



27 JUL 2000

V.34 Industrial Control modem DC:
MDU9095-V34

V.32 Industrial Control modem DC:
MDU9095-V32

V.32 Leased Industrial Control modem DC (Slave):
MDU9095-2LLS

V.32 Leased Line Industrial Control modem DC (Master):
MDU9095-2LLM

Industrial Control Modem DC



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Introduction

The Industrial Control Modems from Black Box are a series of general-purpose industrial modems, which can be used for data communication through Public Switched Telephone Networks or Leased Lines. The modems can operate in 2-wire, full-duplex, asynchronous modes at line rates up to 33.6 Kbps. The modems perform complete handshake and data rate negotiations. All tone and pattern detection functions required by the applicable ITU or Bell standards are supported. Dialing, call progress, and telephone line interface are supported and controlled through the AT command set. The modem connects to the DTE via a serial interface (EIA RS232).

The module has 2 interface ports: Serial interface, RS 232 (9 pole sub-D) with hardware handshake control lines - and the telephone line interface. (6 pole RJ11 modular jack).

A built-in power supply for 12-48VDC is provided with galvanic isolation.

The modems are made in industrial 108mm wide aluminum housing for DIN rail mounting.

Modem Configuration / DTE Commands

The modems are configured by AT commands when in command mode. Command mode is normally when no dial up sequence is executed and when no connection to another modem is established. A command is a line of characters sent from the DTE to the Modem via the serial interface. When setting up your modem you can use a PC with Terminal Software like Hyper Terminal from Microsoft Windows. A command line is always starting with AT (except A/) followed by the specific "body" and terminated by a carriage return (Enter). When a "body" is followed by a "n" it means that the command has several options like ATXn. When the modem receives carriage return the command is executed.

Normally both upper case and lower case characters are allowed but not mixed.

A command line starting with AT can be followed by any number of commands in sequence, except for the commands Z, D or A. Maximum characters in a command line is 39 including A and T.

Four telephone numbers can be stored in the modem.

See the sections "AT Command Summary" and "Configuration of Leased Line Modem" for a summary of the valid AT commands

Default factory configuration profile**Active Profile:**

```
B0 E1 L1 M1 N1 Q0 T V1 W0 X4 Y0 &C1 &D2 &G0 &J0 &K3 &Q5 &R1 &S0 &T5 &X0 &Y0
S00:002 S01:000 S02:043 S03:013 S04:010 S05:008 S06:007 S07:060 S08:002 S09:006
S10:020 S11:095 S12:050 S18:000 S25:005 S26:001 S36:007 S37:000 S38:020 S44:020
S46:138 S48:007 S95:000
```

Stored Profile 0:

```
B0 E1 L1 M1 N1 Q0 T V1 W0 X4 Y0 &C1 &D2 &G0 &J0 &K3 &Q5 &R1 &S0 &T5 &X0
S00:002 S02:043 S06:007 S07:060 S08:002 S09:006 S10:020 S11:095 S12:050 S18:000
S36:007 S37:000 S40:104 S41:195 S46:138 S95:000
```

Stored Profile 1:

```
B0 E1 L1 M1 N1 Q0 T V1 W0 X4 Y0 &C1 &D2 &G0 &J0 &K3 &Q5 &R1 &S0 &T5 &X0
S00:005 S02:043 S06:007 S07:060 S08:002 S09:006 S10:020 S11:095 S12:050 S18:000
S36:007 S37:000 S40:168 S41:195 S46:138 S95:000
```

Telephone Numbers:

```
0=          1=
2=          3=
```



Leased Line Industrial Control Modem DC

Introduction

A Leased Line Modem is a point-to-point connection between two modems directly linked with a telephone cable. Usually the cable will not carry any line feeding voltage.

Both modems require special settings. The modem controller or an operator using a terminal program must apply the correct settings.

One modem must be programmed/initialised to Answer Mode (slave), the other modem to Originate Mode (master). The setting of a dial-up modem to a leased line modem and back is carried out in the S11 register.

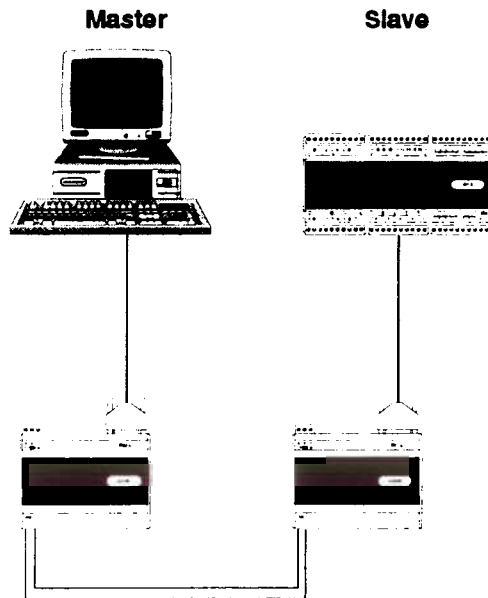
0 means a dial-up connection

1 means a Leased Line Originate Mode (master)

3 means a Leased Line Answer Mode (slave)

The S11 register can be read by the AT\$S11? command in both Off- or Online command mode.

Application



Features

- Automatic connection immediately after applying operating voltage.
- Automatic resumption of the connection after any type of interruption, as soon as the interruption is eliminated.
- Connection with or without MNP4 error correction is possible (LAP- M is possible without additional test protocol on the line, but not recommended).
- Setting of ORG/ANS and LL via S register (LL / ORG as Leased Line Industrial Control Modem DC default)
- Transmit power max. -4 dB for LL (adjustable)
- Gain-to-noise-temperature ratio approx. -40 dB (on interference-free line)
- Terminating resistance of the device approx. 600 ohms
- Works on lines with or without Line Feeding Voltage
- Distances of up to approx. 15 km possible (dependent on line and interference)

Setup procedure

Fundamentally, both modems should have the same settings (except for the specific modes Originate and Answer mode). If the modems have already been reconfigured, they can only be changed in Command Mode (Off - or Online). A Hyper Terminal program can be used to setup the modem via the serial interface.

To change the settings of an Leased Line Industrial Control Modem DC do the following:

1. Connect the Modem to the PC via COM port.
2. Connect Power supply to the Modem. Start the pre-configured Hyper Terminal Connection (correct baud rate etc. - see page 10 Terminal programs).
3. Press the reset bottom on the side of the module to access command mode. The modem returns OK or 0 (depending on Result Code setting).
4. Change the settings as required by your application.
5. Save the new settings by AT&W and <CR>.
6. The correct modem mode must be set again using AT\$S11=1 or AT\$S11=3 and this setting must be saved with AT&W in the internal EEPROM. If the S11 register is 0 or 2, then the device will behave like a normal switched line modem.

7. Return Online Data Mode by pressing Reset for > 5 sec or make a power up reset.

8. Repeat 1-7 on the other modem.

Data transmission with (or without) data compression and error correction (according to pre-setting/initialization) is now possible. MNP should be used for data compression, as with V.42LAP-M the connection may hang up if there is interference on the line.

If the connection is interrupted or broken, the modems will automatically try to re-establish a connection immediately.

Note: The Leased Line modems are not licensed to operate on Public Switched Telephone Networks.

Terminal programs

In the final application, Terminal programs are seldom used for LL applications. LL modems are often put between a host computer and remote computer/controller. However, the modems must always be preconfigured according to the requirements of the interconnection. This can be done by means of a terminal program. Any preferred terminal program may be used (e.g. Hyper Terminal in MS Windows).

Important is the uniformity of the settings for the serial interface on both sides.

Serial Interface Settings:

Block parameters:	7 or 8 data bits Parity Stop bits (1 or 2)
Transmission speed:	300 to 57,600 (normally the same for both modems)
Combinations:	In order to avoid data loss, it is recommended that a flow control mechanism is used, when the serial interfaces uses different speeds.

Hyper Terminal example:

The user must simply set the modems to the required transmission speeds of the serial interface.

It must first be established (cf. manual) at which interface speed the devices connected to the modem (e.g. computer, SPC) actually operate.

The modem in question must be set to this speed using a terminal program. If these speeds are different, flow control must be used.

Open Hyper Terminal in Windows:

Start > Programs > Accessories > Communication > Hyper Terminal
(may first need to be installed from the Windows CD)

In 'Connection Description' window enter a name and select an icon for your connection and closed by clicking on <OK>.

The window 'Phone number' then appears.

Ignore the fields 'Country Code', 'Area Code' and 'Phone Number'.

In the field 'Connect using', select the option 'Direct to COMx' for the active serial interface (x being the COM port you will use) and confirm by clicking on <OK>.

The window 'Port Settings' now appears. Here you set up the transmission properties:

Bits per second, Data bits, Parity, Stop bits and Flow Control.

The default value of the is: **9600, 8, None, 1, Hardware**

Bits per second is set according to the application i.e. the connected DTE (PLC/ RTU). Parity and stop bits should be the same for both modems.

It is recommended to set **Flow Control** to 'Hardware' both if the DTE speed of the modems has to be different or equal. The setting 'None' should only be set if the hardware connected does not support handshake and the DTE speed in both ends are the same.

The 'Xon/Xoff' setting cannot be used.

Each time Hyper Terminal is started, this connection can be opened by its assigned name. The settings can also be changed at a later date using **File > Properties**. Notice that changes in **Port Settings** will only take effect when the Connection is reopened (closed and opened again).

The Hyper Terminal program can now be used to communicate with the modem via the serial interface.

By briefly pressing the reset key, the modem is switched to the offline command mode.

Enter <AT> and press RETURN. OK must appear as the message. You are now able to setup all the parameters you want. The most important parameters are parameters of the connected DTE (PLC/RTU) on the serial port.

By entering <AT&W> and concluding with RETURN, this setting is saved in the internal EEPROM.

If necessary for testing purposes with short telephone lines, the send level must be set as described in on page 12 (if necessary, also conclude with <AT&W>, so that the set-tings are permanently saved).

Finally, the S11 Register must be recreated (see page 8):
ATS11=1 or **ATS11=3** and **AT&W**

Once the settings have been completed, the modem can be returned to online mode by depressing the reset key for slightly longer period (> 5 seconds).

You should then attempt to establish a connection via the telephone line.

Transmit level

The transmitting level depends on the length and quality of the telephone cable. The adaptation for this can be done with the S-91 register.

Recommendation: The S-91 register ought to be set at a value between 5 and 15.

Values below 5 are only to be used for very long lines, i.e. in exceptional cases. For initial operation, (connection between 2 PCs), the value of the S91 register should always be greater than 10.

When installing a Leased Line connection, line quality should be checked. Connect the two modems to the line and let them establish a data connection with a PC, running a terminal program, connected to one of the modems.

When a data connection is established, (DCD LEDs is on) bring the modem in Online Command Mode by pressing reset shortly. The modem returns an OK when in Command Mode.

Read the Line Signal Quality with the command **AT%Q**.

A returned value of 000 to 007 indicates a good quality whereas a value of 008 up to 128 indicates an increasingly poorer line quality. Increase or decrease the transmit level as to improve the Line Quality figure.

If the value cannot be brought below 50, the line speed should be reduced (use the **AT+MS** command). Notice that the transmitting level should be adjusted in both modems. Possible error sources: The values in the S91 register are the opposite of the actual physical send level, i.e. S91=15 actually corresponds to the smallest transmission power, S91=0 to the largest. Therefore, in test operation, short lines with small values in the S91 register (i.e. high transmission power) may lead to over-modulation of the modem input stages.

Appendix A – Technical Specifications

Serial interface

Signal level: RS232C/V24.
 Connector: 9 pole sub-D, female.
 Hardware handshake: DCD, DTR, DSR, RTS, CTS, RI
 Baud Rate: 300, 600, 1200, 2400, 4800, 9600, 19200, 38400, 57600, 115200 (V34 Industrial Control Modem only).
 Format: 7, 8 bit (binary), 1 start bit. Odd, even, No parity, 1, 2 stop bit (if 7 data bit, no parity).
 Default setup: 9600bps, no parity, automatic format/speed sensing

Telephone line interface

Connector: 6 pole RJ11 type modular jack
 Modem Speeds: V.34bis, V.34, V.32bis, V.32, V22bis, V.22A/B, V23 and V.21, Bell 212A and 103

Baud rates: 33.6kbps, 28.8kbs V34 Industrial Control Modem only), 14400, 9600, 4800, 2400, 1200, 300 bps Error correction and data compression boost average data throughput up to 230.4kbps.

Data mode: supported.

Speed buffering at all line speeds up to 115.200bps

Error correction: XOFF/XON or RTS/CTS flow control supported.
 Data compression: V.42 LAPM and MNP 2-4
 V.42 bis and MNPS (MNP10 data throughput enhancement)

REN:

Ring Equivalent Number <1

Modem control:

Hayes compatible. AT command set.

Dial-up:

DTMF dialling

Approvals:

The modem is designed according to European CTR21 standard.

Indicators:

Rxd:
 Txd:
 DCD:
 DTR:
 Power:

Red, indicating receiving data activity.
 Red, indicating transmitting data activity.
 Red, carrier detect/modem connect.
 Red, ready to transmit/receive data.
 Green.

Isolation

Power supply to electronics: 500 V.
Line interface: 1500 V.

Power supply:

Supply voltage: 12 - 48V DC (10,5-60,0V).
Reverse polarity protected.
Protective earth required

Current consumption:

Supply voltage	Typical	Max.
12V	115	140
24V	55	75
48V	30	49

Ambient temperature: -10 to +55 degrees C (+5% to +95% humidity).

EMC: EN 50081-1/EN50082-2.

Climatic:

Dry heat: IEC 68-2-2, Test Bd, Temp. +55°C, Duration 8h.
Cold: IEC 68-2-1, Test Ad, Temp. -10°C, Duration 8h.
Damp heat: IEC 68-2-3, Test Ca, Temp. 40°C, RH 95%, duration 8h.

Mechanical:

Vibration: IEC 68-2-6, Test Fc (sinusoidal), Freq. 10-150Hz, Amp.4g, 5 sweeps in 3 orthogonal axes.
Shock: IEC 68-2-27 (half sine), Acc. 15g, Pulse time 11msec., 3 x 6 shocks.

Protection: IP20.

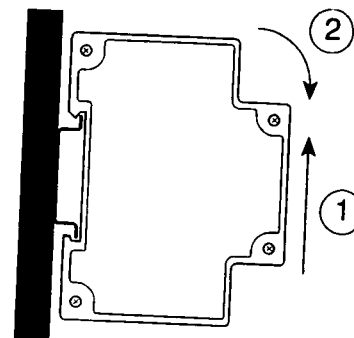
Mounting: 35 mm DIN-rail, EN50022.

Terminals: (power): Max. 1.5 mm² wire.

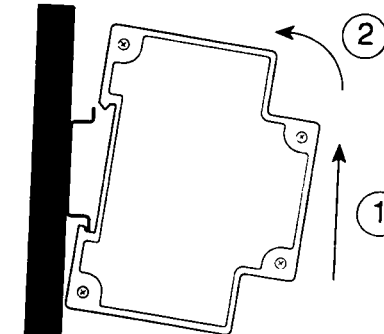
Housing: Anodized aluminum with plastic ends. According to DIN 43880.

Dimensions: HxWxD: 80 (+ connectors) x108 x 62 mm.

Appendix B - Mounting



De-mounting a modem module
Lift the module (1) and twist it out from the top (2) and the module is released from the DIN rail.



Mounting a modem module
Fix the module at the bottom of the DIN rail and lift it (1) while pressing slightly on the top of the module (2).

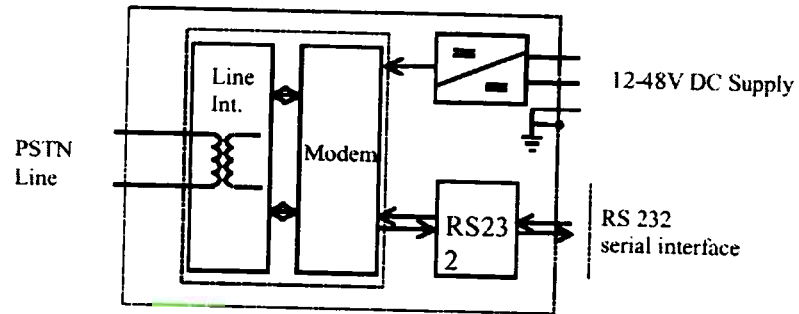
Appendix C – Telephone line interface (RJ11 Modular Jack – 6 pole)

Pin no	Signal name	IO Type	Interface
1	-	-	Not used . No connection needed.
2	-	-	Not used . No connection needed
3	A	BI	Bi-directional phone line (A= TIP)
4	B	BI	Bi-directional phone line (B = RING)
5	-	-	Not used . No connection needed
6	-	-	Not used . No connection needed

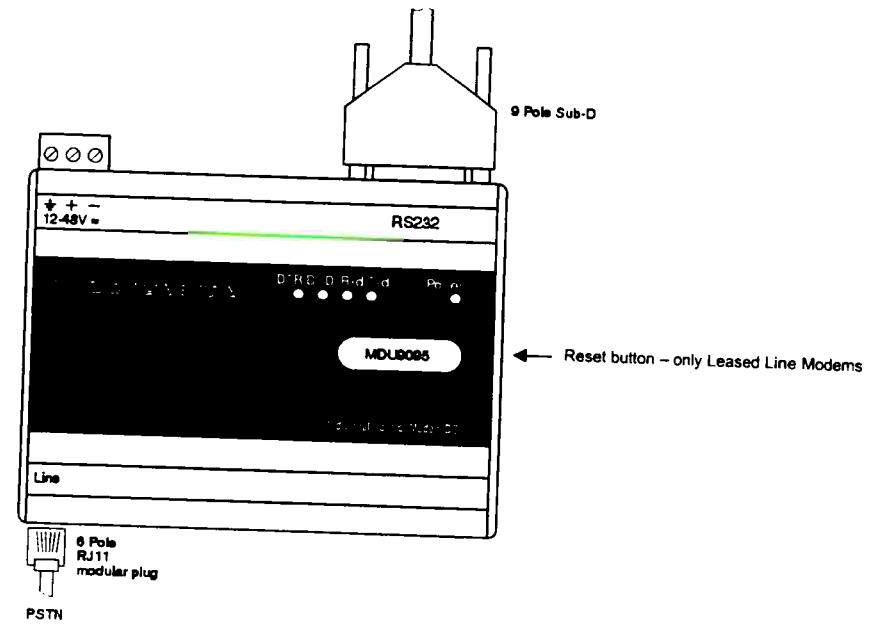
Appendix D – Serial Interface (DB 9 Female Connector)

Pin	Signal label	IO type	Interface
1	DCD	Out	Data Carrier Detect
2	RXD	DCD	Receive Data. The interface uses the RX to send data received from the telco line to the DTE
3	TXD	In	Transmit Data. The DTE uses the TX line to send data to the interface for transmission over the telco line
4	DTR	In	Data Terminal Ready. Turned On when DTE is ready to transmit or receive data
5	SG	Gnd	
6	DSR	Out	Data Set Ready. OFF (high) indicates that the DTE is to disregard all signals appearing on the interface
7	RTS	In	Request To Send. RTS is used to condition the interface for data transmission
8	CTS	Out	Clear To Send. Indicates whether or not the interface (modem) is ready to transmit data. CTS is a response to DTR and RTS
9	RI	Out	Ring indication

Appendix E – Block Diagram



Appendix F – Wiring Diagram



Appendix G – AT Command Summary

Basic AT commands

Command	Function (The default values are typed in bold)
A/	Re-execute command. Will repeat all commands in the command buffer.
A	Go off-hook and attempt to answer a call.
Bn	CCITT or Bell B0 Select V.22 connection at 1200 bps. B1 Select Bell 212A connection at 1200 bps.
CI	Return OK message.
Dn	Dial modifier, n values. 0-9 DTMF digits 0 to 9 P Force pulse dialing T Force DTMF dialing . Dial pause, the time is specified by S8-register W Wait for dial tone, the time specified by S6-register ; Return to command state S=n Dial the number stored in the directory (n = 0 to 3)
En	Command echo E0 Turn off command echo. E1 Turn on command echo.
Fn	Command accepted but no action.
Hn	Disconnect (hang-Up) H0 Initiate a hang-up sequence. H1 If on-hook, go off-hook and enter command mode. The modem will return to on-hook after the time specified in S7.
In	Identification: I0 Report product code. I1 Report pre-computed checksum. I2 Report OK. I3 Report firmware revision, model, and interface type. I4 Report response programmed by an OEM. I5 Report the country code parameter. I6 Report modem data pump model and code revision. I7 Reports the DAA code (W-class models only).

Nn	Automode enable - not valid!
On	Return to On-line data mode O0 Go on-line. O1 Go on-line and initiate a retrain sequence.
P	Force pulse dialing (not supported in hardware)
Qn	Quiet result codes control Q0 Allow result codes to DTE. Q1 Inhibit result codes to DTE.
Sn	Read/Write S-register Sn Select S-Register as default. Sn? Return the value of S-Register n. S=v Set default S-Register to value v. S? Return the value of default S-Register.
T	Force DTMF dialing.
Vn	Result code form: V0 Report short form (terse) result codes. V1 Report long form (verbose) result codes.
Wn	Connect message control W0 Report DTE speed in EC mode. W1 Report line speed, EC protocol and DTE speed. W2 Report DCE speed in EC mode.
Xn	Extended Result Codes: X0 Report basic call progress result codes, i.e., OK, CONNECT, RING, NO CARRIER (also, for busy, if enabled, and dial tone not detected), NO ANSWER and ERROR. X1 Report basic call progress result codes and connections speeds (OK, CONNECT, RING, NO CARRIER (also, for busy, if enabled, and dial tone not detected), NO ANSWER, CONNECT XXXX, and ERROR. X2 Report basic call progress result codes and connections speeds, i.e., OK, CONNECT, RING, NO CARRIER (also, for busy, if enabled, and dial tone not detected), NO ANSWER, CONNECT XXXX, and ERROR. X3 Report basic call progress result codes and connection rate, i.e., OK, CONNECT, RING, NO CARRIER, NO ANSWER, CONNECT XXXX, BUSY, and ERROR. X4 Report all call progress result codes and connection rate, i.e., OK, CONNECT, RING, NO CARRIER, NO ANSWER, CONNECT XXXX, BUSY, NO DIAL TONE and ERROR.

Yn Long Space Disconnect
 Y0 Disable long space disconnect before on-hook.
 Y1 Enable long space disconnect before on-hook.

Zn Soft reset and Restore Profile
 Z0 Restore stored profile 0 after warm reset.
 Z1 Restore stored profile 1 after warm reset.

&Cn RLSD (DCD) Option
 &C0 Force RLSD active regardless of the carrier state.
 &C1 Allow RLSD to follow the carrier state.

&Dn DTR Option
 &D0 Interpret DTR ON-to-OFF transition per &Qn:
 &Q0, &Q5, &Q6 The modem ignores DTR.
 &Q1, &Q4 The modem hangs up.
 &Q2, &Q3 The modem hangs up.
 &D1 Interpret DTR ON-to-OFF transition per &Qn:
 &Q0, &Q1, &Q4, &Q5, &Q6 Asynchronous escape
 (return to command state).
 &Q2, &Q3 The modem hangs up.
 &D2 Interpret DTR ON-to-OFF transition per &Qn:
 &Q0 through &Q6 The modem hangs up.
 &D3 Interpret DTR ON-to-OFF transition per &Qn:
 &Q0, &Q1, &Q4, &Q5, &Q6 The modem performs soft
 reset.
 &Q2, &Q3 The modem hangs up.

&Fn Restore factory configuration
 &F0 Restore factory configuration 0.
 &F1 Restore factory configuration 1.
 &Kn Flow Control :
 &K0 Disable DTE/DCE flow control.
 &K3 Enable RTS/CTS DTE/DCE flow control.
 &K4 Enable XON/XOFF DTE/DCE flow control.
 &K5 Enable transparent XON/XOFF flow control.
 &K6 Enable both RTS/CTS and XON/XOFF flow control.

&Ln Leased Line Operation -, see separate section.
 &L0 Select dial up line operation - always default in PSTN versions

&Qn Sync/Async Mode
 &Q0 Select direct asynchronous mode.
 &Q1 Select sync connect with async off-line command mode.
 &Q2 Select sync connect with async off-line command mode
 and enable DTR dialing of directory zero.
 &Q3 Select sync connect with async off-line command mode
 and enable DTR to act as Talk/Data witch.

&Q4 Select Hayes AutoSync mode.
 &Q5 Modem negotiates an error corrected link.
 &Q6 Select asynchronous operation in normal mode.

&Rn RTS/CTS Option
 &R0 CTS tracks RTS (async) or acts per V.25 (sync).
 &R1 CTS is always active.

&Sn DSR Override
 &S0 DSR is always active.
 &S1 DSR acts per V.25.

&V Display current configurations. Example is shown in the beginning of this section.

&Wn Store Current Configuration:
 &W0 Store the active profile in NVRAM profile 0.
 &W1 Store the active profile in NVRAM profile 1.

&Yn Designate a Default reset Profile
 &Y0 Recall stored profile 0 upon power up.
 &Y1 Recall stored profile 1 upon power up.

&Zn=x Store dial string x to location n (0 to 3).

%En Enable/Disable Line Quality Monitor and Auto-Retrain or Fallback/FallForward
 %E0 Disable line quality monitor and auto retrain.
 %E1 Enable line quality monitor and auto retrain.
 %E2 Enable line quality monitor and fallback/fall forward.

%L Return received line signal level.

%Q Report the line signal quality.

\Gn Data flow control between modems (XON/XOFF).
 \G0 Disables XON/XOFF flow control.
 \G1 Enables XON/XOFF flow control.

\Kn Controls break handling during three states:
 1. When modem receives a break from the DTE:
 \K0,2,4 Enter on-line command mode, no break sent to the remote modem.
 \K1 Clear buffers and send break to remote modem.
 \K3 Send break to remote modem immediately.
 \K5 Send break to remote modem in sequence with transmitted data.

2. When modem receives \B in on-line command state:

- \K0,1 Clear buffers and send break to remote modem.
- \K2,3 Send break to remote modem immediately.
- \K4,5 Send break to remote modem in sequence with transmitted data.

3. When modem receives break from the remote modem:

- \K0,1 Clear data buffers and send break to DTE.
- \K2,3 Send a break immediately to DTE.
- \K4,5 Send a break with received data to the DTE.

- \Nn Select Operating mode
- \N0 Select normal speed buffered mode.
 - \N1 Select direct mode.
 - \N2 Select reliable link mode.
 - \N3 Select auto reliable mode.
 - \N4 Force LAPM mode.
 - \N5 Force MNP mode.

- +MS Select Modulation
The command format is :
+MS=<mod>[,<automode>][,<min_rate>][,<max_rate>]]]<CR>

+MS=? Returns information on supported options
(0,1,2,3,9,10,11,64,69),(0,1),(300-33600),(300-33600) +MS? Returns
selected options: 11,1,300,33600

The modulation parameter options are:

<mod>	Modulation	Possible Rates	Notes
0	V.21	300	
1	V.22	1200	
2	V.22bis	2400 or 1200	
3	V.23	1200	See Note 1
9	V.32	9600 or 4800	
10	V.32bis	14400, 12000, 9600, 7200 or 4800	MDU9095-V32
11	V.34bis	33600, 28800, 26400, 24000, 21600, 19200, 16800, 14400, 12000, 9600, 7200, 4800 or 2400	MDU9095-V34
64	Bell 103		
69	Bell 212		

Notes:
1. For V.23, originating modes transmit 75 bps and receive at 1200 bps; answering modes transmit at 1200 bps and receive at 75 bps. The rate is always specified as 1200 bps. Please note that Half Duplex is not supported.

ECC Commands

- %Cn Enable/Disable Data Compression
 - %C0 Disable data compression.
 - %C1 Enable MNP 5 data compression.
 - %C2 Enable V.42 bis data compression.
 - %C3 Enable both V.42 bis and MNP 5 compression.
- /An Select Maximum MNP Block Size
 - \A0 Set maximum block size in MNP to 64.
 - \A1 Set maximum block size in MNP to 128.
 - \A2 Set maximum block size in MNP to 192.
 - \A3 Set maximum block size in MNP to 256.

\Bn Send break of n x 100 ms. (n= 1...9) (default=3)

MNP 10 Commands

- Kn MNP Extended Services
 - K0 Disable MNP 10 extended services.
 - K1 Enable MNP 10 extended services.
 - K2 Enable MNP 10 extended services detection only.

- SEC=n Enable/Disable MNP10-EC
 - SEC=0 Disable MNP10-EC.
 - SEC=1, [<tx level>] Enable MNP10-EC and set transmit level <tx level> 0 to 30 (0 dBm to -30 dBm).

W-Class Commands

- *B Display list of permanently blacklisted numbers (none).
- *D Display list of delayed numbers (none).
- *NCn Change country to one of eight in NVRAM (always=6).