BE2811A ±5A 19bit current source

Technical specification

references:

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Review	*Date*	*Auteur*	*Modifications*
1	2012-09-25	hc	initial
2	2012-12-14	hc	Prototype delivery

Contents

1 Main description

Two new Bilt modules, the BE2811 and BE2812 references, are introduced for the purpose of driving MAX_IV correctors magnets.
They are high stability bipolar current sources designed to drive an inductor magnet according to a slow data-rate.

The BE2811 source is a 5A single width module designed to be plugged inside a Bilt chassis. Up to 10 BE2811 modules can be gathered into a 19" chassis.

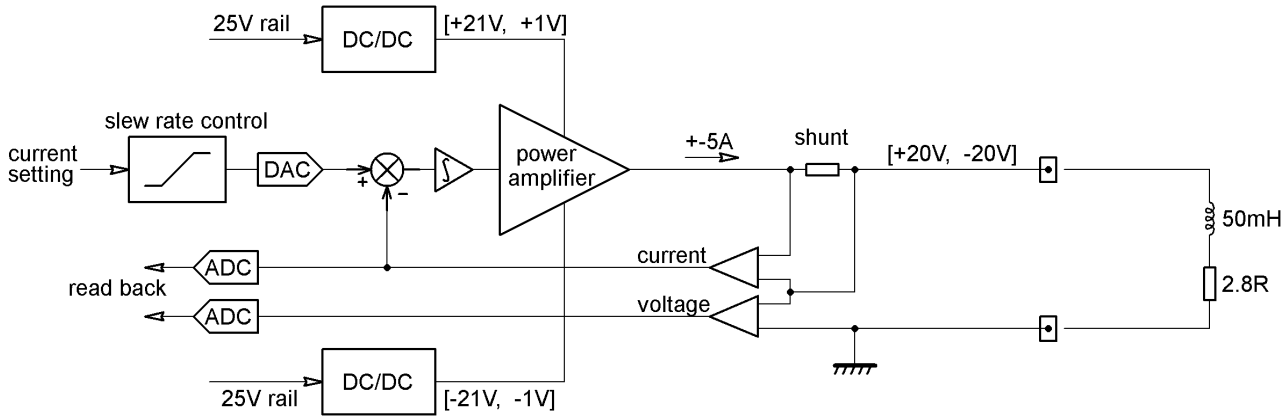
The BE2812 source is a 15A double width module designed to be plugged inside a Bilt chassis. Up to 6 BE2812 modules can be gathered into a 19" chassis.

1.1 Power supply principle

The power stage is a ground referenced linear bipolar power amplifier supplied by two DC/DC switching converters.

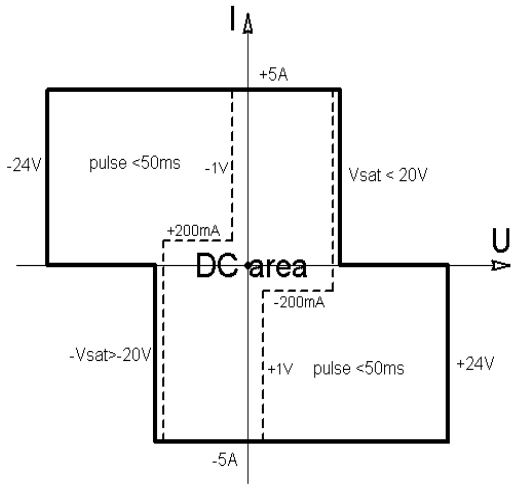
The linear amplifier performs low noise current regulation while the switching converters minimize power dissipation.

BE2811 principle:



The design is optimized for low speed operation, with 50ms settling time and internally limited slew rate.
However, the current regulation of the power amplifier has large enough bandwidth to remove noise possibly induced along the cables and by load inductance coupling.

1.2 Working point control



The bipolar current setting range is fully bipolar and seamless from -5A up to +5A.
In order to drive large inductive loads, the source has both sourcing and sinking capabilities:

- Sourcing power is limited by the +-Vsat voltage. This programmable level performs a user-defined DC power limitation
- Sinking power is limited by an absolute clamping level of +-24V. This level is only intended for pulsed events, shorter than 50ms, as requested for inductance current reset when stopping the source.
- A software alarm will shutdown the source whenever the source is connected to a load which try to settle the working point outside the DC area, (for more than 50ms).
- After the completion of the stop delay of 50ms, an internal relay closes the output with a short-circuit to ground.

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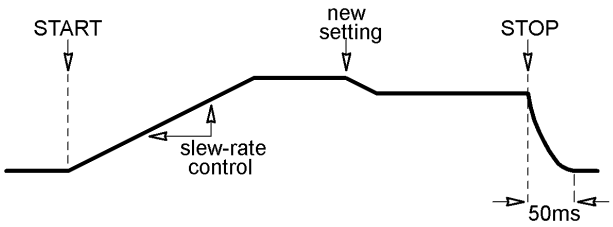
The slew-rate control is used for starting and for any setting update at run time.
The STOP, requested or required by a default, is processed within 50ms, whatever the current level.



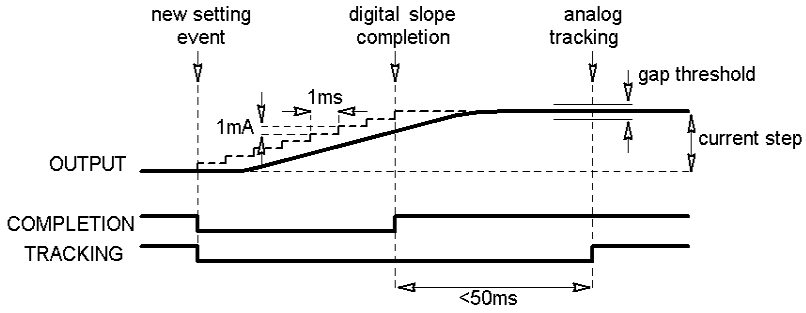
The on-board power supply processor proceeds to DAC access every 1ms for slop control,
and to ADC access every 6ms for high stability regulation settling.

The regulation principle is robust enough to drive any load from short-circuit up to large inductors without the need to tune any regulation parameter.

1.3 Current setting control

1.3.1 Slope and settling control

A current step smaller than 1mA is updated at once by the on-board processor, while a large current setting update is performed by successive steps of 1mA and 1ms duration, thus limiting the slew-rate.

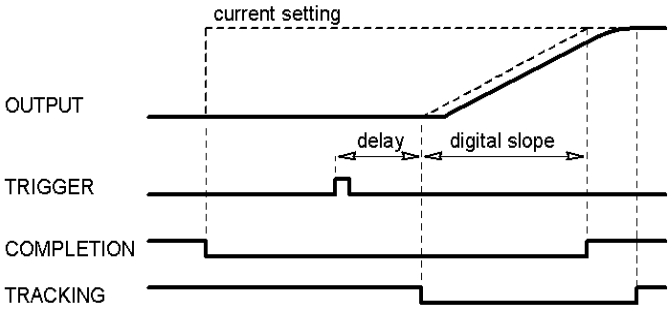


- A low level on the “completion” bit indicates that the digital loop which controls the output update has not yet completed.
The maximum duration for a slope is 10s (full range from -5A up to +5A step)
When proceeding, at any time, the on board controller is able to accept any new current setting value and then to modify the ongoing trajectory according to the last requested value.

- The “tracking” bit indicates when the actual output current has reached the setting value, within a programmable amplitude gap.
The gap amplitude threshold is programmable for characterization purpose: this allows the user to measure the settling time according to any resolution specification and effective noise at the output.
Using a ±3LSB = 114µA = 23ppm gap corresponding to the noise free resolution, the tracking signal will recover within 50ms after the last digital update.

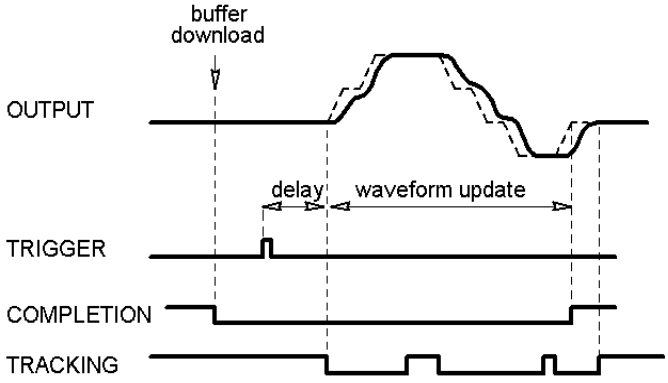
1.3.2 Trigger

A current setting can be postponed using the trigger function.
The trigger event can be either hardware or software.
A programmable delay can be added before actuation.
- The “completion” bit indicates when any postponed setting is waiting for trigger, delay and completion.
- The low level of the “tracking” bit indicates when analog settling is in progress.



1.3.3 Downloaded waveform

A previously downloaded waveform will be triggered as a single step setting.
The waveform will be defined using:
- the number of samples: 1 to 1024
- the sampling period : from 10ms up to 1s
- the optional delay after trigger event
- the optional repeat function (for test purposes)
Each step of the waveform is processed according to the slew-rate limitation.
- The “completion” bit indicates when the downloaded waveform is waiting for trigger, delay and full completion.
- The low level of the “tracking” indicates when analog settling is in progress. Depending on the requested amplitudes and durations, it may toggle many times throughout the process.



2 specifications

2.1.1 Operating range

Parameters	*Conditions/Comments*	*specification*
Current range		±5A
Voltage range	*according to the Vsat programmable parameter (1V to 20V range)*	±20V(*)
Vsat setting accuracy to trig alarm	*Vsat alarm triggering*	+-0,5V
Actual saturated voltage / Vsat accuracy	*Alarm delayed*	+-1,5V
Maximum source DC power / Pmax	*Output cutoff after 10ms over this limit*	90W
Max sink DC power	*Output cutoff after 10ms over this limit*	-200mA or -1V

(*) This value can be decreased to any value down to 1V. It allows the user to limit the available power.

2.1.2 Current setting performances

Parameters	*Conditions/Comments*	*specification*
setting resolution	*Including polarity*	19bit, 1LSB = 20µA
typical setting stability	*(After 3mn self-heating for large power steps)*	+-2,5LSB= 15ppm
maximum setting stability / 30mn and 8h	*After 3mn setting ±1%, at constant ambient temp. within the 16°C-26°C range*	±25ppm
maximum temperature coefficient	*After 3mn setting ±1%, within the 16°C-26°C range*	±15ppm/°C
2-year absolute accuracy		±0,1%
Differential linearity error		±0,5LSB
integral linearity error		±2LSB

2.1.3 Read-back measurements

Parameters	*Conditions/Comments*	*specification*
current read-back resolution	*Including polarity*	19bit, 1LSB = 20µA
voltage read-back resolution	*Including polarity*	16 bit, 1LSB = 763µV
2-year absolute accuracy		±0,1%
current sampling period		6ms
voltage sampling period		25ms
voltage saturation sampling period		1ms

2.1.4 Regulation performances

Parameters	*Conditions/Comments*	*specification*
load inductance range		0mH - 200mH
load resistor range		0Ω - 50Ω
programmable slew rate limitation	*slew rate di/dt < 1V / L(load) for linear operation*	min: 1mA/ms max: 100mA/ms
small step settling time	*10mA step, error < 1LSB = 20µA = 4ppm*	50ms
Maximum STOP cutoff time	*full range current 5A and maximum inductance 200mH*	50ms
current noise p-p 0,1Hz - 10Hz	*5A onto 48mH 2,5Ω load*	8ppm = 2LSB= 40µA
current noise p-p 10Hz - 10KHz		4ppm = 1LSB = 20µA
Response time to load step	*Load impedance step with 100% resistor change*	5ms

2.1.5 Timing and synchronization specifications

Parameters	*Conditions/Comments*	*specification*
Minimum period for proceeding continuous immediate setting update		50ms
Immediate setting digital delay	*from SCPI command acknowledge*	<10ms
Software trigger digital delay	*from broadcast SCPI command*	<10ms
Hardware trigger digital delay	*From active edge of the common trigger input*	<1,2ms
Programmable delay	*range* *resolution*	0 to 1s 1ms steps
Programmable waveform sampling rate	*range* *resolution* *accuracy*	10ms to 1s 10ms steps ±1ms
Maximum read back measurement and status register refresh time		10ms
Minimum period for processing continuous measurement and status read-back		100ms
STOP on alarm response time		1ms

2.1.6 absolute ratings

Parameters	*Conditions/Comments*	*absolute limit*
DC voltage at POWER OUT terminal		POWER GND ±24V
sink DC current when over voltage condition occurs		0,1A
DC voltage between POWER GND terminal and common GND		0V
DC voltage between POWER GND terminal and mains Earth		1,2V
transient voltage at POWER OUT terminal		±36V
output current within operating area		+-5A
sinking current when module is OFF	*(short circuit relay)*	+-1A
voltage between OUT Sense and Power OUT		+-10V
voltage between GND Sense and POWER GND		+-10V

3 Output connections

The front panel of the module is fitted with 2 connectors:

- The power output connector is a 3 pin "SABRE" header from Molex

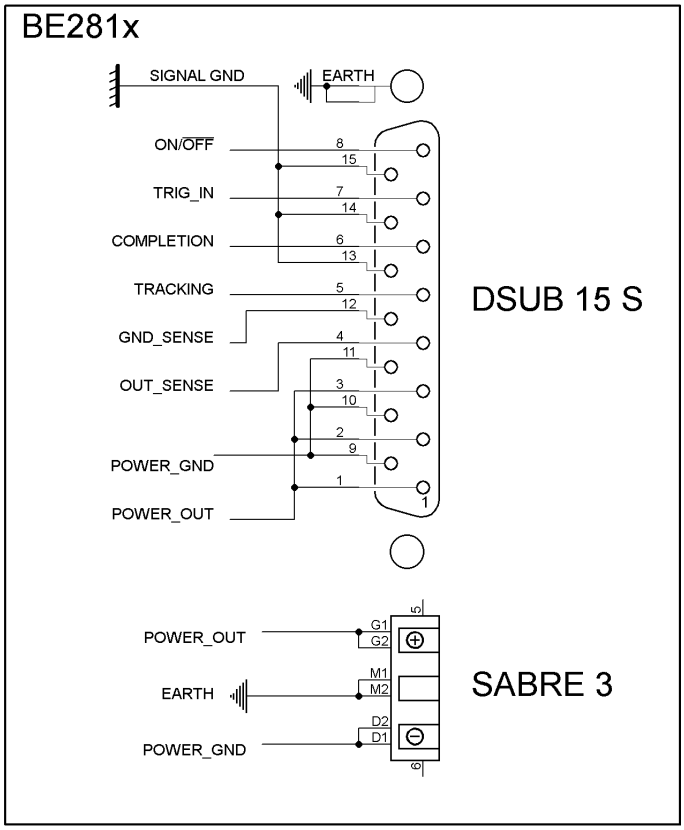
single contact specification is up to 18A

- The Dsub15-S connector gathers both power and control signals

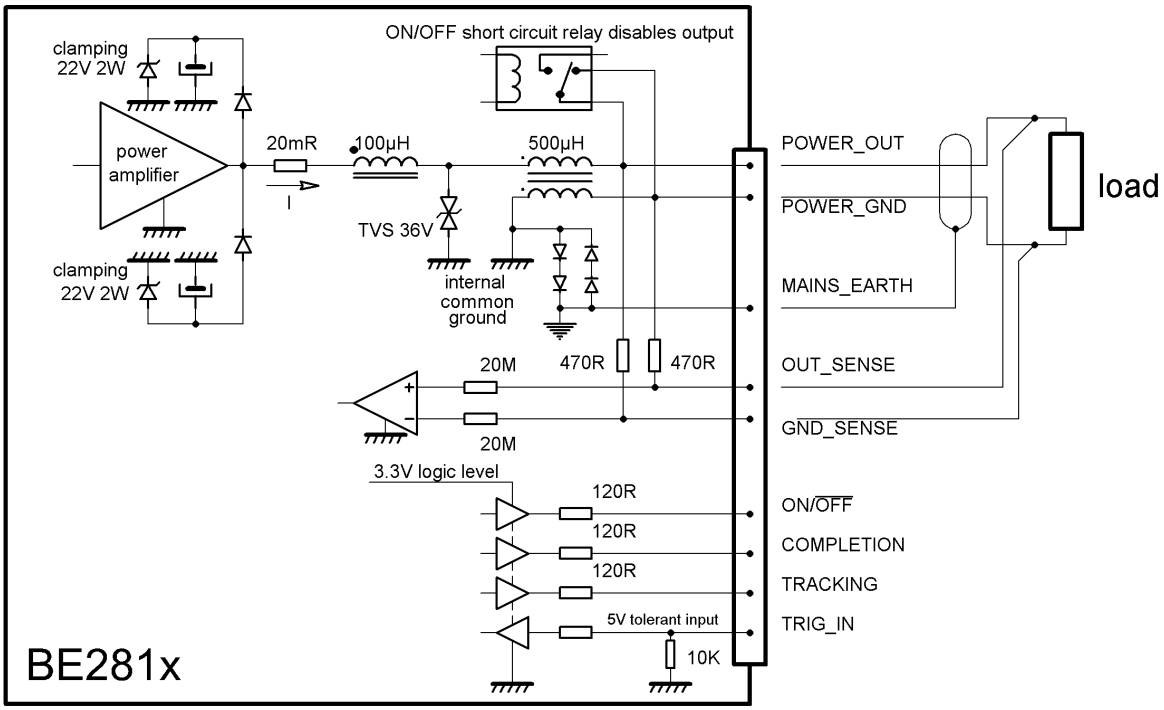
single contact specification is up to 5A, but large wires have to use up to 3 contact for the same signal in order to withstand the current level.

available control signals:

- *out and gnd sense for remote voltage sensing. Internal pull up and down connections are provided, therefore these signals can be left unconnected when not used.*
- *ON/*OFF logic signal indicates the state of the source, according to the green LED onto the front panel.*
- *"COMPLETION" and TRACKING" logic outputs indicates the current setting process.*
- *"TRIG_IN" logic input produces at module level the same synchronization function than the master TRIG input at chassis level (BE718 main controller).*



equivalent schematic of the input/ouput circuitry:



note:

- load power ground must be returned to the module's connector. It is not isolated from the mains Earth (maximum voltage gap is up to 1,2V).
- control signals are referenced to the chassis internal common ground

4 SCPI specific commands

Command	Comments	Default
***idn?**	Complete identification for the BE517 mother board and BX516 daughter board: Revision, date, serial number, software revision, calibration …	
OUTPut [on/off][?]	Enabling / Disabling output	
CURRent [val][?]	Current setting. Use of m,µ,n coefficient allowed, Ex : curr *541 m.* = curr *541E-3* = *curr 0,541*	
CURRent:LATCH [val][?] **CURRent:LATCH:SOURce [0/1][?]**	Latch value in A 0 = Value, 1 = Buffer	
CURRent:SLOPe[val][?]	Current slope in A/s	
CURRent:TRACKing ? **CURRent:TRACKing:LEVel [val][?]**	Global progress reading (between 0 and 1) Maximum gap between output current and setting value (range : 20µA - 5mA)	
CURRent:BUFFer [index,val][index ?] **CURRent:BUFFer:LOOP [on/off][?]** **CURRent:BUFFer:RANGe [index,val][?]** **CURRent:BUFFer:SAMPLe [val][?]**	Index in buffer and current value for specified index Enables loop mode Index of the first value and values count Period between each value in seconds	
CURRent:COMPletion ?		
MEASure:VOLTage ? **MEASure:CURRent ?**	Measurement readings	
TRIGger:STATe [on/off][?] **TRIGger:INITiate** **TRIGger:EDGe [0/1][?]** **TRIGger:SOURce [0/1/2][?]** **TRIGger:DELay [val][?]**	Enables/disables triggering feature Creates a software trigger event Trigger active edge, 0 = rising, 1 = falling 0 = Bbus, 1 = Ext, 2 = Both Trigger delay in second	
VOLTage:RANGe [val][,RangNo][?] **CURRent:RANGe [val][,RangNo][?]**	Range programming.	
VOLTage:RANG:LIST [?] **CURRent:RANG:LIST [?]**	Returns the ranges list (full scale values from lowest to highest). Ex : *curr:range:list?* → *5e-06,3e-05,0.00015,0.001,0.005,0.03,0.15,1,6*	
START:DELay [val][?] **STOP:DELay [val][?]**	Start / Stop delay in ms for the between-sources sequences when synchronized start are requested (groups).	
LIMit[:STATe][on/off][?] **LIMit:DELay [val][?]** **LIMit:CLEar** **LIMit:FAIL?**	Enabling / Disabling of the software thresholds monitoring. Setting of delay before applying thresholds. (0-60000 ms). This delay start at OUTP ON or P:STATE ON received. It is independent of the *start:delay.* Thresholds reset Reading of alarm return	
LIMit:VOLTage:UPPer [val][?] **LIMit:VOLTage:LOWer [val][?]** **LIMit:VOLTage:TSATurate [val][?]**	High/low threshold programming Any values are accepted, without any warning message if out of range. It's then possible to disable one threshold monitoring using any inaccessible out of range value : limit:upp 100m;low -1000;state on (set only UPP threshold to 100mV)	
LIMit:CURRent:UPPer [val][?] **LIMit:CURRent:LOWer [val][?]**	High/low threshold programming	

*Notes: Defaut: Value after *rst command or new module installation. SV: Parameter in nonvolatile memory.*

5 BiltLab control window