BPS COF.L.BEC1
CDE BIPOL IEEE

User Manual
B-EC1

BRUKER

Description of B-EC1

Local and remote control of the power supply

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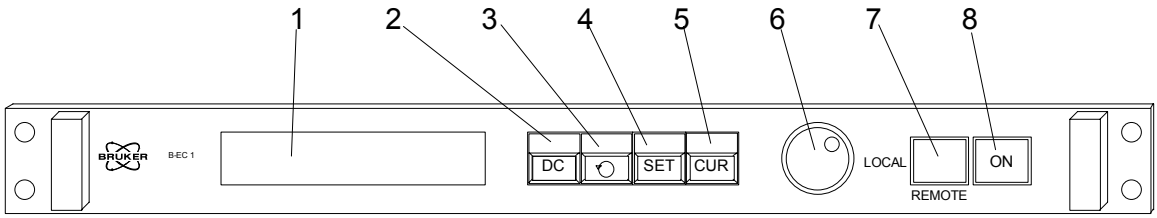


1: Display DAC current, ADC read back, DC on/off and error messages
2: Key DC ON/OFF, RESET, POLARITY with LED, needs SET for complement
3: Key Display selection, ADC read back
4: Key SET, complement for every LED blinking command
5: Key CUR, EXTERNAL REFERENCE, BH-15 REGULATION and CYCLE with LED, needs SET
6: Analog knob
7: Remote / local key
8: Electronic ON key

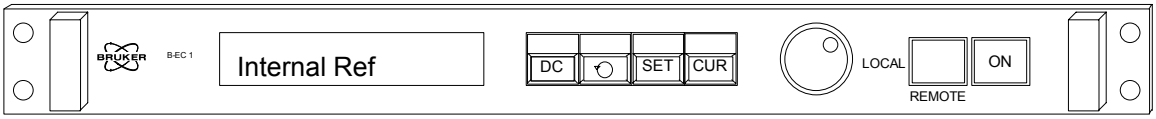
Explanation of technical terms, not all topics applicable for all power supplies:

ADC:	Analog Digital Converter, converts analog voltage to a digital code
DAC:	Digital-Analog-Converter, converts digital code to an analog voltage
LED:	Light Emitting Diode
AC:	Alternate Current
DC:	Direct Current
DCCT:	DC Current Transformer, zero flux current transformer
APB:	Analog Processing Box, contains DCCT and regulation prints
Analog knob:	Digital encoder, can be used like an potentiometer
RS 232 C:	Serial interface norm
^{o}C:	Degree Celsius
U_{ce}:	Collector/emitter voltage of power stage

1. Local control via front panel

1.1 Theory of operation

The following chapters describe the local operation of the power supply controller B-EC1. Throughout the text, the commands and messages concerning the serial interface are described parallel to their manual operation.



Upon electronic power on, the controller is in an initialization state, DC is off, the reference is set internal and the nominal current is set to zero. Reacting on any key press, the status of the power supply is displayed on the front panel. Commands are initiated by pushing one of the command keys. When a command needs an argument, this will be indicated on the key by a blinking LED. The 'SET'-key completes every blinking LED command.

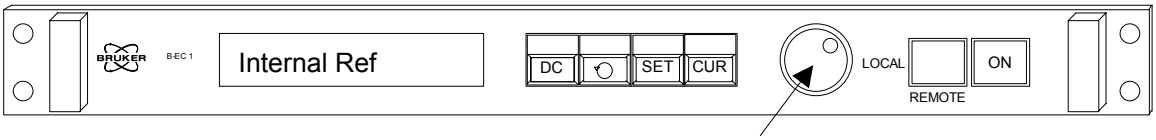
Commands can be skipped by pushing an alternate command key. Keys with more than one function, like 'DC', 'CUR' and the 'Display selection key', can be pushed multiple times, the according menus are arranged in a closed loop. Illegal keystrokes are flagged and ignored. Possible error messages are:

Remote info	Local message	Explanation
E01	FUNCTION E.	Function not supported, e.g. during polarity reversal
E02	ARGUMENT E.	The argument contains unknown characters - not likely in local operation
E03	PORT N/AVAIL	Port not available - this error is not likely in a single port system
E04	LOCAL ERROR	Access denied, check the local / remote switch
E05	RANGE ERROR	The argument is out of the allowed range - not likely in local operation
E06	REF. ERROR	Access denied, Ext Ref or BH-15 active
E07	E. PENDING	DC command denied, there is still an error pending
E08	CYCLE ERROR	Access denied, cycle is active
E09	DC ERROR	Access denied, DC power is OFF

1.1.1 Analog knob

The command 'CUR' allow the use of the quasi analog control knob. Turning the knob slowly, the output can be changed by single bits, increasing the speed will change at a more than proportional rate.

This quasi-analog setting is stored in the internal memory of nominal values and can be preset and read back using the appropriate command key or remote command. Pushing the 'SET'-key disables the knob for the function.



1.1.2 Status information

The power supply is equipped with a security system, its status is read out at the text display. Every error leading to a power-off state of the supply is displayed, multiple errors are flagged in a short form as given in the following table.

By some power supplies, not all interlocks are supported, and might not appear.

In detail	Short form	Explanation
WATER ERROR	W	Water missing
PHASE ERROR	P	Line Phase missing
TEMP ERROR	T	Temperature error
DOOR ERROR	D	Door opened
EXTERN E. 1	1	External error 1
INRUSH E.	I	Inrush fail
CUR LIMIT	C	Current limit
POLARITY E.	U	Polarity Unit

The error messages give information’s about the status of the power supply. Actions necessary upon any error shall now be described more in detail. Also, here is described, what can be done first to recover from an error. But please keep always in mind: The power supply is operated with line voltages, which may be hazardous. Therefore, please be sure what you are doing, before you open any cover or housing.

Message **'Water Error'**, short form **'W'**, remote **'0001Hex'**: Check your local water system, all valves should be opened, water pressure must be corresponding to the PS documentation, also the outlet should not reduce the difference pressure between input to output to less than the value seen in the documentation.

If the power supply still displays the water error, please check the water flow switch.

Message **'Phase Error'**, short form **'P'**, remote **'0002Hex'**: One of the line phases might be missing. Please check them with a volt meter, but please keep in mind the personal hazard of line voltages. Also, the mains transformer may have a loose connection, they can be re-fastened after power down of the system.

Some power supplies have phase follow dependent detectors, so it can be useful to exchange two phases.

Message **'Temp Error'**, short form **'T'**, remote **'0004Hex'**: This message is derived from several temperature contacts in the power supply. First, please try to check the impedance of the external load. Perhaps it became low, e.g. due to a short circuit. This measurement can be made with the power supply itself after cooling down the faulty channel to a sufficient level (check the ADC I and U read back).

Another possibility can be a bad cooling water condition, e.g. high input temperature or high output pressure. If these tests should not bring a positive result, please check the fuses of the pass bank. If more than two transistors should have blown their fuses, please change them individually, or change the complete pass bank, what ever may be easier.

Message **'Door Error'**, short form **'D'**, remote **'0010Hex'**: The door on the backside of the power supply is opened. The power supply is switched off for security reasons. It seems to be a straightforward solution of this error to short-circuit the contact, but please keep in mind the personal security of you and your staff.

Option: Message **'Ground Error'**, short form **'G'**, remote **'0020Hex'**: The ground contact relay has tripped due to a ground voltage exceeding about 10 volt. This results from a ground leak in the power supply or of the load magnet, which can be disconnected to locate the problem.

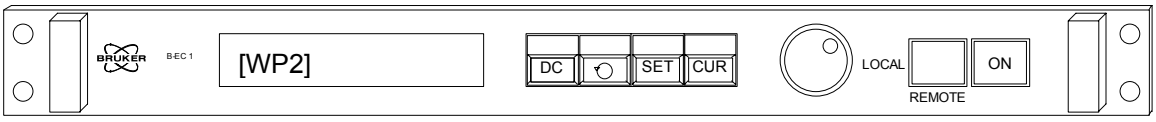
Message **'Extern E. 1'**, or **'EXTERN E. 2**, respectively short form **'1'** or **'2'**, remote **'0008Hex'** or **'0040Hex'**: This is a message derived from the external interlock contacts.

Message **'Cur Limit'**, short form **'C'**, remote **'0100Hex'**: The overcurrent detector on the regulation print has detected an overcurrent. If the error was not only a spurious trip, please check the regulation loop. Best ideas about the performance can be found around the regulation amplifier, where also the overcurrent circuit is located. The ADC on the board is designed to display an overcurrent (and also overvoltage) of up to 10 %. So it might help to check the problem, which might result from a failure of the gain or the offset of the regulation, but also from a defective driver circuit on the pass bank.

Message **'Polarity E.'**, short form **'P'**, remote **'0400Hex'**: during the polarity reversal process, a time out is set. If the read back of the correct polarity is not ok when the time out is passed, this will be flagged by an error message. Also the control voltage of the relay will be reset to avoid a burn-out of the coil.

Message **'Inrush error'**, short form **'I'**, remote **'0800Hex'**: the Power ON sequence with Inrush function has failed.

Example:

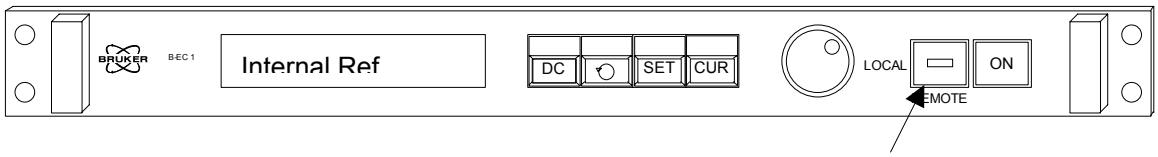


Multiple errors, flagged in a short form: Power supply water (W), line phase (P) and external error 2 (2).

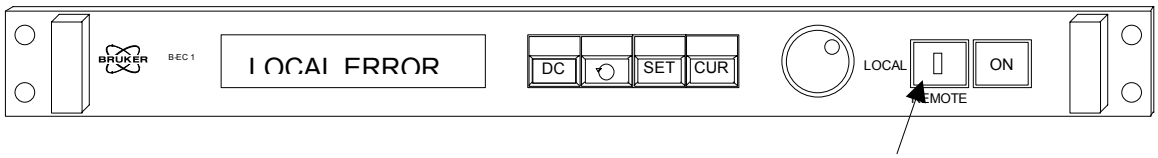
1.2 Explanation of available functions

1.2.1 Change of local/remote state

A key switch is provided to change from local to remote state and back again. A change of local/remote state can be made at the local front panel only, this feature is implemented for security reasons.



The controller is in 'LOCAL' state, commands from the front panel are allowed.



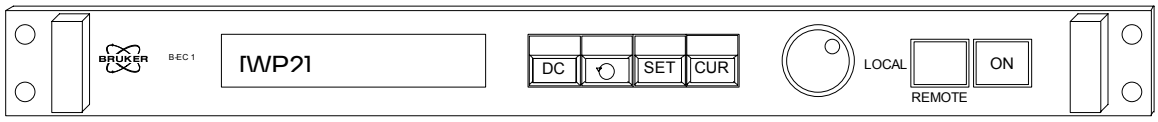
The controller is in 'REMOTE' state, illegal commands from front panel, like 'set current', are flagged with a 'LOCAL E.' message. Interface RS232C or IEEE are allowed.

The appropriate interface command consists of a read back only:

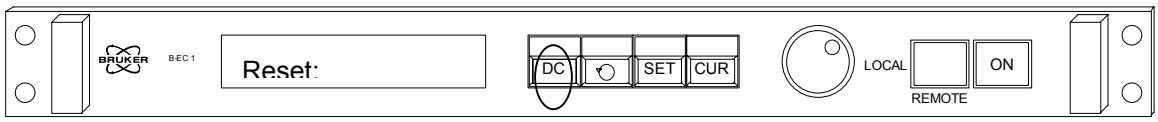
REM/	Check local/remote state	0: local 1: remote

1.2.2 Reset of power supply

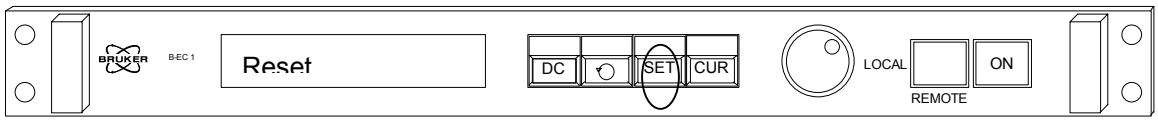
The power supply is equipped with a security system, its status is read out at the text display. Every error leading to a power-off state of the supply is displayed. Error messages concerning the power supply can be reset by pushing the 'DC' key and 'SET' for complement, all status information's should be in neutral condition. The key may be used in local mode only.



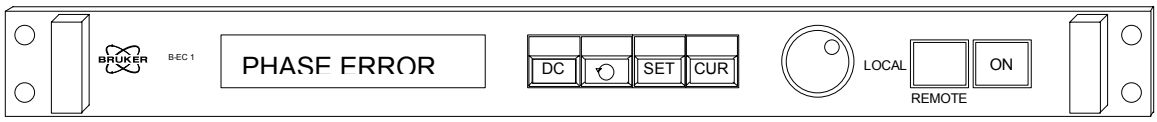
Power supply water (W), line phase (P) and external error 2 (2) (see chapter **1.1.2**).
Push the 'DC' key.



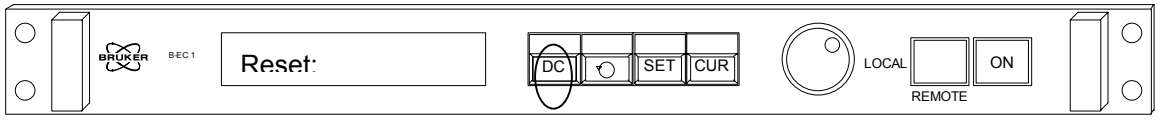
The LED on 'DC' key is blinking, needs 'SET' for complement.
Push the 'SET' key.



'RESET' is done, the text is displayed for 1 second.
'Phase error' is still pending.

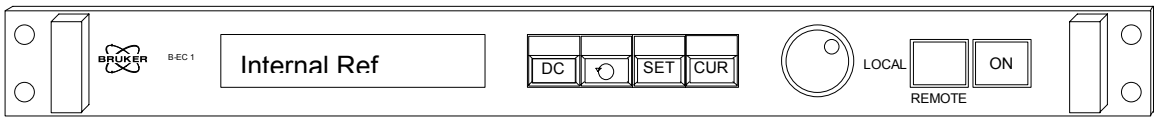


Check the cause of the error (see chapter **1.1.2**), and after correction, push the 'DC' key again.



The LED on 'DC' key is blinking, needs 'SET' for complement.
Push the 'SET' key.

'RESET' is done, the text is displayed for 1 second.



No more errors pending. The power supply will be able to set DC power on.

Remote commands are:

STA/	Read power supply state, see chapter **2.1.1**
RST= 0	Reset error

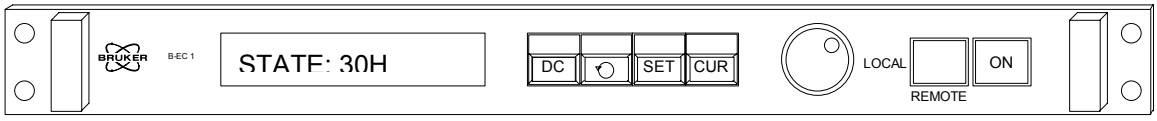
1.2.2.1 Command flow abort

The command can be reached by keeping the 'DC' key more than 1 second pressed. This can be useful if the command flow is locked in a state (see explanations in **2.1.1**).

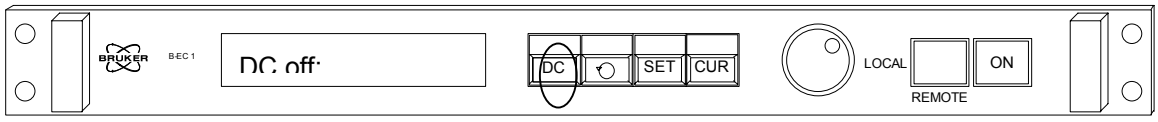
Ex: the command flow can be locked in a state which waits for a polarity reversal unit interlock (state 1C Hex or 30 Hex, see **2.1.1**) or in a state which waits for an ADC read back (ex: 08 Hex). It can be possible that the polarity reversal unit or the ADC has some damage, which locks the controller in the respective state. The command flow can be reset with this function, so you don't have to set electronic power off.

Please, before aborting the command flow, keep in mind that some states can take a long time before there are resolved. By a reset of the command flow the cycle is aborted, too.

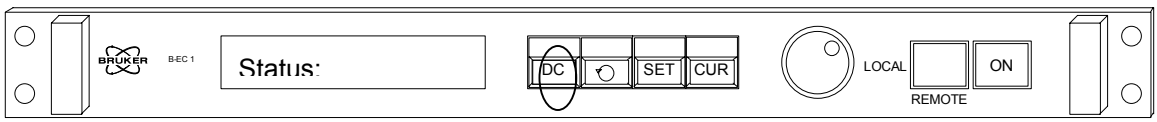
Ex: You set the polarity reversal unit negative and the controller is locked on the state 30 Hex (wait for polarity reversal unit interlock) for a long time. That can result from a damage of the polarity reversal unit.



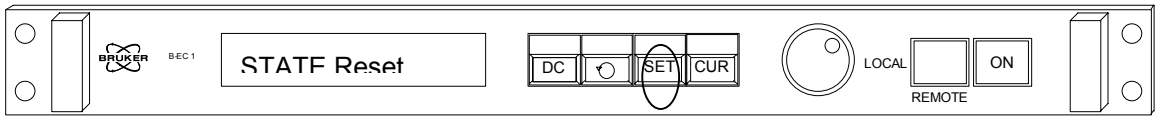
DC power is ON, the controller is in the state 30Hex (wait for the negative read back of the reversal unit). Press and hold the 'DC' key.



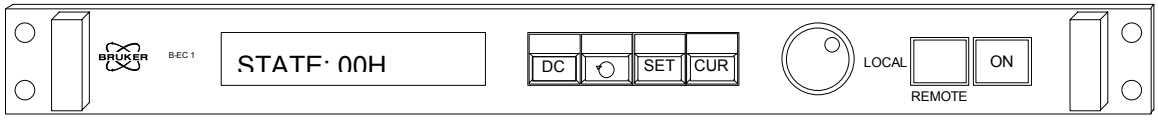
The LED on 'DC' key is blinking, hold the key for 1 second.



Needs 'SET' for complement. Push the 'SET' key.



The command flow is aborted, the text is displayed for 1 second. The state is reset to 00Hex, the cycle function is cleared if it was active.



Remote:	STA = 0	Reset command flow
	STA/	Read command flow (see **2.1.1**)

1.2.2.1 **1.2.3 DC-power on/off**

Using 'DC' and 'SET' for completion, DC power will be set when DC-OFF and reset when DC-ON is read back (the cycle function must be inactive, the controller state must be 00H). The key is disabled in remote state, illegal use will result in a LOCAL ERROR message.

- SET DC ON

By setting DC ON, DAC current is set to zero to avoid transients in the output current. If the power supply is set to external reference or BH-15 control, the customer has to hold them at zero upon DC ON operation (to avoid transients).

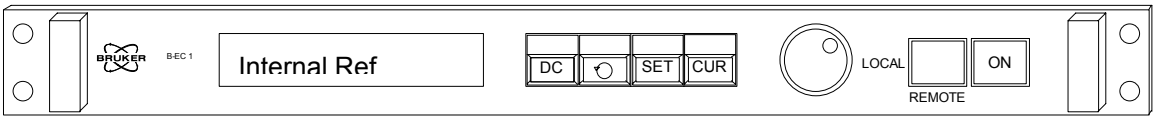
- SET DC OFF

By setting DC OFF, the DAC current ramps to zero. DC is reset only when the ADC current is near zero (about 2% of full range).

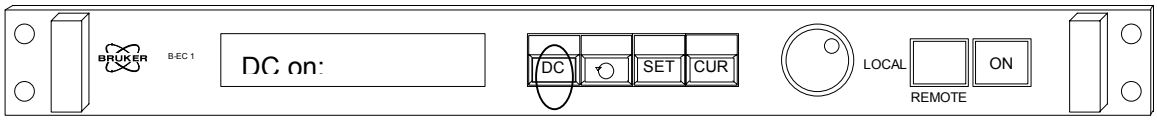
If external reference or BH-15 is set, it will be switched to internal reference, and after DC OFF is set again to external or BH-15 reference like before (to avoid current transients).

DCP/	Test DC-power
DCP= 0	DC-power off
DCP= 1	DC-power on.

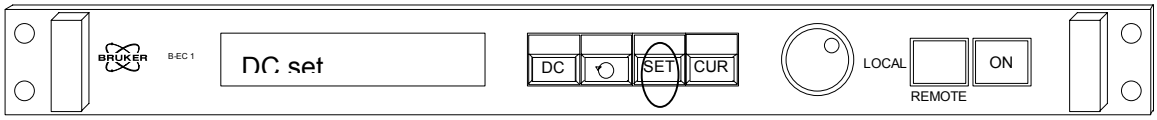
Example:



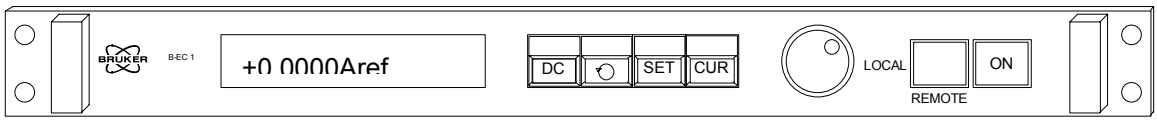
No error pending, and DC OFF. DC can be set using the 'DC' key.
Push the 'DC' key.



The LED on 'DC' key is blinking, needs 'SET' for complement.
Push the 'SET' key.



'DC set' is displayed for 1 second, the LED on the 'DC' key is lit.



DAC value (+0.0000Aref) is displayed, see chapter **1.2.9** (Display selection).

1.2.4 Set polarity positive/negative

Pushing the key 'DC' twice and 'SET' for complete, the reversal unit will be switched from positive to negative polarity or from negative to positive polarity according to the status read back (the cycle function must be inactive, the controller state must be 00H). Display and remote show '?' during the switchover time of the unit. Using the 'display selection key', 'POL UNIT' is displayed in the 'Reference state' (see chapter **1.2.9**, Display selection)

Upon changing the polarity, the DAC current ramps to zero, the external reference or BH-15 will be switched off if it was active. The controller waits for the ADC read back to be near zero and adds two extra seconds for security. Now the reversal unit will be started. Upon the correct read back of the polarity, the external reference or BH-15 will be switched on again, if it was active. The DAC current is set to the stored value before setting the polarity.

During the polarity reversal process, a time out is set according to the used reversal switch. If the read back of the correct polarity is not ok within this time, this will be flagged with an error message. Also, the control voltage of the relay will be reset to avoid a burn out of the coil.

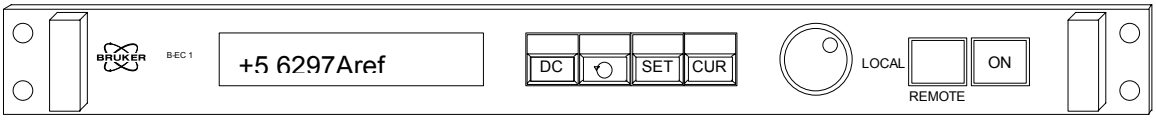
During this operation most other commands are disabled, any wrong command will be rejected with 'FUNCTION'.

The remote functions are:

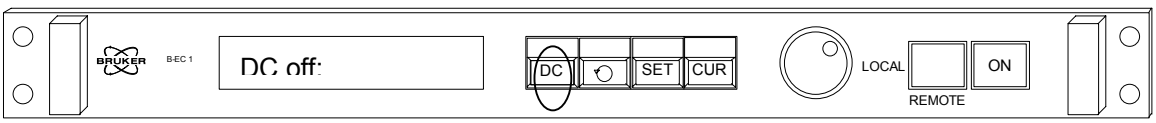
POL/ 0, no polarity reversal unit supplied
1, polarity positive
2, polarity negative
3, polarity unit busy

POL=0 Set polarity positive
POL=1 Set polarity negative

Example:

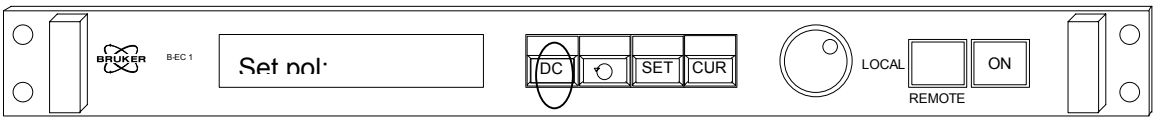


DC power is ON, DAC current is set to 5,6297A.
Push the 'DC' key first time.

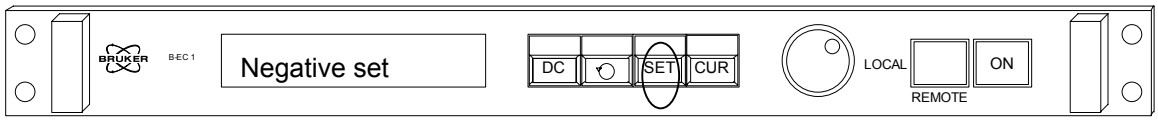


The LED on 'DC' key is blinking.

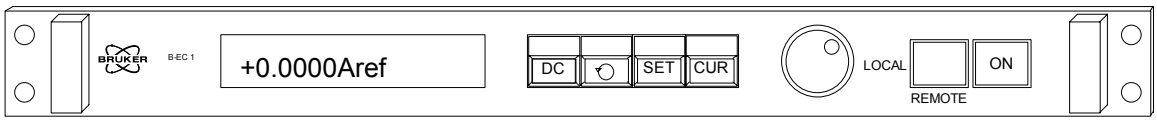
Push the 'DC' key a second time.



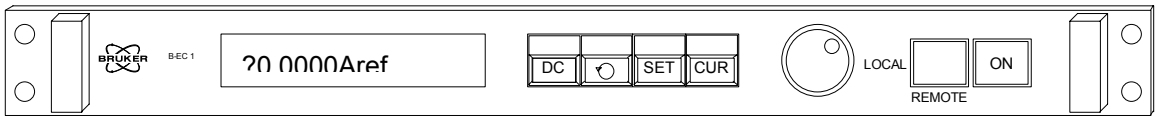
The LED on the 'DC' key is always blinking, needs 'SET' for complement.
Push the 'SET' key.



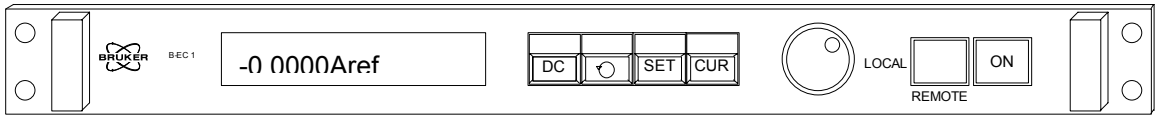
The polarity will be changed to negative (because of positive read back). 'Negative set' is displayed for one second, the LED on the 'DC' key is always lit, DC is always ON.



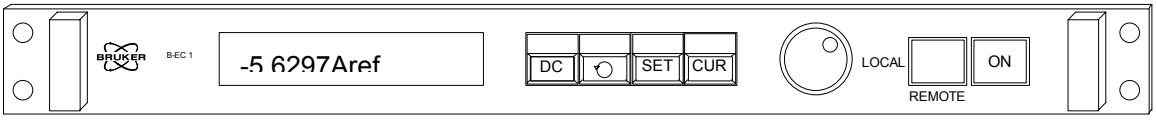
The DAC current ramps to zero, Ext REF or BH-15 is reset if it is active.



The polarity reversal unit is busy.



Negative polarity is set.



DAC current is set to the stored value before setting the polarity. Internal reference, external reference or BH-15 are set, which ever was active - see chapter **1.2.5.**

1.2.5 Set current

The system offers three possibilities to set an output current: Internal reference, external reference or field controller BH-15 (the cycle function must be inactive, the controller state must be 00H).

The next chapters will explain the different modes of operation, here are summarized the remote commands to switch from one mode to another.

EXT/	Read source of reference
EXT=0	Enable internal reference
EXT=1	Enable external reference
EXT=2	Enable BH-15 control

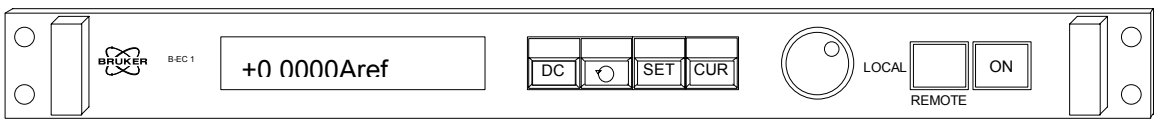
1.2.6 Internal reference, DAC

The current of the power supply can be set using the 'CUR'-key (the cycle function must be inactive, the controller state must be 00H). The blinking LED shows that the analog control knob is allowed: Turning the knob slowly, the output can be changed by single bits, increasing the speed will change the output at a more than proportional rate. The output current will change at a current rate. This quasi-analog setting is stored in the internal memory of nominal values and can be preset and read back using the appropriate command key or remote command.

This function should be completed with 'SET'. Any change of the output value will be displayed during normal operation of the power supply, whether it is a result of remote or local commands. The actual value is stored for further processing. The display is switched to the nominal value, given in ampere.

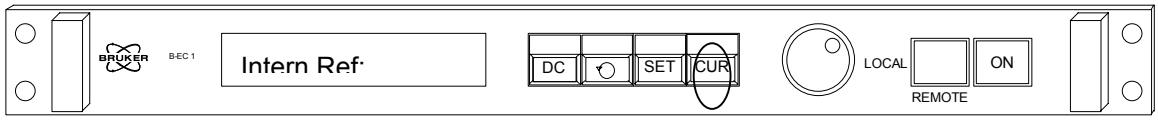
EXT/	Read source of reference, should be 0
EXT=0	Set to internal reference, if not yet 0
CUR/	Read current.
CUR= nn	Set current to nn ampere.

Example:

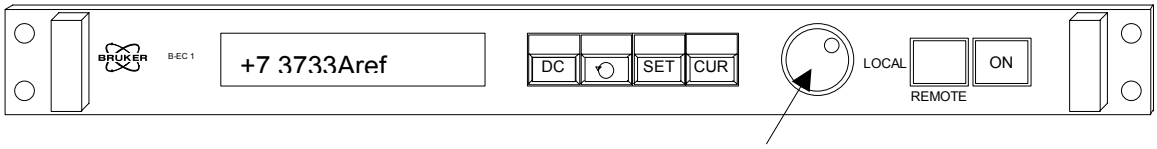


DC is on, DAC current is +0.0000 amperes.

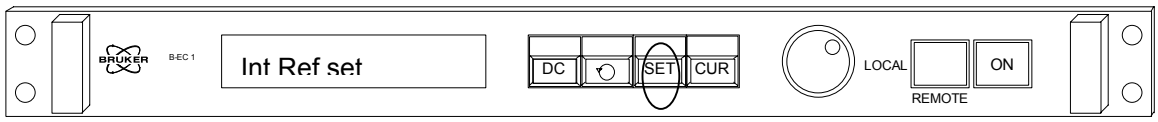
Push the 'CUR' key.



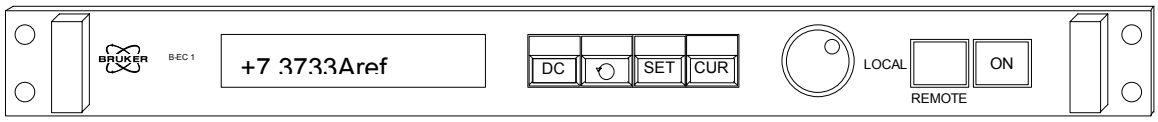
The LED on the 'CUR' key is blinking, 'Intern Ref:' is displayed.
Turn the encoder.



Turning the analog encoder, current is set to +7.3733 amperes. Push the 'SET' key.



The internal reference is set, 'Int Ref set' is displayed for one second.



'Display selection' is automatically set to the nominal value of DAC current.

1.2.7 External reference, 0..10 Volt

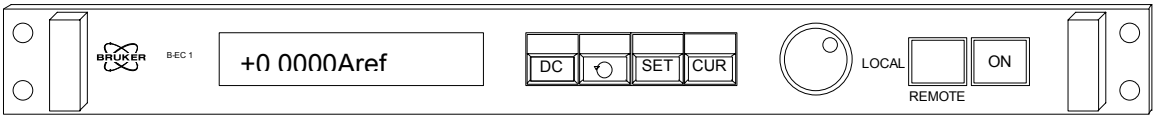
Pushing the key 'CUR' twice and 'SET' for complete, this function allows to have the power supply controlled by an external reference voltage, scale 0 to 10V.

The polarity of the output current is still determined by the reversal unit, if supplied.

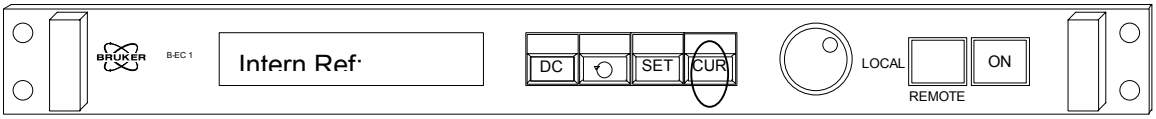
EXT/	Read source of reference, should be 1
EXT=1	Enable external reference
EXT=0	Set internal reference, DAC

The readout displays 'Ext Ref', but can be changed with the 'Display selection' key, as can be seen in chapter **1.2.9**. It may be interesting to switch to the ADC readout of the output current.

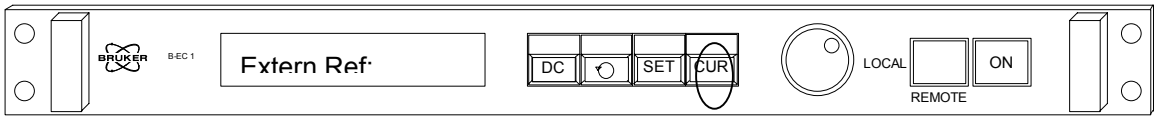
Example:



DC is on, DAC current is at +0.0000 amperes. Push the 'CUR' key first time.

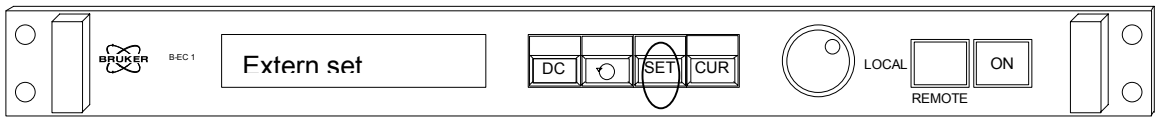


The LED on the 'CUR' key is blinking, 'Intern Ref:' is displayed. Push the 'CUR' key a second time.

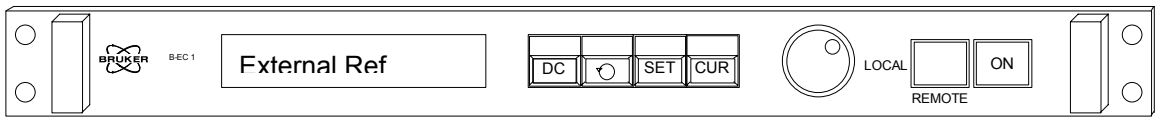


'Extern Ref' is displayed, needs 'SET' for complement.

Push the 'SET' key.



'Extern set' is displayed one second.



'Display selection' is automatically set to 'reference state'.

1.2.8 External regulation, BH-15 field stabilization

Pushing the key 'CUR' three times and 'SET' to complete, this function allows to use external sources or stabilizers (NMR, Hall). The controller is designed to work with a Bruker Hall regulation unit BH-15. The typical operation is:

- Activate the BH-15 unit, switch to mode 1 with '1' and 'MODE'.
- Reset any possible error messages of the B-EC 1 controller with 'DC' and 'SET'.
- Switch on the power supply with 'DC' and 'SET' of the B-EC 1.
- Select the BH-15 function with 'CUR', 'CUR, 'CUR' and 'SET'. The B-EC 1 should now display 'BH-15'.
- Now it is possible to set any desired field with the front panel of the BH-15, e.g. 3500 Gauss with '3500' and 'CF'. The reference and DAC of the B-EC 1 are disabled, the ADC is still working.

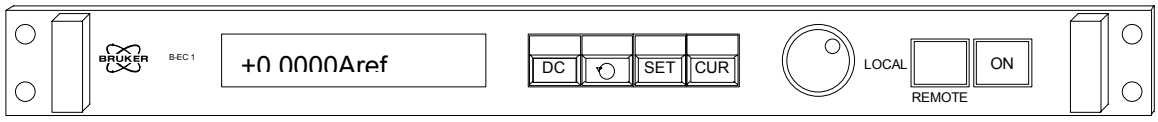
If the power supply should be equipped with a polarity reversal unit, please check the position of your probe head in accordance to the selected polarity. Automatic reversal units are available, which eliminate this problem.

For additional references, please consult the BH-15 manual.

EXT/	Read source of reference, should be 2
EXT=2	Enable BH-15 control
EXT=0	Set internal reference, DAC

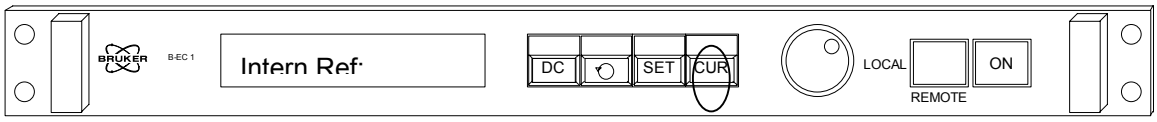
The readout displays 'BH-15', but can be changed with the 'display selection' key, as can be seen in chapter **1.2.9**. It may be interesting to switch to the ADC readout of the output current.

Example:

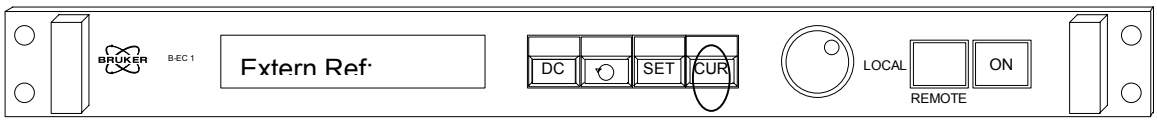


DC is on, DAC current is +0.0000 amperes.

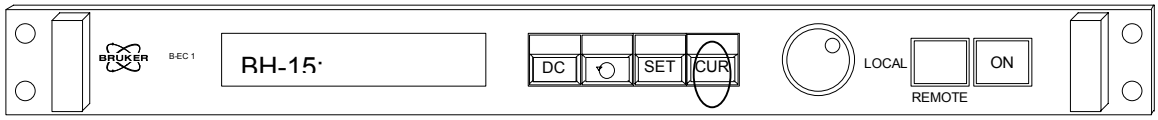
Push the 'CUR' key first time.



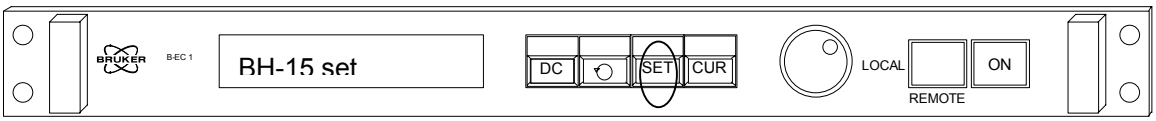
The LED on the 'CUR' key is blinking, 'Current:' is displayed. Push the 'CUR' key a second time.



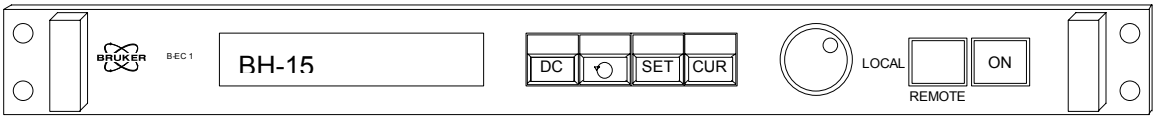
'Ext Ref' is displayed. Push the 'CUR' key a third time.



'BH-15' is displayed, needs 'SET' for complement. Push the 'SET' key.



'BH-15 set' is displayed for one second.



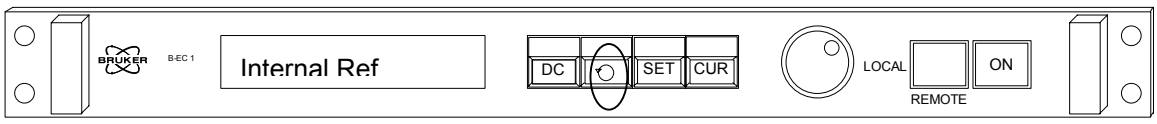
'Display selection' is automatically set to the 'reference state'.

1.2.9 Display selection

This key is used to read the DAC current, the ADC value of output current, output voltage, load resistance, power stage temperature **(option)**, U_{ce} voltage **(option)**, source of reference, number of cycles or the command flow state. Initially, the value of the reference state (or 'POL UNIT' if the reversal unit is busy) is displayed. The read back information is arranged in a closed loop, repeated typing the read back key will return to the first value and on again. Remote commands are:

EXT/	Read source of reference, see chapters **1.2.6**/**1.2.7**/**1.2.8**
CUR/	Read nominal current
CHN/	Read output current
VLT/	Read output voltage
RES/	Read load resistance
TEM/	Read power stage temperature **(option)**
POW/	Read Passbank dissipation
UCE/	Read U_{ce} voltage **(option)**
NBR/	Read actual number of cycles, see chapter **1.3**
STA/	Read actual controller state, see **2.1.1**

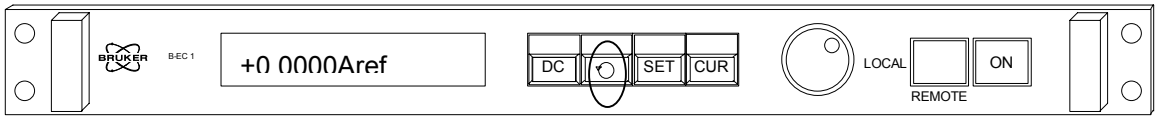
Example:



Initially the 'reference state' is displayed: Internal REF (internal reference set)

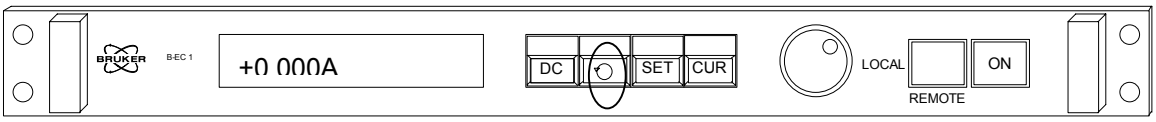
Other possible messages are:
EXT REF (external reference set)
BH-15 (BH-15 reference set)
POL UNIT (polarity unit is busy)

Push the 'Display selection' key

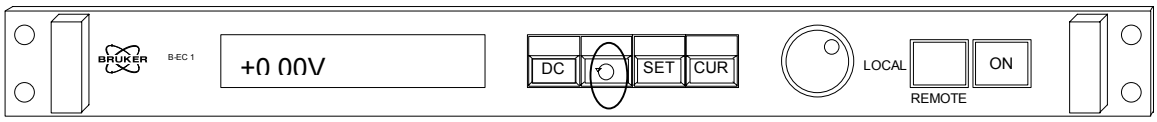


DAC current is displayed (+0.0000).

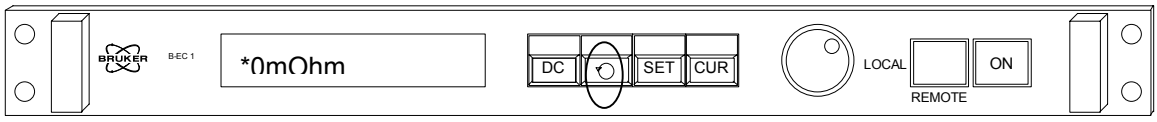
Push the 'Display selection' key.



ADC current read back is displayed (0.000A). Push the 'Display selection' key.

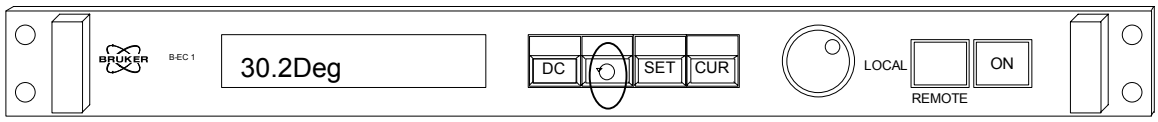


ADC voltage read back is displayed (0.00V). Push the 'Display selection' key.

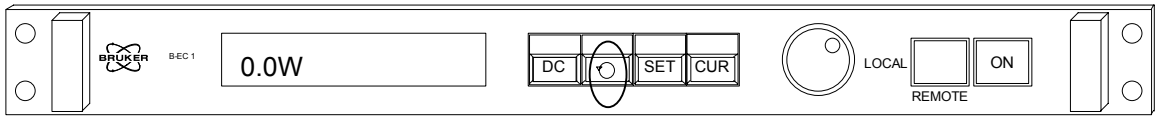


Load resistance is displayed. In case of a current lower than 2% of maximum current range, *0mOhm is displayed.

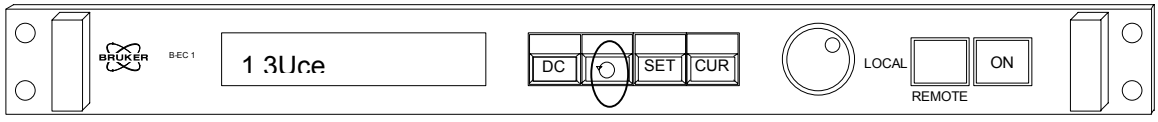
Push the 'Display selection' key **(power stage temperature is an option)**.



Push the 'Display selection' key.
The passbank power dissipation is displayed in W.

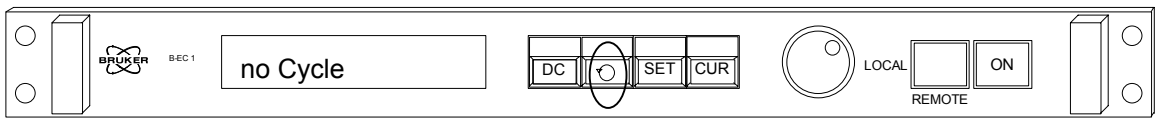


Push the 'Display selection' key
The power stage temperature is displayed in °C. Push the 'Display selection' key **(U_{ce} voltage is an option)**.

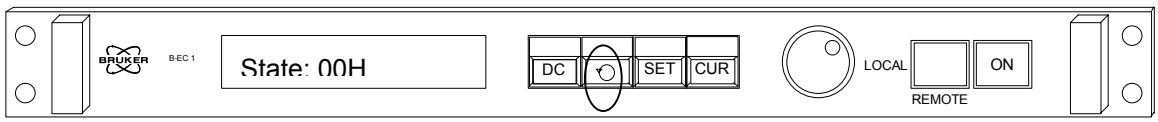


The U_{ce} voltage is displayed in Volt.

Push the 'Display selection' key.



The actual number of cycles is displayed if the cycle function is active, else 'no cycle' is displayed. Push the 'Display selection' key.



The controller state is displayed (see **2.1.1**). Pushing the 'Display selection' key once more will return to the first value and so on.

1.2.10 ADC read back

Current and voltage are read from the ADC. It converts continuously, its read back is calculated from multiple values.

CHN/	Read output current.
VLT/	Read output voltage.
RES/	Load resistance, calculated from multiple values of ADC current and voltage read back (only when the current is higher then 2% of full range).
POW/	Read passbank power dissipation **(option)**.
TEM/	Read power stage temperature in ^{o}C **(option)**.
UCE/	Read U_{ce} voltage **(option)**.

1.3 Cycle

The 'CYCLE' function allows cycling between a lower and an upper current limit. To reach the cycle menus, the 'CUR' key must be hold for one second. Reference must have been set to internal operation.

The first push on the 'CUR' key enters the	'CYCLE END' menu point,
next push on the same key enters the	'CYCLE INTERRUPT' menu point,
next the	'CYCLE START' menu point.
Following points are:	'SET UPPER LIMIT',
	'SET STEPRATE UP',
	'SET TIME UPPER LIMIT',
	'SET LOWER LIMIT',
	'SET STEPRATE DOWN',
	'SET TIME LOWER LIMIT',
and	'SET NUMBER OF CYCLES'.

In the last menu, a press on the 'CUR' key enters the first menu point (CYCLE END) again. 'CYCLE' can be left in every cycle menu by pushing the 'SET' key or any key different from 'CUR'. During cycling, set current operations are not allowed.

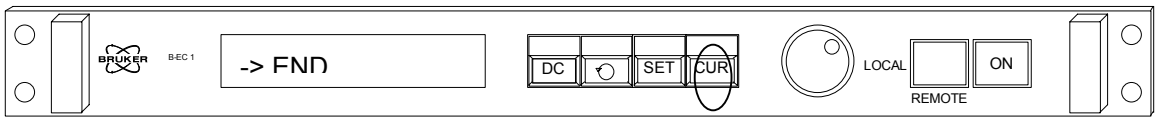
'CYCLE' can be started in the neutral state only, DC must be set. Otherwise this would be flagged with a 'DC ERROR' (remote: E07). The reference must be set to internal, flagged with an 'REF. ER.' (remote: E06).

During cycling, the LED on the 'CUR' key is lit, set operations are forbidden.

CYC/	Read Cycle state	0: End
		1: Running
		2: Interrupt mode

Menu explanation:

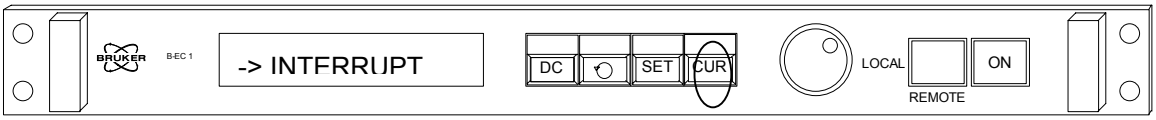
- For reaching the cycle menus, the 'CUR' key must be hold 1s. The LED on the 'CUR' key is blinking.



Cycle end: In this menu, using the 'set' key, a cycle can be stopped. Upon a restart, the cycle begins to slope up from the actual current value to the upper cycle limit.

CYC=0Cycle stop

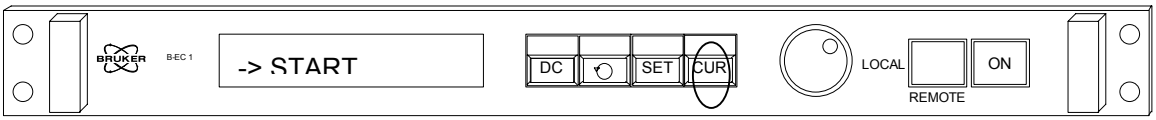
- Push the 'CUR' key once more for reaching the next menu. The LED is always blinking.



Cycle interrupt: Using the 'Set' key, a running cycle can be interrupted. Upon a restart, the cycle will restart at the interrupted position.

CYC=2Cycle interrupt

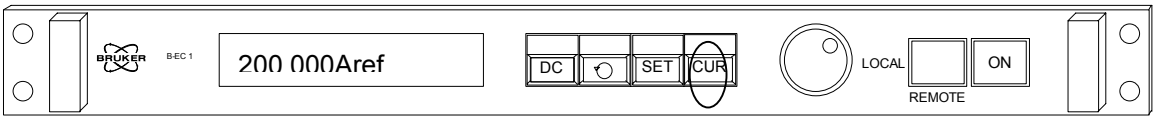
- Push the 'CUR' key once more to reach the next menu. The LED is always blinking.



Cycle Start: Also, using the key 'Set', a cycle can be started. The cycle current upper limit must be different from zero, otherwise this will be flagged by an 'argument error' message.

CYC=1Cycle start

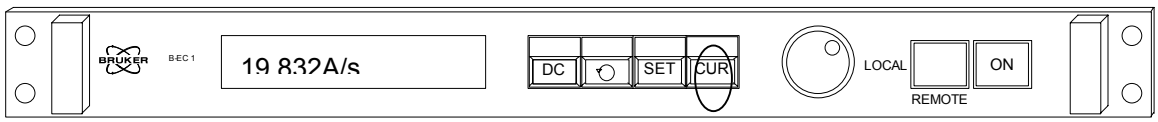
- Push the 'CUR' key once more for reaching the next menu. The LED is always blinking.



Set upper limit: The upper limit of the cycle current is set. Encoder is allowed, the value is given in amperes. At the initialization, the upper limit is set to the current maximum (ex: 200 A).

CCU/	Read Cycle Current Up
CCU= nn	Set Cycle Current Up

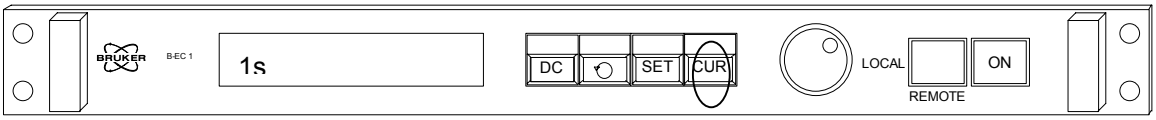
- Push the 'CUR' key once more to reach the next menu. The LED is always blinking.



Set steprate up: Encoder is allowed, the value is given in amperes per second and is limited to 10 seconds for the full current range (ex: about 20 A/s for 200A). At the initialization the steprate up is set to the maximum current rate.

RCU/	Read Rate Current Up
RCU= nn	Set Rate Current Up

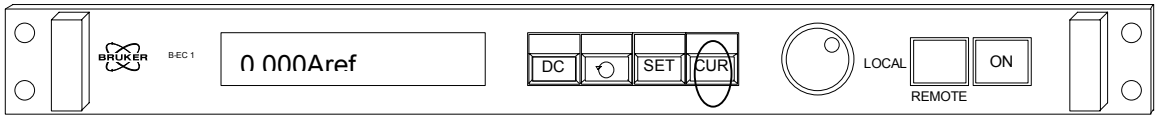
- Push the 'CUR' key once more for reaching the next menu. The LED is always blinking.



Set time upper limit: Encoder is allowed, the value is given in s (seconds). At the initialization the upper time is set to 1 second.

WCU/	Read Wait Current Up
WCU= nn	Set Wait Current Up (0-65535 s)
TIU/	Read actual time Up, decreased by cycling

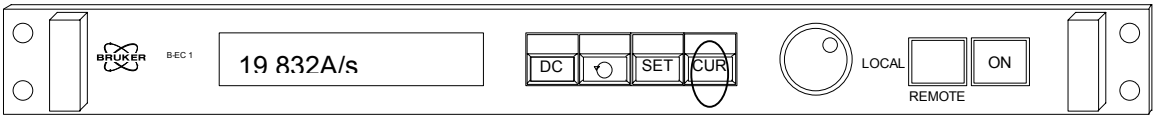
- Push the 'CUR' key once more to enter the next menu. The LED is always blinking.



Set lower limit: The lower limit of the cycle current is set. Encoder is allowed, the value is given in amperes. At the initialization the current lower limit is set to zero.

CCD/	Read Cycle Current Down
CCD= nn	Set Cycle Current Down

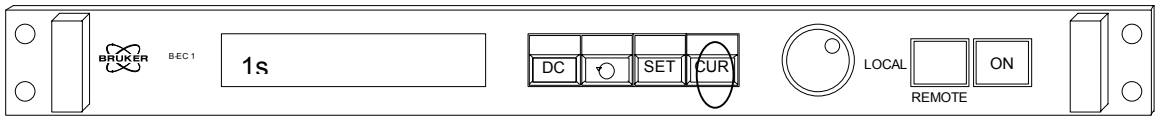
- Push the 'CUR' key once more to reach the next menu. The LED is always blinking.



Set steprate down: Encoder is allowed, the value is given in amperes per second and is limited to 10 seconds for the full current range (ex: ~20 A/s for 200A). At the initialization the steprate up is set to the maximum current rate.

RCD/	Read Rate Current Down
RCD= nn	Set Rate Current Down

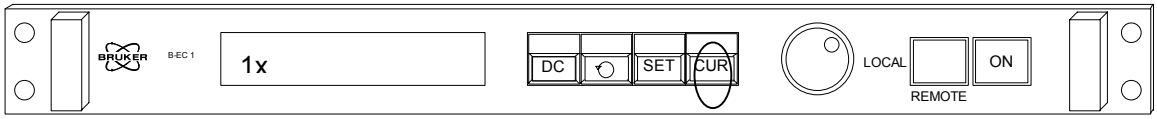
- Push the 'CUR' key once more to reach the next menu. The LED is always blinking.



Set time lower limit: Encoder is allowed, the value is given in seconds. At the initialization the lower time is set to 1 second.

WCD/	Read Wait Current Down
WCD= nn	Set Wait Current Down (0 - 65535 s)
TID/	Read actual time Down, decreased by cycling

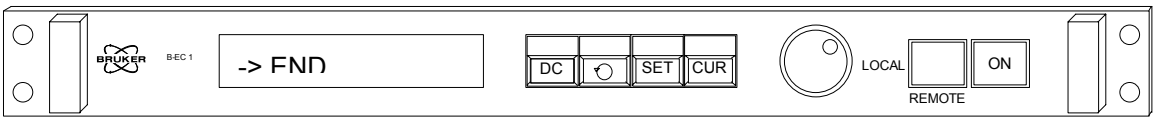
- Push the 'CUR' key once more to enter the next menu. The LED is always blinking. During the initialization the upper time is set to 1 second.



Set number of cycles: The encoder is allowed. Upon electronic power off, the value is saved by battery buffering. The actual cycle number can be read on the display using the 'Display selection key'.

CNB/	Read number of cycles
CNB= nn	Set number of cycles (0 - 65554) 0 is corresponding to 65536 Cycles.
NBR/	Read actual cycle number, decreased by cycling

- In the last menu, a press on the 'CUR' key enters the first menu (CYCLE END) again. If you press 'SET' here, all changes are stored, but the cycling is not yet executed.



Alternatively, you can press 'CUR' twice, to go from 'CYCLE END' via 'CYCLE INTERRUPT' to 'CYCLE START'. Now, with 'SET' cycling is started with the new parameters.

'CYCLE' can be left in every cycle menu by pushing the 'SET' key or any key different from 'CUR'. During cycling, set current operations are not allowed.

2 Remote control

- via RS 232 C

The control unit is equipped with a standard RS 232 C interface. The use of this interface assumes knowledge about the RS 232 C standards, which are not included in this manual.

The system is set to a data rate of 9600 baud, 8 data bits with MSB set to 0, one start bit, one stop bit, no parity. For special applications these values can be changed. The unit gives an echo of all received characters, thus allowing a read back check. A message has to be finished with CR ($0D_{hex}$), the end sign is not echoed. For testing purposes it is possible to attach a serial operating terminal. The connector is wired as a Data Terminal Equipment (DTE).

The interface serves the CTS line. If this input is clamped to a negative voltage, the communication is stopped. Since the controller is always prepared to accept commands, RTS is always tied to +12V. If the user should not need this hardware handshake, the CTS input of the power supply controller can be connected directly to its own RTS output.

- via IEEE 488

The control unit is equipped with a standard IEEE-488 interface, designed to talk, listen and request service. The use of this interface assumes familiarity with IEEE-488 standards, which are not included in this manual.

Setup of the system, addressing

On delivery, the controller is set to a base address of 5.

Pushing the ‘DC’ key during 1 second, the menu ‘abort command flow’ (status) will be entered. One push more on the ‘DC’ key will enter the menu ‘5:Addr IEEE’. Using the analog encoder the IEEE address can be changed (0 → 30D).

Remote:	**IEA/**	Read IEEE address
	IEA=nn	Set IEEE address to... (0→30D)

On delivery, the unit uses 'CR/LF' with EOI as end sign. Also the end sign of the IEEE interface can be change. In the menu ‘x:Addr IEEE’, one push on the ‘DC’ or the ‘SET’ key will enter the menu ‘CR/LF:Endsign’. Turning the analog encoder down, the end sign can be set to CR, turning again the encoder up, the end sign is now set to CR/LF again.

Remote:	**IEE/**	Read the IEEE end sign
	IEE=0/1	Set the IEEE end sign to CR or CR/LF

On delivery, the unit uses 'CR' with EOI as end sign. According to bus specifications, the calling station can be found by using a serial poll. When the calling power supply controller is in serial poll addressed state, a status byte will be sent over the bus with bit 7 set.

2.1 Commands and arguments

The following format of commands will be used with the interface. Command, argument and data are transmitted ASCII-coded, using a fixed format. It is useful to check the echo of every command. If the first character should be an 'E', the controller could not effect the command. Please check the table below.

Remote info	Local message	Explanation
E01	FUNCTION	Function not supported, e.g. during polarity reversal
E02	ARGUMENT	The argument contains unknown characters
E03	PORT N/AVAIL	Port not available
E04	LOCAL ERROR	Access denied, check the local / remote switch
E05	RANGE ERROR	The argument is out of the allowed range
E06	REF. ERROR	Access denied, Ext Ref or BH-15 active
E07	E. PENDING	DC command denied, there is still an error pending
E08	CYCLE ERROR	Access denied, cycle is active
E09	DC ERROR	Access denied, DC power is off

The next table gives a list of all possible commands. The short form 'nn' denotes an argument, e.g. for setting a current.

Remote/local

REM/	Check local/remote state

DC power

DCP/	Test DC-power
DCP= 0	DC-power off
DCP= 1	DC-power on

Set current

CUR/	Read actual current value (A)
CUR= nn	Set current to nn, point to go

Status line read back

CHN/	Read output current (A)
VLT/	Read output voltage (V)
RES/	Read magnet resistance
TEM/	Read power stage temperature (^{o}C) (**option)**
UCE/	Read U_{ce} voltage (V) (**option)**

Set polarity

POL/	0, no polarity reversal unit 1, polarity positive 2, polarity negative 3, polarity unit busy
POL=0	Set polarity positive
POL=1	Set polarity negative

External reference

EXT/	Test source of reference
EXT=0	Internal reference, DAC
EXT=1	External reference 0 .. 10 V
EXT=2	BH-15 control active

Interlocks

RST= 0	Reset error message

Status

STA/	Read all information's about the power supply (**see 2.1.1**).
STA = 0	Reset command flow (**see 1.2.2.1**)

Cycle primary functions

CYC=0	Cycle stop	
CYC=1	Cycle start	
CYC=2	Cycle interrupt	
CYC/	Read Cycle state	0: Stop 1: Running 2: Interrupt

Cycle current up

CCU/	Read Cycle Current Up
CCU= nn	Set Cycle Current Up

Cycle current down

CCD/	Read Cycle Current Down
CCD= nn	Set Cycle Current Down

Cycle rate up

RCU/	Read Rate Current up
RCU= nn	Set Rate Current up

Cycle rate down

RCD/	Read Rate Current Down
RCD= nn	Set Rate Current Down

Cycle time up

WCU/	Read Wait Current up
WCU= nn	Set Wait Current up
TIU/	Read actual time up, decreased by cycling

Cycle time down

WCD/	Read Wait Current Down
WCD= nn	Set Wait Current Down
TID/	Read actual time down, decreased by cycling

Number of cycles

CNB/	Read Number of Cycles
CNB= nn	Set number of cycles (0 - 65535) 0 is corresponding to 65536 Cycles.
NBR/	Read actual Cycle number, decreased by cycling

IEEE Address

IEA/	Read the IEEE address (0 → 30D)
IEA= nn	Set the IEEE address (0 → 30D), should only be used from serial interface.

IEEE end sign

IEE/	0: CR, 1:CR/LF
IEE= 0/1	0: set end sign to CR, 1: set end sign to CR/LF), should only be used from serial interface

2.1.1 Power supply state

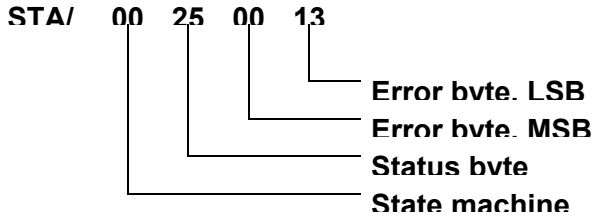
Using the 'STA/' command, the state of the power supply can be read. The read back is given as hexadecimal code which can be easily decoded by an computer.

The first hexadecimal byte **(1)** contains information's about the internal power supply state machine, see the next page. Every command, like DC OFF, initiates the state machine to the beginning of a group of states (ex: 05 Hex). If the conditions of that state are fulfilled, the state counter is incremented. Some states are completed very fast (ex: SET DAC TO ZERO, SET DC OFF), other states can take a couple of seconds (ex: TEST ADC=0, WAIT POL READ BACK). After the last state, the controller returns to the neutral state (00Hex).

Some commands like SET DC ON/OFF, SET POLARITY POSITIVE/NEGATIVE or SET EXT/BH-15 REFERENCE are initiated in the neutral state only, otherwise they are rejected with a 'FUNCTION' error (remote: E01). It can be useful for the customer to know the controller state to understand the process of some commands. Eg.: The controller remains in the state WAIT POL READ BACK for a very long time, the controller is still waiting for the correct polarity read back.

The second hexadecimal byte **(2)** contains information's about the power supply status. Every information is allocated to one bit (ex: remote = bit 0). If an information is true, the bit is active (1), otherwise it is inactive (0). The byte is the addition of all status bits and can be decoded to find the individual information.

The third and the fourth hexadecimal bytes **(3/4)** contain information's about the power supply interlocks. Every interlock is allocated to 1 bit (ex: water = byte 4 / bit 0; overcurrent = byte 3 / bit 0). If an interlock is true, the bit is active (1), otherwise it is inactive (0). The bytes are the addition of all bits and can be decoded to find the individual information. Please see **1.1.2** (status information's),



Error byte, LSB	Value, hex	Explanation	
	1	**Water flow**	
	2	**Phase error**	
	4	Overtemperature	
	8	External error 1	
	10	**Door open**	
	20	Ground fault	Not used
	40	External error 2	Not used
	80	Reserve	Not used

Error byte, MSB	Value, hex	Explanation	
	1	Overcurrent	
	2	Load error	Not used
	4	Polarity unit	Not used
	8	Inrush error	

Status byte	Value, hex	Explanation	
	1	**Remote enabled**	
	2	BH-15 enabled	Not used
	4	**External reference set**	
	8	Cycle active	
	10	Reverse polarity	
	20	**Normal polarity**	
	40	DC power on	
	80	IEEE end sign	

continued...

State machine	Value, hex	State
	0	**Neutral state**
Set DC power off	5	Ramp DAC to 0
	6	Reset ext / BH-15 ref.
	7	Test DAC=0
	8	Test ADC=0
	9	Set SEM
	A	Set DC off
	B	Set ext / BH-15 ref?
	C	Return to neutral state
Set DC power on	F	Set DAC to 0
	10	Test ADC=0
	11	Set Inrush relay on
	12	Set time 1 second
	13	Wait time
	14	Set DC relay on
	15	Set time 1 second
	16	Wait time
	17	Reset Inrush relay and test DC indicat.
	18	Return to neutral state

continued...

State machine	Value, hex	State
Set polarity positive	19	Ramp DAC to 0
	1A	Reset ext / BH-15 ref.
	1B	Test DAC=0
	1C	Test ADC=0
	1D	Set time=2 seconds
	1E	Wait time
	1F	Reset SEM
	20	Set time=2 seconds
	21	Wait time
	22	Set polarity positive, set timeout
	23	Wait pol. read back, check timeout
	24	Set SEM
	25	Set time=1 second
	26	Wait time
	27	Set ext / BH-15 ref?
	28	Return to neutral state
Set polarity negative	2D	Ramp DAC to 0
	2E	Reset ext / BH-15 ref
	2F	Test DAC=0
	30	Test ADC=0
	31	Set time=2 seconds
	32	Wait time
	33	Reset SEM
	34	Set time=2 seconds
	35	Wait time
	36	Set polarity negative, set timeout
	37	Wait polarity read back, check timeout
	38	Set SEM
	39	Set time=1 second
	3A	Wait time
	3B	Set ext / BH-15 ref?
	3C	Return to neutral state
Cycle	51	Current ramp to upper limit
	54	Wait time upper limit
	57	Current ramp to lower limit
	5B	Wait time lower limit

2.2 Example of operation

In chapter **1.2** and the following sub-chapters, the available commands of the power supply are explained. Here, these commands are given in an order to explain the typical operation of the power supply.

After connection of the supply to the load, to the cooling water and to mains, the electronic of the controller has to be activated with the green key ELECTRONIC POWER. Then, please switch to remote operation. Now the supply is ready to accept commands from the interface.

Start procedure:

REM/	This command should return '1',standing for remote operation.
RST=0	Reset of all stored errors, which might have been stored during startup.
STA/	Please refer to chapter **2.1.1**, errors should be cleared.
DCP=1	Activate the main contactor.
DCP/	Should return '1' after several milliseconds, can be checked several times during the startup of the contactor.
STA/	Can be used alternatively to DCP/, this gives all information bits with one command.

Operating phase:

CUR= nn	Set your output current.
CUR/	Gives the momentary current.

Shut down procedure:

CUR= 0	The current may to be set to zero explicitely.
DCP= 0	Switch off the main contactor. The command is effected at the moment when the set current command has finished at zero.

According to your needs, more commands may be added to your program, especially for reading ADC values (CHN/, VLT/) or for reading the status of the supply (STA/).

The power supply is an analog system. DAC values and ADC values will never be identical due to intrinsic errors of linearity, gain and offset and due to resolution differences. Therefore, please never compare ADC and DAC values for being identical, this condition might never be met and could disturb your program flow. Please always define a small error range.

3. Installation of BH-15 control, setup (option)

The installation of a BH-15 field controller consists of several steps. If it has not been done at the Bruker facility, the next lines should help to complete this task.

The controller B-EC 1 should be connected and tested in standard operation, like switching on and off, setting a current and so on. If this phase should fail, please check the operation manual, respective contact Bruker at Wissembourg (F) and don't continue the setup procedure.

It should be possible to check the BH-15 by setting it to mode 5 with the keys '5' and 'MODE', then 'run'. Now the unit should display the actual field value.

For operation in closed loop with the B-EC 1, it should be set to mode 1 with '1' and 'MODE'. Please connect an oscilloscope to print 9707 inside the B-EC 1. Ground can be found on test point 0 (TP 0). The tests should be performed on the output of the regulation amplifier, TP7.

Before testing the BH15 mode, disconnect the output capacitor.

In reference to chapter **1.2.8**:

> Reset any possible error messages and switch on the power supply with 'DC' and 'SET' of the B-EC 1.
>
> Select BH-15 field control with 'CUR', 'CUR', 'CUR' and 'SET'.
>
> Now please set a field with the frontpanel of the BH-15, e.g. 3500 Gauss with '3500' and 'CF'.

The output line should stay well within the limits of +/-10 Volt, noise and ripple should be comparable with the normal operation without external reference. If this line hangs up, possibly the hall sensor is positioned in the wrong direction.

It is possible to adjust the RC feedback on the board W4P20707 near the output with two rotative switches.

4. Hardware information

Power supply socket

1	Status reserve 2	20	24 V Com
2	24 V ~ DC command	21	24 V ~
3	DC on indicator	22	Water error
4	RST Phase error	23	Temp error
5	Ext error 1	24	Door error
6	Ground error	25	External error 2
7	Status Reserve 1	26	Common interlock/indicator
8	24 V ~ Inrush command	27	24 V ~ Normal polarity command
9	24 V ~ Reverse polarity command	28	Normal polarity indicator
10	Reverse polarity indicator	29	nc
11	nc	30	nc
12	ADC voltage +	31	ADC voltage -
13	+15 V	32	AGnd
14	-15 V	33	Control SEM
15	Control SEM	34	BH-15 field correction
16	Pwr stage control Base+	35	NC
17	Pwr stage control Base -	36	NC
18	ADC shunt -	37	ADC shunt +
19	NC		

Analog I/O socket

1	Ref output +10V	14	AGnd
2	Ref output -10V	15	AGnd
3	Fieldstab input	16	AGnd
4	I Image output	17	AGnd
5	Ext reference input high	18	AGnd
6	Ext reference input low	19	AGnd
7	Ext analog IN 1	20	AGnd
8	Ext analog IN 2	21	AGnd
9	DAC serie 12bits OUT	22	AGnd
10	nc	23	nc
11	nc	24	nc
12	nc	25	nc
13	nc		