3.5 IEC-bus Programming

3.5.1 General

The programming of the NGPS is achieved via the 24-way-connector 26 labelled DATA I/O on the rear panel. Data is transmitted in a byte-serial asynchronous bus system which uses an interface conforming to the IEC 625-1 (IEEE 488-1975) standard.

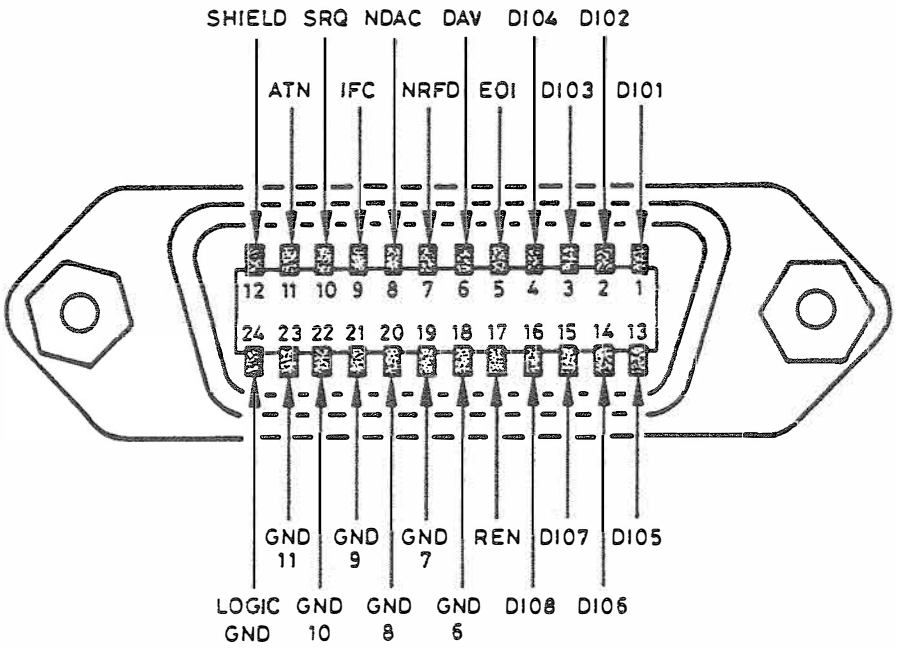


Fig. 3.1 Pin assignment

The American standard IEEE 488-1975 specifies a connector differing from that of IEC standard. The NGPS is equipped with the more frequently used 24-way connector of the IEEE 488-1975 standard. Connection to units equipped with the 25-way IEC-standard connector can easily be made by the use of an adapter. The adapter is available from ROHDE & SCHWARZ under the order designation 216.0188.02.

The IEC bus consists of three groups of lines: the data lines, the clock lines for timing of transfer sequences and the control lines for the management of the system.

The 7-bit ASCII-Code (see table 7.3) is used for character coding so that one complete character per chlock is transferred via the data bus.

Handshaking is not used while parallel poll is carried out. The control function ATN (attention) is used to distinguish between device addressing and data transfer. Combined with the control function EOI (end or identify), the ATN line is used to generate the function IDY (identify) during parallel poll on the bus.

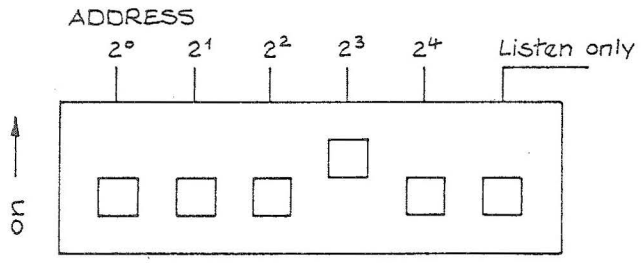
The following interface functions of the IEC bus are provided with the programmable NGPS:

SH 1, AH 1, T 2, TE 2, L 1, LE 1, SR 1, PP 1,
C 0, DC 1, DT 1 and RL 0.

The NGPS can only be programmed if the operating mode switch 20 on the front panel is either in the COMBined mode or in the REMOTE mode.

3.5.2 Setting of Device Address

The device address of the NGPS can be set to one of 31 possible values by means of the address switches 27 located on the rear panel. The address is factorypreset to the value of 8. This is accomplished by setting the switch 2^3 to the ON state whereas all others are in the OFF state. ON thus corresponds to the logical 1.



For programming the NGPS without prior addressing, i.e. without activating the ATN line, (and there are no other devices connected to the bus), the lon (listen only) switch 28 is to be switched to the ON position. With this kind of addressing, the address indicator 19 in the display lights continuously. Otherwise it lights up in the addressed mode and it goes out again, when the device

has received the messages UNL (unlisten) or UNT (untalk) or a reset instruction of the IFC line (interface clear).
The settable device address ranges from 0 to 30. Table 7.5 compiles a list of universal IEC-bus commands and their formats for different controllers. The selected device address in this case is 8.

If more than one device is connected to the IEC bus, the lon switch should remain in the OFF position. After each programming sequence from the controller, the devices should principally be unaddressed by the instructions UNL or UNT to avoid data transfer errors.

3.5.3 Secondary Addresses

For ease of programming, the NGPS may also be addressed via a secondary address. To enable this, the ASCII character DC3 must first be transmitted as a data byte (see Table 7.3).

Instruction with PUC/PPC:
```
XXX   IECOUT8,CHR$(19)
```

The normal addressing mode is reset by sending the character DC2 having called up the NGPS with any secondary address.

Instruction with PUC/PPC:
```
XXX   IECOUT8;0,CHR$(18)
```

The following assignments have been implemented:

secondary address	channel	range
1	A	low
2	A	high
3	B	low
4	B	high
5	A + B	low
6	A + B	high

Other values for secondary addresses are meaningless and do not affect the program run. When addressing the NGPS as a talker (see 3.5.6), secondary address mode should not be used.

Note: Some desktops and controllers automatically generate secondary addresses for I/O operations.

3.5.4 Data Format

After correct addressing of the device as a listener it is ready for data reception. Data are transmitted in the ASCII code (Table 7.3). All data or characters are disregarded before receiving the ASCII characters U, S or P. The first valid character determines the data type of the following string:

U for Voltage
S for Terminator
P for Programming a Ramp

Programming the Terminator

The terminator is used to indicate the end of a data string when the EOI line is not used for this purpose. The possibility to select the terminator is an advantage especially for simple systems and allows adaptation to different controllers or different software.
After the power is switched on, the character CR (carriage return) is automatically initialized as the terminator in the NGPS. One can change this terminator by using the following data string:

"S $"

where the $ character stands for an arbitrary control character of colum 0 or 1 in table 7.3.

3.5.5 Voltage Setting

The second transmitted character, if the first is a U, determines the output channel of the NGPS:

A = channel A
B = channel B
C = A and B channels in parallel
(A and B will have the same output voltage)

The third character stands for the range:

L = low range (-16.3835 V to +16.3835 V)
H = high range (-40.000 V to +40.000 V)

If the channel or range has not to be changed by subsequent programming, these parameters can be omitted in the following data strings. The secondary addresses 1 to 6 can be used instead (see section 3.5.3).

The following examples are formulated in the programming language BASIC. Differences in the I/O operations of different controllers should be taken into account by referring to their manuals.

Example:
```
IECOUT8, "UAL+2;U+4;U+6"
instead of
LECOUT8, "UAL+2;UAL+4;UAL+6"
```

As can be seen from this example, the sign precedes the value of the volts to be set. A space is permitted instead of the + sign. Decimal fractions are indicated by a decimal point. An exponent can follow after the character E (floating point numbers).

Example: Setting 10 Volts

```
   IECOUT8,   "UAL+10"
or IECOUT8;1, "U␣10"
or IECOUT8;1, "U␣10.0"
or IECOUT8;1, "U␣1E+1"
or IECOUT8;1, "U␣100E-1"
```

The exponent must have a sign and up to 2 digits. If a non-valid value is programmed, the whole string will be disregarded and no setting will take place. Fractions of the minimal programmable value are automatically rounded off.

Several values can be input sequentially in a single string, if they are separated by commas or semicolons.

Example: IECOUT8,"UAL␣10;UBH-30"

3.5.6 Set Value Request

A check of the set value of the two channel outputs can be made at any time. The request is caused by the following BASIC instruction:

```
IECIN8,A$
```

Hereby the NGPS is addressed as a talker, the status is transmitted from the voltage source to the controller and assigned to the controller as a string variable A$.

The status is transmitted in the following data format:

```
"UAmn; UBmno"
 ||  | ||
 ||__|_||_________ constant ASCII-characters
```

m = range (H or L)
n = set value of output voltage
o = valid terminator

Example: UAL 10.0000;UBH-30.0000(CR)

If one of the channels is in the OFF state, the value to be stored and later to be called up is transmitted in parenthesis. An analog error (current limiting occurs, ERROR indication lights) of a channel is indicated by an X.

Example: UAL(10.0000);UBHX(CR)

If an analog error occurs, the NGPS activates the SRQ line (service request) thereby requesting service from the controller. If the controller has the means to sense the SRQ line, the main program can be interrupted and a serial poll of all connected devices can be performed. On a status or set value request of the device reporting an error, the SRQ line is reset to its initial state and the program can be continued when the error is removed.

If the controller transmits the instruction IECSPE (serial poll enable) and the NGPS is addressed as a talker, a status byte rather than the set value is output. The status byte contains in bit 1 (the least significant bit), a logical 1 as long as there is current limitation in channel B, in bit 2 a 1 as long as an error occurs in channel A, in bit 7 a 1, if the SRQ line was activated by this device. After the instruction IECSPD (serial poll disable), the set value is output again if the device is addressed as a talker.

If the controller cannot handle a serial poll, there is the possibility of making a parallel poll of all devices on the IEC bus.

The poll can be prepared by assigning a response line to each device after the transmission of the IECPPC message (parallel poll configure) at the beginning of the program (max. 8 devices) with the IECPPE message (parallel poll enable). A parallel poll can be executed at any time and must be initialted by the controller (by activating the ATN line and the EOI line, independent of the SRQ line). With more than 8 devices, the two methods can be combined to increase the poll rate. In this case, one response line is allocated to several devices. If the SRQ lines is activated, a parallel poll is at first executed and after this, a serial poll is executed within the selected group of devices.

For a parallel poll, the NGPS is only able to inform the controller whether the analog error is in channel A or B, because only one response line per device is allocated.
For coding of addresses and instructions see 7.4.

3.5.7 Device Trigger Function

If a test program is to start several devices at a defined instant of time, this can be done by the trigger function.

For initialize the trigger function, the NGPS has to be set to the OFF state at first. This is accomplished by pressing the ON/OFF key 23 in the COMBined or LOCAL mode. The same can be done by the addressed command IECSDC (selected device clear) or the universal command IECDCL (device clear) by the controller. The devices can then be preset and be started by the addressed command IECGXT (group execute trigger). All devices to be triggered have to be addressed first.

This is the fastest way of setting a value for the NGPS because on the trigger instruction the NGPS is directly set to the ON state.

Example:
```
100 IECLAD8
110 IECSDC
120 IECGXT
130 IECUNL
```

3.5.8 Programming an Automatic Voltage Variation (Ramp)

If required, a ramp can be generated, which is programmed via the IEC bus. To define a ramp, the initial and the final voltage value, stepwidth, i.e. voltage jump per step, and time units per step have to be sent to the NGPS.

The ramp is initiated by using the instruction IECGXT (group execute trigger). The voltage increases by the programmed stepwidth n, if the final value is greater than the initial voltage and it decreases if the final value is less than the initial voltage value.

The succeeding jump is executed after time t. The ramp is continued until

a) the programmed final voltage value is reached or
b) m steps have been executed (important for stepwidth 0!) or
c) an interrupt instruction (pause) has been received or
d) an immediate abort, including the return to the initial voltage value, is initiated via IEC bus or manually.

During the execution of a ramp function, the voltage display 14 is switched off. After termination of the ramp or during an interrupt (pause), the actual nominal voltage value of the programmed channel is displayed again. Continuation of a ramp after an interrupt is feasible by using the IECGXT command again.

Note: It is not possible to use different ramps for the two channels. It is only possible to execute a ramp on one channel, while the voltage value of the other one is constant, or to execute the same ramp on both channels (if the initial value has been programmed with UC...).

During a pause, set value request is possible (see 3.5.6). In the data string of the channel in which a ramp is programmed, the U is replaced by a P. Additionally, serial poll and parallel poll are feasible. Parallel poll is possible not only during a pause but also during voltage variation. Manual abort is done by switching the selector switch 20 to LOCAL.

The advantages of the ramp function versus setting step-by-step via IEC bus are as follows:

a) less loading of the IEC bus which is therefore available for other tasks as well,

b) smaller and more accurate time units per step are possible due to crystalcontrolled timebase.

Programming

Channel, range and initial voltage value are input as normally, then this data format follows:

```
IECOUT8,"Pe,n,m,t" + CHR$(13)
```

The first character that has to be transferred is a P. Instead of the commas between e, n, m and t, it is possible to use a semicolon.

The lower case letters used as symbols have the following meaning:

e - final voltage value in volts, data format and range of values same as in the normal program. The final value must be in the same range (in high or low range) as the initial value.

n - stepwidth in LSB (0.5 mV in the low range, 2 mV in the high range),
format: integral without sign or exponent, leading blanks are allowed, range of values from 0 to 65,535.

m - maximum number of steps to be executed, format: same as n, range of values from 1 to 65,535. If the number of steps unimportant, i.e. only the final value is of interest, a large number should be chosen.

t - number of time units per step, time unit: 1 ms;
format: same as n, range of values from 1 to 65,535.

Start instruction:	IECGXT (group execute trigger)
Interrupt:	IECOUT8, "T1"
Continuation:	IECGXT
Abort and return to the initial voltage:	IECOUT8, "T0" or selector switch 20 to "LOCAL"

Example for programming a ramp:

```
100 IECOUT8, "UAL+2"
110 IECOUT8, "P+16.2,200,150,20"
120 IECLAD8
130 IECGXT
140 IECUNL
```

The initial voltage value is 2 volts in the low range. The final value is 16.2 volts. The stepwidth is 200 x 0.5 mV = 100 mV; 150 steps are allowed, i.e. the programmed final value will be reached. The time interval of each step will be 20 ms.

3.6 Combined Mode

The voltage source NGPS can be set manually as well as controlled via the IEC bus, if the selector switch 20 is in position "COMB". The keyboard is in this case locked, as long as the ADDRESS lamp 19 lights. Data transfer via the IEC bus is also blocked, as long as one oft the pushbuttons 21 to 25 is pressed.

By the set value request during a running program described in 3.5.6, a manually set value can be checked by the controller.

3.7 Operation with Remote Sensing

To compensate for the voltage drop across the leads between the NGPS and the load, remove the shorting links between the output sockets and the sensing sockets marked S on the rear panel. Connect the sensing sockets 5 and 9 (channel A) and 10 and 13 (channel B) directly to the load by a two-wire line. Care must be taken for correct polarity!

For additional information see 4.3.

3.8 Series and Parallel Connection

If an output voltage higher than the rated output voltage of the NGPS is required, series connection of two or more voltage sources is possible. Besides correct polarity, attention must be paid to the danger of high potentials.
Potection diodes on the output sockets provide a low resistance current path when feeding in from outside. All ROHDE & SCHWARZ power supplies contain such diodes as standard.

When using voltage drop compensation, the sensing lines must be connected in series. To avoid earthing loops, it is recommended to star-connect the ground terminals.

Parallel connection is not recommended because at least one device would go into current limitation and an analog error would continuously be indicated and out via the IEC bus.

4. Principle of Operation

4.1 Voltage Regulation

For the principle of voltage regulation refer to Fig. 4.1.

In manual as well as in remote control, the nominal voltage value is handed over to a digital-analog-converter (DAC) whose outputs carry a current in proportion to the input voltage. This current generates a voltage drop across a programming resistor which is compared with the actual value of the output voltage. The resulting differential voltage is applied to an operational amplifier and is used to regulate the final

BITS B7 B6 B5 / B4 B3 B2 B1	Ø Ø Ø	Ø Ø 1	Ø 1 Ø	Ø 1 1	1 Ø Ø	1 Ø 1	1 1 Ø	1 1 1
	COMMAND		LISTEN ADDRESS		TALK ADDRESS		SECONDARY ADDRESS	
	ADRSD	UNIV						
Ø Ø Ø Ø	NUL (0)	DLE (16)	SP LA0 (32)	0 LA16 (48)	@ TA0 (64)	P TA16 (80)	\ SA0 (96)	p SA16 (112)
Ø Ø Ø 1	SOH GTL (1)	DC1 LLO (17)	! LA1 (33)	1 LA17 (49)	A TA1 (65)	Q TA17 (81)	a SA1 (97)	q SA17 (113)
Ø Ø 1 Ø	STX (2)	DC2 (18)	" LA2 (34)	2 LA18 (50)	B TA2 (66)	R TA18 (82)	b SA2 (98)	r SA18 (114)
Ø Ø 1 1	ETX (3)	DC3 (19)	# LA3 (35)	3 LA19 (51)	C TA3 (67)	S TA19 (83)	c SA3 (99)	s SA19 (115)
Ø 1 Ø Ø	EOT SDC (4)	DC4 DCL (20)	$ LA4 (36)	4 LA20 (52)	D TA4 (68)	T TA20 (84)	d SA4 (100)	t SA20 (116)
Ø 1 Ø 1	ENQ PPC (5)	NAK PPU (21)	% LA5 (37)	5 LA21 (53)	E TA5 (69)	U TA21 (85)	e SA5 (101)	u SA21 (117)
Ø 1 1 Ø	ACK (6)	SYN (22)	& LA6 (38)	6 LA22 (54)	F TA6 (70)	V TA22 (86)	f SA6 (102)	v SA22 (118)
Ø 1 1 1	BEL (7)	ETB (23)	' LA7 (39)	7 LA23 (55)	G TA7 (71)	W TA23 (87)	g SA7 (103)	w SA23 (119)
1 Ø Ø Ø	BS GET (8)	CAN SPE (24)	(LA8 (40)	8 LA24 (56)	H TA8 (72)	X TA24 (88)	h SA8 (104)	x SA24 (120)
1 Ø Ø 1	HT TCT (9)	EM SPD (25)	) LA9 (41)	9 LA25 (57)	I TA9 (73)	Y TA25 (89)	i SA9 (105)	y SA25 (121)
1 Ø 1 Ø	LF (10)	SUB (26)	* LA10 (42)	: LA26 (58)	J TA10 (74)	Z TA26 (90)	j SA10 (106)	z SA26 (122)
1 Ø 1 1	VT (11)	ESC (27)	+ LA11 (43)	; LA27 (59)	K TA11 (75)	[TA27 (91)	k SA11 (107)	{ SA27 (123)
1 1 Ø Ø	FF (12)	FS (28)	, LS12 (44)	< LA28 (60)	L TA12 (76)	\ TA28 (92)	l SA12 (108)	¦ SA28 (124)
1 1 Ø 1	CR (13)	GS (29)	- LA13 (45)	= LA29 (61)	M TA13 (77)	] TA29 (93)	m SA13 (109)	} SA29 (125)
1 1 1 Ø	SO (14)	RS (30)	. LA14 (46)	> LA30 (62)	N TA14 (78)	^ TA30 (94)	n SA14 (110)	~ SA30 (126)
1 1 1 1	SI (15)	US (31)	/ LA15 (47)	? UNL (63)	O TA15 (79)	_ UNT (95)	o SA15 (111)	RUBOUT (DEL) (127)

	Zeichn.-Nr.	Blatt.-Nr.
		7.2

ROHDE & SCHWARZ	Benennung	Platine-Nr.
	ASCII 7 bit Code	
	zu Gerät: NGPS	

Befehl Instruction	Abk. Abbr.	DIO-Leitungen DIO-lines 8 7 6 5 4 3 2 1	DAV	NRFD	NDAC	ATN	EOI	SRQ	IFC	REN
SELECTED DEVICE CLEAR	SDC	X 0 0 0 0 1 0 0	X	X	X	1	0	X	X	X
PARALLEL POLL CONFIGURE	PPC	X 0 0 0 0 1 0 1	X	X	X	1	0	X	X	X
GROUP EXECUTE TRIGGER	GET	X 0 0 0 1 0 0 0	X	X	X	1	0	X	X	X
DEVICE CLEAR	DCL	X 0 0 1 0 1 0 0	X	X	X	1	0	X	X	X
PARALLEL POLL UNCONFIGURE	PPU	X 0 0 1 0 1 0 1	X	X	X	1	0	X	X	X
SERIAL POLL ENABLE	SPE	X 0 0 1 1 0 0 0	X	X	X	1	0	X	X	X
SERIAL POLL DISABLE	SPD	X 0 0 1 1 0 0 1	X	X	X	1	0	X	X	X
MY LISTEN ADDRESS	MLA	X 0 1 L L L L L	X	X	X	1	0	X	X	X
MY TALK ADDRESS	MTA	X 1 0 T T T T T	X	X	X	1	0	X	X	X
MY SECONDARY ADDRESS	MSA	X 1 1 S S S S S	X	X	X	1	0	X	X	X
PARALLEL POLL ENABLE	PPE	X 1 1 0 S P P P	X	X	X	1	0	X	X	X
PARALLEL POLL DISABLE	PPD	X 1 1 1 D D D D	X	X	X	1	0	X	X	X
PARALLEL POLL RESPONSE 1	PPR1	X X X X X X X 1	X	X	X	1	1	X	X	X
PARALLEL POLL RESPONSE 2	PPR2	X X X X X X 1 X	X	X	X	1	1	X	X	X
PARALLEL POLL RESPONSE 3	PPR3	X X X X X 1 X X	X	X	X	1	1	X	X	X
PARALLEL POLL RESPONSE 4	PPR4	X X X X 1 X X X	X	X	X	1	1	X	X	X
PARALLEL POLL RESPONSE 5	PPR5	X X X 1 X X X X	X	X	X	1	1	X	X	X
PARALLEL POLL RESPONSE 6	PPR6	X X 1 X X X X X	X	X	X	1	1	X	X	X
PARALLEL POLL RESPONSE 7	PPR7	X 1 X X X X X X	X	X	X	1	1	X	X	X
PARALLEL POLL RESPONSE 8	PPR8	1 X X X X X X X	X	X	X	1	1	X	X	X
STATUS BYTE	STB	S 1 S S S S S S	X	X	X	0	X	X	X	X
DATA BYTE	DAB	D D D D D D D D	X	X	X	0	X	X	X	X

Befehl Instruction	PPC / PUC	hp 9835/45	hp 9825	Tektronix 4051/52
Go to local	IECLAD 8 IECGTL IECUNL	LOCAL 708 oder LOCAL 7*	lcl 708 lcl 7*	WBYTE@ 40,1, 63:
Local Lockout	IECLLO	LOCAL LOCKOUT 7	llo 7	WBYTE@ 17:
Device Clear	IECDCL	RESET 7	clr 7	WBYTE@ 20:
Selected Device Clear	IECLAD 8 IECSDC IECUNL	RESET 708	clr 708	WBYTE@ 40,4, 63:
Group Execute Trigger	IECLAD 8 IECGXT IECUNL	TRIGGER 708	trg 708	WBYTE@ 40,8, 63:
Parallel Poll Configure	IECLAD 8 IECPPC IECPPE s_1s_2 IECUNL	PPOLL CONFIGURE 708; mask	polc 708, mask	--
Parallel Poll Unconfigure (univers.)	IECPPU	PPOLL UNCONFIGURE 7	plu 7	--
Parallel Poll Unconfigure (addressed)	IECLAD 8 IECPPD IECUNL	PPOLL UNCONFIGURE 708	plu 708	--
Parallel Poll	IECPPL v%	PPOLL (7)	pol (7) A	--
Serial Poll	IECSPL 8,s%	STATUS 708; s	rds (708) A	POLL A,S;8

* LOCAL 7 schaltet die REMOTE-Leitung ab.
Vor Ausgabe neuer IEC-Bus-Befehle muß mit Remote 7 die REMOTE-Leitung wieder aktiviert werden.

* LOCAL 7 disconnects the REMOTE-line.
Previous to output of new IEC-bus instructions the REMOTE-line must be reactivated by REMOTE 7.