropped:0 overruns:0 frame:0
          TX packets:12 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:0

satel0    Link encap:Ethernet  HWaddr 00:06:70:00:00:02
          inet addr:10.10.10.2  Bcast:10.10.10.255  Mask:255.255.255.0
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:4504 errors:0 dropped:0 overruns:0 frame:0
          TX packets:4762 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:3
```

Interface statistics of IP-LINK 2.

```
-------------------------------------------------------------------------------
Kernel IP routing table
Destination     Gateway         Genmask         Flags Metric Ref    Use Iface
192.168.1.1     *               255.255.255.255 UH    0      0        0 satel0
192.168.1.30    *               255.255.255.255 UH    0      0        0 satel0
192.168.1.0     *               255.255.255.0   U     0      0        0 eth0
10.10.10.0      *               255.255.255.0   U     0      0        0 satel0
127.0.0.0       *               255.0.0.0       U     0      0        0 lo
default         10.10.10.1      0.0.0.0         UG    0      0        0 satel0
```

Routing table of IP-LINK 2. Note the first two routes to single hosts.

NOTE! Depending on the GW 1settings, it may not be possible to ping it from IP-LINK 2. The PING request from IP-LINK 2 originates from the source address 10.10.10.2 and the GW 1 may not be able to response to the right network.

The GW 1 can be pinged from the CPU 2.

It is not possible to ping IP-LINK 2 (192.168.1.31) and CPU 2(192.168.1.32) from CPU 1 unless a single host route to the CPU 1 (192.168.1.29) has been defined in IP-LINK 2.