

1. INTRODUCTION

1.1 General

This chapter provides an introduction to the specifications of F2030 programmable power current source.

1.2 AC line power input

F2030 is equipped with a three-conductor AC power cable, with the grounding wire, which should be firmly connected to a ground (safety ground) at the power outlet. The line voltage should be in the range of AC 220V \pm 5%, 50-60Hz. Line voltages are present across the outer two conductors in power cord. The center conductor of the power cord is the safety ground and connects to the instrument metal chassis and cabinet.

1.3 Specifications

Current:	Output range: -10.0000 to +10.0000A
	Resolution: 0.1mA, 1/100000 F. S.
	Accuracy: \pm (0.05% settings + 2mA)
	Stability: 0.02% of settings at 10A
	Noise and ripple: 1mA RMS (0-300kHz) maximum at 10A
	Floating output for flexibly configuring grounding
	Maximum output power: 1kW to a 10 Ω load
Voltage:	Available output voltage: 0 to 100V DC
	Open output voltage: 120V \pm 5V at 10A
	Current direction alternating:
	By microcontroller controlled relays, with 5 delay-time options
Load:	Current on direction alternating: 1mA maximum
	Minimum load resistance to output up to 10A: 3 Ω
	Output impedance: 500k Ω minimum
	Internal output compensation network fitting strong inductive load.
Protection:	Controllable state of output
	Linear current ramp rate: 0.01 to 2A/s
	Internal overpower protection at low load resistance
Current sweep:	Sweep mode: 3 optional sweep mode
	Linear current ramp rate: 0.01 to 2A/s
	Maximum sweep range: -10 to 10A
Automatics:	RS-232 interface and internal RS232 to USB converter
	Integrated interface commands
	Trigger output
Interaction:	FSTN LCD display with white backlight
	LED indicators
	12-key function keypad
General:	3U full rack instrument
	Line voltage: 220V/50Hz

1.4 Firmware version:

Firmware version in the 17-character product number can be read by computer interface command “*IDN?”, or be displayed in factory default interface.

1.5 Specifications in detail

Specs.	Symbol	Unit	Conditions	Min.	Type.	Max.
INPUT						
Line voltage RMS	Vac	V	Fac=50Hz	209	220	231
Line freq.	Fac	Hz	Vac=220V	48	50	60
Apparent power	Papp	kVA	220V/50Hz	---	1.3	1.5
TEMPERATURE & HUMIDITY						
Ambient temp.	Tamb	°C	Rated accuracy	15	25	35
Storage temp.	Tst	°C	Limited by LCD	0	---	55
Relative humidity	Hamb	%	Tamb=31°C	---	---	80
DC CURRENT						
Output Range	IRng	A	---	-10	---	10
Resolution	IRes	mA	---	---	0.1	---
Accuracy	AI	---	Tamb=15-35°C	±(0.05% settings+2mA)		
Noise/Ripple RMS	NRrms	mA	Iout=10A, 0-300kHz	---	0.8	1
Noise/Ripple p-p	NRp-p	mA	Iout=10A, 0-300kHz	---	5	7
Temp Coefficient	IdT	%/°C	Tamb=15-35°C	---	±0.01	±0.02
Output Impedance	RIO	MΩ	---	0.5	---	---
Power Regulation	PSRR	%	Rated line voltage	---	---	0.01
Ramp Rate	IRR	A/s	---	0.01	---	2
Leakage Current on High Impedance State	IOFF	mA	RL<500Ω	---	---	1
Voltage Pour-in Limit	VINT	V	RL=∞	---	---	120
OUTPUT VOLTAGE						
Output Range	VRng	V	---	-100	---	100
Open Circuit Voltage	Voc	V	---	115	120	125
Open Circuit Voltage on High Impedance State	VOOC	V	Open circuit	---	---	15
OUTPUT POWER						
Maximum Output Power	POM	W	RLDC=10Ω, Iout=10A	---	---	1000
CURRENT DIRECTION REVERSAL						
Delay Time before Rev	TDF	S	---	1	---	5
Delay Time after Rev	TDA	S	---	1	---	3
Current Spike on Rev	IRS	mA	RLDC=15Ω, TDF=5s	---	0.2	1
LOAD						
DC Resistance	RLDC	Ω	Iout=10A	2	---	10
Time Constance	LL	H/Ω	1H/Ω=1s	0	1	2
CURRENT SWEEPING						
Ramp Rate	ISRR	A/s	---	0.01	---	2
Maximum Sweep Current	ISMAX	A	Mode A, B and C	0.0001	---	10
Delay Time before Rev	TDF	S	---	1	---	5
Delay Time after Rev	TDA	S	---	1	---	3
WARM UP						
Warm Up Time	Twm	min	Tamb=15-35°C	5	30	---
DIMENSION & WEIGHT						
Width	W	mm	---	---	434	436
Height	H	mm	Without footings	---	132	135
Depth	D	mm	Without Protruding Parts	---	500	502
Weight	Wgt	kg	Without Accessory and Package	---	25	30
Transportation Weight	Ws	kg	Standard Configuration	---	36	40

1.6 Safety Summary

Observe the following general safety precautions during all phases of instrument operation, service, and repair. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of design, manufacture, and intended use of the instrument. We assume no liability for customer failure to comply with these requirements.

The F2030 protects the operator and surrounding area from electric shock or burn, mechanical hazards, excessive temperature, and spread of fire from the instrument.

Environmental conditions outside of the conditions below may pose a hazard to the operator and surrounding area.

- Temperature: 5° to 40°C.
- Maximum relative humidity of 80% for temperatures up to 31°C decreasing linearly to 50% at 40°C.
- Power supply voltage fluctuations not to exceed $\pm 5\%$ of the nominal voltage.

1.6.1 Ground the instrument

To minimize shock hazard, connect instrument chassis and cabinet to electrical ground. The instrument is equipped with a 3-conductor AC power cable; either plug it into an approved 3-contact outlet or use a 3-contact adapter with the grounding wire (green) firmly connected to a ground (safety ground) at the power outlet. The power jack and mating plug of the power cable meet Underwriters Laboratories (UL) and International Electro-technical Commission (IEC) safety standards.

1.6.2 Do not operate in an explosive atmosphere

Do not operate the instrument in the presence of flammable gases or fumes. It is a safety hazard.

1.6.3 Keep away from live circuits inside the instrument

Operating personnel must not remove instrument covers. Refer component replacement and internal adjustments to qualified maintenance personnel. Do not replace components with power cable connected. To avoid injuries, always disconnect power and discharge circuits before touching them.

1.6.4 Do not substitute parts or modify instrument

Because of the danger of introducing additional hazards, do not install substitute parts or perform any unauthorized modification to the instrument. Return the instrument to an authorized representative for service and repair to ensure that safety features are maintained.

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2. INSTALLATION

2.1 General

This chapter provides the methods of installation and cable connection in rear panel.

2.2 Inspection and unpacking

Inspect shipping containers for external damage. Make all claims for damage (apparent or concealed) or partial loss of shipment in writing to us within five (5) days from receipt of goods. If damage or loss is apparent, please notify the shipping agent immediately.

Open the shipping containers. Use the packing list included with the system to verify receipt of the instrument, sensor, accessories, and manual. Inspect for damage. Inventory all components supplied before discarding any shipping materials. If there is freight damage to the instrument, file proper claims promptly with the carrier and insurance company and notify us. Notify us immediately of any missing parts.

2.3 Installation

F2030 is a full rack 3U instrument, with dimension of $W \times H \times D = 434\text{mm} \times 132\text{mm} \times 500\text{mm}$, and can be installed on desktop or in racks.

F2030 has a weight exceeding 20kg, so that desktop and its supporting should possess at least 50kg weight capability. On a desktop, it is necessary to keep the instrument settling on a flat and horizontal plane, and place the instrument in the center of the desktop, to prevent it from overturning.

F2030 has a relatively large weight for being portaged by one person. We recommend that there should be at least 2 persons to operate the instrument.

2.4 Safety cooling space

Air blast cooling is used in F2030. Air inlet lays in front panel and top covering. Air outlet is in rear panel. When the front panel is faced to the user, internal heat sink is on the left part of the instrument, corresponding to the air outlet in rear panel. The primary internal cooling fan draws cool air from inlet, leads air flowing through heat sink and blows the heat air out from outlet. An auxiliary fan in rear panel helps to draw out the heat air.

Whatever installation, there should be enough safety cooling space to protect F2030 from overheating. Sheltering the inlet or outlet of F2030 will directly lead internal overheating, which may degrade the output accuracy, or in extreme circumstance, lead internal damage.

Generally, there should be at least 100mm in front of front panel and above the top cover, at least 200mm behind the rear panel. We recommend not placing any other instruments or devices above the top cover.

2.5 Heat coupling

F2030 in a long-term operating may release mass heat, which will conduct to top and left cover, through the internal metal parts. This may lead obvious temperature variation, which may cause temperature drift of precision instrument above F2030.

2.6 Rear panel

Rear panel includes: (1) Power & fuse assembly, (2) RS-232C interface, (3) USB interface, (4) Power current output, (5) Trigger out BNC, (6) Primary air outlet, and (7) Auxiliary fan.

2.6.1 Power & fuse assembly

This part provides line power to instrument, via line cord. The assembly includes an IEC line cord input and a fuse drawer. A three-conductor line cord is included in the standard configuration of F2030. Line voltage is present across the outer two conductors. The center conductor is a safety ground and connects to the instrument metal chassis. For safety, plug the cord into a properly grounded three-pronged receptacle.

Before any line power connection, care should be taken to the specifications listed in rear panel. Line voltage should be with $\pm 5\%$ of rated voltage, and the fuse should be ceramic type and be in accordance with the rated specifications.

Users should confirm that the instrument is reliably grounded via line cord. Otherwise, the chassis and the metal cabinet of F2030 may carry voltage exceeds safety voltage limit, which will cause shock hazards.

2.6.2 RS-232C & USB interface

F2030 possesses standard RS-232C interface, with a female 9-pin D type connector in rear panel, from which, the instrument is connected to a computer with a serial communication cable, accessory CAB-232DEC-3.

Besides, the instrument has a USB interface, which is internally converted from RS-232C interface protocol. To a computer, this USB interface is identified and operated as a standard RS-232C serial interface. From the USB standard B-type connector, the instrument is connected to a computer with a standard USB A-B cable, accessory CAB-USB-AB-2.

2.6.3 Power current output

F2030 has a pair of binding posts in rear panel to output power current to loads. When current direction is positive, current flows out from the red post, through the load, returns back into the black post. A green banana jack provides a safety ground level, which may be connected to the metal part of the load, to protect the operators from electric shock hazards.

Since the current output of F2030 is floating from ground, one of but not both terminals of red and black binding posts can be connected to the green banana jack, to provide a determined level referring to safety ground.

The maximum output current of F2030 is 10A. To prevent any overheating, cables connecting F2030 to loads should have enough current carrying capability. The sectional area of wire conductor should not be less than 3 square mm, and is preferred to at least 4 square mm.

The output voltage of F2030, 100V in operating, or up to 125V on open circuit, far exceeding safety voltage limitation, will present in the pair of binding posts, and electric shock hazard may occur. To operate the load safely, user should at first power down the instrument, or at least use OUT key to force the output to high impedance state, and wait for enough time.

2.6.4 Trigger out

F2030 has a BNC connector, which send out triggering out signals. The triggering signal is on the center conductor of the BNC connectors, and the outer casing is for triggering signal ground, which is internally connected to chassis and safety ground. The triggering signal is standard TTL compatible, 0V for low and +5V for high, and is falling edge active.

3. OPERATION

3.1 General

This chapter covers aspects of operation: front panel controls, functions, current settings and sweeping, computer interface configuration and factory default settings.

3.2 Front Panel

F2030 front panel includes: (1) LCD display, (2) LED indicators, (3) keyboard and (4) power switch.

3.2.1 LCD Display

F2030 employs 128×64 graphic dot FSTN LCD display, with white backlight. The display region is divided according to functioning into:

(1) Current setting region

In standard interface, the current setting region has one row to display output current, with a fining symbol under the lowest 4 digits. In current setting interface, there are 2 rows, the first row display output current, and the second row display current settings, with inverse character of adjusting digit. Unit of output current and current setting is mA.

(2) Ramp rate

Displays current ramp rate.

(3) Sweep mode

Displays current sweep mode of SWA, SWB or SWC.

(4) Maximum sweep current

Displays the maximum sweep current, the value is an unsigned number.

(5) Sweep trigger out state

Displays triggering mode, interval and audio of sweep trigger out function.

(6) Normal trigger out state

Displays trigger mode, delay time and audio of normal trigger out function.

(7) Baud rate

Displays baud rate of RS-232C and USB interface, the unit of which is bps.

(8) Keyboard lock

Displays lock or unlock state of keyboard.

(9) Settings region

Displays setting interface of parameters.

3.2.2 LED Indicators

LED indicators are used to indicate: (1) state of output, (2) voltage compliance state, (3) internal over power protection and (4) computer interface selection. When a LED is on, the corresponding function is turning on.

3.2.3 Keyboard

Keyboard is divided into 5 parts of: (1) state control of output, (2) current direction control, (3) instrument functions, (4) enable keys and (5) direction keys.

3.2.4 Power Switch

To the power switch in front panel, 1 is for power on, and 0 is for power off.

3.3 Front Panel Keyboard

As mentioned before, keyboard is divided into 5 functioning regions as:

(1) State control of output

OUT key is to switch state of output between output state and high impedance state.

(2) Current direction control

+/- key is to switch current directions between positive and negative.

(3) Instrument functions

TRIG key is to configure trigger mode, delay time and audio of normal trigger function, and to configure trigger mode, interval and audio of sweep trigger function.

MENU key is to set computer interface, baud rate of serial ports, ramp rate, sweep mode, maximum sweep current and direction reversal delay time.

SWEEP key is to start a current sweep procedure according to sweep mode, maximum sweep current and ramp rate.

STOP/0 key is to zero the output current in standard display interface. This key is also used to stop a current ramp procedure and maintain output as current at the time the key is pressed. In a sweep procedure, the key is to pause the sweep, or stop the procedure when the sweep is paused.

(4) Enable keys

ENT key is to confirm a configuration of parameters. In standard display interface, the key is to enter current setting interface. When a sweep procedure is paused, the key is to continue the procedure.

ESC key is to cancel a configuration of parameters. When it is pressed and held in standard display interface for up to 5 second, F2030 restores parameters to factory default states.

(5) Direction keys

UP/DOWN keys are to fine the selected digit in standard display interface. In current setting interface, the keys are to configure the value of selected digit. In settings interface of parameters, the keys are to select the required parameter.

LEFT/RIGHT keys are to select a digit to be fined in standard display interface, and to select a digit to be configured in current setting interface.

3.4 Current Setting

There are 2 methods to set output current of F2030, using fine function or in current setting interface.

3.4.1 Current fine function

In standard display interface, below one of the lowest 4 digits of the current setting value, an up-down symbol is to select a digit to be fined. Use LEFT and RIGHT keys to select the required digit. UP and DOWN keys are to increase or decrease 1 of the selected digit. In output state, before the output current reaches 10A or triggers the compliance voltage limit, output current will synchronously increase or decrease with UP or DOWN is pressed, whatever the ramp rate is used.

Current fine function is also realized by computer interface command CURFD, CURFUP and CURFDOWN.

3.4.2 Current setting interface

In standard display interface, press ENT to enter current setting interface. The current setting region has 2 rows, the lower row display the setting value. The selected digit is inversed

displayed. Use LEFT/RIGHT keys to select a required digit, and UP/DOWN keys to change the value of the digit. Use +/- key to change the current direction. Press ENT to confirm the setting, or press ESC to cancel.

Computer interface command CUR is also used to set output current.

3.5 Linear Current Ramp

3.5.1 Time constant of inductive load

F2030 is designed to drive inductive load, i.e. electromagnets, Helmholtz coil pairs and solenoids. Such loads have large inductance of L and nonzero DC resistance of R , the ratio L/R is the time constant.

If the time constant is too large, the output current of F2030 may present overshoot response into the load.

3.5.2 Overshoot by time constant

If the time constant of the load is large enough, a current step of the current source output will present obvious overshoot, or oscillation. Amplitude of overshoot is related with step height and load time constant. Larger steps and time constant correspond to larger overshoot amplitude. If the time constant of loads is too large to be regulated by F2030, the step response of output current may present much lower decay rate and much longer damped oscillation.

3.5.3 Linear current ramp

If the current source has a low enough response rate, amplitude of overshoot will be eliminated in a certain extent. But at the same time, low speed current source will bring in much more ripples, which will degrade the output current quality.

F2030 is fast enough to remove most of the ripples brought from line frequency or its double frequency, that is, there will present obvious overshoot when a large step is applied. F2030 uses linear current ramp to eliminate the overshoot. When a target current is configured, F2030 use a constant ramp rate to gradual change the output current to the target, instead of a step response.

3.5.4 Set ramp rate

In standard display interface, press MENU key to display menu items, use UP/DOWN keys to select "Ramp Rate" item, and press ENT to enter ramp rate setting interface.

Ramp rate of F2030 is from 0.01A/s to 2A/s. Use UP/DOWN keys to select required value, which fits the load. Use ENT to confirm the setting, or ESC to cancel.

If configured, the new ramp rate is displayed in the left bottom of LCD.

Computer interface command RATE is to set the ramp rate, and the query RATE? is to query the value.

3.5.5 Step effect of current ramp

Current ramp is realized by changing the internal control signal, which is produced by an internal DAC of F2030. DAC with finite resolution brings step effect.

DAC in F2030 has a fresh rate of 50 every second, and gives 40mA maximum step at the fastest 2A/s ramp rate. At the slowest 0.01A/s rate, there is an only 0.2mA step in ramp, which is entirely smoothed by load time constant, and may be ignored.

3.6 Current Direction and Reverse Delay Time

3.6.1 Current direction and reversal mechanism

F2030 use relays to change output current direction. After powering up, current direction is restored to positive, that is, current flows out from the red binding post, through the load, flows

back into the black binding post, vice versa.

Relay reversal mechanism can produce current of totally equal amplitude, but opposite directions. It is very useful in some application, which is very sensitive to the errors of amplitude between current in different directions.

3.6.2 Reversal procedure

In standard display interface, press +/- key to switch direction. In current setting interface, +/- key is to change the sign of setting value, which takes effect after ENT is pressed.

Relay reversal cannot be issued when output current is not zero, especially with inductive loads. Intensive reversal EMF may destroy the output stage of F2030. Therefore, F2030 employs MCU to totally control the reversal procedure to protect the user and the instrument from reversal EMF.

If a reversal procedure is triggered, F2030 at first restores the amplitude of present current, and (1) decrease the amplitude to zero with the present ramp rate, and then (2) wait for a delay time of TDF to force the actual output current decaying to zero. After (3) driving internal relays, current direction is reversed. After (4) a delay time of TDA, (5) F2030 increase the amplitude to the restored value again.

Reversal procedure is also be triggered by computer interface command PN and REV. When REV command is used, only the former 4 steps are executed, the result amplitude of output current is zero. The query DIR? and CUR? are used to query the current direction.

3.6.3 Set reverse delay time

F2030 provides 5 reverse delay time combinations, 1s+1s, 2s+1s, 3s+1s, 4s+2s and 5s+2s, for TDF+TDA. We strongly recommend users to select delay time combination, as long as possible. The longest delay time combination is able to fit most of inductive loads.

In standard display interface, press MENU key to display menu items, use UP/DOWN keys to select "Reverse Delay" item, and press ENT to enter reverse delay time setting interface. Use UP/DOWN keys to select required value, which fits the load. Use ENT to confirm the setting, or ESC to cancel.

3.6.4 Reversal overshoot

Relay reversal mechanism will present overshoot is the zero output current is not actually zero, which may bring trouble in some applications. In the procedure that relays open and close, there is an open circuit state of output in a short time of less than 100ms. To a nonzero output current, there will present a slightly overshoot. But if this nonzero output current is small enough, i.e. less than 5mA, the overshoot will be small enough to be ignored.

F2030 is able to keep the zero output current within 1mA, to prevent the load almost totally from overshoot. To eliminate the effect of the overshoot, follow these items:

(1) Use the longest reverse delay time combination to wait for the time constant of load for sufficiently decay.

(2) Stop any measure related to F2030, i.e. magnet field and other parameters related to this field in reversal procedures.

(3) Use trigger out function to strictly control the measure sequence, and use large trigger delay time.

(4) In sweep procedure, use trigger out function to synchronize sources and meters. There is no trigger out signal in reversal procedure in a sweep procedure.

3.7 Output Voltage and Load Resistance Limitation

F2030, as a practical current source, has finite output voltage capability. The maximum effective output voltage is $V_{CMPL}=100V$. When output is open, the open output voltage is $V_{OPEN}=120V$.

3.7.1 Voltage compliance state

In output state, under a configured current I_{OUT} , the load resistance R_{LOAD} may be large enough to make output voltage $V_{OUT}=I_{OUT}\times R_{LOAD}$ exceed V_{CMPL} , which means the actual output current may be less than the configured value, there is a output error. For example, 5A current flowing through a 50Ω load will generate 250V output voltage, which is larger than $V_{CMPL}=100V$, that is, the current flowing through the load will be less than 5A, actually it is nearly $V_{OPEN}/5\Omega=2.4A$.

On the output voltage reaches or slightly exceeds V_{CMPL} , the accuracy of output current is not degraded. Although, to confirm the accuracy and completely control the output voltage, F2030 is designed to enter voltage compliance state if output voltage reaches V_{CMPL} .

3.7.2 Voltage compliance indicator

The compliance indicator in the front panel will flash if F2030 enters voltage compliance state. Users can also use computer interface query $CMPLS?$ to check this state.

3.7.3 Maximum load resistance $R_{LOADMAX}$

To keep the output accuracy, V_{OUT} should be lower than V_{CMPL} , which limit the load resistance R_L . The maximum load resistance $R_{LOADMAX}=V_{CMPL}/I_{OUT}$. If $I_{OUT}=8A$, $R_{LOADMAX}=100V/8A=12.5\Omega$. Loads, having resistance larger than 12.5Ω , will not accept full 8A accurate current from F2030.

We recommend that load resistance should not exceed 10Ω if full-scale output current is required.

3.7.4 Long duration loads

Loads, driven for a long time will generate a great quantity of heat. Copper in such loads has positive temperature coefficient, and the load resistance will increase if heated, the TC of which is about $0.4\%/^{\circ}C$. Well designed magnet field generators will change its resistance within 10% limitation. But if in crucial circumstance, there will be 30% variation or more.

To long duration loads, to ensure the long-term stability of magnet field, there should be enough output voltage margins for F2030. We recommend that the cold state load resistance does not exceed 90% of $R_{LOADMAX}$. For example, if $I_{OUT}=10A$, $R_{LOADMAX}=10\Omega$, the cold state load resistance should not exceed 9Ω . If operating circumstance is better, or the load is water-cooled, a 9.4Ω load is acceptable.

3.7.5 Internal power protection and release

If load resistance is too low, a great deal of heat has to be dissipated by F2030, which may destroy the instrument.

F2030 has an internal power dissipation limitation of 350W. If the internal power dissipation P_{DISS} reaches this limit, internal power protection is triggered. This function is fully hardware controlled, not by software query of micro controllers, to provide real-time protection.

On the protection is triggered, F2030 internally drive output into high impedance, and set output current to zero. "OverLoad" indicator will turn on, with information displayed in LCD. Current direction is not changed. If the current ramp or sweep procedure is running, F2030 will immediately stop it.

No operation is accepted, until the protection is released by keyboard or computer interface

commands. Whenever the keyboard is locked, operator is always able to release the protection by press ESC key. Users can also send computer interface command OVLRST to release protection, or use query OVLD? to check the protection state.

3.7.6 Minimum load resistance RLOADMIN and Maximum output current IOUTMAX

Internal power protection gives a limitation of minimum load resistance RLOADMIN under a maximum output current, which brings a limitation of maximum output current IOUTMAX to a fixed load. We recommend the load resistance should not be less than 3Ω if the full-scale output current is required.

3.7.7 Protection triggered by load time constant

Since the internal power protection needs to calculate real-time output current and voltage, overshoot produced by load time constant will accidentally trigger this protection, especially when the ramp rate is high. To prevent this, try lower ramp rate.

Using an additional resistor series with the load will decrease the total time constant, viewed by F2030's output stage. We recommend not using inductive reactors to be in series with loads, even though it can provide enough series resistance, it may cause larger time constant.

3.8 Set State of Output

3.8.1 State of output and load operation after powering up

F2030 has two states to describe output, output state and high impedance state. After powering up, F2030 enters high impedance state.

In output state, F2030 has output current IOUT, no operation of load is permitted. Otherwise, open circuit occurs after load is disconnected from output terminals, and a very high voltage VOPEN will present. After reconnection of loads, VOPEN will be issued to loads in a short time, and produce a current overshoot until F2030 regulates its output stage to IOUT. VOPEN of 120V is high enough to produce electric shock to operators, and the current overshoot is capable to destroy delicate loads.

In high impedance state, output stage of F2030 present high impedance viewed from load, which is able to isolate internal high voltages from output terminals, and load operating is permitted.

3.8.2 Switch state of output

In standard display interface, OUT key is to switch state of output, and Output indicator is to indicate the state. Computer interface command OUT is also used to set the state of output, or query OUT? to check the state.

3.8.3 Output current when entering output state

When F2030 enters output state, output current will increase from zero to destine current setting with present ramp rate.

3.9 Stop Current Ramp, Fast Zero and Stop Direction Reversal

3.9.1 Stop current ramp

In laboratory, operators may expect immediately stopping current ramp and hold the present output. STOP/0 key is to satisfy this requirement. At any moment in current ramp, press this key to stop ramp procedure, output will hold the current at the time the key is pressed. Users can also use computer interface command STOP to realize this function.

3.9.2 Fast zero

Sometimes in system troubleshooting, operator needs fast zeroing output current of F2030.

Set output current to zero in current setting interface can realize the function, but with low speed, especially when ramp rate is low. In standard display interface, when F2030 is in output state, press STOP/0 to zero output current with fast ramp rate of 2A/s, whatever is the present ramp rate. In high impedance state, fast zero function does not work. Computer interface command FAST0 can implement the same function.

3.9.3 Stop direction reversal

Any moment in direction reversal procedure during output is on, press STOP/0 to stop the procedure immediately. Computer interface command STOP is also capable of the function.

3.10 Current Sweep

3.10.1 Sweep modes

F2030 provides three sweep modes, SWA mode, SWB mode and SWC mode.

In SWA mode, current is operated in quad I. Positive current increases from zero to maximum sweep current with present ramp rate, and then return to zero.

In SWB mode, current is operated in quad I and III. Positive current increases from zero to maximum sweep current then returns to zero in quad I. After current direction is switched to negative, negative current increases from zero to maximum sweep current then returns to zero in quad III. Finally, current direction is switched to positive.

In SWC mode, current is operated in quad I and III, then returns quad I again. SWC mode equals SWB combines with SWA.

In standard display interface, press MENU key to display menu items, use UP/DOWN keys to select "Sweep Mode" item, and press ENT to enter sweep mode setting interface. Use UP/DOWN keys to select the required mode, which fits the application. Use ENT to confirm the setting, or ESC to cancel.

Sweep mode can also be configured by computer interface command SWMODE, or queried by SWMODE?.

3.10.2 Maximum sweep current

The maximum sweep current of F2030 is from 0.0001mA to 10A.

In standard display interface, press MENU key to display menu items, use UP/DOWN keys to select "Sweep Max" item, and press ENT to enter maximum sweep current setting interface. Use LEFT/RIGHT to select a digit to adjust, use UP/DOWN keys to fine this digit. Use ENT to confirm the setting, or ESC to cancel.

Maximum sweep current can also be set by computer interface command SWMAX, or queried by SWMAX?.

3.10.3 Ramp rate in sweep

In current sweep, ramp rate follows the present ramp rate. Sweep time can be calculated by sweep mode, maximum sweep current and ramp rate. For example, in SWC mode, when maximum sweep current is 5A and ramp rate is 0.1A/s, the sweep time in each quad is 100 second, and the total sweep time is 300 second, except two parts of reversal delay time.

3.10.4 Start, pause and abort a current sweep

In standard display interface, when F2030 is not in a current sweep and the state of output is output state, press SWEEP key to start a current sweep.

If the output current at the time is not zero or the current direction is not positive, F2030 at first return the output current to zero with 3A/s ramp rate, and reverse the current direction to positive, to initialize the output current and its direction. Afterward, F2030 start a complete current

sweep.

Any moment in a current sweep procedure, including the initialization of output current and its direction before the complete current sweep, press STOP/0 key to pause the sweep. If the keyboard is not locked, press ENT to continue the sweep, or STOP/0 to abort it. If the keyboard is locked, only STOP/0 key is available to abort the procedure.

Such functions can also be realized by computer interface command SWEEP, SWPAUSE, SWCONT and SWABORT.

3.11 Output Impedance

F2030, as an actual current source, has finite output impedance. Output impedance is paralleled with load, and cause current error. F2030 has output impedance up to 500k Ω , which can be totally neglected with predictable appropriate loads.

3.12 Output Compensation Network

3.12.1 Internal compensation network

F2030, as a current source, will present unstable behavior when driving inductive loads. Besides internal frequency compensation in control circuits, F2030 also employs output compensation network to prevent its output stage from oscillation when the time constant of load is within 2s.

Capacitors are exists in the compensation network, they will store the same voltage with output, which may exceeds safety voltage limitation. When F2030 enters high impedance state, voltage storing in compensation capacitors will be discharged to zero within 100ms, by the load loop.

3.12.2 Additional external compensation network

If the time constant is larger than 2s, additional external compensation network may be needed. Film or non-polarized electrolytic capacitors of no less than 10 μ F can be paralleled with loads, which will keep the output stage of F2030 from oscillation when driving loads with time constant up to 5s.

F2030 has open circuit output voltage up to 125V. To guarantee the long-term reliability, capacitors with withstand voltage of at least 250V is required. Since F2030 can operate current in quad III, that is, negative voltage will be issued to load, never use polarized capacitors paralleling with loads, which will lead to serious explode.

The leakage current of electrolytic capacitors can be ignored when predictable appropriate loads are driven, although, they have poor reliability and will be degraded by drying up of electrolyte. It is strongly recommended using film, preferably matalized film capacitors.

Before paralleled to the output binding posts of F2030, capacitors should be entirely discharged by a 10k Ω resistor of 10W, to prevent shocking to F2030's output stage by voltage stored in the capacitors.

3.13 Normal Trigger Out

3.13.1 Normal trigger out signal

F2030 uses current ramp to replace current step, that is, delay is needed before output current reaches the target value. Any measurement in current ramp may cause errors.

In manually operation through keyboard, operator should watch the front panel LCD display to monitor the procedure of current ramp and direction reversal. In operation via computer

interface, by receiving F2030's response of CUR, PN and REV command, computer program can identify the end of current ramp and direction reversal procedure, and designate other instruments to execute their measurement.

Besides, F2030 provides another high speed trigger out function for synchronization of instruments. Trigger out function is capable to improve measurement by avoiding the delay of computer interface.

There is a BNC interface in the rear panel of F2030 to carry trigger out signals. F2030 provides optional trigger modes and delay time. Meanwhile, F2030 also provide trigger audio function convenient to monitor its running state.

3.13.2 Configure trigger modes and delay time

In standard display interface, press TRIG key to enter trigger menu. Use UP/DOWN keys to select "Normal" item and press ENT to enter normal trigger mode setting interface.

Press UP/DOWN key to select "Off", "On" or "On+J". Off is to turn off normal trigger out function, On is to turn on it, and On+J is to turn on with trigger audio.

Press ENT to confirm the selection, or ESC to cancel.

If "On" or "On+J" is selected, normal trigger delay setting interface is displayed. Use UP/DOWN keys to increase or decrease trigger delay time in the range of 0 to 5s, with step of 0.1s. Press ENT to confirm, or ESC to cancel.

Modes, delay time and trigger audio of normal trigger out function can also be set by computer interface command NTRIG and NTRIGD, or queried by NTRIG? and NTRIGD?.

3.13.3 Time sequence of normal trigger out

If normal trigger mode is On or On+J, and F2030 has entered output state, on current fining or ramp completing, after normal trigger delay time, a falling edge active signal sends out of trigger BNC in rear panel. If the mode is On+J, at the moment falling edge signal is sending out, F2030 gives an audio to indicate a trigger out operation.

When F2030 is in output state, operations include current fining, current direction reversal or a current ramp is completed, F2030 sends out normal trigger out signal. If current is configured by computer interface command CUR, F2030 sends out trigger out signal, no matter if the setting value is changed. For example, when two CUR command continuously set current as 1A, the current value is not changed, but F2030 still sends out trigger out signal. When F2030 switches from high impedance state to output state, if present current setting value is not zero, a current ramp occurs and trigger out signal follows.

In high impedance state, F2030 will not sends out trigger out signal, no matter if the current setting value changes or current direction is reversed.

3.13.4 Trigger out interface

The trigger out signal is compatible with TTL levels, and is falling edge active. At BNC in rear panel, trigger out signal is held as high level of +5V in idle. After the falling edge, there is 10ms delay to hold low level of 0, and then returns to high level. The output impedance of trigger out interface is 1k Ω . To avoid obvious level drop, the load impedance should not be less than 10k Ω , and is preferred to be 50k Ω or more. The input voltage tolerance of the interface is from -15V to +15V.

3.14 Sweep Trigger Out

3.14.1 Sweep trigger out signal

In a current sweep procedure, F2030 executes an entire sweep procedure according to

sweep mode, maximum sweep current, ramp rate and reverse delay time. In the procedure, F2030 will not respond to command from keyboard or computer interface, except pause, continue or abort.

If sweep trigger out function is turned on, F2030 will send out sweep trigger out sequence signal to BNC interface in rear panel. The sequence signal is used as synchronization signal to drive other instruments to participate in measurement.

3.14.2 Configure sweep trigger out modes and interval

In standard display interface, press TRIG to enter trigger menu. Use UP/DOWN keys to select "Sweep" item and press ENT to enter sweep trigger setting interface.

Press UP/DOWN key to select "Off", "On" or "On+♪". Off is to turn off sweep trigger out function, On is to turn on it, and On+♪ is to turn on with trigger audio.

Press ENT to confirm the selection, or ESC to cancel.

If "On" or "On+♪" is selected, sweep trigger interval setting interface is displayed. Use UP/DOWN keys to increase or decrease trigger delay interval in the range of 0 to 2s, with step of 0.1s. Press ENT to confirm, or ESC to cancel.

Modes, interval and trigger audio of sweep trigger out function can also be set by computer interface command SWTRIG and SWTRIGINT, or queried by SWTRIG? and SWTRIGINT?.

3.14.3 Sweep trigger out time sequence

On the start of a current sweep, F2030 continuously sends out trigger out signal according to the present interval, except in sweep initialization or current direction reversal. This style of sequence is able to ensure the synchronization between trigger out signal and sweep procedure, and to prevent any current overshoot to do harm to measurement.

If sweep trigger out function is turned on, F2030 sends out trigger out signal, no matter the current sweep procedure is started by pressing SWEEP key or by computer interface command SWEEP.

If the sweep procedure is paused, trigger out signal is also paused, and when procedure is continued, trigger out signal restored. If the procedure is aborted, F2030 stops to send out trigger out signal.

The shortest interval is 0.1ms, that is 10 trigger out signal per second. When ramp rate reaches the maximum value of 2A/s, and the maximum sweep current is full scale of 10A, there are 100 trigger out signal in SWA mode, or 200 in SWB mode, 300 in SWC mode.

3.15 Keyboard Lock

F2030 is capable of keyboard locking, to avoid any conflict between keyboard and computer interface operation. Keyboard lock is issued or released by computer interface command LOCK, and is queried by LOCK?. When keyboard lock is issued, keyboard operation is unavailable, except ESC. Press and hold ESC key for 5 second to restore factory default settings and at the same time release the keyboard lock.

3.16 Computer Interface

3.16.1 Computer interface selection

Besides standard RS-232C interface, F2030 internally converts RS-232C to USB protocol and provides USB interface. After install drivers to computer, the USB interface is identified by computer as a standard RS-232C device, and uses the same baud rate with RS-232C interface.

In standard display interface, press MENU key to display menu items, use UP/DOWN keys

to select "Interface" item, and press ENT to enter interface setting interface. Use UP/DOWN to select RS-232C or USB-232 item, press ENT to confirm, or ESC to cancel.

When a type of interface is selected, the corresponding LED indicator is turned on in front panel.

3.16.2 Baud rate

RS-232C and USB interface share the same baud rate.

In standard display interface, press MENU key to display menu items, use UP/DOWN keys to select "Baud Rate" item, and press ENT to enter baud rate setting interface. Use UP/DOWN to select a baud rate of 300, 600, 1200, 2400 or 9600 bps, press ENT to confirm, or ESC to cancel.

The selected baud rate is display in right bottom of LCD.

3.16.3 Install USB driver

Computer will not automatically identified F2030 via a USB connection. Driver program should be installed in computer. The driver installation program "DRV-USB232 for WinXP" and "DRV-USB232 for Win7" in product CD are compatible with Windows XP and Windows 7/Vista respectively.

When the installation is completed, an OS restart is required. After restarting the computer, enter "Device Manager" of Windows. Double click "Port (COM and LPT)", there should exist an item named "Prolific USB-to-Serial Comm Port (COMx)" item. Double click the item, the property window will present. Configure parameter as:

Bit per second: corresponds to baud rate of F2030

Data bit: 8

Parity: none

Stop bit: 1

Flow control: none

Press "Advanced" button to enter advanced property window of the port, and set port number.

3.17 Factory Default

In standard display interface, press and hold ESC key for 5 second to force F2030 to restore factory default settings. Default parameters are shown after 3 second. Factory default parameters are:

State of output: High impedance

Output current: Positive zero

Computer interface: RS-232C

Baud rate: 9600 bps

Sweep mode: SWC

Maximum sweep current: 10A

Direction reversal delay: 5s+3s

Normal trigger output: Off

Normal trigger delay: 100ms

Sweep trigger output: Off

Sweep trigger interval: 1s

Keyboard: Unlocked

3.18 Grounding

3.18.1 Floating output

The output of F2030 is a floating output, isolated from Earth and safety ground. Voltage between any of the output terminals to Earth or safety ground should not exceed 200V peak. It is strongly recommended that one of the output terminals should be connected to Earth or safety ground to protect operators from shock hazards.

3.18.2 Grounding relationship

F2030 possesses two isolated grounds, one is cabinet ground GND, and the other is internal current source reference ground ISOGND.

GND is connected to Earth by line cord to be the protection earth. Pin 5 and the case of DB9 socket for RS-232C, Pin 4 and the case of USB Standard B socket, case of BNC adapter for trigger out is internally connected to GND.

ISOGND is the reference ground of current source, and is not available out of the F2030 cabinet.

4. COMPUTER INTERFACE

4.1 General

This chapter provides information and operation method of computer interface of F2030. All of functions of F2030 can be operated via computer interface.

4.2 Computer Interface Selection

4.2.1 Computer interface

F2030 provides standard RS-232C interface, and internally converts RS-232C to USB protocol. After driver is installed, computer identifies the USB interface as a standard RS-232C port.

4.2.2 Select port and baud rate

At a moment, users are only capable to use one type of interface. When a type of interface is selected, the other interface will not respond to any command or query.

F2030 deems two type of interface as one standard RS-232C port, internally, and assigns the same baud rate. Before using USB port, remember to install correct driver program corresponding to the present operating system.

4.3 RS-232C Interface General

RS-232C interface used in F2030 matches EIA-232-E standard. Internally, data transmitted through USB interface is also converted to match this standard.

4.3.1 Physical connection

In rear panel, F2030 provides a DB9 connector to connect to a computer. The RS-232C interface is configured as a DCE (Data Communication Equipments) device and connected to a computer via a direct connection cable. The RS-232C driver in F2030 is capable to drive a cable of at most 15 meters long. Longer cables may lead to unstable communication.

4.3.2 Hardware support

Hardware interface of F2030 features:

- (1) Asynchronous clock
- (2) Semi duplex
- (3) 300, 600, 1200, 2400 or 9600 bps baud rate

(4) Flow control is not supported. The user program is in charge of communication at all times. The instrument cannot initiate communication, determine which device should be transmitted at a given time, or guarantee timing between messages. All of this is responsibility of the user program.

4.3.3 Data format

A character is the smallest piece of information that can be transmitted by the interface. Each character is 10 bits long, which contains 8 bit for data in ASCII format, 1 start bit and 1 stop bit. No parity is needed.

F2030 uses two special characters, carriage return CR=0Dh (13) and line feed LF=0Ah (10) as terminators to indicate the end of a message string. F2030 can identify any combination of CR and LF as a terminator, i.e. CR, LF, CR+LF, LF+CR, CR+CR or LF+LF.

4.4 USB Interface General

USB Standard-B interface is to connect F2030 to a computer via a USB A-B cable. To the computer, after driver is installed, the USB interface is identified as a standard RS-232C device.

4.5 Syntax

4.5.1 Message string

A message string is a group of characters assembled to perform an interface function. There are three types of message strings used by F2030, commands, queries and response. The computer issues command and query strings to F2030 through user program, F2030 issues response. Two or more command or query strings can be chained together in one communication, but should be separated by terminators. F2030 responds in sequence, but the total communication string including terminators should not exceed 200 characters in length.

Command strings are issued by the computer and instruct the instrument to perform a function or change a parameter setting. The format of a command string is:

<command mnemonic><space><parameter><terminator>

For example, a command with a parameter, i.e. LOCK 1, or a command with no parameter, i.e. *RST.

Query strings are issued by the computer and instruct the instrument to send a response. The format of a query string is:

<query mnemonic><?><terminator>

For example, the current query CUR?.

Message strings are not case sensitive. Characters in a string can be all in uppercase or in lowercase, or the combination of uppercase and lowercase. For example, to the query SWMODE?, following spellings are also valid: swmode?, Swmode? or swMoDe?.

Response strings are the instrument response or answer to query strings. When the instrument has received and executed a command, or received a command but is incapable to execute, or has received a query, it issues a response string with a terminator. The responding time is typically within 100ms. Some responses take much longer, i.e. when instrument has to execute a current setting command or a current direction reversal command.

4.5.2 Response mechanism

F2030 employs the response mechanism of one response following one command or query. That is, F2030 will respond to any command or query which is of correct syntax. If there is syntax error, F2030 refuses to feedback a response and discards the inaccurate command or query within 100ms.

Before any command or query is issued by the computer to F2030, F2030 should at first enter the standard display interface. Otherwise, F2030 will feed back a response of BUSY, except the command is *RST. If F2030 is executing a long term command, i.e. CUR or PN, it also feeds back a BUSY response to indicate its running state. If the parameter in a command exceeds setting range, or mismatches the specified format, F2030 feeds back an ERROR response.

If there is no terminator following a command or query, F2030 will discard the command or query after waiting for 200ms. Therefore, interval between any adjacent characters in a command or query, including space and terminator, should be less than 200ms.

4.5.3 Flow control

User program should be in charge of the communication at all times. F2030 cannot initial a communication, determine which device should be transmitting at a given time, or guarantee

timing between messages. All of this is the responsibility of the user program.

Following one command/query one response sequence will guarantee the effectiveness of flow control. It is strongly recommended that the user program only transmit one command or query at one time, and immediately waiting for the response from F2030. After the response is received, try the next transmitting.

The response mechanism of F2030 is capable of most regular flow controls. However, to achieve the best communication reliability, the user program should follow items below to get the prospective response of commands or queries:

- (1) Properly format and transmit the command and query including terminators as one string.
- (2) Guarantee that no other communication is started for 100ms after the last terminator is transmitted.
- (3) Prepare to receive a response immediately after transmitting a command or query.
- (4) Receive the entire response from F2030 including the terminators.
- (5) Guarantee that no other communication is started during the response receiving or for 100ms after the response is received.

4.5.4 Receive buffer

F2030 has a receive buffer of 200 bytes. When the user program transmit several commands or queries continuously, F2030 stores received commands and queries in the receive buffer, and execute successively. Once a command or query is executed, a response is feed back to the computer. Terminator [CR] is used to separate responses.

When a long term command is received, i.e. CUR or PN, commands and queries chained after the long term command will not be executed. Generally, the user program will receive a BUSY response, which indicates the running state of F2030.

It is recommended not transmitting commands or queries continuously. If it is required, care should be taken that the long term command is at the end of command/query sequence.

4.5.5 Communication troubleshooting

On new installation:

- (1) Check the interface according to rear panel connection.
- (2) Check comm. port number in the computer.
- (3) Check communication cables to validate that correct cables are used.
- (4) Check instrument and computer baud rate.
- (5) Check the RS-232C configurations of the computer according to 4.3.3.
- (6) Check the USB driver program if RS-232C port works but USB port does not.
- (7) Make sure commands and queries spelled correct are transmitted. A space character is required between command mnemonic and the parameter. No excess space character is required in any position of a message string.
- (8) Always send terminators.
- (9) The interval between two adjacent characters in one command or query should be less than 200ms.

4.6 Commands and Queries

4.6.1 Interface commands

***RST** Instrument reset

Format: *RST[term]

Return: CMLT[CR], F2030 returns to standard display interface

Remarks: Output is in high impedance state, output current restores to zero, current direction restores to positive, stop running current ramp or sweep, release internal power protection.

*RST is a long term command.

4.6.2 Interface queries

***IDN?** Product number query

Format: *IDN?[term]

Return: If F2030 is not in standard display interface, or is running a current ramp or sweep, or is executing a command, returns BUSY[CR] immediately.
F2030 returns a product number of 17 characters with [CR], if F2030 is in standard display interface and is not running a current ramp or sweep. Otherwise F2030 returns BUSY[CR].

Remarks: 17-character product number is F2030nnnn090501xx, in which F2030 is the product model, nnnn is the series number, 090501 is the date of manufacture of May, 1st, 2009, and xx is the firmware version.

4.6.3 Instrument commands

CUR Set output current

Format: CUR<space> \pm xx.xxxx[term]

Return: If F2030 is not in standard display interface, or is running a current ramp or sweep, or is executing a command, F2030 returns BUSY[CR] immediately.
If the parameter is greater than 10.0000 or the floating point format is incorrect, F2030 returns ERROR[CR].
On the output current reaches \pm xx.xxxx, F2030 returns CMLT[CR].

Remarks: The unit of parameter is Ampere.
F2030 supports all valid floating point formats except "x." or "xx.". Only 2 digits before decimal are accepted, and the 5th and more digits after decimal are neglected.
Signal "+" indicates a positive current output, '-' indicates a negative current output. If the signal is omitted, a positive current output is intended.
CUR is a long term command. If F2030 is in output state, the executing period relies on ramp rate and reverse delay time. In current ramp procedure, a STOP command is to stop the ramp, and a FAST0 command is to fast restore the output current to zero.
If F2030 is in high impedance state, and the current direction is not changed, output current is set to the parameter. If direction is changed, F2030 immediately executes a direction reversal.

CURFD Select a fine digit

Format: CURFD<space>n[term], n=0, 1, 2, 3

Return: If F2030 is not in standard display interface, or is running a current ramp or sweep, or is executing a command, F2030 returns BUSY[CR] immediately.
If the parameter is not 0, 1, 2 or 3, F2030 returns ERROR[CR].
After a fine digit is selected, F2030 returns CMLT[CR].

Remarks: 0 is 0.0001A digit, 1 is 0.001A digit, 2 is 0.01A digit, and 3 is 0.1A digit.
CURFD command can be executed in output state or in high impedance state.

CURFDOWN The present fine digit decrease 1

Format:	CURFDOWN[term]
Return:	If F2030 is not in standard display interface, or is running a current ramp or sweep, or is executing a command, F2030 returns BUSY[CR] immediately. After a decrease 1 of the present fine digit is accomplished, F2030 returns CMLT[CR].
Remarks:	If F2030 is in output state, output current immediately changes instead of a current ramp procedure.
CURFUP	The present fine digit increase 1
Format:	CURFUP[term]
Return:	If F2030 is not in standard display interface, or is running a current ramp or sweep, or is executing a command, F2030 returns BUSY[CR] immediately. If the parameter is not 0, 1, 2 or 3, F2030 returns ERROR[CR]. After an increase 1 of the present fine digit is accomplished, F2030 returns CMLT[CR].
Remarks:	If F2030 is in output state, output current immediately changes instead of a current ramp procedure.
FAST0	Output current fast restores to zero
Format:	FAST0[term]
Return:	If F2030 is not in standard display interface, or is running a current ramp or sweep, or is executing a command, F2030 returns BUSY[CR] immediately. When F2030 is in output state, output current decreases to zero at the ramp rate of 3A/s, and then F2030 returns CMLT[CR], if the output current is zero, F2030 immediately returns CMLT[CR]. FAST0 command does not trigger a direction reversal procedure, and F2030 immediately returns CMLT[CR].
Remarks:	FAST0 command does not change the current direction, and can be executed in a current ramp procedure. FAST0 is a long term command.
LOCK	Lock or unlock front panel keyboard
Format:	LOCK<space>0[term], LOCK<space>1[term]
Return:	If F2030 is not in standard display interface, or is running a current ramp or sweep, or is executing a command, F2030 returns BUSY[CR] immediately. LOCK 1 command lock the front panel keyboard and LOCK 0 unlock the keyboard. After lock or unlock function is issued, F2030 returns CMLT[CR]. If the parameter is not 0 or 1, returns ERROR[CR].
Remarks:	0 is to unlock and 1 is to lock the front panel keyboard.
NTRIG	Set normal trigger mode
Format:	NTRIG<space>n[term], n=0, 1, 2
Return:	If F2030 is not in standard display interface, or is running a current ramp or sweep, or is executing a command, F2030 returns BUSY[CR] immediately. NTRIG 0 is to turn off normal trigger function. NTRIG 1 and NTRIG 2 set normal trigger mode as "On" and "On+♪", respectively. After a mode is set, F2030 returns CMLT[CR]. If the parameter is not 0, 1 or 2, F2030 returns ERROR[CR].
Remarks:	0 is turning off, 1 is "On", 2 is "On+♪"

NTRIGD	Set normal trigger delay
Format:	NTRIGD<space>x.x[term]
Return:	If F2030 is not in standard display interface, or is running a current ramp or sweep, or is executing a command, F2030 returns BUSY[CR] immediately. NTRIGD command is always valid whatever normal trigger mode is selected, and F2030 returns CMLT[CR] after the trigger delay is issued. If the parameter is greater than 5.0 or the floating point format is incorrect, returns ERROR[CR].
Remarks:	The unit of parameter is Second. F2030 supports all valid floating point formats except "x.". Only 2 digits and a decimal are accepted.
OUT	Set state of output
Format:	OUT<space>0[term], OUT<space>1[term]
Return:	If F2030 is not in standard display interface, or is running a current ramp or sweep, or is executing a command, F2030 returns BUSY[CR] immediately. When F2030 is in output state, OUT 0 command switches the state of output to high impedance state. After a current ramp procedure is completed, F2030 returns CMLT[CR]. When F2030 is in high impedance state, OUT 0 command only triggers F2030 to return CMLT[CR] immediately. When F2030 is in high impedance state, OUT 1 command switches the state to output state. After a current ramp procedure is completed, F2030 returns CMLT[CR]. When F2030 is in output state, OUT 1 command only triggers F2030 to return CMLT[CR] immediately. If the parameter is not 0 or 1, returns ERROR[CR].
Remarks:	0 is high impedance state, 1 is output state. A current ramp triggered by command OUT 1 can be stopped or be fast returned to zero by command STOP or FAST0 respectively. OUT is a long term command if there will follow a current ramp.
OVLDRST	Release internal power protection
Format:	OVLDRST[term]
Return:	If F2030 is not in standard display interface, or is running a current ramp or sweep, or is executing a command, F2030 returns BUSY[CR] immediately. OVLDRST command always reset the internal protection circuit and F2030 immediately returns CMLT[CR], no matter the internal power protection is triggered or not.
Remarks:	---
PN	Current direction reversal in PN mode
Format:	PN[term]
Return:	If F2030 is not in standard display interface, or is running a current ramp or sweep, or is executing a command, F2030 returns BUSY[CR] immediately. When F2030 is in high impedance state, PN command only reverses current direction, and F2030 returns CMLT[CR] immediately. If F2030 is in output state, when PN command is issued, there will be at first a

current ramp to decrease the amplitude of output current to zero, and then a direction reversal procedure and a current ramp to restore the amplitude of output current.

After the entire procedure is completed, F2030 returns CMLT[CR].

Remarks: PN is a long term command.

RATE Set current ramp rate

Format: RATE<space>x.xx[term]

Return: If F2030 is not in standard display interface, or is running a current ramp or sweep, or is executing a command, F2030 returns BUSY[CR] immediately.
F2030 returns CMLT[CR] after a ramp rate is issued.

If the parameter is greater than 2.00 or lower than 0.01 or the floating point format is incorrect, F2030 returns ERROR[CR].

Remarks: The unit of parameter is Ampere per Second.

F2030 supports all valid floating point formats except "x.". Only 1 digit before decimal is accepted.

REV Current direction reversal in REV mode

Format: REV[term]

Return: If F2030 is not in standard display interface, or is running a current ramp or sweep, or is executing a command, F2030 returns BUSY[CR] immediately.

When F2030 is in high impedance state, REV command only reverses current direction, and F2030 returns CMLT[CR] immediately.

If F2030 is in output state, when REV command is issued, there will be at first a current ramp to decrease the amplitude of output current to zero, and then a direction reversal procedure.

After the entire procedure is completed, F2030 returns CMLT[CR].

Remarks: REV is a long term command.

REVDelay Set current direction reverse delay

Format: REVDelay<space>n[term], n=0, 1, 2, 3, 4

Return: If F2030 is not in standard display interface, or is running a current ramp or sweep, or is executing a command, F2030 returns BUSY[CR] immediately.
F2030 returns CMLT[CR] after a reverse delay time is issued.

If the parameter is not 0, 1, 2, 3 or 4, F2030 returns ERROR[CR].

Remarks: 0 is 1s+1s, 1 is 2s+1s, 2 is 3s+1s, 3 is 4s+2s, and 4 is 5s+2s.

STOP Stop a current ramp or a direction reversal procedure

Format: STOP[term]

Return: If F2030 is not in standard display interface, or is running a sweep, F2030 returns BUSY[CR] immediately.

When F2030 is in high impedance state, it returns CMLT[CR] immediately after STOP command is issued.

When F2030 is in output state, and no current ramp or direction reversal procedure is being executed, F2030 returns CMLT[CR] immediately.

If a current ramp or direction reversal procedure is being executed, STOP command terminates the procedure and F2030 returns CMLT[CR] immediately.
Current amplitude and direction retain the state when STOP is issued.

Remarks: ---

SWEEP Start a current sweep procedure

Format: SWEEP[term]

Return: If F2030 is not in standard display interface, or is running a current ramp or sweep, or is executing a command, F2030 returns BUSY[CR] immediately.
F2030 immediately returns ERROR[CR], if it is in high impedance state.
When F2030 is in output state, it starts a current sweep and immediately returns CMLT[CR].

Remarks: ---

SWABORT Terminate a current sweep procedure

Format: SWABORT[term]

Return: If F2030 is not in standard display interface, or is running a current ramp or is executing a command, F2030 returns BUSY[CR] immediately.
If F2030 is in high impedance state, or not running a current sweep procedure, it returns ERROR[CR] immediately.
Otherwise, F2030 terminates the current sweep procedure, and returns CMLT[CR] immediately.

Remarks: SWABORT command will always terminate a current sweep procedure, no matter the sweep is running or paused.

SWCONT Restore a current sweep procedure from pause state

Format: SWCONT[term]

Return: If F2030 is not in standard display interface, or is running a current ramp or is executing a command, F2030 returns BUSY[CR] immediately.
If F2030 is in high impedance state, or not running a current sweep procedure, or the sweep procedure is not paused, it returns ERROR[CR] immediately.
Otherwise, F2030 restore the current sweep procedure from pause state, and returns CMLT[CR] immediately.

Remarks: ---

SWPAUSE Pause a current sweep procedure

Format: SWPAUSE[term]

Return: If F2030 is not in standard display interface, or is running a current ramp or is executing a command, F2030 returns BUSY[CR] immediately.
If F2030 is in high impedance state, or not running a current sweep procedure, or the sweep procedure is already paused, it returns ERROR[CR] immediately.
Otherwise, F2030 pause the current sweep procedure, and returns CMLT[CR] immediately.

Remarks: ---

SWMODE Set current sweep mode

Format: SWMODE<space>n[term], n=0, 1, 2

Return: If F2030 is not in standard display interface, or is running a current ramp or sweep, or is executing a command, F2030 returns BUSY[CR] immediately.
SWMODE 0, SWMODE 1 and SWMODE 2 correspond to SWA, SWB and SWC, respectively.
F2030 returns CMLT[CR], after a sweep mode is issued.
If the parameter is not 0, 1 or 2, F2030 returns ERROR[CR].

Remarks: 0 is SWA, 1 is SWB, and 2 is SWC.

SWMAX	Set maximum sweep current
Format:	SWMAX<space>±xx.xxxx[term]
Return:	If F2030 is not in standard display interface, or is running a current ramp or sweep, or is executing a command, F2030 returns BUSY[CR] immediately. If the parameter is greater than 10.0000 or lower than 0.0001 or the floating point format is incorrect, F2030 returns ERROR[CR]. F2030 returns CMLT[CR], after the maximum sweep current is issued.
Remarks:	The unit of parameter is Ampere. F2030 supports all valid floating point formats except “x.” or “xx.”. Only 2 digits before decimal are accepted, and the 5 th and more digits after decimal are neglected. The parameter should be an unsigned value.
SWTRIG	Set sweep trigger mode
Format:	SWTRIG<space>n[term], n=0, 1, 2
Return:	If F2030 is not in standard display interface, or is running a current ramp or sweep, or is executing a command, F2030 returns BUSY[CR] immediately. SWTRIG 0 is to turn off sweep trigger function. SWTRIG 1 and SWTRIG 2 set normal trigger mode as “On” and “On+J”, respectively. After a mode is set, F2030 returns CMLT[CR]. If the parameter is not 0, 1 or 2, F2030 returns ERROR[CR].
Remarks:	0 is turning off, 1 is “On”, 2 is “On+J”
SWTRIGINT	Set sweep trigger interval
Format:	SWTRIGINT<space>x.x[term]
Return:	If F2030 is not in standard display interface, or is running a current ramp or sweep, or is executing a command, F2030 returns BUSY[CR] immediately. SWTRIGINT command is always valid whatever sweep trigger mode is selected, and F2030 returns CMLT[CR] after the interval is issued. If the parameter is greater than 2.0 or lower than 0.1, or the floating point format is incorrect, returns ERROR[CR].
Remarks:	The unit of parameter is Second. F2030 supports all valid floating point formats except “x.”. Only 2 digits and a decimal are accepted.

4.6.4 Instrument queries

CMPLS?	Query voltage compliance state
Format:	CMPLS?[term]
Return:	If F2030 is not in standard display interface, or is running a current ramp or sweep, or is executing a command, F2030 returns BUSY[CR] immediately. Otherwise, F2030 returns voltage compliance state of 0[CR], or 1[CR].
Remarks:	0 is not in compliance state (that is, in constant current state), 1 is in compliance state.
CUR?	Query the present output current setting
Format:	CUR?[term]
Return:	If F2030 is not in standard display interface, or is running a current ramp or sweep, or is executing a command, F2030 returns BUSY[CR] immediately. Otherwise, F2030 returns the present current setting of ±xx.xxxx[CR], no

matter F2030 is in output state or high impedance state.

Remarks: The unit of response $\pm xx.xxxx[CR]$ is Ampere.
The “+” signal indicate a positive current direction, and the “-” signal indicate a negative current direction.

CURFD? Query the present fine digit

Format: CURFD?[term]

Return: If F2030 is not in standard display interface, or is running a current ramp or sweep, or is executing a command, F2030 returns BUSY[CR] immediately.
Otherwise, F2030 returns the present fine digit of 0[CR], 1[CR], 2[CR], or 3[CR].

Remarks: 0 is 0.0001A digit, 1 is 0.001A digit, 2 is 0.01A digit, and 3 is 0.1A digit.

DIR? Query the present current direction

Format: DIR?[term]

Return: If F2030 is not in standard display interface, or is running a current ramp or sweep, or is executing a command, F2030 returns BUSY[CR] immediately.
Otherwise, F2030 returns the present current direction of 0[CR] or 1[CR], no matter F2030 is in output state or in high impedance state.

Remarks: 0 is negative, and 1 is positive.

LOCK? Query the present front panel keyboard locking state

Format: LOCK?[term]

Return: If F2030 is not in standard display interface, or is running a current ramp or sweep, or is executing a command, F2030 returns BUSY[CR] immediately.
Otherwise, F2030 returns the present front panel keyboard locking state of 0[CR] or 1[CR].

Remarks: 0 is locking released, and 1 is locking.

NTRIG? Query the present normal trigger mode

Format: NTRIG?[term]

Return: If F2030 is not in standard display interface, or is running a current ramp or sweep, or is executing a command, F2030 returns BUSY[CR] immediately.
Otherwise, F2030 returns the present normal trigger mode of 0[CR], 1[CR] or 2[CR].

Remarks: 0 is turning off, 1 is “On”, 2 is “On+♪”

NTRIGD? Query the present normal trigger delay

Format: NTRIGD?[term]

Return: If F2030 is not in standard display interface, or is running a current ramp or sweep, or is executing a command, F2030 returns BUSY[CR] immediately.
Otherwise, F2030 returns the present normal trigger delay of x.x[CR].

Remarks: The unit of response x.x[CR] is Second. x.x is an unsigned value within the range of 0.0 to 5.0.

OUT? Query the present state of output

Format: OUT?[term]

Return: If F2030 is not in standard display interface, or is running a current ramp or sweep, or is executing a command, F2030 returns BUSY[CR] immediately.
Otherwise, F2030 returns the present state of output of 0[CR] or 1[CR].

Remarks: 0 is in high impedance state, 1 is in output state.

OVLDS?	Query the present internal power protection state
Format:	OVLDS?[term]
Return:	If F2030 is not in standard display interface, or is running a current ramp or sweep, or is executing a command, F2030 returns BUSY[CR] immediately. Otherwise, F2030 returns the present internal power protection state of 0[CR] or 1[CR].
Remarks:	0 is not in protection, 1 is in protection.
RATE?	Query the present current ramp rate
Format:	RATE?[term]
Return:	If F2030 is not in standard display interface, or is running a current ramp or sweep, or is executing a command, F2030 returns BUSY[CR] immediately. Otherwise, F2030 returns the present ramp rate of x.xx[CR].
Remarks:	The unit of response x.xx[CR] is Ampere per Second. x.xx is an unsigned value within the range of 0.01 to 2.00.
REVDELAY?	Query the present current direction reverse delay combination
Format:	REVDELAY?[term]
Return:	If F2030 is not in standard display interface, or is running a current ramp or sweep, or is executing a command, F2030 returns BUSY[CR] immediately. Otherwise, F2030 returns the present reverse delay time combination of 0[CR], 1[CR], 2[CR], 3[CR] or 4[CR].
Remarks:	0 is 1s+1s, 1 is 2s+1s, 2 is 3s+1s, 3 is 4s+2s, 4 is 5s+2s.
SWEEP?	Query the state of a running current sweep procedure
Format:	SWEEP?[term]
Return:	If F2030 is not in standard display interface, or is running a current ramp, or is executing a command, F2030 returns BUSY[CR] immediately. When F2030 is in high impedance state, it returns ERROR[CR] immediately. Otherwise, F2030 returns the present state of sweep procedure of 0[CR], 1[CR] or 2[CR].
Remarks:	0 is sweep is not started or has been aborted, 1 is sweep is running or has been restored from a pause state, and 2 is sweep is paused.
SWMODE?	Query the present current sweep mode
Format:	SWMODE?[term]
Return:	If F2030 is not in standard display interface, or is running a current ramp or sweep, or is executing a command, F2030 returns BUSY[CR] immediately. Otherwise, F2030 returns the present current sweep mode of 0[CR], 1[CR] or 2[CR].
Remarks:	0 is SWA, 1 is SWB, and 2 is SWC.
SWMAX?	Query the maximum sweep current
Format:	SWMAX?[term]
Return:	If F2030 is not in standard display interface, or is running a current ramp or sweep, or is executing a command, F2030 returns BUSY[CR] immediately. Otherwise, F2030 returns the maximum sweep current of xx.xxxx[CR].
Remarks:	The unit of response xx.xxxx[CR] is Ampere. xx.xxxx is an unsigned floating value.
SWTRIG?	Query the present sweep trigger mode

Format: SWTRIG?[term]

Return: If F2030 is not in standard display interface, or is running a current ramp or sweep, or is executing a command, F2030 returns BUSY[CR] immediately. Otherwise, F2030 returns the present sweep trigger mode of 0[CR], 1[CR] or 2[CR].

Remarks: 0 is turning off, 1 is "On", 2 is "On+J"

SWTRIGINT? Query the present sweep trigger interval

Format: SWTRIGINT?[term]

Return: If F2030 is not in standard display interface, or is running a current ramp or sweep, or is executing a command, F2030 returns BUSY[CR] immediately. Otherwise, F2030 returns the present sweep trigger interval of x.x[CR].

Remarks: The unit of response x.x[CR] is Second. x.x is an unsigned value within the range of 0.1 to 2.0.