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HP 4142B Modular DC Source/Moniotor

HP-IB Command Reference Manual

SERIAL NUMBERS

This manual applies directly to instruments with serial numbers 3121J- and above. With changes described in Appendix A, this manual also applies to instruments with serial numbers 2716J-, 2839J-, and 2946J-.

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ENGLISH: Safety Precautions for the HP 4142B

WARNING



HIGH VOLTAGE SHOCK HAZARD (MAX. 1000 V dc)

The HP 41423A HVU (±1000 V), HP 41420A SMU (±200 V), and HP 41421B SMU (±100 V) force dangerous voltages on the FORCE, GUARD, and SENSE terminals. To prevent an electrical shock, the following safety precautions must be observed.

- Ground the HP 4142B using a three-conductor ac power cable.
- Connect the Interlock (INTLK) terminal to a switch that turns off when the shielding box access door is opened.
- For HVU, connect the OUTPUT ON/OFF STATUS terminal to a warning indicator.
- For HVU, perform the operation tests of the INTLK and OUTPUT ON/OFF STATUS circuits at least once a day, before using the HP 4142B.
- Before touching the connections of the FORCE, GUARD, and SENSE terminals, turn the HP 4142B off, and discharge any capacitors (if connected).

  If you do not turn the HP 4142B off, perform the following four steps:
  1) Set the HVU and SMU output switches to off.
  2) For HVU, confirm that the warning indicator is not lit.
  3) Open the shielding box access door (open the INTLK terminal).
  4) Discharge any capacitors, if connected.
- Warn workers around the HP 4142B about dangerous conditions.

JAPANESE: HP 4142Bの安全上の注意



高電圧感電注意 (最大 1000 V dc)

HP 41423A HVU (±1000 V)、HP 41420A SMU (±200 V)、およびHP 41421B SMU (±100 V)は、危険電圧をFORCE端子、GUARD端子、およびSENSE端子に出力します。感電事故防止のため、必ず下記の事項を実施してください。

- 3極電源ケーブルを使用して、HP 4142Bを接地する
- インターロック(INTLK)端子を、シールド･ボックスの蓋が開いたときにオープンとなるよう接続する
- OUTPUT ON/OFF STATUS端子を警告インジケータに接続する(HVU使用時)
- INTLK回路およびOUTPUT ON/OFF STATUS回路の動作テストを、1日に1回以上、使用前に行う(HVU使用時)
- FORCE端子、GUARD端子、およびSENSE端子の接続に触れる前に、HP 4142Bの電源をオフにし、キャパシタが接続されているならば、キャパシタを放電する

  電源をオフにしない場合には、下記の4事項をすべて実施する
  1) HVUおよびSMUの出力スイッチをオフにする
  2) 警告インジケータが消灯していることを確認する(HVU使用時)
  3) シールド･ボックスの蓋をあける(INTLK端子をオープンにする)
  4) キャパシタが接続されているならば、キャパシタを放電する
- 周囲の他の作業者に対しても、高電圧危険に対する注意を徹底する

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GERMAN: Sicherheitsmaßnahmen für den HP 4142B

WARNUNG



HOCHSPANNUNGS-BERÜHRUNGSGEFAHR (MAX. 1000 VDC)

Bei den Geräten HP 41423A HVU (±1000 V), HP 41420A SMU (±200 V) und HP 41421B SMU (±100 V) gefährliche spannungen an den FORCE-, GUARD- und SENSE-Klemmen. Um einen Elektroschock zu vermeiden, sind folgende Sicher-heitsmaßnahmen zu beachten.

- Gerät HP 4142B mit einem Dreileiter-AC-Starkstromkabel erden.
- Die Interlock-Klemme (INTLK) mit einem Schalter ver-binden, der beim Öffnen der Abschirmkasten-Zugangatür ausgeschaltet wird.
- Bei Gerät HVU die Klemme OUTPUT ON/OFF STATUS mit einer Warnanzeige verbinden.
- Bei Gerät HVU die Funktionsprüfungen der Schaltkreise INTLK und OUTPUT ON/OFF STATUS mindestens einmal täglich durchführen, bevor HP 4142B verwendet wird.
- Vor Berühren der Verbindungen an den FORCE-, GUARD- und SENSE-Klemmen, Gerät HP 4142B ausschalten und (falls angeschlossen), die Kondenaatoren entladen.
  Falls HP 4142B nicht ausgeschaltet wird, sind fol-gende vier Schritte durchzuführen:
  1) Die Ausgangschalter von HVU und SMU auf AUS stellen.
  2) Bei HVU kontrollieren, ob die Warnanzeige nicht leuchtet.
  3) Die Zugangstür des abgeschirmten Kasten öffnen (die Klemme INTLK öffnen).
  4) Vorhandene Kondensatoren entladen.
- Die Arbeitskräfte im Bereich des HP 4142B über die be-stehende Gafahr unterrichten.

FRENCH: Consignes de sécurité relatives à l'équipement HP 4142B

DANGER D'ELECTROCUTION



HAUTE TENSION CONTINUE (JUSQU'A 1000 Vc.c.)

Les instruments HP 41423A HVU (±1000 V), HP 41420A SMU (±200 V) et HP 41421B SMU (±100 V) présentent des tensions dangereuses aux bornes "FORCE", "GUARD" et "SENSE". Pour éviter tout risque d'électrocution, respecter les consignes suivantes.

- Mettre à la terre l'équipement HP 4142B en utilisant un câble secteur triphasé.
- Connecter la borne de verrouillage "INTLK" à un commutateur coupant l'alimentation lorsque la porte d'accès à la boite blindée est ouverte.
- Pour le module HVU, connecter la borne "OUTPUT ON/OFF STATUS" à une lampe d'avertissement.
- Pour le module HVU, effectuer les essais de fonctionnement des circuits "INTLK" et "OUTPUT ON/OFF STATUS" au moins une fois par jour, avant d'utiliser l'équipement HP 4142B.
- Avant de toucher les connexions des bornes "FORCE" "GUARD" et "SENSE", mettre hors tension l'équipement HP 4142B et décharger tous les condensateurs éventuellement raccordés.
  Au lieu de mettre l'équipement HP 4142B hors tension, l'on peut procéder de la manière suivante:
  1) Mettre les commutateurs de sortie des modules HVU et SMU en position d'arrêt.
  2) Pour le module HVU, s'assurer que la lampe d'avertissement est éteinte.
  3) Ouvrir la porte d'accès à la boîte blindée (pour mettre hors circuit la borne "INTLK").
  4) Décharger tous les condensateurs éventuellement raccordés.
- Avertir toute personne travaillant à proximité de l'équipement HP 4142B des dangers que présente cet équipement.

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HP-IB COMMAND REFERENCE

Introduction

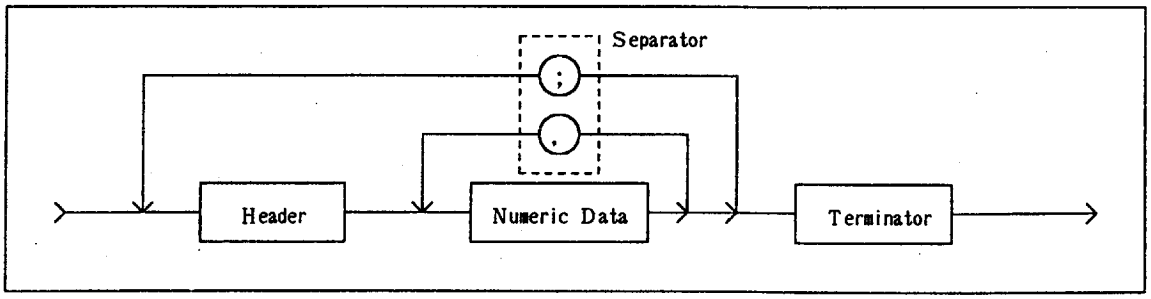
The first part of this manual discusses the HP-IB command input format and the measurement data format.
The remainder of this manual contains detailed descriptions of each command. The commands are listed in alphabetical order. Each entry (1) defines one HP-IB command, (2) shows the measurement mode that the command is used in (if it is for measurement), (3) shows execution conditions (if any exist), (4) shows its syntax, (5) shows its parameters, (6) shows data output format after command execution (if it is a query command or measurement trigger command), (7) explains special information, and (8) provides examples.

The following conventions are used throughout this manual.

Notation	Description
CAPITALS	Commands and hardware acronyms in text and program examples are shown in CAPITAL LETTERS.
italics	Required parameters, which you must substitute a value or variable, are shown in *standard italics* in text and in syntax tables (not in command examples).
[*italics*]	Optional parameters, which you may substitute a value, are shown in *standard italics* and are delimited by brackets [ ]. Most optional parameters have default values assigned, as listed in each syntax table.

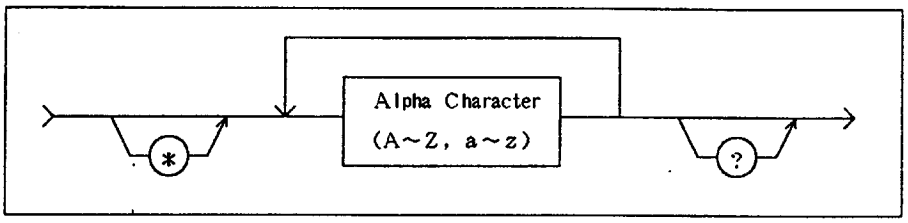
HP-IB Command Input Format

HP 4142B HP-IB commands are composed of a header, numeric data, separator, and terminator, as shown in the syntax diagram in the following figure. Spaces are allowed between the header and numeric data, and before and after each numeric data.



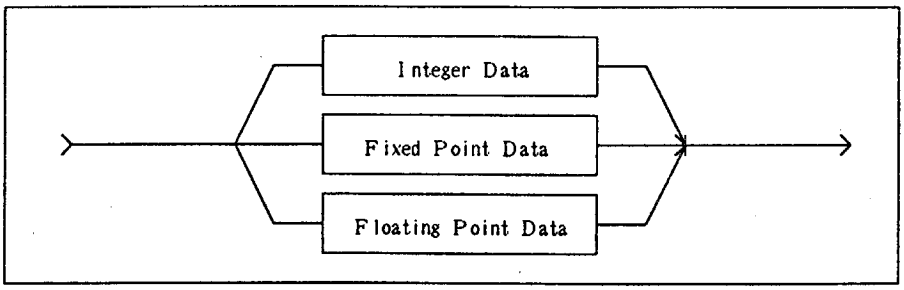
HP-IB Command Syntax Diagram

(1) **Header:**
The header is the command name and always contains alpha characters. The case is ignored. Some command names also contain an asterisk (*) or question mark (?). The following figure shows the syntax diagram for a header.



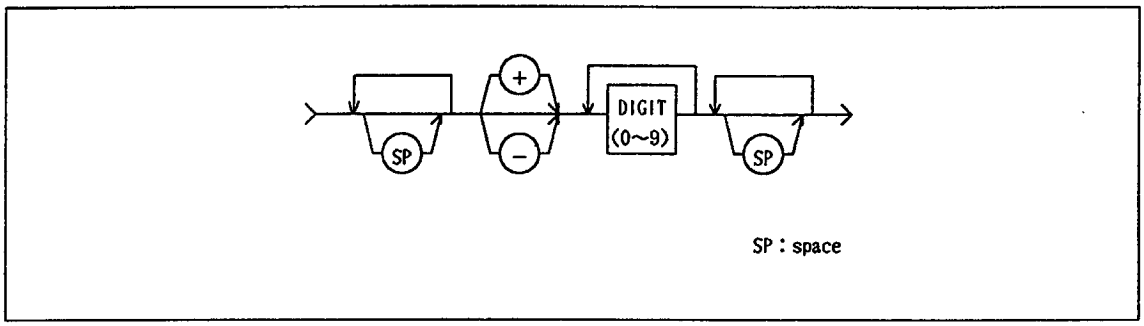
Header Syntax Diagram

(2) **Numeric data:**
Numeric data are the command parameters. You can enter numeric data directly after the header or insert spaces between the header and numeric data. Some parameters require integer data. The following figure shows the syntax diagram for numeric data.

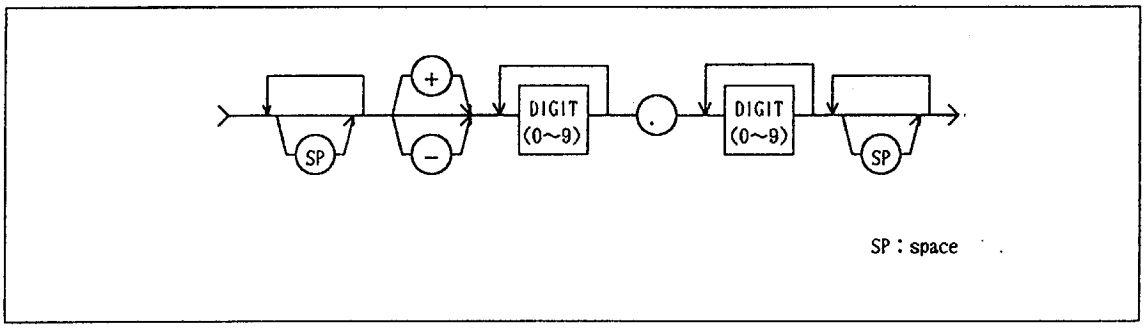


Numeric Data Syntax Diagram

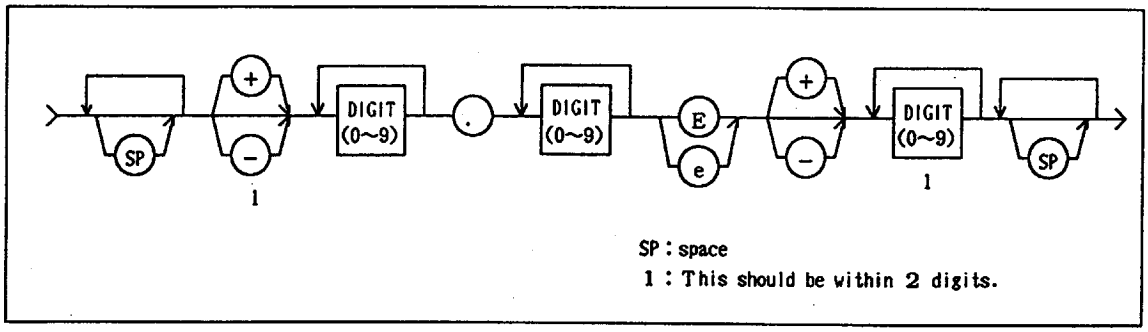
The following 3 figures show the syntax diagrams for integer, fixed-point, and floating-point data, respectively.



Integer Data Syntax Diagram

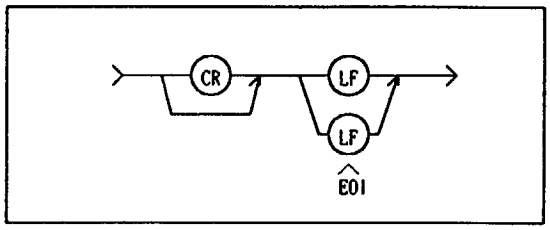


Fixed-Point Data Syntax Diagram



Floating-Point Data Syntax Diagram

(3) **Terminator:**
The terminator completes the HP-IB command entry and starts command execution. The following figure shows the terminator syntax diagram.



Terminator Syntax Diagram

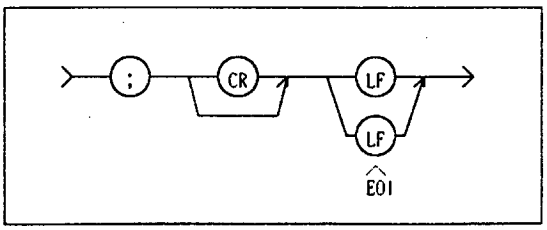
(4) **Separator:**
If you enter multiple commands, use semicolons (;) to separate the commands. Spaces are allowed before and after the semicolons. Command execution starts when the terminator is received, not when the semicolon is received. You can input multiple commands of up to a total of 256 characters (including the terminator). If you input more than 256 characters, the input buffer overflows, and an error is indicated.

Use commas (,) to separate numeric data entries.

NOTE

Do not include the reset command (***RST**) or the abort command (**AB**) in multiple command strings (example: OUTPUT 717;"*RST;CN"). If you do, the other commands in the string (CN) are not executed.

(5) **Special Terminator:**
If a semicolon (;) is inserted before the terminator, as shown in the following figure, the preceding commands are not executed until the next command line is input and another terminator is input without a preceding semicolon. The command lines are then executed together.



Special Terminator

ASCII Measurement Data Output Format

Measurement data (<m_data>) is stored in the output data buffer in either ASCII or BINARY format as specified by the **FMT** command. The following table lists the ASCII measurement data output format. Refer to "Binary Measurement Data Output Format" for information on BINARY measurement data output.

ASCII Measurement Data Output Format (1 of 3)

(1) High Speed Spot, 1ch Pulsed Spot, 2ch Pulsed Spot, and Quasi-pulsed Spot Measurements

<m_data><term>

(2) Spot Measurements

<m_data (ch#A)> [,<m_data (ch#B)> [. . .]] <term>

(3) Staircase Sweep Measurements

<block (step#1)>, <block (step#2), . . . , <block (step#*n*)> <term>

<block> = <m_data (ch#A)> [, <m_data (ch#B)> [. . .]][, <s_data>]

Where *n* is equal to the specified *number of steps* for single-sweep measurements, and equal to double the specified *number of steps* for double-sweep measurements, unless the sweep is aborted by the **AB** command. The number and order of measurement channels are specified by the **MM** command. If specified by the **FMT** command, sweep source data (<s_data>) is also sent at the end of each block.

(4) Pulsed Sweep, Staircase Sweep with Pulsed Bias, and Pulsed Sweep with Pulsed Bias Measurements

<block (step#1)>, <block (step#2)>, . . . , <block (step#*n*)> <term>

<block> = <m_data> [, <s_data>]

Where *n* and <s_data> are the same as described in (3).

(5) Analog Search Measurements

<m_data (search SMU)> [, <m_data (sense SMU)>] <term>

If specified by the **ASM** command, <m_data (sense SMU)> measurements are also made.

ASCII Measurement Data Output Format (2 of 3)

<m_data>/<s_data>:

Measurement (<m_data>) and sweep source (<s_data>) data values are stored in the output data buffer with headers (1) or without headers (2) as specified by the **FMT** command. The default setting is (1).

(1) With headers: <status(1char.)><channel(1char.)><V/I(1char.)><value(12char.)>

(2) Without headers: <value(12char.)>

<status> (1char.)

for <m_data>:
N: Normal measurement data.
F, G, S, T, C, V, X:
An error occurred during measurements. For more information, see Appendix B, "Measurement Data Status."

for <s_data>:
W: Indicates first or intermediate sweep step
E: Indicates final sweep step
Priority: E > W

<channel> (1char.)

A: Ch#1	I: Ch#11	Q: Ch#21
B: Ch#2	J: Ch#12	R: Ch#22
C: Ch#3	K: Ch#13	S: Ch#23
D: Ch#4	L: Ch#14	T: Ch#24
E: Ch#5	M: Ch#15	U: Ch#25
F: Ch#6	N: Ch#16	V: Ch#26
G: Ch#7	O: Ch#17	W: Ch#27
H: Ch#8	P: Ch#18	X: Ch#28

For differential measurements, the HP 4142B shows the unit specified by the **MM** or **TV** command.

<V/I> (1char.)
V: Voltage data
I: Current data

<value> (12char.)
6 digit decimal point number in engineering format. If <status> is V, then <value> = 199.999E+99 and is meaningless.

sn.nnnnnEsnn, snn.nnnnEsnn or snnn.nnnEsnn

s: sign + or -
n: digit (0 to 9)
E: exponent symbol

ASCII Measurement Data Output Format (3 of 3)

<term>:

Measurement data can be terminated (<term>) as follows, as specified by the **FMT** command.

(1) <term> = <CR/LF^EOI>
(Each CR/LF requires two bytes.)

(2) <term> = <,>

The default setting is (1). If <m_data>/<s_data> = <value>, the terminator is automatically set to (1).

Sample Programs

The following are sample programs for ASCII data output format. A description of key program lines follows the program list.

- Program 1:

```
10  ! Vce(sat) and Vbe(sat) Measurement using Spot Function
20  !
30  INTEGER B_ch, C_ch
40  DIM A$[31]
50  ASSIGN @Hp4142 TO 717
60  OUTPUT @Hp4142;"*RST"
70  !                                        Emitter: GNDU
80  B_ch=3                                   ! Base: Ch#3
90  C_ch=2                                   ! Collector: Ch#2
100 Ib=1.E-3
110 Ic=1.E-2
120 !
130 OUTPUT @Hp4142;"CN";B_ch, C_ch
140 OUTPUT @Hp4142;"DI";B_ch, 0, Ib, 2
150 OUTPUT @Hp4142;"DI";C_ch, 0, Ic, 2
160 OUTPUT @Hp4142;"MM";1, C_ch, B_ch
170 OUTPUT @Hp4142;"XE"
180 OUTPUT @Hp4142;"CL"
190 !
200 ENTER @Hp4142;A$
210 PRINT "Vce(sat)= ";A$[4, 15];"[V]"
220 PRINT "Vbe(sat)= ";A$[20,31];"[V]"
230 END
```

40	Defines the string variable, *A$*, for storing measurement data.
170	Outputs a trigger to start the measurement.
200	Enters the measurement data into the string variable, *A$*.
210-220	Displays the measurement results.

- Program 2:

```
10  ! Ic-Vce Measurement using Staircase Sweep Function
20  !
30  OPTION BASE 1
40  INTEGER B_ch, C_ch, Vc_no_step, Var1
50  REAL Vc(101)
60  ASSIGN @Hp4142 TO 717
70  OUTPUT @Hp4142;"*RST"
80  OUTPUT @Hp4142;"FMT";5          ASCII data with header; terminator (,).
90  !                                  Emitter: GNDU
100 B_ch=3                          !  Base: Ch#3
110 C_ch=2                          !  Collector: Ch#2
120 Vc_start=0
130 Vc_stop=1
140 Vc_no_step=101
150 Ic_comp=.01
160 Ib=1.E-5
170 !
180 Vc_step=(Vc_stop-Vc_start)/(Vc_no_step-1)
190 FOR Var1=1 TO Vc_no_step
200    Vc(Var1)=Vc_start+(Var1-1)*Vc_step
210 NEXT Var1
220 !
230 OUTPUT @Hp4142;"CN";B_ch, C_ch
240 OUTPUT @Hp4142;"WV";C_ch, 1, 0, Vc_start, Vc_stop, Vc_no_step, Ic_comp
250 OUTPUT @Hp4142;"MM";2, C_ch
260 OUTPUT @Hp4142;"RI";C_ch, 18
270 !
280 OUTPUT @Hp4142;"DI";B_ch, 0, Ib,2
290 OUTPUT @Hp4142;"XE"
300 !
310 FOR Var1=1 TO Vc_no_step
320    ENTER @Hp4142 USING "#, 3X, 12D, X";Ic
330    PRINT Vc(Var1), Ic
340 NEXT Var1
350 !
360 OUTPUT @Hp4142;"CL"
370 END
```

80	Sets the data output format to ASCII with header and comma (,) as a terminator.
290	Outputs a trigger to start a voltage sweep measurement.
310-340	Enters the measurement data into the variable *Ic*, and displays measurement data.

Binary Measurement Data Output Format

Measurement data can be sent in either ASCII (refer to previous paragraph) or BINARY format. One measurement data requires 12 bytes (without header) or 15 bytes (with header) in ASCII format, and 4 bytes in BINARY format.

Because BINARY data requires fewer bytes, data transfer time between the HP 4142B and the controller is less for BINARY data than for ASCII data. However, overall transfer and conversion time is less for ASCII data (for HP 9000 Series 310 computers running HP BASIC 4.0) because the conversion time from measurement data to measurement values is much less for ASCII data than for BINARY data. Therefore, ASCII format is used for most measurements, and BINARY format is only used when high speed data transfer is required.

Output Format

The following table lists the BINARY data output format.

BINARY Measurement Data Output Format (1 of 4)

(1) High Speed Spot, 1ch Pulsed Spot, 2ch Pulsed Spot, and Quasi-pulsed Spot Measurements

<m_data><term>

(2) Spot Measurements

<m_data(ch#A)>[<m_data(ch#B)>[...]]<term>

(3) Staircase Sweep Measurements

<block(step#1)><block(step#2)> ... <block(step#*n*)><term>
<block> = <m_data(ch#A)>[<m_data(ch#B)>[...]][<s_data>]

Where *n* is equal to the specified *number of steps* for single sweep measurements, and double the specified *number of steps* for double sweep measurements, unless the sweep is aborted by the **AB** command. The number and order of measurement channels are specified by the **MM** command. If specified by the **FMT** command, sweep source data (s_data) is also sent at the end of each block.

(4) Pulsed Sweep, Staircase Sweep with Pulsed Bias, and Pulsed Sweep with Pulsed Bias Measurements

<block(step#1)><block(step#2)> ... <block(step#*n*)><term>
<block> = <m_data>[<s_data>]

where *n* and <s_data> are the same as described in (3).

(5) Analog Search Measurements

<m_data(search SMU)>[<m_data(sense SMU)>]<term>

If specified by the **ASM** command, <m_data(sense SMU)> measurements are also made.

BINARY Measurement Data Output Format (2 of 4)

<m_data>/<s_data>:

<m_data>/<s_data> = <Byte1><Byte2><Byte3><Byte4>

Byte1								Byte2								Byte3								Byte4							
7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
A	B	C						D																E						F	

A: Indicates measurement data (<m_data>) or sweep source data (<s_data>).
- 0: sweep source data
- 1: measurement data

B: Indicates voltage data or current data.
- 0: voltage data
- 1: current data

C: Uses range number to indicate measurement range (for m_data) or output range (for s_data).

C (Range Number)	Measurement/Output Range	
	Voltage Range (V)	Current Range (A)
01010 (10)	0.2	---
01011 (11)	2	1E-9
01100 (12)	20	1E-8
01101 (13)	40	1E-7
01110 (14)	100	1E-6
01111 (15)	200	1E-5
10000 (16)	500	1E-4
10001 (17)	1000	1E-3
10010 (18)	---	1E-2
10011 (19)	---	1E-1
10100 (20)	---	1
10101 (21)	---	10

The current range can be calculated from the range number using the following equation.

$$\text{current range} = 10^{(\text{range number} - 20)}$$

BINARY Measurement Data Output Format (3 of 4)

D: Number of counts expressed by twos complement (17 bit), which is used to calculate the measurement value or sweep source value by the following equations. Full scale is 50000 counts for measurement values, and 20000 counts for sweep source values.

measurement value = (number of counts)(measurement range)/50000

sweep source value = (number of counts)(output range)/20000

If Bit 0 of Byte 1 is "0", the number of counts is positive and equal to the decimal value of <Byte2><Byte3>.

If Bit 0 of Byte 1 is "1", the number of counts is negative. Calculate number of counts by subtracting 65536 from the decimal value of <Byte2><Byte3>.

If E is "011", number of counts has no meaning and is set to +65535.

E: Indicates status for measurement or sweep source data.

For measurement data:
000 (0): Same as N (Normal measurement data) for ASCII format.
001 (1): Same as T for ASCII format.
010 (2): Same as C for ASCII format.
011 (3): Same as V for ASCII format.
100 (4): Same as X for ASCII format.
101 (5): Same as F for ASCII format.
110 (6): Same as G for ASCII format.
111 (7): Same as S for ASCII format.

For sweep source data:
001 (1): Indicates first or intermediate sweep step.
010 (2): Indicates final sweep step.
Priority: 010 > 001

F: Indicates the channel number (Ch#) of the unit that performs the measurement or output the sweep source value.

00001: Ch#1	01011: Ch#11	10101: Ch#21
00010: Ch#2	01100: Ch#12	10110: Ch#22
00011: Ch#3	01101: Ch#13	10111: Ch#23
00100: Ch#4	01110: Ch#14	11000: Ch#24
00101: Ch#5	01111: Ch#15	11001: Ch#25
00110: Ch#6	10000: Ch#16	11010: Ch#26
00111: Ch#7	10001: Ch#17	11011: Ch#27
01000: Ch#8	10010: Ch#18	11100: Ch#28

For differential measurements, the HP 4142B indicates the unit specified by the **MM** or **TV** command.

BINARY Measurement Data Output Format (4 of 4)

<term>:

Output data can be terminated (<term>) in the following way, as specified by the **FMT** command. The default setting is (1).

(1) <term> = <CR/LF^EOI>
(Each CR/LF requires two bytes.)

(2) <term> = <^EOI>
(An EOI is output at the same time as the last data byte and does not require any bytes.)

Sample Program

The following program shows a sample program for performing high speed spot measurements using BINARY data output format. A description of key program lines follows the program list.

- Program:

```
10   ! Sample Program for Binary Data
20   !
30   OPTION BASE 1
40   DIM Data$[20]
50   ASSIGN @Hp4142 TO 717
60   OUTPUT @Hp4142;"*RST"
70   OUTPUT @Hp4142;"FMT";4
80   !                                          Emitter: GNDU
90   B_ch=3                                  ! Base: Ch#3
100  C_ch=2                                  ! Collector: Ch#2
110  !
120  OUTPUT @Hp4142;"CN";B_ch, C_ch
130  OUTPUT @Hp4142;"DV";B_ch, 0, -3, 1.E-7  ! Vb = -3 V
140  OUTPUT @Hp4142;"DV";C_ch, 0, 30, 1.E-7  ! Vc = 30 V
150  OUTPUT @Hp4142;"TI";C_ch, 12            ! Icev Measurement
160  OUTPUT @Hp4142;"TI";B_ch, 12            ! Ibev Measurement
170  !
180  OUTPUT @Hp4142;"DI";C_ch, 0, 1.E-2, 2   ! Ic = 10 mA
190  OUTPUT @Hp4142;"DI";B_ch, 0, 1.E-3, 2   ! Ib = 1 mA
200  OUTPUT @Hp4142;"TV";C_ch                ! Vce(sat) Measurement
210  OUTPUT @Hp4142;"TV";B_ch                ! Vbe(sat) Measurement
220  !
230  OUTPUT @Hp4142;"DI";C_ch, 0, 1E-3, 70   ! Ic = 1 mA
240  OUTPUT @Hp4142;"DI";B_ch, 12, 0, 2      ! Ib = 0 A
250  OUTPUT @Hp4142;"TV";C_ch                ! BVceo Measurement
260  !
270  OUTPUT @Hp4142;"CL"
280  !
290  ENTER @Hp4142 USING "#, 20A";Data$
300  CALL Print_data(Data$)
310  END
320  !
330  SUB Print_data(Data$)
340  DIM A$(5)[4]
350  FOR I=1 TO 5
360    A$(I)=Data$[1+(I-1)*4;4]
370  NEXT I
380  CALL Get_data(A$(1), Value)
390  PRINT "Icev=     ";Value;"[A]"
400  CALL Get_data(A$(2), Value)
410  PRINT "Ibev=     ";Value;"[A]"
420  CALL Get_data(A$(3), Value)
430  PRINT "Vce(sat)= ";Value;"[V]"
440  CALL Get_data(A$(4), Value)
450  PRINT "Vbe(sat)= ";Value;"[V]"
460  CALL Get_data(A$(5), Value)
470  PRINT "BVceo=    ";Value;"[V]"
```

```
480 SUBEND
490 !
500 SUB Get_data(Byte1234$, REAL Value, OPTIONAL INTEGER Status)
510   !
520   INTEGER Byte1, Byte2, Byte3, Byte4, N, I_v
530   !
540   Byte1=NUM(Byte1234$[1;1])
550   Byte2=NUM(Byte1234$[2;1])
560   Byte3=NUM(Byte1234$[3;1])
570   N=NPAR
580   IF N=3 THEN Byte4=NUM(Byte1234$[4;1])
590   !
600   IF BIT(BYTE1, 0)=0 THEN                    ! Positive data
610     Count=Byte2*256.+Byte3                   !   256 = 2^8
620   ELSE                                       ! Negative data
630     Count=-65536.+Byte2*256.+Byte3           !   -65536 = -2^16
640   ENDIF
650   !
660   I_v=BIT(Byte1, 6)                          ! 0: V data    1: I data
670   Range_no=SHIFT(BINAND(Byte1, 62), 1)       ! 62: 00111110
680   SELECT I_v
690   CASE 0                                     ! V range
700     SELECT Range_no
710     CASE 11
720       Range=2
730     CASE 12
740       Range=20
750     CASE 13
760       Range=40
770     CASE 14
780       Range=100
790     CASE 15
800       Range=200
810     CASE 16
820       Range=500
830     CASE 17
840       Range=1000
850     END SELECT
860   CASE 1                                     ! I range
870     Range=10^(Range_no-20)
880   END SELECT
890   !
900   Value=Count/50000*Range
910   !
920   IF N=3 THEN Status=SHIFT(Byte4, 5)
930   !
940 SUBEND
```

70	Sets the data output format to BINARY without CR/LF.
90-270	Performs five high speed spot measurements.
290	Enters the five BINARY measurement data (20 bytes) into one string variable, Data$ (20 char), as ASCII characters.
300	Calls subprogram to display each measurement value.
330-480	Subprogram to display each measurement value.
500-940	Subprogram to convert the measurement data (that was converted to ASCII characters in line 290) to the measurement value.
540-580	Converts measurement data from ASCII to decimal value.
600-640	Calculates the number of counts.
660-880	Calculates the range value.
900	Calculates the measurement value.
920	Calculates the data status #.

AB

The AB command aborts the present operation and subsequent command execution.

Syntax

AB

Remarks

The AB command aborts the present operation, and sets the HP 4142B as listed in the following table.

Present Operation	HP 4142B Setting
Staircase Sweep Measurements	Sets specified *start voltage* or *current*.
1ch Pulsed Spot Measurements	Sets specified *base voltage* or *current*.
Pulsed Sweep Measurements	Sets specified *base voltage* or *current*.
Staircase Sweep with Pulsed Bias Measurements	Sets specified *start voltage* or *current* and *base voltage* or *current*.
Analog Search Measurements	Sets sense and search SMU output to 0 V.
2ch Pulsed Spot Measurements	Sets specified *base voltage* or *current*.
Pulsed Sweep with Pulsed Bias Measurements	Sets specified *base voltage* or *current*.
Quasi-pulsed Spot Measurements	Sets specified *start voltage*.
Self-Test	Same as set by CL command.
Self-Calibration	Same as set by CL command.
WAIT State (PA or WS command)	Settings do not change.
Program Execution (RU or DO command)	Settings do not change.

If you start an operation that you may want to abort, do not send a command after the command or command string that starts the operation. If you do, the AB command cannot enter the command input buffer until the intervening command execution starts, thus the operation cannot be aborted. In this case, use the Device Clear (CLEAR command in HP BASIC) to end the operation.

If the AB command is included in a command string (example: OUTPUT 717;"AB;CN"), the other commands (CN) in the string are not executed.

If the HP 4142B receives an AB command during a sweep measurement, only the measurement data obtained before the sweep was aborted is stored in the output data buffer (dummy data is not stored).

While the unit performs the measurement for detection in the quasi-pulsed spot measurements, the HP 4142B can not receive any commands. Therefore, your computer waits to send commands (including AB) until the unit finishes the measurement.

Example Statements

```
OUTPUT 717; "AB"
```

AIV

The AIV command specifies the V sense SMU (I source/V monitor mode) and its parameters. This command also clears the AVI command setting.

Measurement Mode

Analog search measurement

Syntax

AIV *ch#, output current, target voltage* [, *V compliance*]

Parameters

ch# (integer expression)

Unit	*ch#*
HPSMU	2 to 8
MPSMU	1 to 8

output current (numeric expression, unit: A)

Unit	*output current*	Output Range	Output Reso.	*V compliance* [1] or *target voltage*
HPSMU	0 ≤ |I| ≤ 1.15 nA	1 nA	50 fA	0 to ±200 V
	1.15 nA < |I| ≤ 11.5 nA	10 nA	500 fA	0 to ±200 V
	11.5 nA < |I| ≤ 115 nA	100 nA	5 pA	0 to ±200 V
	115 nA < |I| ≤ 1.15 µA	1 µA	50 pA	0 to ±200 V
	1.15 µA < |I| ≤ 11.5 µA	10 µA	500 pA	0 to ±200 V
	11.5 µA < |I| ≤ 115 µA	100 µA	5 nA	0 to ±200 V
	115 µA < |I| ≤ 1.15 mA	1 mA	50 nA	0 to ±200 V
	1.15 mA < |I| ≤ 11.5 mA	10 mA	500 nA	0 to ±200 V
	11.5 mA < |I| ≤ 50 mA	100 mA	5 µA	0 to ±200 V
	50 mA < |I| ≤115 mA	100 mA	5 µA	0 to ±100 V
	115 mA < |I| ≤ 125 mA	1 A	50 µA	0 to ±100 V
	125 mA < |I| ≤ 350 mA	1 A	50 µA	0 to ±40 V
	350 mA < |I| ≤ 700 mA	1 A	50 µA	0 to ±20 V
	700 mA < |I| ≤ 1 A	1 A	50 µA	0 to ±14 V
MPSMU	0 ≤ |I| ≤ 1.15 nA	1 nA	50 fA	0 to ±100 V
	1.15 nA < |I| ≤ 11.5 nA	10 nA	500 fA	0 to ±100 V
	11.5 nA < |I| ≤ 115 nA	100 nA	5 pA	0 to ±100 V
	115 nA < |I| ≤ 1.15 µA	1 µA	50 pA	0 to ±100 V
	1.15 µA < |I| ≤ 11.5 µA	10 µA	500 pA	0 to ±100 V
	11.5 µA < |I| ≤ 115 µA	100 µA	5 nA	0 to ±100 V
	115 µA < |I| ≤ 1.15 mA	1 mA	50 nA	0 to ±100 V
	1.15 mA < |I| ≤ 11.5 mA	10 mA	500 nA	0 to ±100 V
	11.5 mA < |I| ≤ 20 mA	100 mA	5 µA	0 to ±100 V
	20 mA < |I| ≤ 50 mA	100 mA	5 µA	0 to ±40 V
	50 mA < |I| ≤100 mA	100 mA	5 µA	0 to ±20 V

[1] For smooth feedback operation, set *V compliance* at least 10% higher than *target voltage*.

The *output current* parameter sets the sense SMU output current, and this value determines the I output range of the sense SMU by Auto ranging, as shown in the above table.

target voltage (numeric expression, unit: V)

For allowable *target voltage* values, see *"output current"*. The resolution of *target voltage* depends on the *V compliance* as follows.

V compliance	*target voltage* Resolution
0 ≤ |V| ≤ 2 V	100 µV
2 V < |V| ≤ 20 V	1 mV
20 V < |V| ≤ 40 V	2 mV
40 V < |V| ≤ 100 V	5 mV
100 V < |V| ≤ 200 V	10 mV

[*V compliance*] (numeric expression, unit: V)

For allowable *V compliance* values, see *"output current"*.

Default:

- If the source unit is set to I source mode before the trigger:
  Default = the setting before trigger
- If the source unit is set to V source mode before the trigger:
  Default = none

V compliance polarity is automatically set to the same polarity as *output current*, regardless of the specified *V compliance* polarity. If *output current* = 0, the V compliance polarity is positive.

For sense SMU V measurements, V measurement range is automatically set to the lowest range that includes *V compliance*.

Remarks

This command setting is cleared by the AVI command.

Example Statements

```
OUTPUT 717;"AIV1, 1E-5, 5"
OUTPUT 717;"AIV3, 2E-6, 3, 10"
```

ASM

The ASM command sets the *search operation mode*, *search measurement mode*, and *feedback integration time* for an analog search measurement.

Measurement Mode

Analog search measurement

Syntax

ASM *search operation mode*, *search measurement mode* [, *feedback integration time*]

Parameters

search operation mode (integer expression)

search operation mode	**Description**
1	negative feedback search
2	positive feedback search
3	ramp wave search (greater than target)
4	ramp wave search (less than target)

Initial Setting = 1

search measurement mode (integer expression)

search measurement mode	**Description**
1	search SMU V measurement
2	search SMU I measurement
3	search SMU V and sense SMU V or I [1] measurement
4	search SMU I and sense SMU V or I [1] measurement

[1] If the sense SMU is in V monitor mode, V measurement is made. If the sense SMU is in I monitor mode, I measurement is made.

Initial Setting = 1

[*feedback integration time*] (numeric expression, Unit: s)

Search SMU Output Range [1]	*feedback integration time*	**Resolution**
2 V	50E-6 to 450E-6 0.5E-3 to 4.5E-3 5E-3 to 45E-3 50E-3 to 450E-3	50E-6 0.5E-3 5E-3 50E-3
20 V	5E-6 to 45E-6 50E-6 to 450E-6 0.5E-3 to 4.5E-3 5E-3 to 45E-3	5E-6 50E-6 0.5E-3 5E-3
40 V	2.5E-6 to 4.5E-6 5E-6 to 45E-6 50E-6 to 450E-6 0.5E-3 to 4.5E-3 5E-3 to 25E-3	0.5E-6 5E-6 50E-6 0.5E-3 5E-3
100 V	1E-6 to 4.5E-6 5E-6 to 45E-6 50E-6 to 450E-6 0.5E-3 to 4.5E-3 5E-3 to 10E-3	0.5E-6 5E-6 50E-6 0.5E-3 5E-3
200 V	0.5E-6 to 4.5E-6 5E-6 to 45E-6 50E-6 to 450E-6 0.5E-3 to 4.5E-3 5E-3	0.5E-6 5E-6 50E-6 0.5E-3 ---

[1] The *feedback integration time* allowed depends on the V output range that is automatically set for the search SMU. Refer to the ASV command description.

Initial Setting = 5E-3
Default = previous setting

The *feedback integration time* parameter has no meaning when the *search operation mode* parameter is set to 3 or 4.

Example Statements

```
OUTPUT 717;"ASM2, 1, 5E-4"
OUTPUT 717;"ASM1, 3"
```

ASV

The ASV command specifies the search SMU and its parameters for an analog search measurement.

Measurement Mode

Analog search measurement

Syntax

ASV *ch#, search start voltage, search stop voltage* [, *ramp rate*] [, *I compliance*]

Parameters

ch# (integer expression)

Unit	*ch#*
HPSMU	2 to 8
MPSMU	1 to 8

search start voltage (numeric expression, Unit: V)
search stop voltage (numeric expression, Unit: V)

Unit	*search start voltage* [1]	*search stop voltage* [1]
HPSMU	0 to ±200 V	0 to ±200 V
MPSMU	0 to ±100 V	0 to ±100 V

[1] |*search start voltage* - *search stop voltage*| (= D) must be within the following area.

Unit	**Greater Value G in** |*search start voltage*| **and** |*search stop voltage*|	**D**
HPSMU	0 ≤ G ≤ 2 V 2 V < G ≤ 20 V 20 V < G ≤ 40 V 40 V < G ≤ 100 V 100 V < G ≤ 200 V	0.1 V ≤ D 1 V ≤ D 2 V ≤ D 5 V ≤ D 10 V ≤ D ≤ 200 V
MPSMU	0 ≤ G ≤ 2 V 2 V < G ≤ 20 V 20 V < G ≤ 40 V 40 V < G ≤ 100 V	0.1 V ≤ D 1 V ≤ D 2 V ≤ D 5 V ≤ D ≤ 100 V

The output range is automatically set to the lowest range that includes *search start voltage*, *search stop voltage*, and |*search stop voltage* - *search start voltage*|.

For search SMU V measurement, measurement range is set to the same range as the output range.

Output Range	*search start voltage* **Resolution**	*search stop voltage* **Resolution**
2 V	1.25 mV	10 mV
20 V	12.5 mV	100 mV
40 V	25 mV	200 mV
100 V	62.5 mV	500 mV
200 V	125 mV	1 V

[*ramp rate*] (numeric expression, Unit: V/s)

Output Range	*ramp rate*	**Resolution**
2 V	0.5 to 5 5.5 to 50 55 to 500 550 to 5000	0.05 V/s 0.5 V/s 5 V/s 50 V/s
20 V	5.5 to 50 55 to 500 550 to 5000 55500 to 50000	0.5 V/s 5 V/s 50 V/s 500 V/s
40 V	10 to 50 55 to 100 110 to 500 550 to 1000 1100 to 5000 5500 to 10000 11000 to 50000 55000 to 100000	1 V/s 5 V/s 10 V/s 50 V/s 100 V/s 500 V/s 1000 V/s 5000 V/s
100 V	25 to 50 55 to 250 275 to 500 550 to 2500 2750 to 5000 5500 to 25000 27500 to 50000 55000 to 100000	2.5 V/s 5 V/s 25 V/s 50 V/s 250 V/s 500 V/s 2500 V/s 5000 V/s
200 V	55 to 500 550 to 5000 5500 to 50000 55000 to 100000	5 V/s 50 V/s 500 V/s 5000 V/s

Default = 500 V/s

[*I compliance*] (numeric expression, Unit: A)

Unit	Output Range	*I compliance* [1]
HPSMU	2 V	±(1 pA to 1 A)
	20 V (|V| ≤ 14 V) [2]	±(1 pA to 1 A)
	20 V (|V| >14 V) [3]	±(1 pA to 700 mA)
	40 V	±(1 pA to 350 mA)
	100 V	±(1 pA to 125 mA)
	200 V	±(1 pA to 50 mA)
MPSMU	2 V	±(1 pA to 100 mA)
	20 V	±(1 pA to 100 mA)
	40 V	±(1 pA to 50 mA)
	100 V	±(1 pA to 20 mA)

[1] If 0 ≤ |*I compliance*| < 1 pA, I compliance is set to 1 pA or -1 pA.
[2] For |*search start voltage*| ≤ 14 V and |*search stop voltage*| ≤ 14 V.
[3] For |*search start voltage*| > 14 V or |*search stop voltage*| > 14 V.

Default:

- If the source unit is set to V source mode before the trigger:
  Default = the setting before trigger
- If the source unit is set to I source mode before the trigger:
  Default = none

I compliance polarity is automatically set to the same polarity as *search stop voltage*, regardless of the specified *I compliance* polarity. If *search stop voltage* = 0, I compliance polarity is positive.

For search SMU I measurement, I measurement range is set to the lowest range that includes *I compliance*.

Example Statements

```
OUTPUT 717;"ASV3, 0, 15, 50, 1E-5"
OUTPUT 717;"ASV3, 1, 15, 100"
```

AT

The AT command sets the *hold time* and *delay time* for an analog search measurement.

Measurement Mode

Analog search measurement

Syntax

AT *hold time*, *delay time*

Parameters

hold time (numeric expression, Unit: s)

hold time	**Resolution**
0 to 65.535	1E-3

Initial Setting = 0

delay time (numeric expression, Unit: s)

delay time	**Resolution**
0 to 65.535	1E-3

Initial Setting = 0

Example Statements

```
OUTPUT 717;"AT10, 0.2"
OUTPUT 717;"AT5, 3E-3"
```

AV

The AV command sets the number of samples that are taken (A/D conversion) and averaged for the measurement. However, the HP 4142B cannot perform averaging when using the pulse function or when making I measurements using a VS (high speed spot measurement special function).

Measurement Mode

Spot / Staircase sweep / Analog search / Quasi-pulsed Spot / High speed spot measurements

Syntax

AV *averaging number* [, *averaging mode*]

Parameters

averaging number (numeric expression)
[*averaging mode*] (integer expression)

averaging number	*averaging mode*	**Description**
1 to 1023	0	Auto mode: (number of samples) = (RMS [1])(*averaging number*)
1 to 1023	1	Manual mode [1]: (number of samples) = *averaging number*
-1 to -1023	0, 1 (meaningless)	Power Line Cycle mode: (number of power line cycles) = - (*averaging number*) 32 samples are taken and averaged for each power line cycle specified.

[1] RMS (Required minimum samples) is the minimum number of samples required to assure an accurate HP 4142B measurement. See the following table. In Manual mode, the actual number of samples taken is equal to the *averaging number*. Therefore, to satisfy the specification, you must specify an *averaging number* greater than or equal to the required minimum samples.

Initial Setting of *averaging number* = 1
Initial Setting of *averaging mode* = 0
Default of *averaging mode* = 0

Unit	Measurement	Required Minimum Samples
SMU	V I	1 1 to 25 [1]
HCU	V I	1 1
HVU	V I	1 1 to 25 [2]
VM	V	1

[1] See below table, "Required Minimum Samples for SMU Current Measurements."
[2] See below table, "Required Minimum Samples for HVU Current Measurements."

Required Minimum Samples for SMU Current Measurements

		V Output Range [1]		
		2 V, 20 V, 40 V	100 V	200 V
I Meas. Range	1 nA to 10 µA	4	10	25
	100 µA to 1 A	1	1	1

[1] If the SMU is in I source mode, V output range is the lowest range that includes *V compliance*.

Required Minimum Samples for HVU Current Measurements

		V Output Range [1]		
		100 V	200 V	500, 1000 V
I Meas. Range	100 nA to 10 µA	10	25	25
	100 µA	4	6	10
	1 mA, 10 mA	1	1	1

[1] If the HVU is in I source mode, V output range is the lowest range that includes *V compliance*.

Example Statements

```
OUTPUT 717;"AV100, 0"
OUTPUT 717;"AV-10"
```

AVI

The AVI command specifies I sense SMU (V source/I monitor mode) and its parameters for an analog search measurement. This command also clears the AIV command setting.

Measurement Mode

Analog search measurement

Syntax

AVI *ch#*, *output voltage*, *target current* [, *I compliance*]

Parameters

ch# (integer expression)

Unit	*ch#*
HPSMU	2 to 8
MPSMU	1 to 8

output voltage (numeric expression, Unit: V)

Unit	*output voltage*	Output Range	Output Reso.	*target current*	*I compliance* [1]
HPSMU	0 ≤ |V| ≤ 2 V	2 V	100 µV	0 to ±1 A	±(1 pA to 1 A)
	2 V < |V| ≤ 14 V	20 V	1 mV	0 to ±1 A	±(1 pA to 1 A)
	14 V < |V| ≤ 20 V	20 V	1 mV	0 to ±700 mA	±(1 pA to 700 mA)
	20 V < |V| ≤ 40 V	40 V	2 mV	0 to ±350 mA	±(1 pA to 350 mA)
	40 V < |V| ≤ 100 V	100 V	5 mV	0 to ±125 mA	±(1 pA to 125 mA)
	100 V < |V| ≤ 200 V	200 V	10 mV	0 to ±50 mA	±(1 pA to 50 mA)
MPSMU	0 ≤ |V| ≤ 2 V	2 V	100 µV	0 to ±100 mA	±(1 pA to 100 mA)
	2 V < |V| ≤ 20 V	20 V	1 mV	0 to ±100 mA	±(1 pA to 100 mA)
	20 V < |V| ≤ 40 V	40 V	2 mV	0 to ±50 mA	±(1 pA to 50 mA)
	40 V < |V| ≤ 100 V	100 V	5 mV	0 to ±20 mA	±(1 pA to 20 mA)

[1] For smooth feedback operation, set an *I compliance* value that is at least 10% more than the *target current*.
If 0 ≤ |*I compliance*| < 1 pA, the I compliance is set to 1 pA or -1 pA.

The *output voltage* parameter sets the sense SMU output voltage, and this value determines the V output range of the sense SMU by Auto ranging, as shown in the above table.

target current (numeric expression, unit: A)

For allowable *target current* values, see "*output voltage*". The resolution of *target current* depends on the *I compliance* value as follows.

I compliance	*target current* **Resolution**
0 ≤ |I| ≤ 1.15 nA	50 fA
1.15 nA < |I| ≤ 11.5 nA	500 fA
11.5 nA < |I| ≤ 115 nA	5 pA
115 nA < |I| ≤ 1.15 µA	50 pA
1.15 µA < |I| ≤ 11.5 µA	500 pA
11.5 µA < |I| ≤ 115 µA	5 nA
115 µA < |I| ≤ 1.15 mA	50 nA
1.15 mA < |I| ≤ 11.5 mA	500 nA
11.5 mA < |I| ≤ 115 mA	5 µA
115 mA < |I| ≤ 1 A	50 µA

[*I compliance*] (numeric expression, unit: A)

For allowable *I compliance* values, see "*output voltage*".

Default:

- If the source unit is set to V source mode before the trigger:
  Default = the setting before trigger
- If the source unit is set to I source mode before the trigger:
  Default = none

I compliance polarity is automatically set to the same polarity as *output voltage*, regardless of the specified *I compliance* polarity. If *output voltage* = 0, I compliance polarity is positive.

For sense SMU I measurements, I measurement range is set to the lowest range that includes *I compliance*.

Remarks

This command setting is cleared by the AIV command.

Example Statements

```
OUTPUT 717;"AVI1, 5, 1E-3, 1.15E-3"
OUTPUT 717;"AVI3, 2, 1E-6, 1.15E-6"
```

BC

The BC command clears the output data buffer that stores measurement data and query command response data. This command does not change the measurement settings.

Syntax

BC

Example Statements

OUTPUT 717;"BC"

BDM

The BDM command specifies the detection interval, and either voltage or current measurement for quasi-pulsed measurements.

Measurement Mode

Quasi-pulsed measurements

Syntax

BDM *detection interval* [, *V/I measurement*]

Parameters

detection interval (numeric expression)

detection interval	**Description**
0	Short
1	Long

Initial Setting = 0

V/I measurement (numeric expression)

V/I measurement	**Description**
0	Voltage measurement of the unit specified by MM.
1	Current measurement of the unit specified by MM.

Initial Setting = 0

Example Statements

OUTPUT 717;"BDM0,1"

BDT

The BDT command specifies the *hold time* and *delay time* for quasi-pulsed measurements.

Measurement Mode

Quasi-pulsed measurements

Syntax

BDT *hold time*, *delay time*

Parameters

hold time (numeric expression, Unit: s)

hold time	**Resolution**
0 to 655.35	0.01

Initial Setting = 0

delay time (numeric expression, Unit: s)

delay time	**Resolution**
0 to 6.5535	0.0001

Initial Setting = 0

Example Statements

```
OUTPUT 717;"BDT0.1,0.01"
OUTPUT 717;"BDT0,1E-3"
```

BDV

The BDV command specifies the quasi-pulsed source and its parameters.

Measurement Mode

Quasi-pulsed measurements

Syntax

BDV *ch#, output range, start voltage, stop voltage* [, *Icompliance*]

Parameters

ch# (integer expression)

Unit	*ch#*
HPSMU	2 to 8
MPSMU	1 to 8
HVU	2 to 8

output range (integer expression)

Unit	*output range*	Description
HPSMU MPSMU HVU	0, 11 to 15 0, 11 to 14 0, 14 to 17	0: Auto ranging 11: 2 V Limited Auto ranging 12: 20 V Limited Auto ranging 13: 40 V Limited Auto ranging 14: 100 V Limited Auto ranging 15: 200 V Limited Auto ranging 16: 500 V Limited Auto ranging 17: 1000 V Limited Auto ranging

For Auto ranging, the output range is set to the lowest range that includes *start voltage* and *stop voltage*.
For Limited Auto ranging, the specified unit output is set to the specified range, if this range includes both the *start voltage* and *stop voltage* values. If not, it is set to the same range as Auto ranging.

Unit	Output Range	Output Voltage	Output Reso.	*I compliance* [1]
HPSMU	2 V	$0 \leq \|V\| \leq 2$ V	100 µV	±(1 pA to 1 A)
	20 V	$0 \leq \|V\| \leq 14$ V	1 mV	±(1 pA to 1 A)
		$14 \text{ V} < \|V\| \leq 20$ V		±(1 pA to 700 mA)
	40 V	$0 \leq \|V\| \leq 40$ V	2 mV	±(1 pA to 350 mA)
	100 V	$0 \leq \|V\| \leq 100$ V	5 mV	±(1 pA to 125 mA
	200 V	$0 \leq \|V\| \leq 200$ V	10 mV	±(1 pA to 50 mA)
MPSMU	2 V	$0 \leq \|V\| \leq 2$ V	100 µV	±(1 pA to 100 mA)
	20 V	$0 \leq \|V\| \leq 20$ V	1 mV	±(1 pA to 100 mA)
	40 V	$0 \leq \|V\| \leq 40$ V	2 mV	±(1 pA to 50 mA)
	100 V	$0 \leq \|V\| \leq 100$ V	5 mV	±(1 pA to 20 mA)
HVU	100 V	$0 \leq \|V\| \leq 100$ V	10 mV	±(1 nA to 10 mA)
	200 V	$0 \leq \|V\| \leq 200$ V	20 mV	±(1 nA to 10 mA)
	500 V	$0 \leq \|V\| \leq 500$ V	50 mV	±(1 nA to 10 mA)
	1000 V	$0 \leq \|V\| \leq 1000$ V	100 mV	±(1 nA to 10 mA)

[1] For SMUs, if $0 \leq |I \text{ compliance}| < 1$ pA, I compliance is set to 1 pA or -1 pA.
For HVUs, if $0 \leq |I \text{ compliance}| < 1$ nA, I compliance is set to 1 nA or -1 nA.

start voltage (numeric expression, Unit: V)
stop voltage (numeric expression, Unit: V)

Unit	*start pulse voltage* [1] *stop pulse voltage* [1]
HPSMU	0 to ±200
MPSMU	0 to ±100
HVU	0 to ±1000 [2]

[1] $|start\ voltage - stop\ voltage|$ must be greater than or equal to 10 V.
[2] The *start voltage* and *stop voltage* polarity must be the same.

[*I compliance*] (numeric expression, Unit: A)

For allowable *I compliance* values, see "*output range*".

Default:

- If the specified source unit is set to V source mode before the trigger:
  Default = the setting before trigger
- If the specified source unit is set to I source mode before the trigger:
  Default = none

The polarity of I compliance is automatically set to the same polarity as the *stop voltage*, regardless of the specified *I compliance* polarity. If the *stop voltage* = 0, the I compliance polarity is positive for the SMU, and is the same as the output polarity of the POL command at the measurement trigger for the HVU.

Remarks

For the HVU, set the output polarity to the same polarity as the *start voltage* and *stop voltage* before the measurement trigger (command: POL).

Example Statements

```
OUTPUT 717;"BDV7,0,0,200,1E-3"
```

CA

The CA command performs Self-Calibration.
When you execute the CA command, the output switches of the specified units are set to OFF (same conditions as after the CL command execution).

Execution Conditions

No unit is in the HIGH VOLTAGE state (forcing more than ±42 V, or *V compliance* set to more than ±42 V).
For the HVU Self-Calibration, the INTLK terminal is shorted.

Syntax

CA [*slot#*]

Parameters

[*slot#*] (integer expression)

Unit	*slot#*	Description
HPSMU	2 to 8	Use the larger *slot#* of the two occupied slots.
MPSMU	1 to 8	
HCU	2 to 8	Use the larger *slot#* of the two occupied slots.
HVU	2 to 8	Use the larger *slot#* of the two occupied slots.
VS/VMU	1 to 8	The VS1, VS2, VM1, and VM2 are calibrated.
AFU	1 to 8	

Default = all units from slot#1 to #8.

Mainframe ADC section is always calibrated regardless of *slot#*.

Example Statements

```
OUTPUT 717;"CA"
OUTPUT 717;"CA1"
```

CL

The CL command disables the specified units by setting the output switches to OFF. VMs do not have an output switch, and thus are not disabled by CL command execution.

Execution Conditions

No unit is in the HIGH VOLTAGE state (forcing more than 42 V, or *V compliance* set to more than 42 V). However, if you do not specify the *ch#*, there are no execution conditions.

Syntax

CL [*ch#*] [, *ch#*] [, *ch#*] [, *ch#*] [, *ch#*] [, *ch#*] [,*ch#*] [, *ch#*]

Parameters

[*ch#*] (integer expression)

Unit	*ch#*
HPSMU	2 to 8
MPSMU	1 to 8
HCU	2 to 8
HVU	2 to 8
VS1	1 to 8, 11 to 18
VS2	21 to 28

Default = all units that have an output switch

If you specify *ch#* (up to 8 can be specified at once), the HP 4142B sets units to 0 V in the specified order.

If you do not specify *ch#*, the HP 4142B sets all units to 0 V in order from high V range (output range or measurement range) to low V range.

Remarks

The CL command sets the specified units to the following conditions:

Item	SMU/HCU/HVU/VS
Output Switch	OFF
Output	Open
Power Consumption	0 W

This command first sets the following conditions, then sets the output switch to OFF.

Item	SMU	HCU	HVU	VS
Source Mode	V	V	V	---
Output Voltage	0 V	0 V	0 V	0 V
Output Polarity	---	---	+	---
V Range	20 V	2 V	100 V	20 V
I Compliance	100 µA	1 µA	100 µA	---
I limit	---	---	---	100 mA
I Range	100 µA	1 mA	100 µA	100 mA
Filter	ON	---	ON	---

Example Statements

```
OUTPUT 717;"CL"
OUTPUT 717;"CL11, 2, 3, 5"
```

CM

The CM command sets Auto-Calibration ON or OFF.
If Auto-Calibration is ON and output switches of all units have been OFF for 30 minutes, the HP 4142B automatically calibrates all units every 30 minutes.

Syntax

CM *auto calibration*

Parameters

auto calibration (integer expression)

auto calibration	**Description**
0	Auto-Calibration OFF
1	Auto-Calibration ON

Initial Setting = 1

Example Statements

```
OUTPUT 717;"CM0"
OUTPUT 717;"CM1"
```

CN

The CN command enables the specified units by setting the output switches to ON.

WARNING

SETTING THE OUTPUT SWITCH TO ON ENABLES THE UNIT TO FORCE DANGEROUS VOLTAGES.

WHEN THE UNIT IS NOT IN USE, SET THE OUTPUT SWITCH TO OFF WHENEVER POSSIBLE.

Execution Conditions

No unit is in the HIGH VOLTAGE state (forcing more than 42 V, or *V compliance* set to more than 42 V).
For the HVU, the INTLK terminal is shorted.

Syntax

CN [*ch#*] [, *ch#*] [, *ch#*] [, *ch#*] [, *ch#*] [, *ch#*] [,*ch#*] [, *ch#*]

Parameters

[*ch#*] (integer expression)

Unit	*ch#*
HPSMU	2 to 8
MPSMU	1 to8
HCU	2 to 8
HVU	2 to 8
VS1	1 to 8, 11 to 18
VS2	21 to 28

Default = all units that have an output switch

If you specify *ch#* (up to 8 can be specified at once), the HP 4142B sets the output switches to ON in the specified order. If you do not specify *ch#*, the HP 4142B sets all output switches to ON in the order from lower slot# to higher slot#.

Remarks

The CN command sets the specified units to the following conditions:

Item	SMU	HCU	HVU	VS
Output Switch	ON	ON	ON	ON
Source Mode	V	V	V	---
Output Voltage	0 V	0 V	0 V	0 V
Output Polarity	---	---	+	---
V Range	20 V	2 V	100 V	20 V
I Compliance	100 µA	1 µA	100 µA	---
I limit	---	---	---	100 mA
I Range	100 µA	1 mA	100 µA	100 mA
Filter	[1]	---	[1]	---
Power Consumption	0 W	10 W	10 W	2.2 W

[1] Does not change.

If the output switch of the specified unit is already set to ON, the CN command does nothing.

If the output switch of a unit is OFF, the unit does not respond to setting commands (DV, DI, DZ, and IN) or to measurement trigger commands (TV, TI, XE and TRIGGER). However, the VMs do not have output switches, and can be used without this command.

Example Statements

```
OUTPUT 717;"CN1, 2, 4, 5, 16, 26"
OUTPUT 717;"CN11, 2, 3, 5"
```

DI

The DI command forces *output current* from the specified unit.

Execution Conditions

CN command has been executed for the specified unit.
If |*V compliance*| > 42 V, the **INTLK** terminal has been shorted.

Syntax

For SMUs:

DI *ch#*, *output range*, *output current* [, *V compliance*] [, *compliance polarity mode*]

For HVUs:

DI *ch#*, *output range*, *output current* [, *V compliance*]

For HVUs, you can send the *compliance polarity mode* parameter, but it has no meaning.

Parameters

ch# (integer expression)

Unit	*ch#*
HPSMU	2 to 8
MPSMU	1 to 8
HVU	2 to 8

output range (integer expression)

Unit	*output range*	Description
HPSMU	0, 11 to 20	0: Auto ranging
MPSMU	0, 11 to 19	11: 1 nA Limited Auto ranging
HVU	0, 13 to 18	12: 10 nA Limited Auto ranging
		13: 100 nA Limited Auto ranging
		14: 1 µA Limited Auto ranging
		15: 10 µA Limited Auto ranging
		16: 100 µA Limited Auto ranging
		17: 1 mA Limited Auto ranging
		18: 10 mA Limited Auto ranging
		19: 100 mA Limited Auto ranging
		20: 1 A Limited Auto ranging

For Auto ranging, the output range is set to the lowest range that includes *output current*.

For Limited Auto ranging, the output range is set to the specified range, if this range includes *output current*. If not, it is set to the same range as Auto ranging.

Unit	Output Range	Output Current	Output Reso.	*V compliance* [1]	
				No Pulse Used	**Pulse Used**
HPSMU	1 nA	$0 \leq \|I\| \leq 1.15$ nA	50 fA	0 to ±200 V	---
	10 nA	$0 \leq \|I\| \leq 11.5$ nA	500 fA	0 to ±200 V	0 to ±2 V
	100 nA	$0 \leq \|I\| \leq 115$ nA	5 pA	0 to ±200 V	0 to ±2 V
	1 µA	$0 \leq \|I\| \leq 1.15$ µA	50 pA	0 to ±200 V	0 to ±2 V
	10 µA	$0 \leq \|I\| \leq 11.5$ µA	500 pA	0 to ±200 V	0 to ±2 V
	100 µA	$0 \leq \|I\| \leq 115$ µA	5 nA	0 to ±200 V	0 to ±200 V
	1 mA	$0 \leq \|I\| \leq 1.15$ mA	50 nA	0 to ±200 V	0 to ±200 V
	10 mA	$0 \leq \|I\| \leq 11.5$ mA	500 nA	0 to ±200 V	0 to ±200 V
	100 mA	$0 \leq \|I\| \leq 50$ mA	5 µA	0 to ±200 V	0 to ±200 V
		50 mA < $|I| \leq$115 mA	5 µA	0 to ±100 V	0 to ±100 V
	1 A	$0 \leq \|I\| \leq 50$ mA	50 µA	0 to ±200 V	0 to ±200 V
		50 mA < $\|I\| \leq 125$ mA	50 µA	0 to ±100 V	0 to ±100 V
		125 mA < $\|I\| \leq 350$ mA	50 µA	0 to ±40 V	0 to ±40 V
		350 mA < $\|I\| \leq 700$ mA	50 µA	0 to ±20 V	0 to ±20 V
		700 mA < $\|I\| \leq 1$ A	50 µA	0 to ±14 V	0 to ±14 V
MPSMU	1 nA	$0 \leq \|I\| \leq 1.15$ nA	50 fA	0 to ±100 V	---
	10 nA	$0 \leq \|I\| \leq 11.5$ nA	500 fA	0 to ±100 V	0 to ±2 V
	100 nA	$0 \leq \|I\| \leq 115$ nA	5 pA	0 to ±100 V	0 to ±2 V
	1 µA	$0 \leq \|I\| \leq 1.15$ µA	50 pA	0 to ±100 V	0 to ±2 V
	10 µA	$0 \leq \|I\| \leq 11.5$ µA	500 pA	0 to ±100 V	0 to ±2 V
	100 µA	$0 \leq \|I\| \leq 115$ µA	5 nA	0 to ±100 V	0 to ±100 V
	1 mA	$0 \leq \|I\| \leq 1.15$ mA	50 nA	0 to ±100 V	0 to ±100 V
	10 mA	$0 \leq \|I\| \leq 11.5$ mA	500 nA	0 to ±100 V	0 to ±100 V
	100 mA	$0 \leq \|I\| \leq 20$ mA	5 µA	0 to ±100 V	0 to ±100 V
		20 mA < $\|I\| \leq 50$ mA	5 µA	0 to ±40 V	0 to ±40 V
		50 mA < $|I| \leq$100 mA	5 µA	0 to ±20 V	0 to ±20 V
HVU	100 nA	$0 \leq \|I\| \leq 115$ nA	50 pA	0 to ±1000 V	0 to ±1000 V
	1 µA	$0 \leq \|I\| \leq 1.15$ µA	500 pA	0 to ±1000 V	0 to ±1000 V
	10 µA	$0 \leq \|I\| \leq 11.5$ µA	5 nA	0 to ±1000 V	0 to ±1000 V
	100 µA	$0 \leq \|I\| \leq 115$ µA	50 nA	0 to ±1000 V	0 to ±1000 V
	1 mA	$0 \leq \|I\| \leq 1.15$ mA	500 nA	0 to ±1000 V	0 to ±1000 V
	10 mA	$0 \leq \|I\| \leq 10$ mA	5 µA	0 to ±1000 V	0 to ±1000 V

[1] If a pulse source (not including the quasi-pulsed source) is used and the specified constant I source performs measurements, the "Pulse Used" column applies. If the constant I source does not perform measurements or no pulse source is used, the "No Pulse Used" column applies.

output current (numeric expression, Unit: A)

Unit	*output current*
HPSMU	0 to ±1
MPSMU	0 to ±100E-3
HVU	0 to ±10E-3 [1]

[1] If the HVU output polarity is positive, *output current* ≥ 0.
If the HVU output polarity is negative, *output current* ≤ 0.
You can change the HVU output polarity by the POL command.

For *output current* resolution, see "*output range*".

[*V compliance*] (numeric expression, Unit: V)

For allowable *V compliance* values, see "*output range*".

Default:

- If the source unit is set to I source mode:
  Default = the previous setting
- If the source unit is set to V source mode:
  Default = none

For the SMU, when *compliance polarity mode* is 0 (Auto mode), the V compliance polarity is automatically set to the same polarity as *output current*, regardless of the specified *V compliance* polarity. If *output current* = 0, the V compliance polarity is positive.
When *compliance polarity mode* is 1 (Manual mode), the specified *V compliance* polarity is used.

For the HVU, the V compliance polarity is set to the same as the output polarity.

NOTE

If you set the *compliance polarity mode* of the **DI** command to Manual, set *V compliance* (Vcomp) as follows. If *V compliance* is not set in one of the ways shown below, the SMU output may be an unwanted opposite polarity current (Irev), instead of the desired *output current* (Iset).

1) If the specified Iset is positive or zero, set Vcomp more positive than Vrev.
2) If the specified Iset is negative, set Vcomp less positive than Vrev.

Vrev is the voltage that occurs at the SMU output terminal when Irev is forced to the DUT. |Irev| = |Iset| + |ΔI|, where ΔI is 2% to 10% of the maximum value in the range that outputs Iset.

[*compliance polarity mode*] (integer expression)

Unit	*compliance polarity mode*	Description
SMU	0 1	Auto mode Manual mode

Default = 0

For an explanation of the two modes, see "[*V compliance*]".

Example Statements

```
OUTPUT 717;"DI1, 0, 1E-6, 50, 1"
OUTPUT 717;"DI3, 14, 5E-7, 20, 0"
```

DO

The DO command executes HP 4142B internal memory programs (up to 8 programs) in the order you specify.

Execution Conditions

The specified programs have been stored by using the ST and END commands.

Syntax

DO *program#* [, *program#*] [, *program#*] [, *program#*] [, *program#*] [, *program#*] [, *program#*] [, *program#*]

Parameters

program# (numeric expression)

program#: 1 to 99

Example Statements

```
OUTPUT 717;"DO1, 2, 6, 4, 7, 15, 20, 5"
OUTPUT 717;"DO2, 6"
```

DV

The DV command forces *output voltage* from the specified unit.

Execution Conditions

CN command has been executed for the specified unit.
If |*output voltage*| > 42 V, the **INTLK** terminal is shorted.

Syntax

For SMUs:

DV *ch#*, *output range*, *output voltage* [, *I compliance*] [, *compliance polarity mode*]

For HVUs:

DV *ch#*, *output range*, *output voltage* [, *I compliance*]

For VSs:

DV *ch#*, *output range*, *output voltage*

For HVUs, you can send the *compliance polarity mode* parameter, and you can send the *I compliance* and *compliance polarity mode* parameters for VSs, but they have no meaning.

Parameters

ch# (integer expression)

Unit	*ch#*
HPSMU	2 to 8
MPSMU	1 to 8
HVU	2 to 8
VS1	1 to 8, 11 to 18
VS2	21 to 28

output range (integer expression)

Unit	*output range*	Description
HPSMU MPSMU HVU VS	0, 11 to 15 0, 11 to 14 0, 14 to 17 0, 12, 13	0: Auto ranging 11: 2 V Limited Auto ranging 12: 20 V Limited Auto ranging 13: 40 V Limited Auto ranging 14: 100 V Limited Auto ranging 15: 200 V Limited Auto ranging 16: 500 V Limited Auto ranging 17: 1000 V Limited Auto ranging

For Auto ranging, the output range is set to the lowest output range that includes *output voltage*.
For Limited Auto ranging, the output range is set to the specified range, if this range includes *output voltage*. If not, it is set to the same range as Auto ranging.

Unit	Output Range	Output Voltage	Output Reso.	*I compliance* [1]	
				No Pulse Used [2]	Pulse Used
HPSMU	2 V	$0 \leq \lvert V \rvert \leq 2$ V	100 µV	±(1 pA to 1 A)	±(2 nA to 1 A)
	20 V	$0 \leq \lvert V \rvert \leq 14$ V	1 mV	±(1 pA to 1 A)	±(20 µA to 1 A)
		$14 \text{ V} < \lvert V \rvert \leq 20$ V	1 mV	±(1 pA to 700 mA)	±(20 µA to 700 mA)
	40 V	$0 \leq \lvert V \rvert \leq 40$ V	2 mV	±(1 pA to 350 mA)	±(20 µA to 350 mA)
	100 V	$0 \leq \lvert V \rvert \leq 100$ V	5 mV	±(1 pA to 125 mA)	±(20 µA to 125 mA)
	200 V	$0 \leq \lvert V \rvert \leq 200$ V	10 mV	±(1 pA to 50 mA)	±(20 µA to 50 mA)
MPSMU	2 V	$0 \leq \lvert V \rvert \leq 2$ V	100 µV	±(1 pA to 100 mA)	±(2 nA to 100 mA)
	20 V	$0 \leq \lvert V \rvert \leq 20$ V	1 mV	±(1 pA to 100 mA)	±(20 µA to 100 mA)
	40 V	$0 \leq \lvert V \rvert \leq 40$ V	2 mV	±(1 pA to 50 mA)	±(20 µA to 50 mA)
	100 V	$0 \leq \lvert V \rvert \leq 100$ V	5 mV	±(1 pA to 20 mA)	±(20 µA to 20 mA
HVU	100 V	$0 \leq \lvert V \rvert \leq 100$ V	10 mV	±(1 nA to 10 mA)	±(1 nA to 10 mA)
	200 V	$0 \leq \lvert V \rvert \leq 200$ V	20 mV	±(1 nA to 10 mA)	±(1 nA to 10 mA)
	500 V	$0 \leq \lvert V \rvert \leq 500$ V	50 mV	±(1 nA to 10 mA)	±(1 nA to 10 mA)
	1000 V	$0 \leq \lvert V \rvert \leq 1000$V	100 mV	±(1 nA to 10 mA)	±(1 nA to 10 mA)
VS	20 V	$0 \leq \lvert V \rvert \leq 20$ V	1 mV	--- (100 mA) [3]	--- (100 mA) [3]
	40 V	$0 \leq \lvert V \rvert \leq 40$ V	2 mV	--- (20 mA) [3]	--- (20 mA) [3]

[1] If a pulse source (not including the quasi-pulsed source) is used and the specified constant V source performs measurements, the "Pulse Used" column applies. If the constant V source does not perform measurements or no pulse source is used, the "No Pulse Used" column applies.
For HVUs, if $0 \leq \lvert I \text{ compliance} \rvert < 1$ nA, I compliance is set to 1 nA or -1 nA.
[2] For SMUs, if $0 \leq \lvert I \text{ compliance} \rvert < 1$ pA, I compliance is set to 1 pA or -1 pA.
[3] Current Limiter value.

output voltage (numeric expression, Unit: V)

Unit	*output voltage*
HPSMU	0 to ±200
MPSMU	0 to ±100
HVU	0 to ±1000 [1]
VS	0 to ±40

[1] If the HVU output polarity is positive, *output voltage* ≥ 0.
If the HVU output polarity is negative, *output voltage* ≤ 0.
You can change the HVU output polarity by the POL command.

For *output voltage* resolution, see "*output range*".

[*I compliance*] (numeric expression, Unit: A)

For allowable *I compliance* values, see "*output range*".

Default:
- If the source unit is set to V source mode:
  Default = the previous setting
- If the source unit is set to I source mode:
  Default = none

For the SMU, when *compliance polarity mode* is "0" (Auto mode), the I compliance polarity is automatically set to the same polarity as *output voltage*, regardless of the specified *I compliance* polarity. If *output voltage* = 0, the I compliance polarity is positive.
When *compliance polarity mode* is "1" (Manual mode), the specified *I compliance* polarity is used.

For the HVU, the I compliance polarity is set to the same as the output polarity.

[*compliance polarity mode*] (integer expression)

Unit	*compliance polarity mode*	Description
SMU	0	Auto mode
	1	Manual mode

Default = 0

For an explanation of the two modes, see "[*V compliance*].

Example Statements

```
OUTPUT 717;"DV1, 0, 20, 1E-6, 0"
OUTPUT 717;"DV28, 12, 10"
```

DZ

The DZ command sets the specified units to Zero Output.

Execution Conditions

CN command has been executed for the specified units.

Syntax

DZ [*ch#*] [, *ch#*] [, *ch#*] [, *ch#*] [, *ch#*] [, *ch#*] [,*ch#*] [, *ch#*]

Parameters

[*ch#*] (integer expression)

Unit	*ch#*
HPSMU	2 to 8
MPSMU	1 to 8
HCU	2 to 8
HVU	2 to 8
VS1	1 to 8, 11 to 18
VS2	21 to 28

Default = all units in which the output switch setting is ON

You can specify up to 8 *ch#* at once, and the HP 4142B sets units to Zero Output in the specified order. If you do not specify *ch#*, the HP 4142B sets all units to Zero Output in order from high V range (output or measurement range) to low V range.

Remarks

The DZ command sets the specified units to the following conditions:

Item	SMU	HCU	HVU	VS
Output Switch	ON	ON	ON	ON
Source Mode	V	V	V	---
Output Voltage	0 V	0 V	0 V	0 V
Output Polarity	---	---	[1]	---
V Range	[1]	[1]	[1]	[1]
I Compliance	[2]	1 µA	[2]	---
I Range	[2]	1 mA	[2]	[1]
Filter	[1]	---	[1]	---

[1] Does not change.

[2] 100 µA or less. (For ranges from 1 nA to 100 µA, keeps the present range and sets the range value. For present ranges from 1 mA to 1 A, sets 100 µA at 100 µA range. The present range is the I output range if the unit is in I source mode, or the lowest range that includes *I compliance*, if the unit is in V source mode.)

When this command executes, the HP 4142B first stores the unit settings (V/I output values, V/I output ranges, and V/I compliance values). To return the units to the stored settings, execute the RZ command. For more information on how to restore unit settings, refer to the RZ command in this manual.

Example Statements

```
OUTPUT 717;"DZ"
OUTPUT 717;"DZ11, 21, 3, 5, 6, 7"
```

END

The END command is used with the ST command to store a program in the internal program memory of the HP 4142B. See the ST command.

ERC

The ERC command controls the output of the **CONTROL** connector pins.

Syntax

ERC *control mode*, *control value* [, *dry switching*]

Parameters

control mode (integer expression)

control mode	Description
1	Module selector (HP 16087A / HP 16088B) control
2	16 bits external relay control

control value (integer expression)

control mode	*control value*	Description
1	0 1 2 3	Connects no unit. Connects SMU. Connects HVU. Connects HCU.
2	0 to 65535 (0 to 2^{16}-1)	Specify the decimal value of the bits that are forced Low. Unspecified bits are forced High.

Initial Setting = 0 (for both *control mode*s)

dry switching (integer expression)

control mode	*dry switching*	Description
1	0, 1	Dry switching on
2	0 1	Dry switching on Dry switching off

Default = 0

For dry switching on, the HP 4142B automatically sets all outputs of source units to zero (same as the conditions after DZ command execution), and changes the outputs of the **CONTROL** connector pins, then returns all outputs to the condition of the outputs before receiving the ERC command.

For dry switching off, the HP 4142B changes the outputs of the **CONTROL** connector pins without changing all the outputs of the source units. For *control mode* = 1, you can not set the dry switching to off.

Example Statements

```
OUTPUT 717;"ERC";1, 1
OUTPUT 717;"ERC";2, 65535, 1
OUTPUT 717;"ERC";2, 2^15+2^10+2^2
OUTPUT 717;"ERC";2, 0
```

ERR?

The ERR? query command transfers error codes from the HP 4142B error register to the output data buffer (query buffer).

Syntax

ERR?

Output Data

error code#1, error code#2, error code#3, error code#4 <CR/LF^EOI>

error code#1 to *#4* = *xxx*(3 digits), *nxxx*(4 digits), or *nnxxx*(5 digits)

xxx: error code
n or *nn*: channel number

For details about error codes, see the appendix titled "Error Messages" in this manual.

Example Statements

```
10  DIM A$[23]
20  OUTPUT 717;"ERR?"
30  ENTER 717;A$
40  DISP A$
50  END
```

FL

The FL command sets the filter of specified units to ON or OFF.
When using an SMU or HVU as a pulsed source (not including the quasi-pulsed source), set the filter of that unit to OFF (to enable pulsed output) before measurement trigger.

Syntax

FL *filter* [, *ch#*] [, *ch#*] [,*ch#*] [, *ch#*] [, *ch#*] [, *ch#*] [, *ch#*] [, *ch#*]

Parameters

filter (integer expression)

filter	**Description**
0	Filter OFF
1	Filter ON

Initial Setting = 1

[*ch#*] (integer expression)

Unit	*ch#*
HPSMU	2 to 8
MPSMU	1 to 8
HVU	2 to 8

Initial Setting = all HPSMUs, MPSMUs, and HVUs.
Default = all HPSMUs, MPSMUs, and HVUs.

Remarks

You can send the FL command to the HCUs and VSs, but it has no meaning.

Example Statements

```
OUTPUT 717;"FL"
OUTPUT 717;"FL1, 1, 3, 5, 8"
```

FMT

The FMT command clears the HP 4142B output data buffer and specifies measurement data output format.
Query command output data is always stored in the query buffer in ASCII format, regardless of this command.

Syntax

FMT *output data format* [, *output data mode*]

Parameters

output data format (integer expression)

output data format	Description
1	ASCII data format with header; terminator (CR/LF^EOI).
2	ASCII data format without header; terminator (CR/LF^EOI).
3	Binary data format; terminator (CR/LF^EOI).
4	Binary data format; terminator (^EOI).
5	ASCII data format with header; terminator (,).

Initial Setting = 1

For details about output data format, refer to "ASCII Measurement Data Output Format" or "Binary Measurement Data Output Format" at the beginning of this manual.

[*output data mode*] (integer expression)

output data mode	Description
0	Source data is not output.
1	Primary sweep source data is output with sweep measurement data.
2	Secondary sweep source data is output with synchronous sweep measurement data.

Initial Setting = 0
Default = 0

For details about output data format, refer to "ASCII Measurement Data Output Format" or "Binary Measurement Data Output Format" at the beginning of this manual.

Example Statements

```
OUTPUT 717;"FMT1"
OUTPUT 717;"FMT2, 1"
```

*IDN?

The *IDN? query command requests the instrument model number and the ROM version number, and stores the results in the HP 4142B output data buffer (query buffer). You can then use the controller to read the output data buffer (ENTER statement in HP BASIC).

Syntax

*IDN?

Output Data

HEWLETT PACKARD, 4142B, 0, *ROM version number* <CR/LF^EOI>

Example Statements

```
10  DIM A$[30]
20  OUTPUT 717;"*IDN?"
30  ENTER 717;A$
40  DISP A$
50  END
```

IN

The IN command sets the specified units to Zero Output with output range change.

Execution Conditions

CN command has been executed for the specified unit.

Syntax

IN [*ch#*] [, *ch#*] [, *ch#*] [, *ch#*] [, *ch#*] [, *ch#*] [, *ch#*] [, *ch#*]

Parameters

[*ch#*] (integer expression)

Unit	*ch#*
HPSMU	2 to 8
MPSMU	1 to 8
HCU	1 to 8
HVU	2 to 8
VS1	1 to 8, 11 to 18
VS2	21 to 28

Default = all units in which the output switch setting is ON.

You can specify up to 8 *ch#* at once, and the HP 4142B sets the units to Zero Output in the specified order. If you do not specify a *ch#*, the HP 4142B sets all units to Zero Output in order from high V range (output or measurement range) to low V range.

Remarks

The IN command sets the specified units to the following conditions, which are same as the conditions after CN command execution.

Item	SMU	HCU	HVU	VS
Output Switch	ON	ON	ON	ON
Source Mode	V	V	V	---
Output Voltage	0 V	0 V	0 V	0 V
Output Polarity	---	---	[1]	---
V Range	20 V	2 V	100 V	20 V
I Compliance	100 µA	1 µA	100 µA	---
I Limit	---	---	---	100 mA
I Range	100 µA	1 mA	100 µA	100 mA
Filter	[1]	---	[1]	---
Power Consumption	0 W	10 W	10 W	2.2 W

[1] Does not change.

Example Statements

```
OUTPUT 717;"IN"
OUTPUT 717;"IN11, 21, 3, 5, 6, 8"
```

LOP?

The LOP? query command requests the operation status of all source units (SMUs, HCUs, HVUs, and VSs) and stores the results in the HP 4142B output data buffer (query buffer).

Syntax

LOP?

Output data

LOP *slot1 status, slot2 status, ... , slot8 status* <CR/LF^EOI>

When the HP 4142B executes this command, eight status numbers, corresponding from slots 1 to 8 respectively, are stored in the output data buffer. You can then use the controller to read the output data buffer (ENTER statement in HP BASIC).

Eight status numbers are stored regardless of the unit configuration, and each number has two digits. The status numbers indicate whether the units are operating normally, or if there is a compliance or oscillation problem. The following table lists *slot status* number meanings.

slot status	**Meaning**
00	No SMU/HCU/HVU/VS is installed, or installed SMU/HCU/HVU/VS output switch is OFF.
01	SMU/HCU/HVU is in V source mode, and I compliance is not reached.
02	SMU/HCU/HVU forces positive current, and V compliance is not reached.
03	SMU/HCU/HVU forces negative current, and V compliance is not reached.
	Both VSs operate correctly.
10	Both VSs reach the I limit.
11	SMU/HCU/HVU reaches V compliance.
	Only VS1 operates correctly (VS2 reaches the I limit).
12	SMU/HCU/HVU reaches positive current compliance.
	Only VS2 operates correctly (VS1 has reached the I limit).
13	SMU/HCU/HVU reaches negative I compliance.
20	SMU/HVU is oscillating.
30	The output of the HVU has not settled.

The HPSMU, HCU, and HVU occupies two slots. The status number is returned for the higher slot#, and 00 is returned for the lower slot#.

Example Statements

```
10 DIM A$[23]
20 OUTPUT 717;"LOP?"
30 ENTER 717;A$
40 DISP A$
50 END
```

*LRN?

The *LRN? (learn) query command requests information about unit settings or HP 4142B command parameter settings, and stores the results in the HP 4142B output data buffer (query buffer). You can then use the controller to read the output data buffer (ENTER statement in HP BASIC).

Syntax

*LRN? *type*

Parameters / Output Data Format

type (integer expression)

type	**Description / Output Data Format**
0	Output switch ON/OFF status: CN [*ch#*] [, *ch#*] ... [, *ch#*] <CR/LF^EOI> If no output switches are ON, the following is returned. CL <CR/LF^EOI>

type	**Description / Output Data Format**
1 to 8	SMU/HCU/HVU source status, or VM operation mode: 1 to 8 of *type* correspond to the unit *ch#*. The *output range* shows the present output range. It does not show the specified ranging mode. If an SMU is installed at the specified channel, and the output switch is ON, the following is returned. DV *ch#, output range, output voltage, I compliance, compliance polarity mode* <CR/LF^EOI> or DI *ch#, output range, output current, V compliance, compliance polarity mode* <CR/LF^EOI> If an SMU is installed at the specified channel, and the output switch is OFF, the following is returned. CL *ch#* If an HCU is installed at the specified channel, the following is returned. CN *ch#* <CR/LF^EOI> or CL *ch#* <CR/LF^EOI> If an HVU is installed at the specified channel, the following is returned. POL *ch#, output polarity*; DV *ch#, output range, output voltage, I compliance, compliance polarity mode* <CR/LF^EOI> or POL *ch#, output polarity*; DI *ch#, output range, output current, V compliance, compliance polarity mode* <CR/LF^EOI> or CL *ch#* <CR/LF^EOI> If a VS/VMU is installed at the specified channel, the following is returned. The *output range* shows the output range and does not show the ranging mode. (DV *VS1ch#, output range, output voltage*; or CL *VS1ch#*;) (DV *VS2ch#, output range, output voltage*; or CL *VS2ch#*;) VM *ch#, VM operation mode* <CR/LF^EOI>

type	**Description / Output format**
11 to 18	VS1 source status and VM operation mode: 11 to 18 of *type* correspond to the unit *ch#*. The *output range* shows the present output range. It does not show the specified ranging mode. DV *VS1ch#, output range, output voltage*; VM *ch#, VM operation mode* <CR/LF^EOI> or CL *VS1ch#*; VM *ch#, VM operation mode* <CR/LF^EOI>
21 to 28	VS2 source status and VM operation mode: 21 to 28 of *type* correspond to the unit *ch#*. The *output range* shows the present output range. It does not show the specified ranging mode. DV *VS2ch#, output range, output voltage*; VM *ch#, VM operation mode* <CR/LF^EOI> or CL *VS2ch#*; VM *ch#, VM operation mode* <CR/LF^EOI>
30	Filter ON/OFF status: Returns filter ON/OFF status to the following format: FL0 [*ch#*] [,*ch#*] ... [,*ch#*]; FL1 [*ch#*] [,*ch#*] ... [,*ch#*] <CR/LF^EOI> If all filters are OFF, returns the following: FL0 <CR/LF^EOI> If all filters are ON, returns the following: FL1 <CR/LF^EOI>
31	TM, AV, CM, FMT, and MM command settings: TM *trigger mode*; AV *averaging number*, [*averaging mode*]; CM *auto calibration*; FMT *output data format, output data mode* [;MM *measurement mode* [*ch#*] [,*ch#*] ... [,*ch#*]] <CR/LF^EOI>

type	**Description / Output format**
32	RI and RV command settings: (RI *ch#, I measurement range* or RV *ch#, V measurement range*) [(;RI *ch#, I measurement range* or ;RV *ch#, V measurement range*)] : : [(;RI *ch#, I measurement range*; or ;RV *ch#, V measurement range*;)] <CR/LF^EOI>
33	WV, WI, WSV, WSI, WM, and WT command settings (Staircase sweep parameter settings): WM *automatic sweep abort function, output after sweep*; WT *hold time, delay time* [(;WV *ch#, sweep mode, output range, start voltage, stop voltage,* *number of steps* [,*I compliance*] [,*power compliance*] or ;WI *ch#, sweep mode, output range, start current, stop current,* *number of steps* [,*V compliance*] [,*power compliance*])] [(;WSV *ch#, output range, start voltage, stop voltage* [,*I compliance*] [,*power compliance*] or ;WSI *ch#, output range, start current, stop current* [,*V compliance*] [,*power compliance*])] <CR/LF^EOI>
34	PV, PI, PWV, PWI, PT command settings (Pulsed source parameter settings): PT *hold time, pulse width, pulse period*; [(;PV *ch#, output range, base voltage, pulse voltage* [,*I compliance*] or ;PI *ch#, output range, base current, pulse current* [,*V compliance*])] [(;PWV *ch#, sweep mode, output range, base voltage, start pulse voltage,* *stop pulse voltage, number of steps* [,*I compliance*] or ;PWI *ch#, sweep mode, output range, base current, start pulse current,* *stop pulse current, number of steps* [,*V compliance*])] <CR/LF^EOI>

type	**Description / Output format**
35	ASV, AVI, AIV, ASM, AT command settings (Analog search measurement parameter settings): ASM *search operation mode, search measurement mode* [,*feedback integration time*]; AT *hold time, delay time* [;ASV *ch#, search start voltage, search stop voltage* [,*ramp rate*] [,*I compliance*]] [(;AVI *ch#, output voltage, target current* [,*I compliance*] or ;AIV *ch#, output current, target voltage* [,*V compliance*])] <CR/LF^EOI>
36	PDV, PDI, PDM command settings: PDM [*ch#*] [;PDV *ch#, output range, base voltage, pulse voltage* [, *I compliance*]] <CR/LF^EOI> or PDM [*ch#*] [;PDI *ch#, output range, base current, pulse current* [, *V compliance*]] <CR/LF^EOI>
37	BDV, BDT, BDM command settings: BDM *detection interval* [,*V/I measurement*]; BDT *hold time, delay time* [;BDV *ch#, output range, stop voltage* [,*I compliance*]]
38	ERC command setting: ERC1, *control value*; ERC2, *control value* [,*dry switching*]

Example Statements

```
10  DIM A$[100]
20  OUTPUT 717;"*LRN?33"
30  ENTER 717;A$
40  PRINT A$
50  END
```

LST?

The LST? query command stores a catalog of internal memory programs or a specific program listing in the output data buffer (query buffer) of the HP 4142B.

Syntax

Displaying catalog of internal memory programs:

LST?

Listing a specific program:

LST? [*program#*]

Parameters

[*program#*] (numeric expression)

program#: 1 to 99

Output Data

Displaying catalog of internal memory programs (LST?):

number of programs, [*program#*], [*program#*], ... , [*program#*] <CR/LF^EOI>

If you do not specify a *program#*, the HP 4142B returns the total number of programs stored, and all currently used *program#*s.

Listing a specific program (LST? [*program#*]):

ST *program#* <CR/LF^EOI>
[*saved command #1*] <CR/LF^EOI>
[*saved command #2*] <CR/LF^EOI>
:
:
[*saved command #n*] <CR/LF^EOI>
END <CR/LF^EOI>

If you specify *program#*, the HP 4142B returns the specified program listing. To read this listing, set up a loop containing the ENTER command, and continue the loop until encountering the END command. The commands are read one at a time until the END command is encountered.

Example Statements

```
10 DIM A$[30]
20 OUTPUT 717;"ST3;CN;DV1,0,20,1E-6;TI1;CL;END"
30 OUTPUT 717;"LST?3"
40 LOOP
50    ENTER 717;A$
60    PRINT A$
70 EXIT IF A$="END"
80 END LOOP
90 END
```

```
10 DIM A$[30]
20 OUTPUT 717;"LST?"
30 ENTER 717;A$
40 DISP A$
50 END
```

MM

The MM command sets the measurement mode and measurement units.

Measurement Mode

Spot / Staircase sweep / 1ch pulsed spot / Pulsed sweep / Staircase sweep with pulsed bias / Analog search / 2ch pulsed spot / Pulsed sweep with pulsed bias / Quasi-pulsed spot measurements

Syntax

For Spot and Staircase sweep measurements:

MM *measurement mode*, *ch#* [, *ch#*] [, *ch#*] [, *ch#*] [, *ch#*] [, *ch#*] [, *ch#*] [, *ch#*]

For 1ch pulsed spot, Pulsed sweep, Staircase sweep with pulsed bias, 2ch pulsed spot, and Pulsed sweep with pulsed bias measurements:

MM *measurement mode*, *ch#*

For Analog search measurements:

MM *measurement mode*

For Quasi-pulsed spot measurements:

MM *measurement mode* [, *ch#*]

Parameters

measurement mode (integer expression)

measurement mode	**Description**
1	Spot measurement
2	Staircase sweep measurement
3	1ch pulsed spot measurement
4	Pulsed sweep measurement
5	Staircase sweep with pulsed bias measurement
6	Analog search measurement
7	2ch pulsed spot measurement
8	Pulsed sweep with pulsed bias measurement
9	Quasi-pulsed spot measurement

[*ch#*] (integer expression)

measurement mode	**Number of available *ch#*s**	**Unit**	*ch#*
1, 2	1 to 8	HPSMU MPSMU HCU VM1 VM2	2 to 8 1 to 8 2 to 8 1 to 8, 11 to 18 21 to 28
3, 4, 5, 7, 8	1	HPSMU MPSMU HCU VM1 VM2	2 to 8 1 to 8 2 to 8 1 to 8, 11 to 18 21 to 28
6	0 [1]	HPSMU MPSMU	--- ---
9	0 [2] to 1	HPSMU MPSMU HVU	2 to 8 1 to 8 2 to 8

[1] If you specify *ch#* for an analog search measurement, an error occurs. For analog search measurements, specify measurement channels using the ASM command.

[2] If you do not specify *ch#* for quasi-pulsed spot measurement, the measurement is performed by the unit specified in the BDV command.

When the measurement unit is an SMU, HCU, or HVU, an SMU/HCU/HVU set to V source mode performs an I measurement, even if the output value is 0 V, and an SMU/HCU/HVU set to I source mode performs a V measurement, even if output value is 0 A. However, for the quasi-pulsed spot measurement, specify either a V measurement or an I measurement by using the BDM command.

If you specify more than one *ch#*s in spot or staircase sweep measurements, the measurements are performed in the specified order.

Example Statements

```
OUTPUT 717;"MM1, 1"
OUTPUT 717;"MM2, 1, 3"
OUTPUT 717;"MM6"
```

NUB?

The NUB? query command checks the number of measurement data in the output data buffer, and stores the results in the output data buffer (query buffer). You can then use the controller to read the query buffer (ENTER statement in HP BASIC).

Syntax

NUB?

Output Data

number of measurement data <CR/LF^EOI>

Example Statements

```
10  OUTPUT 717;"NUB?"
20  ENTER 717;A
30  DISP A
40  END
```

*OPC?

The HP 4142B stores a "1" in the output data buffer (query buffer) after *OPC command execution. The *OPC? query command is used to determine when the HP 4142B has completed a measurement or setting operation.

Syntax

*OPC?

Output Data

1<CR/LF^EOI>

Example Statement

```
10  OUTPUT 717;"CN"
20  OUTPUT 717;"DI";1,0,1E-10,1
30  OUTPUT 717;"*OPC?"
40  ENTER 717;A
50  OUTPUT 723;"DCV"            ! DCV: Measurement command of the HP 3457A
60  END
```

OS

The OS command causes the HP 4142B to send a trigger signal from the rear panel TRIGGER OUTPUT terminal.

Syntax

OS

Example Statement

```
OUTPUT 717;"OS"
```

PA

The PA command pauses command execution or internal memory program execution, until a trigger (XE command or the trigger which is specified by TM command) is received or until the specified *wait time* has elapsed. The trigger only releases the wait status. It does not start the measurement.

Syntax

PA [*wait time*]

Parameters

wait time (numeric expression, Unit: s)

wait time	**Resolution**
0 to 99.9999	100 µs

Default = until a trigger (XE command or the trigger which is specified by TM command) is received.

Example Statements

```
OUTPUT 717;"PA"
OUTPUT 717;"PA10"

10  OUTPUT 717;"CN"
20  OUTPUT 717;"DI";1,0,1E-10,1
30  OUTPUT 717;"PA100E-3"
40  OUTPUT 717;"TV1"
50  ENTER 717;A
60  DISP A
70  END
```

Remarks

If you send the PA command after the DV or DI command, the *wait time* includes the wait time of the DV or DI command for the output setting.

PDI

The PDI command specifies the pulsed I source and its parameters. This command also clears the PDV command setting.
For 2ch pulsed spot measurements, one pulse channel is set by PV or PI command and the other pulse channel is set by PDV or PDI command.
For pulsed sweep with pulsed bias measurements, the pulse sweep source is set by PWV or PWI command, the pulse bias is set by PDV or PDI command.

Measurement Mode

2ch pulsed spot / Pulsed sweep with pulsed bias measurements

Syntax

For SMUs

PDI *ch#, output range, base current, pulse current* [, *V compliance*]

For HCUs

PDI *ch#, output range, base current, pulse current, V compliance*

Parameters

ch# (integer expression)

Unit [1]	*ch#*
HPSMU	2 to 8
MPSMU	1 to 8
HCU	2 to 8

[1] At least one of the pulse channels (channel set by the PV or PI command and channel set by the PDV or PDI command) must be an HCU.

output range (integer expression)

Unit	*output range*	Description
HPSMU MPSMU HCU	0, 12 to 20 0, 12 to 19 0, 17 to 21	0: Auto ranging 12: 10 nA Limited Auto ranging 13: 100 nA Limited Auto ranging 14: 1 µA Limited Auto ranging 15: 10 µA Limited Auto ranging 16: 100 µA Limited Auto ranging 17: 1 mA Limited Auto ranging 18: 10 mA Limited Auto ranging 19: 100 mA Limited Auto ranging 20: 1 A Limited Auto ranging 21: 10 A Limited Auto ranging

For Auto ranging, the output range is set to the lowest range that includes *base current* and *pulse current*.
For Limited Auto ranging, the output range is set to the specified range, if this range includes both the *base current* and *pulse current* values. If not, it is set to the same range as Auto ranging.

Unit	Output Range	Output Current	Output Reso.	*V compliance*
HPSMU	10 nA	$0 \leq \|I\| \leq 11.5$ nA	500 fA	0 to ±2 V
	100 nA	$0 \leq \|I\| \leq 115$ nA	5 pA	0 to ±2 V
	1 µA	$0 \leq \|I\| \leq 1.15$ µA	50 pA	0 to ±2 V
	10 µA	$0 \leq \|I\| \leq 11.5$ µA	500 pA	0 to ±2 V
	100 µA	$0 \leq \|I\| \leq 115$ µA	5 nA	0 to ±200 V
	1 mA	$0 \leq \|I\| \leq 1.15$ mA	50 nA	0 to ±200 V
	10 mA	$0 \leq \|I\| \leq 11.5$ mA	500 nA	0 to ±200 V
	100 mA	$0 \leq \|I\| \leq 50$ mA	5 µA	0 to ±200 V
		50 mA < $|I| \leq$115 mA	5 µA	0 to ±100 V
	1 A	$0 \leq \|I\| \leq 50$ mA	50 µA	0 to ±200 V
		50 mA < $\|I\| \leq 125$ mA	50 µA	0 to ±100 V
		125 mA < $\|I\| \leq 350$ mA	50 µA	0 to ±40 V
		350 mA < $\|I\| \leq 700$ mA	50 µA	0 to ±20 V
		700 mA < $\|I\| \leq 1$ A	50 µA	0 to ±14 V
MPSMU	10 nA	$0 \leq \|I\| \leq 11.5$ nA	500 fA	0 to ±2 V
	100 nA	$0 \leq \|I\| \leq 115$ nA	5 pA	0 to ±2 V
	1 µA	$0 \leq \|I\| \leq 1.15$ µA	50 pA	0 to ±2 V
	10 µA	$0 \leq \|I\| \leq 11.5$ µA	500 pA	0 to ±2 V
	100 µA	$0 \leq \|I\| \leq 115$ µA	5 nA	0 to ±100 V
	1 mA	$0 \leq \|I\| \leq 1.15$ mA	50 nA	0 to ±100 V
	10 mA	$0 \leq \|I\| \leq 11.5$ mA	500 nA	0 to ±100 V
	100 mA	$0 \leq \|I\| \leq 20$ mA	5 µA	0 to ±100 V
		20 mA < $\|I\| \leq 50$ mA	5 µA	0 to ±40 V
		50 mA < $|I| \leq$100 mA	5 µA	0 to ±20 V
HCU	1 mA	$0 \leq \|I\| \leq 1.15$ mA	100 nA	0 to ±10 V
	10 mA	$0 \leq \|I\| \leq 11.5$ mA	1 µA	0 to ±10 V
	100 mA	$0 \leq \|I\| \leq 115$ mA	10 µA	0 to ±10 V
	1 A	$0 \leq \|I\| \leq 1.15$ A	100 µA	0 to ±10 V
	10 A	$0 \leq \|I\| \leq 10$ A	1 mA	0 to ±10 V

base current (numeric expression, Unit: A)
pulse current (numeric expression, Unit: A)

Unit	*base current* [1]	*pulse current* [1]
HPSMU	0 to ±1	0 to ±1
MPSMU	0 to ±100E-3	0 to ±100E-3
HCU	0 [2]	0 to ±10

[1] The *pulse current* and *base current* polarity must be the same.
[2] During base value output, the HCU output is 0 V and no current.

[*V compliance*] (numeric expression, Unit: V)

For allowable *V compliance* values, see *"output range"*.

Default:

- If the specified source unit is set to I source mode before the trigger:
  Default = the setting before trigger
- If the specified source unit is set to V source mode before the trigger:
  Default = none

The V compliance polarity is automatically set to the same polarity as *pulse current* and *base current*, regardless of the specified *V compliance* polarity. If *pulse current* = 0 and *base current* = 0, the V compliance polarity is positive for the SMU, and is the same as the previous polarity for the HCU.

For HCUs, the specified *V compliance* is set only during *pulse current* output. During the base value output, the output voltage is fixed to 0 V and the I compliance is fixed to 0.1% of the range value in I output range (regardless of pulsed V or I source).

Remarks

This command setting is cleared by the PDV command.

For SMU pulsed output, the filter must be OFF before the measurement trigger (command: FL).

If you set the HCU to -0 A (0 A at negative output polarity) to force a negative voltage, set the HCU to negative output once and perform a dummy measurement before setting 0 A as in the following example.

```
250  OUTPUT 717;"PI";Ch, 0, 0, -1E-7, Compliance
260  OUTPUT 717;"MM";3, Ch;";XE;BC"
270  OUTPUT 717;"PDI";Ch, 0, 0, 0, Compliance
```

Example Statements

```
OUTPUT 717;"PDI1,16,3E-5,5E-5,20"
OUTPUT 717;"PDI3,15,1E-7,5E-6,5"
```

PDM

When you use two HCUs as pulse sources for the 2ch pulsed spot or pulsed sweep with pulsed bias measurement, the PDM command specifies the HCU that the *pulse width* in the PT command is set.
The pulse width of the other HCU is fixed to about 1 ms, and cannot be specified.
If one pulse source is an SMU and the other pulse source is an HCU, specify the HCU.

Measurement Mode

2ch pulsed spot / Pulsed sweep with pulsed bias measurements

Syntax

PDM [*primary pulse ch#*]

Parameters

[*primary pulse ch#*] (integer expression)

Unit	*primary pulse ch#*
HCU	2 to 8

Initial Setting = The unit that is specified by the PDV or PDI command, if the two pulse sources are HCUs. If not, then the HCU.

Default = The unit that is specified by the PDV or PDI command, if the two pulse sources are HCUs. If not, then the HCU.

Example Statements

```
OUTPUT 717;"PDM2"
OUTPUT 717;"PDM"
```

PDV

The PDV command specifies the pulsed V source and its parameters. This command also clears the PDI command setting.
For 2ch pulsed spot measurements, one pulse channel is set by PV or PI command, and the other pulse channel is set by PDV or PDI command.
For pulsed sweep with pulsed bias measurements, the pulsed sweep source is set by PWV or PWI command, the pulse bias is set by PDV or PDI command.

Measurement Mode

2ch pulsed spot / Pulsed sweep with pulsed bias measurements

Syntax

PDV *ch#*, *output range*, *base voltage*, *pulse voltage* [, *I compliance*]

Parameters

ch# (integer expression)

Unit [1]	*ch#*
HPSMU	2 to 8
MPSMU	1 to 8
HCU	2 to 8

[1] At least one of the pulse channels (channel set by the PV or PI command and channel set by the PDV or PDI command) must be an HCU.

output range (integer expression)

Unit	*output range*	Description
HPSMU MPSMU HCU	0, 11 to 15 0, 11 to 14 0, 11, 12	0: Auto ranging 11: 2 V Limited Auto ranging 12: 20 V Limited Auto ranging 13: 40 V Limited Auto ranging 14: 100 V Limited Auto ranging 15: 200 V Limited Auto ranging

For Auto ranging, the output range is set to the lowest range that includes *base voltage* and *pulse voltage*.
For Limited Auto ranging, the output range is set to the specified range, if this range includes both the *base voltage* and *pulse voltage* values. If not, it is set to the same range as Auto ranging.

Unit	Output Range	Output Voltage	Output Reso.	*I compliance* [1]
HPSMU	2 V	0 ≤ |V| ≤ 2 V	100 µV	±(2 nA to 1 A)
	20 V	0 ≤ |V| ≤ 14 V	1 mV	±(20 µA to 1 A)
		14 V < |V| ≤ 20 V	1 mV	±(20 µA to 700 mA)
	40 V	0 ≤ |V| ≤ 40 V	2 mV	±(20 µA to 350 mA)
	100 V	0 ≤ |V| ≤ 100 V	5 mV	±(20 µA to 125 mA
	200 V	0 ≤ |V| ≤ 200 V	10 mV	±(20 µA to 50 mA)
MPSMU	2 V	0 ≤ |V| ≤ 2 V	100 µV	±(2 nA to 100 mA)
	20 V	0 ≤ |V| ≤ 20 V	1 mV	±(20 µA to 100 mA)
	40 V	0 ≤ |V| ≤ 40 V	2 mV	±(20 µA to 50 mA)
	100 V	0 ≤ |V| ≤ 100 V	5 mV	±(20 µA to 20 mA)
HCU	2 V	0 ≤ |V| ≤ 2 V	200 µV	±(1 µA to 10 A)
	20 V	0 ≤ |V| ≤ 10 V	2 mV	±(1 µA to 10 A)

[1] For HCUs, if 0 ≤ \|*I compliance*\| < 1 µA, I compliance is set to 1 µA or -1 µA.

base voltage (numeric expression, Unit: V)
pulse voltage (numeric expression, Unit: V)

Unit	*base voltage*	*pulse voltage*
HPSMU	0 to ±200	0 to ±200
MPSMU	0 to ±100	0 to ±100
HCU	0	0 to ±10

[*I compliance*] (numeric expression, Unit: A)

For allowable *I compliance* values, see *"output range"*.

Default:

- If the specified source unit is set to V source mode before the trigger:
  Default = the setting before trigger
- If the specified source unit is set to I source mode before the trigger:
  Default = none

The I compliance polarity is automatically set to the same polarity as *pulse voltage*, regardless of the specified *I compliance* polarity. If *pulse voltage* = 0, the I compliance polarity is positive for the SMU, and is the same as the previous polarity for the HCU.

For HCUs, the specified *I compliance* is set only during *pulse voltage* output. During *base voltage* (0 V) output, the I compliance is set to 0.1% of the range value at the lowest I range that includes *I compliance*, regardless of specified value.

Remarks

This command setting is cleared by the PDI command.

For SMU pulsed output, the filter must be OFF before the measurement trigger (command: FL).

If you set the HCU to -0 V (0 V at negative output polarity) to force a negative current, set the HCU to negative output once and perform a dummy measurement before setting 0 V as in the following example.

```
250  OUTPUT 717;"PV";Ch, 0, 0, -2E-4, Compliance
260  OUTPUT 717;"MM";3, Ch;";XE;BC"
270  OUTPUT 717;"PDV";Ch, 0, 0, 0, Compliance
```

Example Statements

```
OUTPUT 717;"PDV1,12,0,5,1E-4"
OUTPUT 717;"PDV3,12,-3,5,1E-5"
```

PI

The PI command specifies the pulsed I source and its parameters. This command also clears the PV command setting.

Measurement Mode

1ch pulsed spot / Staircase sweep with pulsed bias / 2ch pulsed spot measurements

Syntax

For SMUs/HVUs:

PI *ch#, output range, base current, pulse current* [, *V compliance*]

For HCUs:

PI *ch#, output range, base current, pulse current, V compliance*

Parameters

ch# (integer expression)

Measurement Mode	Unit	*ch#*
1ch pulsed spot, Staircase sweep with pulsed bias measurements	HPSMU MPSMU HCU HVU	2 to 8 1 to 8 2 to 8 2 to 8
2ch pulsed spot measurement [1]	HPSMU MPSMU HCU	2 to 8 1 to 8 2 to 8

[1] At least one of the pulse channels (channel set by the PV or PI command and channel set by the PDV or PDI command) must be an HCU.

output range (integer expression)

Unit	*output range*	Description
HPSMU MPSMU HCU HVU	0, 12 to 20 0, 12 to 19 0, 17 to 21 0, 13 to 18	0: Auto ranging 12: 10 nA Limited Auto ranging 13: 100 nA Limited Auto ranging 14: 1 µA Limited Auto ranging 15: 10 µA Limited Auto ranging 16: 100 µA Limited Auto ranging 17: 1 mA Limited Auto ranging 18: 10 mA Limited Auto ranging 19: 100 mA Limited Auto ranging 20: 1 A Limited Auto ranging 21: 10 A Limited Auto ranging

For Auto ranging, the output range is set to the lowest range that includes *base current* and *pulse current*.
For Limited Auto ranging, the output range is set to the specified range, if this range includes both the *base current* and *pulse current* values. If not, it is set to the same range as Auto ranging.

Unit	Output Range	Output Current	Output Reso.	*V compliance*
HPSMU	10 nA	$0 \leq \|I\| \leq 11.5$ nA	500 fA	0 to ±2 V
	100 nA	$0 \leq \|I\| \leq 115$ nA	5 pA	0 to ±2 V
	1 µA	$0 \leq \|I\| \leq 1.15$ µA	50 pA	0 to ±2 V
	10 µA	$0 \leq \|I\| \leq 11.5$ µA	500 pA	0 to ±2 V
	100 µA	$0 \leq \|I\| \leq 115$ µA	5 nA	0 to ±200 V
	1 mA	$0 \leq \|I\| \leq 1.15$ mA	50 nA	0 to ±200 V
	10 mA	$0 \leq \|I\| \leq 11.5$ mA	500 nA	0 to ±200 V
	100 mA	$0 \leq \|I\| \leq 50$ mA	5 µA	0 to ±200 V
		50 mA < $|I| \leq$115 mA	5µ A	0 to ±100 V
	1 A	$0 \leq \|I\| \leq 50$ mA	50 µA	0 to ±200 V
		50 mA < $\|I\| \leq 125$ mA	50 µA	0 to ±100 V
		125 mA < $\|I\| \leq 350$ mA	50 µA	0 to ±40 V
		350 mA < $\|I\| \leq 700$ mA	50 µA	0 to ±20 V
		700 mA < $\|I\| \leq 1$ A	50 µA	0 to ±14 V
MPSMU	10 nA	$0 \leq \|I\| \leq 11.5$ nA	500 fA	0 to ±2 V
	100 nA	$0 \leq \|I\| \leq 115$ nA	5 pA	0 to ±2 V
	1 µA	$0 \leq \|I\| \leq 1.15$ µA	50 pA	0 to ±2 V
	10 µA	$0 \leq \|I\| \leq 11.5$ µA	500 pA	0 to ±2 V
	100 µA	$0 \leq \|I\| \leq 115$ µA	5 nA	0 to ±100 V
	1 mA	$0 \leq \|I\| \leq 1.15$ mA	50 nA	0 to ±100 V
	10 mA	$0 \leq \|I\| \leq 11.5$ mA	500 nA	0 to ±100 V
	100 mA	$0 \leq \|I\| \leq 20$ mA	5 µA	0 to ±100 V
		20 mA < $\|I\| \leq 50$ mA	5 µA	0 to ±40 V
		50 mA < $|I| \leq$100 mA	5 µA	0 to ±20 V
HCU	1 mA	$0 \leq \|I\| \leq 1.15$ mA	100 nA	0 to ±10 V
	10 mA	$0 \leq \|I\| \leq 11.5$ mA	1 µA	0 to ±10 V
	100 mA	$0 \leq \|I\| \leq 115$ mA	10 µA	0 to ±10 V
	1 A	$0 \leq \|I\| \leq 1.15$ A	100 µA	0 to ±10 V
	10 A	$0 \leq \|I\| \leq 10$ A	1 mA	0 to ±10 V
HVU	100 nA	$0 \leq \|I\| \leq 115$ nA	50 pA	0 to ±1000 V
	1 µA	$0 \leq \|I\| \leq 1.15$ µA	500 pA	0 to ±1000 V
	10 µA	$0 \leq \|I\| \leq 11.5$ µA	5 nA	0 to ±1000 V
	100 µA	$0 \leq \|I\| \leq 115$ µA	50 nA	0 to ±1000 V
	1 mA	$0 \leq \|I\| \leq 1.15$ mA	500 nA	0 to ±1000 V
	10 mA	$0 \leq \|I\| \leq 10$ mA	5 µA	0 to ±1000 V

base current (numeric expression, Unit: A)
pulse current (numeric expression, Unit: A)

Unit	*base current* [1]	*pulse current* [1]
HPSMU	0 to ±1	0 to ±1
MPSMU	0 to ±100E-3	0 to ±100E-3
HCU	0 [2]	0 to ±10
HVU	0 to ±10E-3 [3]	0 to ±10E-3 [3]

[1] The *pulse current* and *base current* polarity must be the same.
[2] During base value output, the HCU output is 0 V and no current.
[3] If the difference of the voltage at the *base current* and the voltage at the *pulse current* exceeds the following values, you cannot perform the correct measurement because the pulse output is not settled to within the maximum pulse width of 50 ms.

Range	*pulse current*	Maximum Voltage Difference
10 mA to 10 µA	10 mA to 4 µA 1 µA 100 nA	about 600 V about 190 V about 19 V
1 µA, 100 nA	1µA 100 nA 10 nA	about 400 V about 40 V about 4 V

[*V compliance*] (numeric expression, Unit: V)

For allowable *V compliance* values, see *"output range."*

Default:

- If the specified source unit is set to I source mode before the trigger:
  Default = the setting before trigger
- If the specified source unit is set to V source mode before the trigger:
  Default = none

The V compliance polarity is automatically set to the same polarity as *pulse current* and *base current*, regardless of the specified *V compliance* polarity. If *pulse current* = 0 and *base current* = 0, the V compliance polarity is positive for the SMU, and the same as the previous polarity for the HCU, and the same as the output polarity for the HVU.

For HCUs, the specified *V compliance* is set only during *pulse current* output. During the base value output, the output voltage is fixed to 0 V and the I compliance is fixed to 0.1% of the range value in I output range (regardless of pulsed V or I source).

Remarks

This command setting is cleared by the PV command.

For SMU or HVU pulsed output, the filter must be OFF before the measurement trigger (command: FL).

For the HVU, set the output polarity to the same polarity as the *base* and *pulse* values before the measurement trigger (command: POL).

If you set the HCU to -0 A (0 A at negative output polarity) to force a negative voltage, set the HCU to negative output once and perform a dummy measurement before setting 0 A as in the following example.

```
250  OUTPUT 717;"PI";Ch, 0, 0, -1E-7, Compliance
260  OUTPUT 717;"MM";3, Ch;";XE;BC"
270  OUTPUT 717;"PI";Ch, 0, 0, 0, Compliance
```

Example Statements

```
OUTPUT 717;"PI1,16,3E-5,5E-5,20"
OUTPUT 717;"PI3,15,1E-7,5E-6,5"
```

POL

The POL command changes the HVU output polarity, and sets the output voltage to 0 V. If the output switch of the unit is set to off, this command also sets the switch to on.

WARNING

SETTING THE OUTPUT SWITCH TO ON ENABLES THE UNIT TO FORCE DANGEROUS VOLTAGES.

WHEN THE UNIT IS NOT IN USE, SET THE OUTPUT SWITCH TO OFF WHENEVER POSSIBLE.

Execution Conditions

The INTLK terminal is shorted.
No other unit is in the HIGH VOLTAGE state (forcing more than 42 V, or *V compliance* set to more than 42 V).

Syntax

POL *ch#, output polarity*

Parameters

ch# (integer expression)

Unit	*ch#*
HVU	2 to 8

output polarity (integer expression)

polarity	Description
0	+ polarity
1	- polarity

Remarks

If the output switch of the unit is set to on, the output polarity of the unit is changed as follows:

1) Sets the unit to 0 V (same condition as the DZ command execution).
2) Waits for either of the following:
   - Until the unit continues to measure the output voltage of the unit, and the output voltage becomes less than or equal to 30 V.
   - Until 500 ms elapse.
3) Sets the output switch to off.
4) Changes the output polarity.
5) Sets the output switch to on.

PT

The PT command sets *hold time*, *pulse width*, and *pulse period* for a pulsed source.

Measurement Mode

1ch pulsed spot / Pulsed sweep / Staircase sweep with pulsed bias / 2ch pulsed spot / Pulsed sweep with pulsed bias measurements

Syntax

For 1ch pulsed spot, 2ch pulsed spot measurements:

PT *hold time*, *pulse width* [, *pulse period*]

For Staircase sweep with pulsed bias, Pulsed sweep, Pulsed sweep with pulsed bias measurements:

PT *hold time*, *pulse width*, *pulse period*

Parameters

hold time (numeric expression, Unit: s)

hold time	**Resolution**
0 to 655.35	0.01

Initial Setting = 0

pulse width (numeric expression, Unit: s)

Measurement Mode	Pulse Unit	*pulse width*	Resolution
1ch pulsed spot, Pulsed sweep, Staircase sweep with pulsed bias	HPSMU MPSMU HVU VS HCU	1E-3 to 50E-3 1E-3 to 50E-3 1E-3 to 50E-3 1E-3 to 50E-3 100E-6 to 1E-3 [1]	100E-6 100E-6 100E-6 100E-6 100E-6
2ch pulsed spot, Pulsed sweep with with pulsed bias	HCU [2]	100E-6 to 800E-6 [1]	100E-6

[1] If *pulse period* = 0, *pulse width* = 100E-6 to 700E-6.

[2] When one pulsed source is an HCU and the other pulsed source is an SMU, the *pulse width* is set to the HCU. The pulse width of the SMU is automatically fixed to about 1 ms. When both pulsed sources are HCUs, the *pulse width* is set to the HCU that is specified by the PDM command and the pulse width of the other HCU is automatically fixed to about 1 ms.

Initial Setting = 1E-3

[*pulse period*] (numeric expression, Unit: s)

Measurement Mode	Pulse Source(s)	HCU I setting [1]	*pulse period*
1ch pulsed spot, Staircase sweep with pulsed bias, Pulsed sweep	SMU, HVU, or VS	---	see below #2
	HCU	Iset ≤ 1 A	see below #3
		Iset > 1 A	see below #4
2ch pulsed spot, Pulsed sweep with pulsed bias	HCU and SMU	Iset ≤ 1 A	see below #3
		Iset > 1 A	see below #4
	HCU and HCU	Secondary: Iset ≤ 1 A Primary: Iset < 1 A	see below #3
		Secondary: Iset ≤ 1 A Primary: Iset > 1 A	see below #4
		Secondary: Iset > 1 A Primary: Iset = any	see below #5

[1] If the HCU is V source mode:
Iset = |*I compliance*|
If the HCU is I source mode:
Iset = |*pulse current*| or |Max(*start pulse current*, *stop pulse current*)|
Primary: Specified HCU by PDM command.
Secondary: Not specified HCU by PDM command.

[2] Max[10E-3, 2*(*pulse width*)] to 500E-3, 0[6] (pulse duty ≤ 50%)
[3] 10E-3 to 500E-3, 0[6]
[4] Max[10E-3, 100*(*pulse width*)] to 500E-3, 0[6] (pulse duty ≤ 1%)
[5] 100E-3 to 500E-3

[6] If you set *pulse period* = 0, pulse period is not set. The *pulse period* can only be set to 0 when the measurement mode is 1ch or 2ch pulsed spot measurement. However, if you use two HCUs in the 2ch pulsed spot measurement, you cannot set *pulse period* to 0.

pulse period Resolution: 100E-6

Initial Setting = 10E-3
Default = 0

Example Statements

```
OUTPUT 717;"PT10.0,0.01,0.2"
OUTPUT 717;"PT5,0.005,0.1"
```

PV

The PV command specifies the V pulsed source and its parameters. This command also clears the PI command setting.

Measurement Mode

1ch pulsed spot / Staircase sweep with pulsed bias / 2ch pulsed spot measurements

Syntax

For SMUs/HCUs/HVUs:

PV *ch#, output range, base voltage, pulse voltage* [, *I compliance*]

For VSs:

PV *ch#, output range, base voltage, pulse voltage*

For VSs, you can send the *I compliance* parameter, but it has no meaning.

Parameters

ch# (integer expression)

Measurement Mode	Unit	*ch#*
1ch pulsed spot / Staircase sweep with pulsed bias measurements	HPSMU MPSMU HCU HVU VS1 VS2	2 to 8 1 to 8 2 to 8 2 to 8 1 to 8, 11 to 18 21 to 28
2ch pulsed spot measurement [1]	HPSMU MPSMU HCU	2 to 8 1 to 8 2 to 8

[1] At least one of the pulse channels (channel set by the PV or PI command and channel set by the PDV or PDI command) must be the HCU.

output range (integer expression)

Unit	*output range*	Description
HPSMU MPSMU HCU HVU VS	0, 11 to 15 0, 11 to 14 0, 11, 12 0, 14 to 17 0, 12, 13	0: Auto ranging 11: 2 V Limited Auto ranging 12: 20 V Limited Auto ranging 13: 40 V Limited Auto ranging 14: 100 V Limited Auto ranging 15: 200 V Limited Auto ranging 16: 500 V Limited Auto ranging 17: 1000 V Limited Auto ranging

For Auto ranging, the output range is set to the lowest range that includes *base voltage* and *pulse voltage*.
For Limited Auto ranging, the output range is set to the specified range, if this range includes both the *base voltage* and *pulse voltage* values. If not, it is set to the same range as Auto ranging.

Unit	Output Range	Output Voltage	Output Reso.	*I compliance* [1]
HPSMU	2 V	$0 \leq \|V\| \leq 2$ V	100 µV	±(2 nA to 1 A)
	20 V	$0 \leq \|V\| \leq 14$ V	1 mV	±(20 µA to 1 A)
		$14 \text{ V} < \|V\| \leq 20$ V	1 mV	±(20 µA to 700 mA)
	40 V	$0 \leq \|V\| \leq 40$ V	2 mV	±(20 µA to 350 mA)
	100 V	$0 \leq \|V\| \leq 100$ V	5 mV	±(20 µA to 125 mA
	200 V	$0 \leq \|V\| \leq 200$ V	10 mV	±(20 µA to 50 mA)
MPSMU	2 V	$0 \leq \|V\| \leq 2$ V	100 µV	±(2 nA to 100 mA)
	20 V	$0 \leq \|V\| \leq 20$ V	1 mV	±(20 µA to 100 mA)
	40 V	$0 \leq \|V\| \leq 40$ V	2 mV	±(20 µA to 50 mA)
	100 V	$0 \leq \|V\| \leq 100$ V	5 mV	±(20 µA to 20 mA
HCU	2 V	$0 \leq \|V\| \leq 2$ V	200 µV	±(1 µA to 10 A)
	20 V	$0 \leq \|V\| \leq 10$ V	2 mV	±(1 µA to 10 A)
HVU	100 V	$0 \leq \|V\| \leq 100$ V	10 mV	±(1 nA to 10 mA)
	200 V	$0 \leq \|V\| \leq 200$ V	20 mV	±(1 nA to 10 mA)
	500 V	$0 \leq \|V\| \leq 500$ V	50 mV	±(1 nA to 10 mA)
	1000 V	$0 \leq \|V\| \leq 1000$ V	100 mV	±(1 nA to 10 mA)
VS	20 V	$0 \leq \|V\| \leq 20$ V	1 mV	--- (100 mA) [2]
	40 V	$0 \leq \|V\| \leq 40$ V	2 mV	--- (20 mA) [2]

[1] For HCUs, if $0 \leq |I \text{ compliance}| < 1$ µA, I compliance is set to 1 µA or -1 µA.
For HVUs, if $0 \leq |I \text{ compliance}| < 1$ nA, I compliance is set to 1 nA or -1 nA.
[2] Current Limiter value.

base voltage (numeric expression, Unit: V)
pulse voltage (numeric expression, Unit: V)

Unit	*base voltage*	*pulse voltage*
HPSMU	0 to ±200	0 to ±200
MPSMU	0 to ±100	0 to ±100
HCU	0	0 to ±10
HVU	0 to ±1000 [1]	0 to ±1000 [1]
VS	0 to ±40	0 to ±40

[1] The *base voltage* and *pulse voltage* polarity must be the same.
If the difference of the *base voltage* and *pulse voltage* exceeds the following values, you cannot perform the correct measurement because the pulse output is not settled to within the maximum pulse width of 50 ms.

I compliance	**Maximum Voltage Difference**
10 mA to 4 µA	about 600 V
1µA	about 400 V
100 nA	about 40 V
10 nA	about 4 V

[*I compliance*] (numeric expression, Unit: A)

For allowable *I compliance* values, see "*output range*".

Default:

- If the specified source unit is set to V source mode before the trigger:
  Default = the setting before trigger
- If the specified source unit is set to I source mode before the trigger:
  Default = none

For the SMU or HCU, I compliance polarity is automatically set to the same polarity as *pulse voltage*, regardless of the specified *I compliance* polarity. If *pulse voltage* = 0, the I compliance polarity is positive for the SMU, and is the same as the previous polarity for the HCU

For the HVU, I compliance polarity is automatically set to the same polarity as *pulse voltage* and *base voltage*, regardless of the specified *I compliance* polarity. If *pulse voltage* = 0 and *base voltage* = 0, the I compliance polarity is the same as the output polarity for the HVU.

For HCUs, the specified *I compliance* is set only during *pulse voltage* output. During *base voltage* (0 V) output, the I compliance is set to 0.1% of the range value at the lowest I range that includes *I compliance*, regardless of the specified value.

Remarks

This command setting is cleared by the PI command.

For SMU or HVU pulsed output, the filter must be OFF before the measurement trigger (command: FL).

For the HVU, set the output polarity to the same polarity as the *base* and *pulse* values before the measurement trigger (command: POL).

If you set the HCU to -0 V (0 V at negative output polarity) to force a negative current, set the HCU to negative output once and perform a dummy measurement before setting 0 V as in the following example.

```
250  OUTPUT 717;"PV";Ch, 0, 0, -2E-4, Compliance
260  OUTPUT 717;"MM";3, Ch;";XE;BC"
270  OUTPUT 717;"PV";Ch, 0, 0, 0, Compliance
```

Example Statements

```
OUTPUT 717;"PV1,12,0,5,1E-4"
OUTPUT 717;"PV3,12,-3,5,1E-5"
```

PWI

The PWI command specifies the I pulsed sweep source and its parameters. This command clears the PWV command setting.

Measurement Mode

Pulsed sweep / Pulsed sweep with pulsed bias measurements

Syntax

For SMUs/HVUs:

PWI *ch#, sweep mode, output range, base current, start pulse current, stop pulse current, number of steps* [, *V compliance*]

For HCUs:

PWI *ch#, sweep mode, output range, base current, start pulse current, stop pulse current, number of steps, V compliance*

Parameters

ch# (integer expression)

Measurement Mode	Unit	*ch#*
Pulsed sweep measurement	HPSMU MPSMU HCU HVU	2 to 8 1 to 8 2 to 8 2 to 8
Pulsed sweep with Pulsed bias measurement [1]	HPSMU MPSMU HCU	2 to 8 1 to 8 2 to 8

[1] At least one of the pulse channels (channel set by the PWV or PWI command and channel set by the PDV or PDI command) must be an HCU.

sweep mode (integer expression)

sweep mode	**Description**
1	linear sweep (single stair)
3	linear sweep (double stair)

output range (integer expression)

Unit	*output range*	**Description**
HPSMU	0, 12 to 20	0: Auto ranging
MPSMU	0, 12 to 19	12: 10 nA Limited Auto ranging
HCU	0, 17 to 21	13: 100 nA Limited Auto ranging
HVU	0, 13 to 18	14: 1 µA Limited Auto ranging
		15: 10 µA Limited Auto ranging
		16: 100 µA Limited Auto ranging
		17: 1 mA Limited Auto ranging
		18: 10 mA Limited Auto ranging
		19: 100 mA Limited Auto ranging
		20: 1 A Limited Auto ranging
		21: 10 A Limited Auto ranging

For Auto ranging, the output range is set to the lowest range that includes *base current, start pulse current, stop pulse current.*

For Limited Auto ranging, the output range is set to the specified range, if this range includes *base current, start pulse current,* and *stop pulse current.* If not, it is set to the same range as Auto ranging.

During the pulsed sweep, the output range does not change.

Unit	Output Range	Output Current	Output Reso.	*V compliance*
HPSMU	10 nA	$0 \leq \|I\| \leq 11.5$ nA	500 fA	0 to ±2 V
	100 nA	$0 \leq \|I\| \leq 115$ nA	5 pA	0 to ±2 V
	1 µA	$0 \leq \|I\| \leq 1.15$ µA	50 pA	0 to ±2 V
	10 µA	$0 \leq \|I\| \leq 11.5$ µA	500 pA	0 to ±2 V
	100 µA	$0 \leq \|I\| \leq 115$ µA	5 nA	0 to ±200 V
	1 mA	$0 \leq \|I\| \leq 1.15$ mA	50 nA	0 to ±200 V
	10 mA	$0 \leq \|I\| \leq 11.5$ mA	500 nA	0 to ±200 V
	100 mA	$0 \leq \|I\| \leq 50$ mA	5 µA	0 to ±200 V
		50 mA < $\|I\| \leq 115$ mA	5 µA	0 to ±100 V
	1 A	$0 \leq \|I\| \leq 50$ mA	50 µA	0 to ±200 V
		50 mA < $\|I\| \leq 125$ mA	50 µA	0 to ±100 V
		125 mA < $\|I\| \leq 350$ mA	50 µA	0 to ±40 V
		350 mA < $\|I\| \leq 700$ mA	50 µA	0 to ±20 V
		700 mA < $\|I\| \leq 1$ A	50 µA	0 to ±14 V
MPSMU	10 nA	$0 \leq \|I\| \leq 11.5$ nA	500 fA	0 to ±2 V
	100 nA	$0 \leq \|I\| \leq 115$ nA	5 pA	0 to ±2 V
	1 µA	$0 \leq \|I\| \leq 1.15$ µA	50 pA	0 to ±2 V
	10 µA	$0 \leq \|I\| \leq 11.5$ µA	500 pA	0 to ±2 V
	100 µA	$0 \leq \|I\| \leq 115$ µA	5 nA	0 to ±100 V
	1 mA	$0 \leq \|I\| \leq 1.15$ mA	50 nA	0 to ±100 V
	10 mA	$0 \leq \|I\| \leq 11.5$ mA	500 nA	0 to ±100 V
	100 mA	$0 \leq \|I\| \leq 20$ mA	5 µA	0 to ±100 V
		20 mA < $\|I\| \leq 50$ mA	5 µA	0 to ±40 V
		50 mA < $\|I\| \leq 100$ mA	5 µA	0 to ±20 V
HCU	1 mA	$0 \leq \|I\| \leq 1.15$ mA	100 nA	0 to ±10 V
	10 mA	$0 \leq \|I\| \leq 11.5$ mA	1 µA	0 to ±10 V
	100 mA	$0 \leq \|I\| \leq 115$ mA	10 µA	0 to ±10 V
	1 A	$0 \leq \|I\| \leq 1.15$ A	100 µA	0 to ±10 V
	10 A	$0 \leq \|I\| \leq 10$ A	1 mA	0 to ±10 V
HVU	100 nA	$0 \leq \|I\| \leq 115$ nA	50 pA	0 to ±1000 V
	1 µA	$0 \leq \|I\| \leq 1.15$ µA	500 pA	0 to ±1000 V
	10 µA	$0 \leq \|I\| \leq 11.5$ µA	5 nA	0 to ±1000 V
	100 µA	$0 \leq \|I\| \leq 115$ µA	50 nA	0 to ±1000 V
	1 mA	$0 \leq \|I\| \leq 1.15$ mA	500 nA	0 to ±1000 V
	10 mA	$0 \leq \|I\| \leq 10$ mA	5 µA	0 to ±1000 V

base current (numeric expression, Unit: A)
start pulse current (numeric expression, Unit: A)
stop pulse current (numeric expression, Unit: A)

Unit	*base current* [1]	*start pulse current* [1] *stop pulse current* [1]
HPSMU	0 to ±1	0 to ±1
MPSMU	0 to ±100E-3	0 to ±100E-3
HCU	0 [2]	0 to ±10
HVU	0 to ±10E-3 [3]	0 to ±10E-3 [3]

[1] The *start pulse current*, *stop pulse current* and *base current* must be the same polarity.
[2] During base value output, the HCU output is 0 V and no current.
[3] If the difference of voltage at the *base current* and voltage at the pulse current exceeds the following value, you cannot perform the correct measurement because the pulse output is not settled within maximum pulse width 50 ms.

Range	pulse current	Maximum Voltage Difference
10 mA to 10 µA	10 mA to 4 µA 1 µA 100 nA	about 600 V about 190 V about 19 V
1 µA, 100 nA	1µA 100 nA 10 nA	about 400 V about 40 V about 4 V

number of steps (numeric expression)

number of steps: 2 to 1001 [1]

[1] The maximum *number of steps* is restricted by the capacity of the output data buffer. For ASCII data format, 1023 measurement data can be stored in the output data buffer. For binary data format, 4095 measurement data can be stored in the output data buffer.

[*V compliance*] (numeric expression, Unit: V)

For allowable *V compliance* values, see "*output range*".

Default:

- If the specified source unit is set to I source mode before the trigger:
  Default = the setting before trigger
- If the specified source unit is set to V source mode before the trigger:
  Default = none

For SMUs and HVUs, the V compliance polarity is automatically set to the same polarity as the *start pulse current*, *stop pulse current*, and *base current*, regardless of the specified *V compliance* polarity. If the *start pulse current* = 0, *stop current* = 0, and *base current* = 0, the V compliance polarity is positive for the SMU, and is the same as the output polarity for the HVU.

For HCUs, the V compliance polarity is automatically set to the same polarity as each step pulse current, regardless of the specified *V compliance* polarity. If the step current = 0, the V compliance polarity is same as the previous polarity.
For HCUs, the specified *V compliance* is set only during *pulse current* output. During base value output, the output voltage is fixed to 0 V and the I compliance is fixed to 0.1% of the range value of I output range, regardless of the pulsed V or I source.

Remarks

This command setting is cleared by the PWV command.

For SMU or HVU pulsed output, the filter must be OFF before the measurement trigger (command: FL).

For the HVU, set the output polarity to the same polarity as the *base* and *pulse* values before the measurement trigger (command: POL).

Example Statements

```
OUTPUT 717;"PWI1,1,0,0,1E-3,1E-1,100"
OUTPUT 717;"PWI3,3,0,1E-7,1E-7,1E-2,50,20"
```

PWV

The PWV command specifies the V pulsed sweep source and its parameters. This command also clears the PWI command setting.

Measurement Mode

Pulsed sweep / Pulsed sweep with pulsed bias measurements

Syntax

For SMUs/HCUs/HVUs:

PWV *ch#, sweep mode, output range, base voltage, start pulse voltage, stop pulse voltage, number of steps* [, *I compliance*]

For VSs:

PWV *ch#, sweep mode, output range, base voltage, start pulse voltage, stop pulse voltage, number of steps*

For VSs, you can send the *I compliance* parameter, but it has no meaning.

Parameters

ch# (integer expression)

Measurement Mode	Unit	*ch#*
Pulsed sweep measurement	HPSMU MPSMU HCU HVU VS1 VS2	2 to 8 1 to 8 2 to 8 2 to 8 1 to 8, 11 to 18 21 to 28
Pulsed sweep with pulsed bias measurement [1]	HPSMU MPSMU HCU	2 to 8 1 to 8 2 to 8

[1] At least one of the pulse channels (channel set by the PWV or PWI command and channel set by the PDV or PDI command) must be an HCU.

sweep mode (integer expression)

sweep mode	**Description**
1	linear sweep (single stair)
3	linear sweep (double stair)

output range (integer expression)

Unit	*output range*	**Description**
HPSMU	0, 11 to 15	0: Auto ranging
MPSMU	0, 11 to 14	11: 2 V Limited Auto ranging
HCU	0, 11, 12	12: 20 V Limited Auto ranging
HVU	0, 14 to 17	13: 40 V Limited Auto ranging
VS	0, 12, 13	14: 100 V Limited Auto ranging
		15: 200 V Limited Auto ranging
		16: 500 V Limited Auto ranging
		17: 1000 V Limited Auto ranging

For Auto ranging, the output range is set to the lowest range that includes *base voltage*, *start pulse voltage*, and *stop pulse voltage*.
For Limited Auto ranging, the output range is set to the specified range, if this range includes both the *base voltage*, *start pulse voltage* and *stop pulse voltage* values. If not, it is set to the same range as Auto ranging.

During the pulsed sweep, the output range does not change.

Unit	Output Range	Output Voltage	Output Reso.	*I compliance* [1]
HPSMU	2 V	$0 \leq \lvert V \rvert \leq 2$ V	100 µV	±(2 nA to 1 A)
	20 V	$0 \leq \lvert V \rvert \leq 14$ V	1 mV	±(20 µA to 1 A)
		$14 \text{ V} < \lvert V \rvert \leq 20$ V		±(20 µA to 700 mA)
	40 V	$0 \leq \lvert V \rvert \leq 40$ V	2 mV	±(20 µA to 350 mA)
	100 V	$0 \leq \lvert V \rvert \leq 100$ V	5 mV	±(20 µA to 125 mA
	200 V	$0 \leq \lvert V \rvert \leq 200$ V	10 mV	±(20 µA to 50 mA)
MPSMU	2 V	$0 \leq \lvert V \rvert \leq 2$ V	100 µV	±(2 nA to 100 mA)
	20 V	$0 \leq \lvert V \rvert \leq 20$ V	1 mV	±(20 µA to 100 mA)
	40 V	$0 \leq \lvert V \rvert \leq 40$ V	2 mV	±(20 µA to 50 mA)
	100 V	$0 \leq \lvert V \rvert \leq 100$ V	5 mV	±(20 µA to 20 mA
HCU	2 V	$0 \leq \lvert V \rvert \leq 2$ V	200 µV	±(1 µA to 10 A)
	20 V	$0 \leq \lvert V \rvert \leq 10$ V	2 mV	±(1 µA to 10 A)
HVU	100 V	$0 \leq \lvert V \rvert \leq 100$ V	10 mV	±(1 nA to 10 mA)
	200 V	$0 \leq \lvert V \rvert \leq 200$ V	20 mV	±(1 nA to 10 mA)
	500 V	$0 \leq \lvert V \rvert \leq 500$ V	50 mV	±(1 nA to 10 mA)
	1000 V	$0 \leq \lvert V \rvert \leq 1000$ V	100 mV	±(1 nA to 10 mA)
VS	20 V	$0 \leq \lvert V \rvert \leq 20$ V	1 mV	--- (100 mA) [2]
	40 V	$0 \leq \lvert V \rvert \leq 40$ V	2 mV	--- (20 mA) [2]

[1] For HCUs, if $0 \leq \lvert I \text{ compliance} \rvert < 1$ µA, I compliance is set to 1 µA or -1 µA.
For HVUs, if $0 \leq \lvert I \text{ compliance} \rvert < 1$ nA, I compliance is set to 1 nA or -1 nA.

[2] Current Limiter value.

base voltage (numeric expression, Unit: V)
start pulse voltage (numeric expression, Unit: V)
stop pulse voltage (numeric expression, Unit: V)

Unit	*base voltage*	*start pulse voltage* *stop pulse voltage*
HPSMU	0 to ±200	0 to ±200
MPSMU	0 to ±100	0 to ±100
HCU	0	0 to ±10
HVU	0 to ±1000 [1]	0 to ±1000 [1]
VS	0 to ±40	0 to ±40

[1] The *start pulse voltage*, *stop pulse voltage*, and *base voltage* must be the same polarity. If the difference of the *base voltage* and pulse voltage exceeds the following values, you cannot perform the correct measurement because the pulse output is not settled to within the maximum pulse width of 50 ms.

I compliance	**Maximum Voltage Difference**
10 mA to 4 µA	about 600 V
1µA	about 400 V
100 nA	about 40 V
10 nA	about 4 V

number of steps (numeric expression)

number of steps: 2 to 1001 [1]

[1] The maximum *number of steps* is restricted by the capacity of the output data buffer. For ASCII data format, 1023 measurement data can be stored in the output data buffer. For binary data format, 4095 measurement data can be stored in the output data buffer.

[*I compliance*] (numeric expression, Unit: A)

For allowable *I compliance* values, see *"output range"*.

Default:

- If the specified source unit is set to V source mode before the trigger:
  Default = the setting before trigger
- If the specified source unit is set to I source mode before the trigger:
  Default = none

For SMUs, the I compliance polarity is automatically set to the same polarity as the *start pulse voltage*, regardless of the specified *I compliance* polarity. If the *start pulse voltage* = 0, the I compliance polarity is positive.

For HVUs, the I compliance polarity is automatically set to the same polarity as the *start pulse voltage*, *stop pulse voltage*, and *base voltage*, regardless of the specified *I compliance* polarity. If *start pulse voltage* = 0, *stop pulse voltage* = 0, and *base voltage* = 0, the I compliance polarity is the same as the output polarity.

For HCUs, the I compliance polarity is automatically set to the same polarity as the step pulse voltage, regardless of the specified *I compliance* polarity. If the step pulse voltage = 0, the I compliance polarity is same as the previous polarity.

For HCUs, the specified *I compliance* is set only during pulse voltage output. During *base voltage* (0 V) output, the I compliance is set to 0.1% of range value at the lowest I range that includes *I compliance*, regardless of the specified value.

Remarks

This command setting is cleared by the PWI command.
For SMU or HVU pulsed output, the filter must be OFF before the measurement trigger (command: FL).

For the HVU, set the output polarity to the same polarity as the *base* and *pulse* values before the measurement trigger (command: POL).

Example Statements

```
OUTPUT 717;"PWV1,1,0,0,50,100,20,1E-4"
OUTPUT 717;"PWV3,3,14,-2,0,100,100,0.1"
```

RCV

The RCV command enables units that fail Self-Test.
If a unit fails Self-Test, the unit is disabled and does not respond to any command except the RCV and *TST? command. The RCV command enables the unit so that it can receive commands again.
This command should only be used for servicing the HP 4142B. DO NOT use this command during normal operation.

Syntax

RCV *slot#*

Parameters

slot# (integer expression)

Unit	*slot#*	Description
HPSMU	2 to 8	Use the larger *slot#* of the two occupied slots.
MPSMU	1 to 8	
HCU	2 to 8	Use the larger *slot#* of the two occupied slots.
HVU	2 to 8	Use the larger *slot#* of the two occupied slots.
VS/VMU	1 to 8	VS1, VS2, VM1, and VM2 are enabled.
AFU	1 to 8	

Remarks

If the HP 4142B fails Self-Test, contact the Hewlett-Packard Sales and Service Office.

Example Statements

```
OUTPUT 717;"RCV1"
OUTPUT 717;"RCV3"
```

RI

The RI command specifies the I measurement ranging mode for all types of measurements, except analog search measurements and high speed spot measurements.
The RI command only specifies the measurement ranging mode or measurement range. The range changing occurs immediately after the trigger (that is, during the measurements).

Measurement Mode

Spot / Staircase sweep / 1ch pulsed spot / Pulsed sweep / Staircase sweep with pulsed bias / 2ch pulsed spot / Pulsed sweep with pulsed bias / Quasi-pulsed spot measurements

Syntax

RI *ch#*, *I measurement range*

Parameters

ch# (integer expression)

Unit	*ch#*
HPSMU	2 to 8
MPSMU	1 to 8
HCU	2 to 8
HVU	2 to 8

I measurement range (integer expression)

Unit	Measurement Mode	Output Range	*I measurement range*
HPSMU	No Pulse Used	All	0, ±(11 to 20)
	Pulse Used	2 V 20 V to 200 V	0, +(11 to 20), -(12 to 20) 0, +(11 to 20), -(16 to 20)
MPSMU	No Pulse Used	All	0, ±(11 to 19)
	Pulse Used	2 V 20 V to 200 V	0, +(11 to 19), -(12 to 19) 0, +(11 to 19), -(16 to 19)
HCU	All	All	0, ±(17 to 21)
HVU	All	All	0, ±(13 to 18)

I measurement range	Description [1]	
	No Pulse Used Measurement Mode	**Pulse Used Measurement Mode**
0	Auto	Compliance
11	1 nA Ltd Auto	Compliance
12	10 nA Ltd Auto	Compliance
13	100 nA Ltd Auto	Compliance
14	1 µA Ltd Auto	Compliance
15	10 µA Ltd Auto	Compliance
16	100 µA Ltd Auto	Compliance
17	1 mA Ltd Auto	Compliance
18	10 mA Ltd Auto	Compliance
19	100 mA Ltd Auto	Compliance
20	1 A Ltd Auto	Compliance
21	10 A Ltd Auto	Compliance
-11	1 nA range fixed	
-12	10 nA range fixed	
-13	100 nA range fixed	
-14	1 µA range fixed	
-15	10 µA range fixed	
-16	100 µA range fixed	
-17	1 mA range fixed	
-18	10 mA range fixed	
-19	100 mA range fixed	
-20	1 A range fixed	
-21	10 A range fixed	

[1] Auto: Auto ranging, Ltd Auto: Limited Auto ranging,
Compliance: Compliance range

Initial Setting = 0

Remarks

For analog search measurements, I measurement range is set to Compliance range.
For high speed spot measurements, I measurement range is set by TI command.

Example Statements

```
OUTPUT 717;"RI1,0"
OUTPUT 717;"RI3,-15"
```

*RST

The *RST command resets the HP 4142B (mainframe and all units) to the initial settings, but does not clear program memory and Self-Calibration data.

Syntax

*RST

Remarks

If this command is included in a command string (example: OUTPUT 717;"*RST;CN"), the other commands (CN) in the string are not executed.

If you want to reset units while a sweep measurement is being performed, you must first send the AB command, then the *RST command.

Device Clear (CLEAR statement for HP BASIC) resets the HP 4142B more directly than this command, bypassing the input buffer.

Example Statement

OUTPUT 717;"*RST"

RU

The RU command sequentially executes the HP 4142B internal memory programs.

Syntax

RU *start program#*, *stop program#*

Execution Conditions

The specified programs have been stored by using ST and END commands from *start program#* through *stop program#*.

Parameters

start program# (numeric expression)
stop program# (numeric expression)

start program#[1]: 1 to 99
stop program#[1]: 1 to 99

[1] The *stop program#* must be greater than or equal to the *start program#*.

Example Statements

```
OUTPUT 717;"RU1,10"
OUTPUT 717;"RU3,6"
```

RV

The RV command specifies the V measurement ranging mode for all types of VM measurements, except high speed spot measurements.
The RV command only specifies the measurement ranging mode or measurement range. The range changing occurs immediately after the trigger (that is, during the measurements).

Measurement Mode

Spot / Staircase sweep / 1ch pulsed spot / Pulsed sweep / Staircase sweep with pulsed bias / 2ch pulsed spot / Pulsed sweep with pulsed bias measurements

Syntax

RV *ch#*, *V measurement range*

Parameters

ch# (integer expression)

Unit	*ch#*
VM1 VM2	1 to 8, 11 to 18 21 to 28

V measurement range (integer expression)

VM operation mode	*V measurement range*
Grounded mode Differential mode	0, ±(11 to 13) 0, ±(10, 11)

V measurement range	Description	
	No Pulse Used Measurement Mode	**Pulse Used Measurement Mode**
0	Auto ranging	40 V range fixed
10, -10	0.2 V range fixed	-----
11, -11	2 V range fixed	2 V range fixed
12, -12	20 V range fixed	20 V range fixed
13, -13	40 V range fixed	40 V range fixed

Initial Setting = 0

Remarks

For differential mode, the ranging mode of the VM (VM1 or VM2) specified by the MM command is used.

For SMUs/HCUs/HVUs, the V measurement range is set to the Compliance range.
For high speed spot measurements, the V measurement range is set by the TV command.

Example Statements

```
OUTPUT 717;"RV1,0"
OUTPUT 717;"RV12,11"
```

RZ

The RZ command returns the unit to the settings that are stored by the DZ command and clears the stored unit settings. The DZ command stores the unit settings (V/I output values, V/I output ranges, and V/I compliance values), then sets the unit to Zero Output. The stored unit settings are cleared by a Device Clear (HP BASIC CLEAR), *RST, RZ, CL, CA, or *TST?.

Execution Conditions

DZ command has been executed for the specified unit, and after that, the RZ, CL, CA, *TST?, *RST or Device Clear command is not executed for the specified unit.
DZ command has been executed for the specified HVU, and the output polarity is set to the polarity of the DZ command execution.

Syntax

RZ [*ch#*] [, *ch#*] [, *ch#*] [, *ch#*] [, *ch#*] [, *ch#*] [, *ch#*] [, *ch#*]

Parameters

[*ch#*] (integer expression)

Unit	*ch#*
HPSMU	2 to 8
MPSMU	1 to 8
HCU	2 to 8
HVU	2 to 8
VS1	1 to 8, 11 to 18
VS2	21 to 28

Default = all units that satisfy the conditions described in "Execution Conditions".

You can specify up to 8 *ch#* at once using the RZ command, and the HP 4142B returns the stored unit settings in the specified order. If you do not specify a *ch#*, the HP 4142B returns the settings in the order that the DZ command stored them.

Example Statements

```
OUTPUT 717;"RZ"
OUTPUT 717;"RZ11,21,3,5,6,7"
```

SCR

The SCR command scratches the specified program from the program memory of the HP 4142B.

Syntax

SCR [*program#*]

Parameters

[*program#*] (numeric expression)

program#: 1 to 99

Default = all programs stored in program memory are scratched.

Example Statements

```
OUTPUT 717;"SCR2"
OUTPUT 717;"SCR5"
```

*SRE

The *SRE command removes the mask from each of the specified bits, and masks the bits that are not specified.

Syntax

*SRE *bit*

Parameters

bit (integer expression)

bit: 0 to 63, 128 to 191

Initial Setting = 0 (All bits masked except Bit 6)

To specify bits, use the decimal value of the bits as follows.

Decimal Value	Bit Number	Description
1	Bit 0	Data Ready
2	Bit 1	Wait
4	Bit 2	not used
8	Bit 3	Interlock Open
16	Bit 4	Set Ready
32	Bit 5	Error
---	Bit 6	RQS (You cannot mask this bit.)
128	Bit 7	Shut Down

For example, to remove the mask from Bit 3, execute *SRE8.
To remove the masks from Bit 0, Bit 4, and Bit 7 (1 + 16 + 128 = 145), execute *SRE145.
If *bit* is 0, all bits except Bit 6 are masked.

Example Statements

```
OUTPUT 717;"*SRE6"
OUTPUT 717;"*SRE128"
```

*SRE?

The *SRE? query command requests information about which bits of the status byte are masked, and stores the results in the output data buffer (query buffer). You can then use the controller to read the output data buffer (ENTER statement in HP BASIC).

Syntax

*SRE?

Output Data

masked bits <CR/LF^EOI>

The masked bits are represented by the corresponding decimal values.

Decimal Value	Bit Number	Description
1	Bit 0	Data Ready
2	Bit 1	Wait
4	Bit 2	not used
8	Bit 3	Interlock Open
16	Bit 4	Set Ready
32	Bit 5	Error
---	Bit 6	RQS (You cannot mask this bit.)
128	Bit 7	Shut Down

For example, if 25 (1 + 8 + 16 = 25) is returned, then the masks of Bit 0, Bit 3, and Bit 4 of the status byte are removed.
If *masked bits* is 0, all bits are masked.

Example Statements

```
10  OUTPUT 717;"*SRE?"
20  ENTER 717;A
30  DISP A
40  END
```

ST

The ST command is used with the END command to store a program in the internal program memory of the HP 4142B.
The ST command indicates the start of the program, and assigns the *program#*. If the assigned *program#* already exists, the HP 4142B deletes the old program, and stores the new one. The END command indicates the end of the program. If you forget to include the END command, the HP 4142B stores commands until program memory is full. Use the DO or RU command to execute stored programs.

Syntax

ST *program#*; [*command*;] [*command*;] ... [*command*;] END

or

ST *program#*<CR/LF^EOI>
[*command*]<CR/LF^EOI>
[*command*]<CR/LF^EOI>
:
:
[*command*]<CR/LF^EOI>
END

Parameters

program# (integer expression)

program#: 1 to 99

[*command*] (character strings)

Specify commands according to normal syntax--no special syntax necessary.

Below are commands that can and cannot be stored in program memory.

Can be stored in program memory:

AIV, ASM, ASV, AT, AV, AVI, BC, BDM, BDT, BDV, CL, CN, DI, DO, DV, DZ, ERC, FL, FMT, IN, MM, OS, PA, PDM, PDI, PDV, PI, POL, PT, PV, PWI, PWV, RI, RU, RV, RZ, TI, TM, TV, VM, WI, WM, WS, WSI, WSV, WT,WV, XE, *SRE

Cannot be stored in program memory:

AB, CA, CM, END, ERR?, LOP?, LST?,NUB?, RCV, ST, UNT?, WNU?, *IDN?, *LRN?, *OPC?, *RST, SRE?, *STB?,*TST?

Example Statements

```
OUTPUT 717;"ST1;DV1,0,20,1E-6,0;TI1,0;END"

OUTPUT 717;"ST4"
OUTPUT 717;"WI1,1,19,0,0.1,100,40,0.5"
OUTPUT 717;"DV4,0,5,1E-4"
OUTPUT 717;"XE"
OUTPUT 717;"END"
```

*STB?

The *STB? query command stores the decimal representation of the status byte in the output data buffer (query buffer). You can then use the controller to read the output data buffer (ENTER statement in HP BASIC).

Syntax

*STB?

Output Data Format

status byte <CR/LF^EOI>

The *STB command is functionally identical to the SPOLL command in HP BASIC. The *status byte* output data is a decimal number that indicates which bits of the status byte are ON ("1"). Bits of the status byte indicate conditions that may require attention.
This command does not clear the status byte. (The SPOLL command clears the status byte.)

Decimal Value	Bit Number	Description
1	Bit 0	Data Ready
2	Bit 1	Wait
4	Bit 2	not used
8	Bit 3	Interlock Open
16	Bit 4	Set Ready
32	Bit 5	Error
---	Bit 6	RQS (You cannot mask this bit.)
128	Bit 7	Shut Down

For example, if 40 (8 + 32 = 40) is returned, then Bit 3 and Bit 5 are set to 1.

Example Statements

```
10  OUTPUT 717;"*STB?"
20  ENTER 717;A
30  DISP A
40  END
```

TI

The TI command is the trigger command for high speed spot I measurement.
This command performs a high speed spot I measurement, independent of the source mode (V/I source mode), trigger mode (TM command), and measurement mode (MM command).

Measurement Mode

High speed spot measurements

Execution Conditions

CN command has been executed for the specified unit.

Syntax

For SMUs/HCUs/HVUs:

TI *ch#* [, *I measurement range*]

For VSs:

TI *ch#*

For VSs, you can send the *I measurement range* parameter, but it has no meaning.

Output Data

See "ASCII Measurement Data Output Format" or "Binary Measurement Data Output Format" at the beginning of this manual.

Parameters

ch# (integer expression)

Unit	*ch#*
HPSMU	2 to 8
MPSMU	1 to 8
HCU	2 to 8
HVU	2 to 8
VS1	1 to 8, 11 to 18
VS2	21 to 28

[*I measurement range*] (integer expression)

Unit	*I measurement range*	Description
HPSMU MPSMU HCU HVU	0, ±(11 to 20) 0, ±(11 to 19) 0, ±(17 to 21) 0, ±(13 to 18)	0: Auto ranging 11: 1 nA Limited Auto ranging 12: 10 nA Limited Auto ranging 13: 100 nA Limited Auto ranging 14: 1 µA Limited Auto ranging 15: 10 µA Limited Auto ranging 16: 100 µA Limited Auto ranging 17: 1 mA Limited Auto ranging 18: 10 mA Limited Auto ranging 19: 100 mA Limited Auto ranging 20: 1 A Limited Auto ranging 21: 10 A Limited Auto ranging -11: 1 nA range fixed -12: 10 nA range fixed -13: 100 nA range fixed -14: 1 µA range fixed -15: 10 µA range fixed -16: 100 µA range fixed -17: 1 mA range fixed -18: 10 mA range fixed -19: 100 mA range fixed -20: 1 A range fixed -21: 10 A range fixed

Default = Compliance range, if the specified unit is in V source mode, or same as I output range, if the specified unit is in I source mode.

If the specified unit is in I source mode, *I measurement range* is ignored, and the I measurement range is set to the I output range.

Remarks

If the TI command is executed for a VS, the I measurement range is determined by the V output range. If the VS output range is 20 V, the I measurement range is set to 100 mA. If the VS output range is 40 V, the I measurement range is set to 20 mA.

Example Statements

```
OUTPUT 717;"TI1"
OUTPUT 717;"TI1,-14"
OUTPUT 717;"TI26"
```

TM

The TM command specifies the *trigger mode* for all types of measurements except high speed spot measurements, and for wait status release by the PA command.

Measurement Mode

Spot / Staircase sweep / 1ch pulsed spot / Pulsed sweep / Staircase sweep with pulsed bias / Analog search / 2ch pulsed spot / Pulsed sweep with pulsed bias / Quasi-pulsed spot measurements

Syntax

TM *trigger mode*

Parameters

trigger mode (integer expression)

trigger mode	Description
1	XE, HP-IB GET (Group Execute Trigger, TRIGGER command in HP BASIC) are available.
2	XE is available.
3	XE, External trigger (signal via the TRIGGER INPUT terminal) are available.
4	XE, MM (Automatic trigger after the MM command execution) are available.

Initial Setting = 1

If *trigger mode* is set to 3 and the measurement is performed by external trigger signal via TRIGGER INPUT terminal, the HP 4142B outputs a pulse signal via the TRIGGER OUTPUT terminal on the rear panel.

Example Statements

```
OUTPUT 717;"TM1"
OUTPUT 717;"TM3"
```

*TST?

The *TST? query command starts the HP 4142B Self-Test, and stores the results in the output data buffer (query buffer). You can then use the controller to read the output data buffer (ENTER command in HP BASIC).
When you execute the *TST? command, the output switches of the specified units are set to OFF (same conditions as after the CL command execution).
*TST? command also performs Self-Calibration.

Execution Conditions

No unit is in the HIGH VOLTAGE state (forcing more than ±42 V, or *V compliance* set to more than ±42 V).
For the HVU Self-Test, the INTLK terminal is shorted.

Syntax

*TST? [*slot#*]

Parameters

[*slot#*] (integer expression)

Unit	*slot#*
Mainframe and all units	0
HPSMU [1]	2 to 8
MPSMU	1 to 8
HCU [1]	2 to 8
HVU [1]	2 to 8
VS/VMU	1 to 8
AFU	1 to 8
Mainframe	9

[1] To perform Self-Test, you must specify the higher *slot#* of occupied two slots.

Default = 0

Output Data

test results <CR/LF^EOI>

The *test results* are stored in the output data buffer. Use the following table to interpret the results.

test results	**Description**
0	passed
1	Slot 1 unit failed
2	Slot 2 unit failed
4	Slot 3 unit failed
8	Slot 4 unit failed
16	Slot 5 unit failed
32	Slot 6 unit failed
64	Slot 7 unit failed
128	Slot 8 unit failed
256	Mainframe failed
512	Did not perform Self-test on one or more HVUs. Short the **INTLK** terminal and perform Self-test again.
1024	Did not perform Self-test on one or more HVUs, and lost the Self-calibration data of the HVU(s). Short the INTLK terminal and perform Self-test again.

If more than one unit failed, the *test results* equal the sum of the numbers corresponding to the failed units.

Remarks

If the HP 4142B fails Self-Test, contact the Hewlett-Packard Sales and Service Office.

Units that failed Self-Test are disabled except for the *TST? command, and can only be enabled by the RCV command.

Example Statements

```
10  OUTPUT 717;"*TST?"
20  ENTER 717;A
30  DISP A
40  END
```

TV

The TV command is the trigger command for high speed spot V measurements.
This command performs a V measurement independent of source mode (V/I source mode), trigger mode (TM command), and measurement mode (MM command).

Measurement Mode

High speed spot measurements

Execution Conditions

CN command has been executed for the specified unit. However, when you specify the VM, there are no execution conditions.

Syntax

For SMUs/HCUs/HVUs:

TV *ch#*

For VMs:

TV *ch#* [, *V measurement range*]

For SMUs, HCUs, or HVUs, you can send the *V measurement range* parameter, but it has no meaning.

Output Data

See "ASCII Measurement Data Output Format" or "Binary Measurement Data Output Format" at the beginning of this manual.

Parameters

ch# (integer expression)

Unit	*ch#*
HPSMU	2 to 8
MPSMU	1 to 8
HCU	2 to 8
HVU	2 to 8
VM1	1 to 8, 11 to 18
VM2	21 to 28

[*V measurement range*] (integer expression)

VM Operation Mode	*V measurement range*	Description
Grounded mode Differential mode	0, ±(11 to 13) 0, ±(10, 11)	0: Auto ranging 10, -10: 0.2 V range fixed 11, -11: 2 V range fixed 12, -12: 20 V range fixed 13, -13: 40 V range fixed

Default = 0

Remarks

For SMUs/HCUs/HVUs, if the specified unit is in V source mode, the measurement range is set to the same as the V output range. If the unit is in I source mode, the V measurement range is set to Compliance range.

Example Statements

```
OUTPUT 717;"TV1"
OUTPUT 717;"TV1,12"
```

UNT ?

The UNT? query command requests the model and revision numbers of all plug-in units installed in the HP 4142B, and stores the results in the HP 4142B output data buffer (query buffer).

Syntax

UNT? [, *mode*]

Parameters

[*mode*] (integer expression)

mode	Description
0	Request to all plug-in units.
1	Request to all plug-in units and CONTROL unit.

Default = 0

Output Data Format

For *mode* = 0:

model# at slot#1, rev# at slot#1; model# at slot#2, rev# at slot#2; ... ; model# at slot#8, rev# at slot#8 <CR/LF^EOI>

For *mode* = 1:

control unit part#, control unit rev#, model# at slot#1, rev# at slot#1; model# at slot#2, rev# at slot#2; ... ; model# at slot#8, rev# at slot#8 <CR/LF^EOI>

If no unit is installed at a slot, *model#* = 0, *rev#* = 0, and *part#* = 0 are stored for that slot. The HPSMU, HCU, and HVU occupy two slots, and the model and revision number data are stored corresponding to the larger slot number.

Example:

For *mode* = 0:

0,0; HP41420A,3; HP41421B,3; HP41425A,0; 0,0; 0,0; 0,0; 0,0<CR/LF^EOI>

For *mode* = 1:

04142-61011,0; 0,0; HP41420A,3; HP41421B,3; HP41425A,0; 0,0; 0,0; 0,0; 0,0<CR/LF^EOI>

Example Statements

```
10   DIM A$[87]
20   OUTPUT 717;"UNT?"
30   ENTER 717;A$
40   DISP A$
50   END
```

VM

The VM command sets the V measurement operation mode for the specified VM.

Unit

VM

Syntax

VM *ch#, VM operation mode*

Parameters

ch# (integer expression)

VM slot#	*ch#*
1	1, 11, or 21
2	2, 12, or 22
3	3, 13, or 23
4	4, 14, or 24
5	5, 15, or 25
6	6, 16, or 26
7	7, 17, or 27
8	8, 18, or 28

VM operation mode (integer expression)

VM operation mode	**Description**
1	Grounded measurement
2	Differential measurement

Initial Setting = 1

Example Statements

```
OUTPUT 717;"VM1,1"
OUTPUT 717;"VM5,2"
```

WI

The WI command specifies the I staircase sweep source and its parameters. This command also clears the WV, WSV, and WSI command settings.

Measurement Mode

Staircase sweep / Staircase sweep with pulsed bias measurements

Syntax

For Staircase Sweep Measurement (No Pulse Used):

WI *ch#, sweep mode, output range, start current, stop current, number of steps* [, *V compliance*] [, *power compliance*]

For Staircase Sweep with Pulsed Bias Measurement (Pulse Used):

WI *ch#, sweep mode, output range, start current, stop current, number of steps* [, *V compliance*]

Parameters

ch# (integer expression)

Unit	*ch#*
HPSMU	2 to 8
MPSMU	1 to 8
HVU	2 to 8

sweep mode (integer expression)

Measurement Mode	*sweep mode*	Description
Staircase sweep measurement	1	linear sweep (single stair)
	2	log sweep (single stair)
	3	linear sweep (double stair)
	4	log sweep (double stair)
Staircase sweep with pulsed bias measurement	1	linear sweep (single stair)
	3	linear sweep (double stair)

output range (integer expression)

Unit	*output range*	Description
HPSMU MPSMU HVU	0, 11 to 20 0, 11 to 19 0, 13 to 18	0: Auto ranging 11: 1 nA Limited Auto ranging 12: 10 nA Limited Auto ranging 13: 100 nA Limited Auto ranging 14: 1 µA Limited Auto ranging 15: 10 µA Limited Auto ranging 16: 100 µA Limited Auto ranging 17: 1 mA Limited Auto ranging 18: 10 mA Limited Auto ranging 19: 100 mA Limited Auto ranging 20: 1 A Limited Auto ranging

During a linear sweep, the output range does not change. If you specify Auto ranging for a linear sweep, the output range is set to the lowest range that includes *start current* and *stop current*. For Limited Auto ranging, the output range is set to the specified range, if this range includes *start current* and *stop current*. If not, it is set to the same range as Auto ranging.

During a log sweep, the output range changes. If you specify Auto ranging for a log sweep, the range changes so that each current step is forced at the lowest range that includes the step current in all ranges. For Limited Auto ranging, the range changes so that the current is forced at the lowest range that includes the step current in the specified range and higher.

Unit	Output Range	Output Current	Output Reso.	*V compliance* [1]	
				No Pulse Used [2]	**Pulse Used**
HPSMU	1 nA	$0 \leq \|I\| \leq 1.15$ nA	50 fA	0 to ±200 V	---
	10 nA	$0 \leq \|I\| \leq 11.5$ nA	500 fA	0 to ±200 V	0 to ±2 V
	100 nA	$0 \leq \|I\| \leq 115$ nA	5 pA	0 to ±200 V	0 to ±2 V
	1 µA	$0 \leq \|I\| \leq 1.15$ µA	50 pA	0 to ±200 V	0 to ±2 V
	10 µA	$0 \leq \|I\| \leq 11.5$ µA	500 pA	0 to ±200 V	0 to ±2 V
	100 µA	$0 \leq \|I\| \leq 115$ µA	5 nA	0 to ±200 V	0 to ±200 V
	1 mA	$0 \leq \|I\| \leq 1.15$ mA	50 nA	0 to ±200 V	0 to ±200 V
	10 mA	$0 \leq \|I\| \leq 11.5$ mA	500 nA	0 to ±200 V	0 to ±200 V
	100 mA	$0 \leq \|I\| \leq 50$ mA	5 µA	0 to ±200 V	0 to ±200 V
		50 mA < $|I| \leq$115 mA	5 µA	0 to ±100 V	0 to ±100 V
	1 A	$0 \leq \|I\| \leq 50$ mA	50 µA	0 to ±200 V	0 to ±200 V
		50 mA < $\|I\| \leq 125$ mA	50 µA	0 to ±100 V	0 to ±100 V
		125 mA < $\|I\| \leq 350$ mA	50 µA	0 to ±40 V	0 to ±40 V
		350 mA < $\|I\| \leq 700$ mA	50 µA	0 to ±20 V	0 to ±20 V
		700 mA < $\|I\| \leq 1$ A	50 µA	0 to ±14 V	0 to ±14 V
MPSMU	1 nA	$0 \leq \|I\| \leq 1.15$ nA	50 fA	0 to ±100 V	---
	10 nA	$0 \leq \|I\| \leq 11.5$ nA	500 fA	0 to ±100 V	0 to ±2 V
	100 nA	$0 \leq \|I\| \leq 115$ nA	5 pA	0 to ±100 V	0 to ±2 V
	1 µA	$0 \leq \|I\| \leq 1.15$ µA	50 pA	0 to ±100 V	0 to ±2 V
	10 µA	$0 \leq \|I\| \leq 11.5$ µA	500 pA	0 to ±100 V	0 to ±2 V
	100 µA	$0 \leq \|I\| \leq 115$ µA	5 nA	0 to ±100 V	0 to ±100 V
	1 mA	$0 \leq \|I\| \leq 1.15$ mA	50 nA	0 to ±100 V	0 to ±100 V
	10 mA	$0 \leq \|I\| \leq 11.5$ mA	500 nA	0 to ±100 V	0 to ±100 V
	100 mA	$0 \leq \|I\| \leq 20$ mA	5 µA	0 to ±100 V	0 to ±100 V
		20 mA < $\|I\| \leq 50$ mA	5 µA	0 to ±40 V	0 to ±40 V
		50 mA < $|I| \leq$100 mA	5 µA	0 to ±20 V	0 to ±20 V
HVU	100 nA	$0 \leq \|I\| \leq 115$ nA	50 pA	0 to ±1000 V	0 to ±1000 V
	1 µA	$0 \leq \|I\| \leq 1.15$ µA	500 pA	0 to ±1000 V	0 to ±1000 V
	10 µA	$0 \leq \|I\| \leq 11.5$ µA	5 nA	0 to ±1000 V	0 to ±1000 V
	100 µA	$0 \leq \|I\| \leq 115$ µA	50 nA	0 to ±1000 V	0 to ±1000 V
	1 mA	$0 \leq \|I\| \leq 1.15$ mA	500 nA	0 to ±1000 V	0 to ±1000 V
	10 mA	$0 \leq \|I\| \leq 10$ mA	5 µA	0 to ±1000 V	0 to ±1000 V

[1] For measurement modes with no pulsed source, the "No Pulse Used" column applies. For measurement modes that use a pulsed source, the "Pulse Used" column applies.

[2] If (*sweep mode* = log) and (*power compliance* = omitted), apply the *V compliance* values in the highest output range during the sweep.
If you specify the *power compliance*, the allowable *V compliance* values are 0 to ± (the maximum value of the unit), regardless of the output range.

start current (numeric expression, Unit: A)
stop current (numeric expression, Unit: A)

Unit	*start current* *stop current*
HPSMU	0 to ±1
MPSMU	0 to ±100E-3
HVU	0 to ±10E-3 [1]

[1] The polarity of the *start current* and *stop current* must be the same.

number of steps (numeric expression)

number of steps: 2 to 1001 [1]

[1] The maximum *number of steps* is restricted by the capacity of the output data buffer. For ASCII data format, 1023 measurement data can be stored in the output data buffer. For binary data format, 4095 measurement data can be stored in the output data buffer.

[*V compliance*] (numeric expression, Unit: V)

For allowable *V compliance* values, see *"output range"*.

Default:

- If the source unit is set to I source mode before the trigger:
  Default = the setting before trigger
- If the source unit is set to V source mode before the trigger:
  Default = none

The V compliance is automatically set to the same polarity as each step current, regardless of the specified *V compliance* polarity. If step current = 0, the V compliance polarity is positive for the SMU, and is the same as the output polarity for the HVU.

[*power compliance*] (numeric expression, Unit: W)

Unit	*power compliance*	Resolution
HPSMU	1E-3 to 14	1E-3
MPSMU	1E-3 to 2	1E-3
HVU	1E-3 to 10	1E-3

Default = Does not set the power compliance.

Remarks

This command setting is cleared by the WV command.

For the HVU, set the output polarity to the same polarity as the *start* and *stop* values before the measurement trigger (command: POL).

Example Statements

```
OUTPUT 717;"WI1,1,12,0,5E-9,100,5E-2,0.01"
OUTPUT 717;"WI3,2,0,0,0.1,500,10,2"
```

WM

The WM command sets the *automatic sweep abort function* for staircase sweep sources (SMUs, HCUs, HVUs, and VSs) and pulsed sweep source (SMUs, HCUs, HVUs, and VSs), and *output after sweep* settings for the staircase sweep sources.

Measurement Mode

Staircase sweep / Pulsed sweep / Staircase sweep with pulsed bias / Pulsed sweep with pulsed bias measurements

Syntax

WM *automatic sweep abort function* [, *output after sweep*]

Parameters

automatic sweep abort function (integer expression)

automatic sweep abort function	**Description**
1	Disabled
2	Enabled

Initial Setting = 1

[*output after sweep*] (integer expression)

output after sweep	**Description**
1	*start* value
2	*stop* value

Initial Setting = 1
Default = 1

Example Statements

```
OUTPUT 717;"WM1,2"
OUTPUT 717;"WM2,1"
```

WNU?

The WNU? query command requests the number of sweep steps specified by the sweep command, and stores the results in the HP 4142B output data buffer (query buffer). You can then use the controller to read the output data buffer (ENTER statement in HP BASIC).

Syntax

WNU?

Output Data

number of sweep steps <CR/LF^EOI>

After executing this command, the HP 4142B reports the *number of steps* parameter that was specified by the sweep command (PWI, PWV, WI, or WV). If you want to know the *number of steps* for a pulsed sweep, you must specify MM4 or MM8 before using this command, otherwise the *number of steps* for the staircase sweep is reported.

Example Statement

```
10  OUTPUT 717;"WNU?"
20  ENTER 717;A
30  DISP A
40  END
```

WS

The WS command causes the HP 4142B to go into a WAIT state until the HP 4142B receives an external trigger signal via the TRIGGER INPUT terminal on the rear panel.

Syntax

WS [*waiting mode*]

Parameters

[*waiting mode*] (integer expression)

waiting mode	Description
1	Continue if trigger was already received.
2	Wait for next trigger.

Default = 1

Example Statements

```
10  OUTPUT 717;"MM1, 11"
20  OUTPUT 717;"WS2"
30  OUTPUT 717;"XE"
40  ENTER A
50  DISP A
60  END
```

Remarks

If you want to end a WAIT state, execute the AB or *RST command. If you send any other commands first while the HP 4142B is in the WAIT state, these WAIT state ending commands are not effective because the command input buffer is full. In this case, use the Device Clear (CLEAR command in HP BASIC) to end the WAIT state.

WSI

The WSI command specifies the secondary I staircase sweep source (that is synchronized with the primary I staircase sweep source set by WI command) and its parameters.
Therefore, the number of sweep steps and the sweep mode are the same as *number of steps* and *sweep mode* specified by the WI command.
It is impossible to synchronize a secondary I staircase sweep source with a V staircase sweep source or a pulsed source.

Measurement Mode

Staircase sweep measurements

Execution Conditions

The parameters of the WI command are set.

Syntax

WSI *ch#*, *output range*, *start current*, *stop current* [, *V compliance*] [, *power compliance*]

Parameters

ch# (integer expression)

Unit	*ch#*
HPSMU	2 to 8
MPSMU	1 to 8
HVU	2 to 8

output range (integer expression)

Unit	*output range*	Description
HPSMU	0, 11 to 20	0: Auto ranging
MPSMU	0, 11 to 19	11: 1 nA Limited Auto ranging
HVU	0, 13 to 18	12: 10 nA Limited Auto ranging
		13: 100 nA Limited Auto ranging
		14: 1 μA Limited Auto ranging
		15: 10 μA Limited Auto ranging
		16: 100 μA Limited Auto ranging
		17: 1 mA Limited Auto ranging
		18: 10 mA Limited Auto ranging
		19: 100 mA Limited Auto ranging
		20: 1 A Limited Auto ranging

During a linear sweep (*sweep mode* is specified by WI command), the output range does not change. If you specify Auto ranging for a linear sweep, the output range is set to the lowest range that includes *start current* and *stop current*. For Limited Auto ranging, the output range is set to the specified range if this range includes *start current* and *stop current*. If not, it is set to the same range as Auto ranging.

During a log sweep, the output range changes. If you specify Auto ranging for a log sweep, the range changes so that each step current is forced at the lowest range that includes the step current in all ranges. For Limited Auto ranging, the range changes so that each step current is forced at the lowest range that includes the step current in the specified range and higher.

Unit	Output Range	Output Current	Output Reso.	*V compliance* [1]
HPSMU	1 nA	$0 \leq \|I\| \leq 1.15$ nA	50 fA	0 to ±200 V
	10 nA	$0 \leq \|I\| \leq 11.5$ nA	500 fA	0 to ±200 V
	100 nA	$0 \leq \|I\| \leq 115$ nA	5 pA	0 to ±200 V
	1 µA	$0 \leq \|I\| \leq 1.15$ µA	50 pA	0 to ±200 V
	10 µA	$0 \leq \|I\| \leq 11.5$ µA	500 pA	0 to ±200 V
	100 µA	$0 \leq \|I\| \leq 115$ µA	5 nA	0 to ±200 V
	1 mA	$0 \leq \|I\| \leq 1.15$ mA	50 nA	0 to ±200 V
	10 mA	$0 \leq \|I\| \leq 11.5$ mA	500 nA	0 to ±200 V
	100 mA	$0 \leq \|I\| \leq 50$ mA	5 µA	0 to ±200 V
		50 mA < $|I| \leq$115 mA	5 µA	0 to ±100 V
	1 A	$0 \leq \|I\| \leq 50$ mA	50 µA	0 to ±200 V
		50 mA < $\|I\| \leq 125$ mA	50 µA	0 to ±100 V
		125 mA < $\|I\| \leq 350$ mA	50 µA	0 to ±40 V
		350 mA < $\|I\| \leq 700$ mA	50 µA	0 to ±20 V
		700 mA < $\|I\| \leq 1$ A	50 µA	0 to ±14 V
MPSMU	1 nA	$0 \leq \|I\| \leq 1.15$ nA	50 fA	0 to ±100 V
	10 nA	$0 \leq \|I\| \leq 11.5$ nA	500 fA	0 to ±100 V
	100 nA	$0 \leq \|I\| \leq 115$ nA	5 pA	0 to ±100 V
	1 µA	$0 \leq \|I\| \leq 1.15$ µA	50 pA	0 to ±100 V
	10 µA	$0 \leq \|I\| \leq 11.5$ µA	500 pA	0 to ±100 V
	100 µA	$0 \leq \|I\| \leq 115$ µA	5 nA	0 to ±100 V
	1 mA	$0 \leq \|I\| \leq 1.15$ mA	50 nA	0 to ±100 V
	10 mA	$0 \leq \|I\| \leq 11.5$ mA	500 nA	0 to ±100 V
	100 mA	$0 \leq \|I\| \leq 20$ mA	5 µA	0 to ±100 V
		20 mA < $\|I\| \leq 50$ mA	5 µA	0 to ±40 V
		50 mA < $|I| \leq$100 mA	5 µA	0 to ±20 V
HVU	100 nA	$0 \leq \|I\| \leq 115$ nA	50 pA	0 to ±1000 V
	1 µA	$0 \leq \|I\| \leq 1.15$ µA	500 pA	0 to ±1000 V
	10 µA	$0 \leq \|I\| \leq 11.5$ µA	5 nA	0 to ±1000 V
	100 µA	$0 \leq \|I\| \leq 115$ µA	50 nA	0 to ±1000 V
	1 mA	$0 \leq \|I\| \leq 1.15$ mA	500 nA	0 to ±1000 V
	10 mA	$0 \leq \|I\| \leq 10$ mA	5 µA	0 to ±1000 V

[1] If (*sweep mode* = log) and (*power compliance* = omitted), apply the *V compliance* values in the highest output range during the sweep.
If you specify the *power compliance*, the allowable *V compliance* values are 0 to ± (the maximum value of the unit), regardless of the output range.

start current (numeric expression, Unit: A)
stop current (numeric expression, Unit: A)

Unit	*start current* *stop current*
HPSMU	0 to ±1
MPSMU	0 to ±100E-3
HVU	0 to ±10E-3 [1]

[1] The *start current* and *stop current* polarity must be the same.

[*V compliance*] (numeric expression, Unit: V)

For allowable *V compliance* values, see *"output range"*.

Default:

- If the source unit is set to I source mode before the trigger:
  Default = the setting before trigger
- If the source unit is set to V source mode before the trigger:
  Default = none

The *V compliance* polarity is automatically set to the same polarity as each step current, regardless of the specified *V compliance* polarity. If the step current = 0, the V compliance polarity is positive for the SMU, and is the same as the output polarity for the HVU.

[*power compliance*] (numeric expression, Unit: W)

Unit	*power compliance*	Resolution
HPSMU	1E-3 to 14	1E-3
MPSMU	1E-3 to 2	1E-3
HVU	1E-3 to 10	1E-3

Default = Does not set the power compliance.

Remarks

This command setting is cleared by the WI or WV command.

For the HVU, set the output polarity to the same polarity as the *start* and *stop* values before the measurement trigger (command: POL).

Example Statements

```
OUTPUT 717;"WSI1,16,0,4E-5,20,1"
OUTPUT 717;"WSI2,0,1E-3,1E-2,5"
```

WSV

The WSV command specifies the secondary V staircase sweep source that is synchronized with the primary V staircase sweep source set by WV command and its parameters.
Therefore, the number of sweep steps and the sweep mode are the same as the *number of steps* and the *sweep mode* specified by the WV command.
It is impossible to synchronize a secondary V staircase sweep source with an I staircase sweep source or a pulsed source.

Measurement Mode

Staircase sweep measurement

Execution Conditions

The parameters of the WV command are set.

Syntax

For SMUs/HVUs:

WSV *ch#*, *output range*, *start voltage*, *stop voltage* [, *I compliance*] [, *power compliance*]

For VSs:

WSV *ch#*, *output range*, *start voltage*, *stop voltage*

For VSs, you can send the *I compliance* and *power compliance* parameters, but they have no meaning.

Parameters

ch# (integer expression)

Unit	*ch#*
HPSMU	2 to 8
MPSMU	1 to 8
HVU	2 to 8
VS1	1 to 8, 11 to 18
VS2	21 to 28

output range (integer expression)

Unit	*output range*	Description
HPSMU MPSMU HVU VS	0, 11 to 15 0, 11 to 14 0, 14 to 17 0, 12, 13	0: Auto ranging 11: 2 V Limited Auto ranging 12: 20 V Limited Auto ranging 13: 40 V Limited Auto ranging 14: 100 V Limited Auto ranging 15: 200 V Limited Auto ranging 16: 500 V Limited Auto ranging 17: 1000 V Limited Auto ranging

During a linear/log V sweep, the output range does not change. If you specify Auto ranging, the output range is set to the lowest range that includes *start voltage* and *stop voltage*. For Limited Auto ranging, the output range is set to the specified range, if this range includes *start voltage* and *stop voltage*. If not, it is set to the same range as Auto ranging.

However, if you specify *power compliance* for the SMU, and the I compliance value (the smaller value of (*power compliance*)/(step output voltage) and *I compliance*) is greater than the maximum current for the present V output range, then the V output range is changed according to the output voltage, as follows. The SMU output is momentarily set to 0 V if range changing occurs.

Unit	Step Output Voltage (Vo)	Output Range
SMU	0 V ≤ Vo ≤ 20 V 20 V < Vo ≤ 40 V 40 V < Vo ≤ 100 V	20 V 40 V 100 V

Unit	Output Range	Output Voltage	Output Reso.	*I compliance* [1] [2]
HPSMU	2 V	$0 \leq \|V\| \leq 2$ V	100 µV	±(1 pA to 1 A)
	20 V	$0 \leq \|V\| \leq 14$ V	1 mV	±(1 pA to 1 A)
		$14 \text{ V} < \|V\| \leq 20$ V	1 mV	±(1 pA to 700 mA)
	40 V	$0 \leq \|V\| \leq 40$ V	2 mV	±(1 pA to 350 mA)
	100 V	$0 \leq \|V\| \leq 100$ V	5 mV	±(1 pA to 125 mA)
	200 V	$0 \leq \|V\| \leq 200$ V	10 mV	±(1 pA to 50 mA)
MPSMU	2 V	$0 \leq \|V\| \leq 2$ V	100 µV	±(1 pA to 100 mA)
	20 V	$0 \leq \|V\| \leq 20$ V	1 mV	±(1 pA to 100 mA)
	40 V	$0 \leq \|V\| \leq 40$ V	2 mV	±(1 pA to 50 mA)
	100 V	$0 \leq \|V\| \leq 100$ V	5 mV	±(1 pA to 20 mA)
HVU	100 V	$0 \leq \|V\| \leq 100$ V	10 mV	±(1 nA to 10 mA)
	200 V	$0 \leq \|V\| \leq 200$ V	20 mV	±(1 nA to 10 mA)
	500 V	$0 \leq \|V\| \leq 500$ V	50 mV	±(1 nA to 10 mA)
	1000 V	$0 \leq \|V\| \leq 1000$ V	100 mV	±(1 nA to 10 mA)
VS	20 V	$0 \leq \|V\| \leq 20$ V	1 mV	--- (100 mA) [3]
	40 V	$0 \leq \|V\| \leq 40$ V	2 mV	--- (20 mA) [3]

[1] If you specify the *power compliance*, the allowable *I compliance* is as follows: ±(the minimum value of the unit) to ±(the maximum value of the unit)

[2] For SMUs, if $0 \leq |I \text{ compliance}| < 1$ pA, I compliance is set to 1 pA or -1 pA. For HVUs, if $0 \leq |I \text{ compliance}| < 1$ nA, I compliance is set to 1 nA or -1 nA.

[3] Current Limiter value.

start voltage (numeric expression, Unit: V)
stop voltage (numeric expression, Unit: V)

Unit	*start voltage* *stop voltage*
HPSMU	0 to ±200
MPSMU	0 to ±100
HVU	0 to ±1000 [1]
VS	0 to ±40

[1] The *start voltage* and *stop voltage* polarity must be the same.

See "*output range*" about the resolution.

[*I compliance*] (numeric expression, Unit: A)

For allowable *I compliance* values, see *"output range"*.

Default:

- If the source unit is set to V source mode before the trigger:
  Default = the setting before trigger
- If the source unit is set to I source mode before the trigger:
  Default = none

The I compliance polarity is automatically set to the same polarity as each step voltage, regardless of the specified *I compliance* polarity. If step voltage = 0, the I compliance polarity is positive for the SMU, and is the same as the output polarity for the HVU.

[*power compliance*] (numeric expression, Unit: W)

Unit	*power compliance*	Resolution
HPSMU	1E-3 to 14	1E-3
MPSMU	1E-3 to 2	1E-3
HVU	1E-3 to 10	1E-3

Default = Does not set the power compliance.

Remarks

This command setting is cleared by the WV and WI command.

For the HVU, set the output polarity to the same polarity as the *start* and *stop* values before the measurement trigger (command: POL).

Example Statements

```
OUTPUT 717;"WSV1,12,0,10,3E-3,1"
OUTPUT 717;"WSV3,15,0,200,1E-4"
```

WT

The WT command sets the *hold time* and *delay time* for staircase sweep measurements.

Measurement Mode

Staircase sweep measurement

Syntax

WT *hold time*, *delay time*

Parameters

hold time (numeric expression, Unit: s)

hold time	**Resolution**
0 to 655.35	0.01

Initial Setting = 0

delay time (numeric expression, Unit: s)

delay time	**Resolution**
0 to 65.535	0.001

Initial Setting = 0

Example Statements

```
OUTPUT 717;"WT10,0.01"
OUTPUT 717;"WT5,2E-1"
```

WV

The WV command specifies the V staircase sweep source and its parameters. This command also clears the WI, WSI and WSV command settings.

Measurement Mode

Staircase sweep / Staircase sweep with pulsed bias measurements

Syntax

For SMUs/HVUs and Staircase Sweep Measurement (No Pulse Used):

WV *ch#, sweep mode, output range, start voltage, stop voltage, number of steps* [, *I compliance*] [, *power compliance*]

For SMUs/HVUs and Staircase Sweep with Pulsed Bias Measurement (Pulse Used):

WV *ch#, sweep mode, output range, start voltage, stop voltage, number of steps* [, *I compliance*]

For VSs:

WV *ch#, sweep mode, output range, start voltage, stop voltage, number of steps*

For VSs, you can send the *I compliance* and *power compliance* parameters, but they have no meaning.

Parameters

ch# (integer expression)

Unit	*ch#*
HPSMU	2 to 8
MPSMU	1 to 8
HVU	2 to 8
VS1	1 to 8, 11 to 18
VS2	21 to 28

sweep mode (integer expression)

Measurement Mode	*sweep mode*	Description
Staircase sweep measurement	1 2 3 4	linear sweep (single stair) log sweep (single stair) linear sweep (double stair) log sweep (double stair)
Staircase sweep with pulsed bias measurement	1 3	linear sweep (single stair) linear sweep (double stair)

output range (integer expression)

Unit	*output range*	Description
HPSMU MPSMU HVU VS	0, 11 to 15 0, 11 to 14 0, 14 to 17 0, 12, 13	0: Auto ranging 11: 2 V Limited Auto ranging 12: 20 V Limited Auto ranging 13: 40 V Limited Auto ranging 14: 100 V Limited Auto ranging 15: 200 V Limited Auto ranging 16: 500 V Limited Auto ranging 17: 1000 V Limited Auto ranging

During a linear/log V sweep, the output range does not change. If you specify Auto ranging, the output range is set to the lowest range that includes *start voltage* and *stop voltage*. For Limited Auto ranging, the output range is set to the specified range, if this range includes *start voltage* and *stop voltage*. If not, it is set to the same range as Auto ranging.

However, if you specify *power compliance* to the SMU, and the I compliance value (the smaller value of (*power compliance*)/(step output voltage) and *I compliance*) is greater than the maximum current for the present V output range, then the V output range is changed according to the output voltage, as follows. The SMU output is momentarily set to 0 V if range changing occurs.

Unit	Step Output Voltage (Vo)	Output Range
SMU	0 V ≤ Vo ≤ 20 V 20 V < Vo ≤ 40 V 40 V < Vo ≤ 100 V	20 V 40 V 100 V

Unit	Output Range	Output Voltage	Output Reso.	*I compliance* [1]	
				No Pulse Used [2,3]	**Pulse Used**
HPSMU	2 V	0 ≤ |V| ≤ 2 V	100 µV	±(1 pA to 1 A)	±(2 nA to 1 A)
	20 V	0 ≤ |V| ≤ 14 V	1 mV	±(1 pA to 1 A)	±(20 µA to 1 A)
		14 V<|V|≤ 20 V	1 mV	±(1 pA to 700 mA)	±(20 µA to 700 mA)
	40 V	0 ≤ |V| ≤ 40 V	2 mV	±(1 pA to 350 mA)	±(20 µA to 350 mA)
	100 V	0 ≤ |V| ≤ 100 V	5 mV	±(1 pA to 125 mA)	±(20 µA to 125 mA
	200 V	0 ≤ |V| ≤ 200 V	10 mV	±(1 pA to 50 mA)	±(20 µA to 50 mA)
MPSMU	2 V	0 ≤ |V| ≤ 2 V	100 µV	±(1 pA to 100 mA)	±(2 nA to 100 mA)
	20 V	0 ≤ |V| ≤ 20 V	1 mV	±(1 pA to 100 mA)	±(20 µA to 100 mA)
	40 V	0 ≤ |V| ≤ 40 V	2 mV	±(1 pA to 50 mA)	±(20 µA to 50 mA)
	100 V	0 ≤ |V| ≤ 100 V	5 mV	±(1 pA to 20 mA)	±(20 µA to 20 mA
HVU	100 V	0 ≤ |V| ≤ 100 V	10 mV	±(1 nA to 10 mA)	±(1 nA to 10 mA)
	200 V	0 ≤ |V| ≤ 200 V	20 mV	±(1 nA to 10 mA)	±(1 nA to 10 mA)
	500 V	0 ≤ |V| ≤ 500 V	50 mV	±(1 nA to 10 mA)	±(1 nA to 10 mA)
	1000 V	0 ≤ |V| ≤ 1000V	100 mV	±(1 nA to 10 mA)	±(1 nA to 10 mA)
VS	20 V	0 ≤ |V| ≤ 20 V	1 mV	--- (100 mA) [4]	---(100 mA) [4]
	40 V	0 ≤ |V| ≤ 40 V	2 mV	--- (20 mA) [4]	--- (20 mA) [4]

[1] For measurement mode with no pulsed source, the "No Pulse Used" column applies. For measurement mode with pulsed source, the "Pulse Used" column applies. Apply this table when the specified sweep source is used in the pulse used measurement mode.
For HVUs, if 0 ≤ |*I compliance*| < 1 nA, I compliance is set to 1 nA or -1 nA.

[2] If you specify the *power compliance*, the allowable *I compliance* is as follows:
±(the minimum value of the unit) to ±(the maximum value of the unit)

[3] For SMUs, if 0 ≤ |*I compliance*| < 1 pA, I compliance is set to 1 pA or -1 pA.

[4] Current Limiter value.

start voltage (numeric expression, Unit: V)
stop voltage(numeric expression, Unit: V)

Unit	*start voltage* *stop voltage*
HPSMU	0 to ±200
MPSMU	0 to ±100
HVU	0 to ±1000 [1]
VS	0 to ±40

[1] The *start voltage* and *stop voltage* polarity must be the same.

number of steps (numeric expression)

number of steps: 2 to 1001 [1]

[1] The maximum *number of steps* is restricted by the capacity of the output data buffer. For ASCII data format, 1023 measurement data can be stored in the output data buffer. For binary data format, 4095 measurement data can be stored in the output data buffer.

[*I compliance*] (numeric expression, Unit: A)

For allowable *I compliance* values, see *"output range"*.

Default:

- If the source unit is set to V source mode before the trigger:
  Default = the setting before trigger
- If the source unit is set to I source mode before the trigger:
  Default = none

The I compliance polarity is automatically set to the same polarity as each step voltage, regardless of the specified *I compliance* polarity. If the step voltage = 0, the I compliance polarity is positive for the SMU, and is the same as the output polarity for the HVU.

[*power compliance*] (numeric expression, Unit: W)

Unit	*power compliance*	Resolution
HPSMU	1E-3 to 14	1E-3
MPSMU	1E-3 to 2	1E-3
HVU	1E-3 to 10	1E-3

Default = Does not set the power compliance

Remarks

This command setting is cleared by the WI command.

For the HVU, set the output polarity to the same polarity as the *start* and *stop* values before the measurement trigger (command: POL).

Example Statements

```
OUTPUT 717;"WV1,1,12,0,10,10,3E-3,1"
OUTPUT 717;"WV3,2,15,0,200,200,1E-4"
```

XE

The XE command triggers the HP 4142B to perform measurements, except for high speed spot measurements.
However, when the PA command is executed and the HP 4142B is set to the wait state, the XE command only releases the wait state and does not perform the measurements.

Measurement Mode

Spot / Staircase sweep / 1ch pulsed spot / Pulsed sweep / Staircase sweep with pulsed bias / Analog search / 2ch pulsed spot / Pulsed sweep with pulsed bias / Quasi-pulsed spot measurements

Execution Conditions

Measurement Mode	Commands that must have been executed [1]
Spot	CN [2], MM
Staircase sweep (1ch)	CN, MM, (WV or WI), POL
Staircase sweep (2ch)	CN, MM, ((WV and WSV) or (WI and WSI)), POL
1ch pulsed spot	CN, MM, (PV or PI), FL, POL
Pulsed sweep	CN, MM, (PWV or PWI), FL, POL
Staircase sweep with pulsed bias	CN, MM, (WV or WI), (PV or PI), FL, POL
Analog search	CN, MM, ASV, (AIV or AVI)
2ch pulsed spot	CN, MM, (PV or PI), (PDV or PDI), FL
Pulsed sweep with pulsed bias	CN, MM, (PWV or PWI), (PDV or PDI), FL
Quasi-pulsed spot	CN, MM, BDV, POL

[1] FL command is required only when the SMU or HVU output is a pulse voltage or current.
POL command is required only when you change the HVU output polarity.

[2] In spot measurements, the CN command is not required when the measurement unit is a VM.

If any unit is set to the HIGH VOLTAGE state (forcing more than ±42 V, or *V compliance* set to more than ±42 V) after the trigger (XE), the **INTLK** terminal is shorted.

If you release the wait status which is set by PA, there are no execution conditions.

Syntax

XE

Output Data

See "ASCII Measurement Data Output Format" or "Binary Measurement Data Output Format" at the beginning of this manual.

Example Statement

```
OUTPUT 717;"XE"
```

APPENDIX A

MANUAL CHANGES

HP 4142Bs may vary slightly, depending on the Serial Number and the version of the ROM-based firmware. The information in this manual applies directly to an HP 4142B with the serial number prefix listed on the title page of this manual. This appendix contains information for customizing this manual, so that all the information pertains to the HP 4142B that you are using.

To customize this manual for your HP 4142B, refer to the following table, and make all of the manual changes corresponding to the serial number of your HP 4142B and version of the ROM-based firmware.

To see the version of your HP 4142B ROM-based firmware, send:

```
10    OUTPUT 717;"*IDN?"
20    ENTER 717;A, B, Version
30    DISP Version
40    END
```

Manual Changes by Serial Number

Serial Prefix or Number	ROM Version	Make Manual Changes
2716Jxxxxx 2839Jxxxxx	2.21, 2.40, 2.50 2.51, 2.52	1, 2
	3.0, 3.1	2
	4.0 and above	No changes
2946Jxxxxx	3.0, 3.1	2
	4.0 and above	No changes

- **Change 1**

Throughout this manual, delete any descriptions referring to the HP 41422A HCU, and to the 40 V, 100 V, and 200 V range of the Search SMU in the Analog feedback measurements.

You cannot use your HP 4142B with the HP 41422A HCU, and cannot use the 40 V, 100 V, and 200 V range of the Search SMU in Analog feedback Measurements.

• Change 2

You cannot use the following functions. Throughout this manual, delete any descriptions referring to the following.

- HP 41423A HVU
- CONTROL connector
- Quasi-pulsed spot measurement
- Optional parameter of the **UNT?** command
- **BDM**, **BDT**, **BDV**, **ERC**, and **POL** commands

Change the description as follows:

Before change: Program memory size: 20 kbyte
After change: Program memory size: 5 kbyte

Before change: Number of program steps of the program memory: about 2000
After change: Number of program steps of the program memory: about 500

APPENDIX B

ERROR MESSAGES

ERROR/FAILURE Display

The front panel **ERROR/FAILURE Display** indicates the status of the HP 4142B by displaying one of the following: **0** to **8**, **A**, **C**, **E**, **F**, **H**, **P**, or **U**. See the descriptions below.

0: Displayed during normal operating conditions: The HP 4142B or specified plug-in unit(s) passed Self-Test or Self-Calibration.

C: The HP 4142B or specified plug-in unit(s) are now performing Self-Test or Self-Calibration.

E: The HP 4142B received an undefined command; all succeeding commands did not execute. Check for correct command syntax and out-of-range parameters.

F: Command execution not allowed due to present HP 4142B settings; normally caused by an incorrect input command sequence.

If you set the **INTLK** terminal to open while the output switch of an HVU is set to on, and while another HVU is performing Self-Test/Self-Calibration by the **CA** or ***TST?** command with the optional parameter *ch#*, then the HP 4142B stops the Self-Test/Self-Calibration of the unit to set the HVU output switch to off (error codes 565 and 202). In this case, the unit that is stopped from performing Self-Test/Self-Calibration loses the calibration data from Self-Calibration. Be sure to perform Self-Calibration before measurements on the unit that lost the calibration data. If a unit does not have the calibration data, the unit cannot perform measurements within the accuracy of the specifications. Note that even if the unit loses the calibration data, the unit performs measurements and no errors occur. If the command is the ***TST?**, the HP 4142B does not return the query data to your computer.

If a sweep measurement is aborted by the power compliance function or automatic sweep abort function, an **F** is displayed to indicate that the specified function works.

H: Output switches of all measurement units are disconnected to prevent damage to the HP 4142B from overvoltage or overcurrent, or from a momentary power loss. Check the input voltage, input current, cable connections, and ac power. Reconnect the output switches with the **CN** command.

U: The HVU Self-Test or HVU Self-Calibration cannot be performed because the **INTLK** terminal is open.

If the error code is 565 or 567, the HVU lost the calibration data of the Self-Calibration. Be sure to perform the HVU Self-Calibration before measurements. If the HVU loses the calibration data, the HVU cannot perform measurements within the accuracy of the specifications. Note that even if the HVU loses the calibration data, the HVU still performs measurements and no errors occur.

1 to **8**, **A**, **P**:

The HP 4142B failed. If a plug-in unit failed, **1** to **8** indicates the slot # of the failed unit. **A** indicates a failure in the HP 4142B analog-to-digital conversion (ADC) section; **P** indicates a failure in the HP 4142B central processing unit (CPU). If more than one failure occurs, the **ERROR/FAILURE** display indicates the last failure detected during Self-Test or Self-Calibration. Self-Test and Self-Calibration are performed in the following order.

1) CPU
2) ADC
3) All plug-in units by slot # (ascending), except the AFU.
4) AFU

To determine whether a multiple failure occurred, execute the ***TST?** command. This command performs the Self-Test again and displays test results on the controller.

If a plug-in unit fails, remove the failed unit from slot and use a known good unit to perform your measurement. Contact the nearest Hewlett-Packard Sales and Service office for assistance.

If an **A**, **E**, **F**, **H**, **P**, **U**, or **1** to **8** is displayed, details about errors (error codes) are stored in the error register. Refer to "ERROR CODE" in this Appendix for error code descriptions.

The **ERROR/FAILURE Display** and error register are initialized (set to **0** and "0, 0, 0, 0", respectively) when the ***RST**, **ERR?**, or Device Clear (HPBASIC **CLEAR** statement) is executed. The error register is also initialized when **CA** or ***TST?** command execution begins.

Error Codes

If errors occur, the HP 4142B can store up to 4 error codes in the error register. Execute the **ERR?** command to transfer the error codes from the error register to the output data buffer. You can then use the controller to read the output data buffer (ENTER statement in HP BASIC).

error code, error code, error code, error code CR/LF^EOI

The output of the error codes is in the order that they occurred, and only the first four error codes are sent. If no errors occurred, *0s* are sent. The following are the error codes and their meanings.

Error Code	Meaning
100	Undefined HP-IB command.
102	Improper numeric data syntax.
103	Improper position of terminator (CR/LF) in the HP-IB command.
120	Improper parameter value.
121	Improper *Channel#*. *Channel#* must be 1 to 8, 11 to 18, or 21 to 28.
122	Improper number of channels specified in **MM**, **FL**, **CN**, **CL**, **IN**, **DZ**, or **RZ** command.
123	Improper SMU/HCU/HVU *V* or *I compliance* value.
124	Improper *measurement range* or *output range* value.
125	For analog search measurements, the *target* value must be less than the *compliance* value.
126	When current pulse source is specified by **PI**, **PWI**, or **PDI** command, SMU/HVU *base current* and *pulse current* must be set to the same polarity. If *base current* ≥ 0, then *pulse current* must be ≥ 0; if *base current* ≤ 0, then *pulse current* must be ≤ 0.
127	The difference of *search start voltage* and *search stop voltage* in **ASV** command is out of range.
128	Improper SMU *V* or *I compliance* value in **PV**, **PI**, **PWV**, **PWI**, **PDV**, or **PDI** commands (*V* or *I compliance* value exceeds the limit on pulse output). Or 1 nA range cannot be used. Or AUTO ranging cannot be used when *pulse current* is less than 1.15 nA (in case of *V compliance* ≤ 2V) or less than 11.5 µA (in case of *V compliance* > 2 V).
129	*Pulse width* must be less than (*pulse period* / 2).
130	For a log sweep (in **WV**, **WI**, **WSV**, or **WSI** command), the *start* or *stop* value cannot be 0, and the polarity of the *start* and *stop* values must be the same.
150	Command input buffer is full. Maximum number of characters that can be input at one time is 256 (including terminator).
151	Specified unit cannot execute this HP-IB command.
152	Unit failed Self-Test. Cannot perform setting. If you perform the setting to repair the HP 4142B, send the RCV command.
153	A unit is not installed at specified channel. Or you cannot use the ERC command because the CONTROL unit is not installed.

160	**ST** command cannot be input twice before **END** command.
161	**ST** command must be input before **END** command.
162	A command that cannot be stored in program memory is input between **ST** and **END** commands.
190-199	An error occurred that could not be defined. Correct the error that occurred before this error, then run the program again. If no error occurred before this error, contact the nearest Hewlett-Packard service office because there may be an error in the HP 4142B firmware.
200	This HP-IB command cannot be executed when the output switch of the unit is OFF.
201	Specify the *compliance* when you change the source mode of SMU/HVU. Or HCU *V compliance* cannot be omitted in **PI**, **PWI**, or **PDI** command.
202	When **INTLK** terminal is open, the High voltage state (*Output voltage* or *V compliance* is set to greater than 42 V) and the HVU output switch cannot be set to on. If the **INTLK** terminal is opened while they are set to on, outputs of all units are set to 0 V, and the HVU output switches are set to off.
203	Output switch cannot be set to ON in high voltage state (*Output voltage* or *V compliance* is set to greater than 42 V).
204	Output switch cannot be set to OFF in high voltage state (*Output voltage* or *V compliance* is set to greater than 42 V). However, **CL** command without parameters can set output switches of all units to OFF.
205	**RZ** command cannot be executed before **DZ** command.
206	**RZ** command cannot be executed if one of the specified channels has been used in a previous **RZ** command.
207	Total output of all units exceeds maximum power output of the HP 4142B. This error may also occur when you perform Self-Test or Self-calibration with only one unit specified. In this case, after disconnecting some or all the output switches of the unit to OFF, send the command of the Self-Test or Self-Calibration again. During the Self-Test or Self-Calibration, the HP 4142B consumes the following power. HPSMU: 20 W, MPSMU: 2 W, HCU: 10.02 W, HVU: 11 W, VS: 2.2 W
208	20 V or 40 V range is not available for differential measurement by VM.
209	0.2 V range not available for grounded measurement by VM.
210	EXT trigger measurement cannot be performed when HP 4142B is busy.
211	HP-IB GET command (TRIGGER statement in HPBASIC) is valid only in trigger mode 1.
212	Improper SMU *V* or *I compliance* value in **DV**, **DI**, **PV**, **PI**, **PWV**, **PWI**, **PDV**, **PDI**, **ASV**, **AVI**, or **AIV** command. Do not omit *V* or *I compliance*; specify a proper value.
213	Self-Calibration or Self-Test cannot be performed in high voltage state (*Output voltage* or *V compliance* is set to greater than 42 V).
214	*Measurement mode* must be set by **MM** command before measurement trigger.

215 Change the HVU output polarity to the same polarity in the settings for the **DV**, **DI**, **PV**, **PI**, or **BDV** command by using the **POL** command before the **DV**, **DI**, or measurement trigger. Or, before the **RZ** command, return the HVU output polarity to polarity after the **DZ** command execution.

220 Set sweep channel by **WV** or **WI** command, before staircase sweep (**MM2**) measurement trigger, before staircase sweep with pulsed bias (**MM5**) measurement trigger, or before setting synchronous sweep channel by **WSV** or **WSI** command.

221 Set pulse sweep channel by **PWV** or **PWI** command before pulsed sweep (**MM4**) measurement trigger.

222 Set pulse bias channel by **PV** or **PI** command before staircase sweep with pulsed bias (**MM5**) measurement trigger.

223 Improper SMU *V* or *I compliance* value in **WV**, **WI**, **WSV**, or **WSI** command. Do not omit *V* or *I compliance*; specify a proper value.

224 Main sweep channel (set by **WV** or **WI**) and synchronous sweep channel (set by **WSV** or **WSI**) must be set to different channels and same source mode i.e., both channels are either voltage sources (set by **WV** and **WSV**) or current sources (set by **WI** and **WSI**).

225 Synchronous sweep source data cannot be output because synchronous sweep source channel is not set by the **WSV** or **WSI** command.

226 A log sweep cannot be specified by **PWV**, **PWI** command. Or a log sweep cannot be specified by **WV** or **WI** command during the staircase sweep with pulsed bias measurements (**MM5**).

227 Sweep measurement aborted by automatic sweep abort function or because sweep source output reached *V*, *I*, or *power compliance*.

228 Must specify *pulse period* for pulse sweep (**MM4**), staircase sweep with pulse bias (**MM5**), or pulsed sweep with pulsed bias (**MM8**) measurements.

229 Change the HVU output polarity to the same polarity in the settings for the **WV**, **WI**, **WSV**, **WSI**, **PWV**, or **PWI** command by using the **POL** command before measurement trigger.

230 Pulse source must be set before measurement trigger. **PV** or **PI** command is required for 1ch pulsed spot measurement (**MM3**). **PV** or **PI**, and **PDV** or **PDI** commands are required for 2ch pulsed spot measurements (**MM7**). **PWV** or **PWI**, and **PDV** or **PDI** commands are required for pulsed sweep with pulsed bias measurements (**MM8**).

231	Improper SMU *V* or *I output range* value in **PV**, **PI**, **PWV**, **PWI**, **PDV**, **PDI**, **WV**, or **WI** command (*V* or *I compliance* value exceeds the limit on pulse output). Do not omit *V* or *I compliance*; specify a proper value.
232	Improper SMU voltage or current measurement range for pulse measurement. Specify the higher current measurement range by RI command. Or in current measurement, set *I compliance* of measurement channel to larger. Or in voltage measurement, set *V compliance* of measurement channel to 2 V or less.
233	Set SMU/HVU Filter of pulse source channel to OFF for pulse measurements by **FL** command.
236	Differential measurement by VM cannot be performed for pulse measurements.
237	HCU pulse duty (*pulse width / pulse period*) is too large in **PT** command.
238	HCU *pulse width* is too large in **PT** command. Or, if you use two HCUs in 2ch pulsed spot measurements, you cannot specify *pulse period* to 0.
239	SMU/HVU/VS *pulse width* is smaller than the minimum value 1ms in **PT** command.
240	Set the search SMU by **ASV** command before analog search measurement trigger.
241	Set the sense SMU by **AVI** or **AIV** command before analog search measurement trigger.
242	Analog Feedback Unit is not installed, or Analog Feedback Unit failed Self-Test.
243	Search (set by **ASV**) and sense (set by **AVI** or **AIV**) channel units must be SMUs for analog search measurements.
244	*Target* value cannot exceed *compliance* value.
246	Improper *ramp rate* or *feedback integration time* value for V output range of search SMU.
247	Search SMU and sense SMU must be different channels.
253	Program memory is full.
254	HP-IB GET command (TRIGGER statement in HPBASIC) or EXT trigger input is invalid between **ST** and **END** commands.
255	In program memory, nesting of programs (one program calling another) cannot be greater than 8.
260	Data output buffer for measurement data is full.
280-299	An error occurred that can not be defined. Correct the error that occurred before this error, then run the program again. If no error occurred before this error, contact the nearest Hewlett-Packard service office because there may be an error in the HP 4142B firmware.

301	A momentary power loss occurred. All output switches are set to OFF.
302	Something is wrong with the power supply section of the HP 4142B mainframe or plug-in unit. All output switches are set to OFF. Confirm by Self-Test whether unit works normally.
303	Overvoltage that exceeds maximum voltage at the present current range is sent to the MPSMU. All output switches are set to OFF.
304	Overvoltage or overcurrent is input to GNDU, or Force line of the GNDU is not connected to the DUT. All output switches are set to OFF.
305	Overcurrent that exceeds maximum current at the present voltage range is input to the SMU (HPSMU and MPSMU). All output switches are set to OFF.
306	The executing command is canceled because the data communication between the HP 4142B and the computer via the HP-IB is interrupted by a hardware reset of your computer, or because the HP-IB cable was disconnected, or by some other interruption. Send the command again.
307	This unit is not supported by this ROM version. Until you change the ROM, use the HP 4142B with this unit removed.
308	For the HCU, one of the following errors occurred. All output switches are set to off. • Overvoltage (more than ±10 V) is input to FORCE LOW of the HCU. Connect FORCE LOW of the HCU to GNDU. • Overvoltage (more than ±6 V) is input between FORCE LOW and SENSE LOW of the HCU. Connect FORCE LOW and SENSE LOW of the HCU to GNDU correctly, or make the wiring resistance of FORCE LOW lower (recommendation: less than 150 mΩ). • Overvoltage (more than ±30 V) is input between FORCE HIGH and FORCE LOW of the HCU. For the HVU, one of the following errors occurred. All output switches are set to off. • Overvoltage is input. • Overcurrent is input. • Opposite polarity voltage or current is input. • Something is wrong with the HVU power amplifier. Confirm that the unit is functioning properly with Self-Test.
380-399	An error occurred that can not be defined. Correct the error that occurred before this error, then run the program again. If no error occurred before this error, contact the nearest Hewlett-Packard service office because there may be an error in the HP 4142B firmware.

410	CPU module is not functioning properly. CPU module failed ROM Identification Test of Self-Test.
411	CPU module is not functioning properly. CPU module failed ROM Checksum Test of Self-Test.
412	CPU module is not functioning properly. CPU module failed Timer IC Test of Self-Test.
413	CPU module is not functioning properly. CPU module failed Digital-to-Analog Section Bus Isolator Test of Self-Test. Or the PS module +5 V output voltage is not within limits.
415	GNDU/ADC module is not functioning properly. ADC section of GNDU/ADC failed ADC Conversion Function Test of Self-Test.
416	GNDU/ADC module is not functioning properly. ADC section of GNDU/ADC failed ADC Linearity Test of Self-Test.
417	GNDU/ADC module is not functioning properly. ADC section of GNDU/ADC failed ADC Accuracy Test of Self-Test.
420	SMU is not functioning properly. SMU failed V Output/ Measurement Function Test of Self-Test.
421	SMU is not functioning properly. SMU failed I Output/ Measurement Function Test of Self-Test.
422	SMU is not functioning properly. SMU failed Common Mode Rejection Test of Self-Test.
423	SMU is not functioning properly. SMU failed I Monitor Amp. Offset Error Test of Self-Test.
424	SMU is not functioning properly. SMU failed V Monitor Amp. Offset Error Test of Self-Test.
425	SMU is not functioning properly. SMU failed I Output and V Measurement Function Test of Self-Test.
426	SMU is not functioning properly. SMU failed V Monitor Amp. Gain Error Test of Self-Test.
427	SMU is not functioning properly. SMU failed I Monitor Amp. Gain Error Test of Self-Test.
428	SMU is not functioning properly. SMU failed V DAC Test of Self-Test.
429	SMU is not functioning properly. SMU failed I DAC Test of Self-Test.
433	SMU is not functioning properly. SMU failed +I Bias Circuit Test of Self-Test.
434	SMU is not functioning properly. SMU failed -I Bias Circuit Test of Self-Test.
435	SMU is not functioning properly. SMU failed I Range Circuit Test of Self-Test.
436	SMU is not functioning properly. SMU failed Power Amp. Supply Voltage Switching Circuit Test of Self-Test.
437	SMU is not functioning properly. SMU failed Oscillation Detect Circuit Test of Self-Test.
440	VS/VMU is not functioning properly. VS and VM failed V Output/Measurement Function Test of Self-Test.
441	VS/VMU is not functioning properly. VM failed Gain Error Test of Self-Test.
442	VS/VMU is not functioning properly. VM failed Offset Error Test of Self-Test.

443	VS/VMU is not functioning properly. VS failed Lower DAC Test of Self-Test.
444	VS/VMU is not functioning properly. VS failed Upper DAC Test of Self-Test.
445	VS/VMU is not functioning properly. VS failed 40 V Range Gain Error Test
447	VS/VMU is not functioning properly. VM failed Differential Mode Gain Error Test of Self-Test.
448	VS/VMU is not functioning properly. VM failed Differential Mode Offset Error Test of Self-Test.
449	VS/VMU is not functioning properly. VS failed I Limit Detect Circuit Test of Self-Test.
450	VS/VMU is not functioning properly. VS failed I Limit Circuit Test of Self-Test.
451	VS/VMU is not functioning properly. VS failed I Measurement Function Test of Self-Test.
461	AFU is not functioning properly. AFU failed Target Value Setting Lower DAC Test of Self-Test.
462	AFU is not functioning properly. AFU failed Target Value Setting Upper DAC Test of Self-Test.
463	AFU is not functioning properly. AFU failed Search Start Voltage Setting DAC Test of Self-Test.
464	AFU is not functioning properly. AFU failed Error Amp. Offset Voltage Test of Self-Test.
465	AFU is not functioning properly. AFU failed Integrator Offset Current Test of Self-Test.
466	AFU is not functioning properly. AFU failed Search Stop Voltage Accuracy Test of Self-Test.
467	AFU is not functioning properly. AFU failed Ramp Rate Accuracy Test of Self-Test.
468	AFU is not functioning properly. AFU failed Error Amp. Function Test of Self-Test.
469	AFU is not functioning properly. AFU failed Settle Detect Circuit Test of Self-Test.
470	AFU is not functioning properly. AFU failed Target and Sense Value Comparator Test of Self-Test.
471	AFU is not functioning properly. AFU failed Search Stop Voltage Limit Detect Circuit Test of Self-Test.
480-499	An error occurred that can not be defined. Correct the error that occurred before this error, then run the program again. If no error occurred before this error, contact the nearest Hewlett-Packard service office because there may be an error in the HP 4142B firmware.
500	HCU is not functioning properly. HCU failed V DAC Function Test of Self-Test.
501	HCU is not functioning properly. HCU failed I Pulse DAC Function Test of Self-Test.
502	HCU is not functioning properly. HCU failed I Monitor Offset Error Test of Self-Test.
503	HCU is not functioning properly. HCU failed 0 V Output Test of Self-Test.

504	HCU is not functioning properly. HCU failed V Monitor Offset Error Test of Self-Test.
505	HCU is not functioning properly. HCU failed I Monitor Gain Error Test of Self-Test.
506	HCU is not functioning properly. HCU failed -2 V Range V Gain Error Test of Self-Test.
507	HCU is not functioning properly. HCU failed +2 V Range V Gain Error Test of Self-Test.
508	HCU is not functioning properly. HCU failed -20 V Range V Gain Error Test of Self-Test.
509	HCU is not functioning properly. HCU failed +20 V Range V Gain Error Test of Self-Test.
510	HCU is not functioning properly. HCU failed -2 V Range V Offset Error Test of Self-Test.
511	HCU is not functioning properly. HCU failed +2 V Range V Offset Error Test of Self-Test.
512	HCU is not functioning properly. HCU failed -20 V Range V Offset Error Test of Self-Test.
513	HCU is not functioning properly. HCU failed +20 V Range V Offset Error Test of Self-Test
514	HCU is not functioning properly. HCU failed +I Pulse Gain Error Test of Self-Test.
515	HCU is not functioning properly. HCU failed -I Pulse Gain Error Test of Self-Test.
516	HCU is not functioning properly. HCU failed +I Pulse Offset Error Test of Self-Test.
517	HCU is not functioning properly. HCU failed -I Pulse Offset Error Test of Self-Test.
518	HCU is not functioning properly. HCU failed +I Base Gain Error Test of Self-Test.
519	HCU is not functioning properly. HCU failed -I Base Gain Error Test of Self-Test.
520	HCU is not functioning properly. HCU failed +I Base Offset Error Test of Self-Test.
521	HCU is not functioning properly. HCU failed -I Base Offset Error Test of Self-Test.
522	HCU is not functioning properly. HCU failed 1mA Range Output/Measurement Function Test of Self-Test.
523	HCU is not functioning properly. HCU failed 10mA Range Output/Measurement Function Test of Self-Test.
524	HCU is not functioning properly. HCU failed 100mA Range Output/Measurement Function Test of Self-Test.
525	HCU is not functioning properly. HCU failed +I Bias Circuit Off Test of Self-Test.
526	HCU is not functioning properly. HCU failed +I Bias Circuit On Test of Self-Test.
527	HCU is not functioning properly. HCU failed -I Bias Circuit Off Test of Self-Test.
528	HCU is not functioning properly. HCU failed -I Bias Circuit On Test of Self-Test.
529	HCU is not functioning properly. HCU failed I Pulse Output/ Measurement Function Test of Self-Test.
530	HCU is not functioning properly. HCU failed V Pulse Output/ Measurement Function Test of Self-Test.

540	HVU is not functioning properly. HVU failed V Monitor Gain Error Test of Self-Test/Self-Calibration.
541	HVU is not functioning properly. HVU failed V Monitor Offset Error Test of Self-Test/Self-Calibration.
542	HVU is not functioning properly. HVU failed I Monitor Gain Error Test of Self-Test/Self-Calibration.
543	HVU is not functioning properly. HVU failed I Monitor + Polarity Offset Error Test of Self-Test/Self-Calibration.
544	HVU is not functioning properly. HVU failed I Monitor - Polarity Offset Error Test of Self-Test/Self-Calibration.
545	HVU is not functioning properly. HVU failed VDAC + Polarity Test of Self-Test/Self-Calibration.
546	HVU is not functioning properly. HVU failed VDAC - Polarity Test of Self-Test/Self-Calibration.
547	HVU is not functioning properly. HVU failed IDAC + Polarity Test of Self-Test/Self-Calibration.
548	HVU is not functioning properly. HVU failed IDAC - Polarity Test of Self-Test/Self-Calibration.
549	HVU is not functioning properly. HVU failed Power Amp. 0 V Output Test of Self-Test.
550	HVU is not functioning properly. HVU failed V Monitor 0 V Measurement Test of Self-Test.
551	HVU is not functioning properly. HVU failed Power Amp. 100 V Output Test of Self-Test.
552	HVU is not functioning properly. HVU failed V Monitor 100 V Measurement Test of Self-Test.
553	HVU is not functioning properly. HVU failed -V Limit Loop Function Test of Self-Test.
554	HVU is not functioning properly. HVU failed +V Limit Loop Function Test of Self-Test.
555	HVU is not functioning properly. HVU failed Power Amp. O V Output Test or +V/-V Limit Loop Function Test of Self-Test.
556	HVU is not functioning properly. HVU failed Power Amp. Offset Error Test of Self-Test.
557	HVU is not functioning properly. HVU failed +V Limit Loop Operation Accuracy Test of Self-Test.
558	HVU is not functioning properly. HVU failed -V Limit Loop Operation Accuracy Test of Self-Test.
559	HVU is not functioning properly. HVU failed +V/-V Limit Loop Function Test of Self-Test.
560	HVU is not functioning properly. HVU failed Power Amp. Control Circuit Function Test of Self-Test.
561	HVU is not functioning properly. HVU failed Loop Detector Function Test of Self-Test.
562	HVU is not functioning properly. HVU failed Current Range Function Test of Self-Test.
563	HVU is not functioning properly. HVU failed +I Bias Circuit Function Test of Self-Test.
564	HVU is not functioning properly. HVU failed -I Bias Circuit Function Test of Self-Test.

565	If you performed Self-Test or Self-Calibration on all units, the Self-Test/Self-Calibration of the HVU stopped and skipped to the next unit because the **INTLK** is opened. Be sure to perform the HVU Self-Calibration or Self-Test because the HVU lost the calibration data. Or if you performed the Self-Test or Self-Calibration only on one unit while the HVU output switch is set to on, the Self-Test/Self-Calibration stopped because the **INTLK** is open while the HVU output switch is set to on. Be sure to perform the Self-Test or Self-Calibration on the unit that stopped because the unit lost calibration data. Note that if the unit does not have the calibration data, the unit cannot force and measure the output within the accuracy of the specifications.
566	Self-Test or Self-Calibration is not performed on the HVU because the **INTLK** terminal is open.
567	At power-on, Self-Test is not performed on the HVU because the **INTLK** terminal is open. The HVU does not have the calibration data. Be sure to perform the HVU Self-Test. Note that if the unit does not have the calibration data, the unit cannot force and measure the output within the accuracy of the specifications.
600	The unit specified by the **PDM** must be one of the units specified by **PDV/PDI** and **PV/PI** for 2ch pulsed spot measurement (**MM7**), or must be one of the units specified by **PDV/PDI** and **PWV/PWI** for pulsed sweep with pulsed bias measurement (**MM8**).
601	At least one of the units specified by **PDV/PDI** and **PV/PI** must be the HCU for 2ch pulsed spot measurement (**MM7**). Or at least one of the units specified by **PDV/PDI** and **PWV/PWI** must be the HCU for pulsed sweep with pulsed bias measurement (**MM8**).
602	The unit specified by **PV** or **PI** must be the HPSMU, MPSMU, or HCU for 2ch pulsed spot measurement (**MM7**). Or the unit specified by **PWV** or **PWI** must be the HPSMU, MPSMU, or HCU for pulsed sweep with pulsed bias measurement (**MM8**).
603	The units specified by **WV/WI** and **PV/PI** are duplicate for staircase sweep with pulsed bias measurement (**MM5**). Or the units specified by **PDV/PDI** and **PV/PI** are duplicate for 2ch pulsed spot measurement (**MM7**). Or the units specified by **PDV/PDI** and **PWV/PWI** are duplicate for pulsed sweep with pulsed bias measurement (**MM8**).
610	Set the quasi-pulsed source by the **BDV** command before a quasi-pulsed spot measurement trigger.
611	For quasi-pulsed measurement, the monitor unit that is specified by **MM** command must be an HVU, HPSMU, or MPSMU.
1100-8611	For this type of error code (*nxxx*), *n* is the slot# for the plug-in unit and *xxx* is the error code.
11100-28611	For this type of error code (*nnxxx*), *nn* is the *channel*# for the VS/VMU and *xxx* is the error code.

Measurement Data Status

The following shows the measurement data status. The priority of status is:

Priority: F > X > V > C > T > S > G > N

For quasi-pulsed spot measurement:

Priority: S or G > F > X > V > C > T > N

The following numbers in the parentheses denote the measurement data status for Binary format.

N (0): Normal measurement data. For quasi-pulsed spot measurement, normal measurement data when the quasi-pulsed source reaches the *stop voltage*.

G (6): For analog search measurement:
The *target* value is not reached during a search (between *search start voltage* and *search stop voltage*).

For quasi-pulsed spot measurement:
The detection time is over the limit (3 s for Short mode, 12 s for Long mode). Set the *detection interval* to Long. If this status occurs even if the *detection interval* is set to Long, perform the spot measurement by constant source.

Or perform the following to speed up the settling time:
- Make the *I compliance* of the quasi-pulsed source larger.
- Make the *start voltage* larger.

S (7): For analog search measurement:
Measurement is made before the feedback search is complete.

For quasi-pulsed spot measurement:
The settling detection cannot be performed because the output slew rate is too slow. Perform the following:
- Set the *detection interval* to Long to enable the detection for the slow slew rate. If this status occurs even when the *detection interval* is set to Long, perform the spot measurement by constant source or pulsed measurement.
- Make the *I compliance* of the quasi-pulsed source larger to speed up the slew rate.

Or the settling detection cannot be performed because the quasi-pulsed source output voltage when the current reaches the *I compliance* is less than 10 V from the *start voltage*. Perform the pulsed measurement or spot measurement.

T (1): Another channel(s) reach V compliance, I compliance, power compliance, or the current limit of VS. In I compliance, the compliance of the opposite polarity that you specify is also set.

Or another HCU voltage output(s) does not settle before measurement. Perform the following:

- Make the *pulse width* larger to wait for settling time.
- Make the *I compliance* larger to speed up settling time.

C (2): This measurement channel reaches V compliance, I compliance, power compliance, or current limit of VS. In I compliance, the compliance of the opposite polarity that you specify is also set.

Or this HCU voltage output does not settle before measurement. Perform the following:

- Make the *pulse width* larger to wait for the settling time.
- Make the *I compliance* larger to speed up the settling time.

Note that status C occurs even if status C and T occur together.

V (3): This channel output exceeds the measurement range. The measurement value is a dummy value (199.999E+99 for ASCII format). Make the measurement range higher.

Or dummy data (199.999E+99 for ASCII format) is stored because the sweep measurement is automatically aborted by the automatic sweep abort function or power compliance.

X (4): One or more SMU/HVU(s) is oscillating.

Or, one or more SMU/HVU output(s) does not settle before measurement. Perform the following:

- Make the wait time, *delay time*, or *pulse width* larger to wait for the settling time.
- Make the *I compliance* larger to speed up the settling time.
- For pulsed measurement, make the *base* value closer to the *pulse* value to reduce the settling time.
- For current output by the limited auto ranging, make the I output range lower to speed up the settling time.

F (5): One or more HVU output(s) does not settle before the measurement. Perform the following:

- Make the wait time, *delay time*, or *pulse width* larger to wait for the settling time.
- Make the *I compliance* larger to speed up the settling time.
- For pulsed measurement, make the *base* value closer to *pulse* value to reduce the settling time.
- For current output by limited auto ranging, make the I output range lower to speed up the settling time.

For pulsed measurement, if the *pulse width* is set to maximum (50 ms), perform the quasi-pulsed spot measurement or spot measurement by constant source.

W (1): Indicates the sweep source data of the first or intermediate sweep step. For sweep source data, the status is always W or E. If the number of sweep steps is 1, the status is E.

E (2): Indicates the sweep source data of the final sweep step. For sweep source data, the status is always W or E. If the number of sweep steps is 1, the status is E.

The second character of the measurement data for ASCII format indicates the measurement channel number for measurement data, and indicates the sweep source channel number for sweep source data, as follows.

<channel>:			
	A: Ch#1	I: Ch#11	Q: Ch#21
	B: Ch#2	J: Ch#12	R: Ch#22
	C: Ch#3	K: Ch#13	S: Ch#23
	D: Ch#4	L: Ch#14	T: Ch#24
	E: Ch#5	M: Ch#15	U: Ch#25
	F: Ch#6	N: Ch#16	V: Ch#26
	G: Ch#7	O: Ch#17	W: Ch#27
	H: Ch#8	P: Ch#18	X: Ch#28

For differential measurements, the HP 4142B shows the unit specified by the **MM** or **TV** command.

The third character of the measurement data for ASCII format indicates the voltage data or current data as follows.

<V/I>:	
	V: Voltage data
	I: Current data

NOTES

APPENDIX C

COMMAND CLASSIFICATION

HP-IB commands for the HP 4142B are classified by function as follows.

UNIT SETUP	
Resets the HP 4142B	***RST**
Performs Calibration	**CA**
Connects Output Switches	**CN**
Disconnects Output Switches	**CL**
Constant V Source Setup	**DV**
Constant I Source Setup	**DI**
Sets Output Voltage to 0 V	**DZ, IN**
Returns from 0 V Output to Previous Setting	**RZ**
Filter Setup	**FL**
Sets Output Polarity	**POL**
Averaging Mode Setup	**AV**
VM Operation Mode Setup	**VM**
Output Data Format Setup	**FMT**
Clears Output Data Buffer	**BC**
ERROR INFORMATION	
Error Information	**ERR?**
Executes Self-Test	***TST?**
SPOT MEASUREMENTS	
Connects/disconnects Output Switches	**CN, CL**
Constant V Source Setup	**DV**
Constant I Source Setup	**DI**
Sets Output Polarity	**POL**
Waits time	**PA**
Measurement Mode Setup	**MM**
Trigger	**XE**
Sets Output Voltage to 0 V	**DZ, IN**
V Measurement Range Setup	**RV**
I Measurement Range Setup	**RI**
VM Operation Mode Setup	**VM**
Averaging Mode Setup	**AV**
Trigger Mode Setup	**TM**
Output Data Format Setup	**FMT**
Filter Setup	**FL**

STAIRCASE SWEEP MEASUREMENTS

Connects/disconnects Output Switches	**CN, CL**
V Sweep Source Setup	**WV, WSV**
I Sweep Source Setup	**WI, WSI**
Hold Time and Delay Time Setup	**WT**
Sets Output Polarity	**POL**
Measurement Mode Setup	**MM**
Trigger	**XE**
Sets Output Voltage to 0 V	**DZ, IN**
V/I Measurement Range Setup	**RV, RI**
VM Operation Mode Setup	**VM**
Averaging Mode Setup	**AV**
Trigger Mode Setup	**TM**
Output Data Format Setup	**FMT**
Automatic Sweep Abort Function Setup	**WM**
Constant V/I Source Setup	**DV, DI, POL**
Waits time	**PA**
Filter Setup	**FL**
Aborts Sweep Operation	**AB**

1CH PULSED SPOT MEASUREMENTS

Connects/disconnects Output Switches	**CN, CL**
Pulsed V Source Setup	**PV**
Pulsed I Source Setup	**PI**
Pulsed Source Timing Setup	**PT**
Filter Setup	**FL**
Sets Output Polarity	**POL**
Measurement Mode Setup	**MM**
Trigger	**XE**
Sets Output Voltage to 0 V	**DZ, IN**
V/I Measurement Range Setup	**RV, RI**
Trigger Mode Setup	**TM**
Output Data Format Setup	**FMT**
Constant V/I Source Setup	**DV, DI, POL**
Waits time	**PA**
Aborts Pulsed Spot Measurement	**AB**

PULSED SWEEP MEASUREMENTS

Connects/disconnects Output Switches	**CN, CL**
Pulsed V Sweep Source Setup	**PWV**
Pulsed I Sweep Source Setup	**PWI**
Pulsed Source Timing Setup	**PT**
Filter Setup	**FL**
Sets Output Polarity	**POL**
Measurement Mode Setup	**MM**
Trigger	**XE**
Sets Output Voltage to 0 V	**DZ, IN**
V/I Measurement Range Setup	**RV, RI**
Trigger Mode Setup	**TM**
Output Data Format Setup	**FMT**
Automatic Sweep Abort Function Setup	**WM**
Constant V/I Source Setup	**DV, DI, POL**
Waits time	**PA**
Aborts Sweep Operation	**AB**

STAIRCASE SWEEP WITH PULSED BIAS MEASUREMENTS

Connects/disconnects Output Switches	**CN, CL**
V Sweep Source Setup	**WV**
I Sweep Source Setup	**WI**
Pulsed V Source Setup	**PV**
Pulsed I Source Setup	**PI**
Pulsed Source Timing Setup	**PT**
Filter Setup	**FL**
Sets Output Polarity	**POL**
Measurement Mode Setup	**MM**
Trigger	**XE**
Sets Output Voltage to 0 V	**DZ, IN**
V/I Measurement Range Setup	**RV, RI**
Trigger Mode Setup	**TM**
Output Data Format Setup	**FMT**
Automatic Sweep Abort Function Setup	**WM**
Constant V/I Source Setup	**DV, DI, POL**
Waits time	**PA**
Aborts Sweep Operation	**AB**

2CH PULSED SPOT MEASUREMENTS

Connects/disconnects Output Switches	**CN, CL**
Pulsed V Source Setup	**PV, PDV**
Pulsed I Source Setup	**PI, PDI**
Pulsed Source Timing Setup	**PT**
Primary Pulsed Source Setup	**PDM**
Filter Setup	**FL**
Measurement Mode Setup	**MM**
Trigger	**XE**
Sets Output Voltage to 0V	**DZ, IN**
V/I Measurement Range Setup	**RV, RI**
Trigger Mode Setup	**TM**
Output Data Format Setup	**FMT**
Constant V/I Source Setup	**DV, DI, POL**
Waits time	**PA**
Aborts Pulsed Spot Measurement	**AB**

PULSED SWEEP WITH PULSED BIAS MEASUREMENTS

Connects/disconnects Output Switches	**CN, CL**
Pulsed V Sweep Source Setup	**PWV**
Pulsed I Sweep Source Setup	**PWI**
Pulsed V Source Setup	**PDV**
Pulsed I Source Setup	**PDI**
Pulsed Source Timing Setup	**PT**
Primary Pulsed Source Setup	**PDM**
Filter Setup	**FL**
Measurement Mode Setup	**MM**
Trigger	**XE**
Sets Output Voltage to 0 V	**DZ, IN**
V/I Measurement Range Setup	**RV, RI**
Trigger Mode Setup	**TM**
Output Data Format Setup	**FMT**
Automatic Sweep Abort Function Setup	**WM**
Constant V/I Source Setup	**DV, DI, POL**
Waits time	**PA**
Aborts Sweep Operation	**AB**

ANALOG SEARCH MEASUREMENTS

Connects/disconnects Output Switches	**CN, CL**
Search SMU Setup	**ASV**
Sense SMU Setup	**AIV, AVI**
Search Mode Setup	**ASM**
Hold Time and Delay Time Setup	**AT**
Measurement Mode Setup	**MM**
Trigger	**XE**
Sets Output Voltage to 0 V	**DZ, IN**
V/I Measurement Range Setup	**ASV, AIV, AVI**
Averaging Mode Setup	**AV**
Trigger Mode Setup	**TM**
Output Data Format Setup	**FMT**
Constant V/I Source Setup	**DV, DI, POL**
Waits time	**PA**
Filter Setup	**FL**
Aborts Search Operation	**AB**

QUASI-PULSED SPOT MEASUREMENTS

Connects/disconnects Output Switches	**CN, CL**
Quasi-pulsed Source Setup	**BDV**
Hold Time and Delay Time Setup	**BDT**
Specifies Detection Interval and V or I Measurement	**BDM**
Sets Output Polarity	**POL**
Measurement Mode Setup	**MM**
Trigger	**XE**
Sets Output Voltage to 0 V	**DZ, IN**
I Measurement Range Setup	**RI**
Averaging Mode Setup	**AV**
Trigger Mode Setup	**TM**
Output Data Format Setup	**FMT**
Constant V/I Source Setup	**DV, DI, POL**
Waits time	**PA**
Filter Setup	**FL**
Aborts Quasi-pulsed Spot Measurement	**AB**

HIGH SPEED SPOT MEASUREMENTS

Connects/disconnects Output Switches	**CN, CL**
Constant V Source Setup	**DV**
Constant I Source Setup	**DI**
Sets Output Polarity	**POL**
Waits time	**PA**
V Measurement Range Setup and Trigger	**TV**
I Measurement Range Setup and Trigger	**TI**
Sets Output Voltage to 0 V	**DZ, IN**
VM Operation Mode Setup	**VM**
Averaging Mode Setup	**AV**
Output Data Format Setup	**FMT**
Filter Setup	**FL**

TRIGGER

Measurement Mode Setup	**MM**
Trigger Mode Setup	**TM**
Triggers Measurement	**XE**
Triggers High Speed Spot Current Measurement	**TI**
Triggers High Speed Spot Voltage Measurement	**TV**
Waits for External Trigger	**WS, PA**
Outputs Trigger Signal to External Instrument	**OS**
Aborts Wait State	**AB**

PROGRAM MEMORY FUNCTION

Stores Programs	**ST, END**
Executes Programs	**DO, RU**
Lists Programs	**LST?**
Scratches Programs	**SCR**
Waits time	**PA**
Aborts Program Execution	**AB**

SELF-TEST

Executes Self-Test	***TST?**
Error Information	**ERR?**
Aborts Self-Test	**AB**

SELF-CALIBRATION

Performs Calibration	**CA, *TST?**
Auto-Calibration Function Setup	**CM**
Aborts Self-Calibration	**AB**

OUTPUT DATA BUFFER

Clears Output Data Buffer	**BC**
Output Data Format Setup	**FMT**
Number of Output Data in Data Buffer	**NUB?**

STATUS BYTE

Service Request Mask Enable	***SRE**
Service Request Query Command	***SRE?**
Status Byte	***STB?**

MEASUREMENTS WITH EXTERNAL INSTRUMENTS

Outputs Trigger Signal to External Instrument	**OS**
Waits for External Trigger	**WS, PA**
Detects when Operation is Completed	***OPC?**
Measurement Trigger Mode Setup	**TM**
Waits time	**PA**
Aborts Wait State	**AB**
CONTROL Connector Output Setup	**ERC**

QUERY

Error Information	**ERR?**
Model Number and ROM Version	***IDN?**
Plug-in Unit Operation Status	**LOP?**
Plug-in Unit Output and Measurement Settings	***LRN?**
Contents of Program Memory	**LST?**
Number of Output Data in Data Buffer	**NUB?**
Detects when Operation is Completed	***OPC?**
Mask Condition of the Status Byte	***SRE?**
Contents of the Status Byte	***STB?**
Executes Self-Test	***TST?**
Information about Installed Plug-in Units	**UNT?**
Number of Sweep Steps	**WNU?**

CLEAR

Resets the HP 4142B	***RST**
Clears Measurement Unit	**CL**
Clears Output Data Buffer	**BC**
Scratches Programs	**SCR**

WAIT

Waits time	**PA**
Waits for External Trigger	**WS**
Waits for Trigger (Pause/Continue)	**PA, XE, TM**
Aborts Wait State	**AB**

HPSMU/MPSMU

Connects/disconnects Output Switches	**CN, CL**
Constant V/I Source Setup	**DV, DI**
Sets Output Voltage to 0 V	**DZ, IN**
Filter Setup	**FL**
Sweep V/I Source Setup	**WV, WI, WSV, WSI**
Pulsed V/I Source Setup	**PV, PI, PDV, PDI**
Pulsed Sweep V/I Source Setup	**PWV, PWI**
Search/Sense SMU Setup	**ASV, AVI, AIV**
Quasi-pulsed Source Setup	**BDV**
High Speed Spot Measurement Trigger	**TV, TI**
Measurement Channel Setup	**MM**
I Measurement Range Setup	**RI**
Averaging Mode Setup	**AV**

HCU

Connects/disconnects Output Switches	**CN, CL**
Pulsed V/I Source Setup	**PV, PI, PDV, PDI**
Pulsed Sweep V/I Source Setup	**PWV, PWI**
Primary Pulse Channel Setup	**PDM**
Measurement Channel Setup	**MM**
I Measurement Range Setup	**RI**
High Speed Spot Measurement Trigger	**TV, TI**

HVU

Connects/disconnects Output Switches	**CN, CL**
Sets Output Polarity	**POL**
Constant V/I Source Setup	**DV, DI**
Sets Output Voltage to 0 V	**DZ, IN**
Filter Setup	**FL**
Sweep V/I Source Setup	**WV, WI, WSV, WSI**
Pulsed V/I Source Setup	**PV, PI**
Pulsed Sweep V/I Source Setup	**PWV, PWI**
Quasi-pulsed Source Setup	**BDV**
High Speed Spot Measurement Trigger	**TV, TI**
Measurement Channel Setup	**MM**
I Measurement Range Setup	**RI**
Averaging Mode Setup	**AV**

VS

Connects/disconnects Output Switches	**CN, CL**
Constant V Source Setup	**DV**
Sets Output Voltage to 0V	**DZ, IN**
Sweep V Source Setup	**WV, WSV**
Pulsed V Source Setup	**PV**
Pulsed Sweep V Source Setup	**PWV**
I Measurement Trigger	**TI**

VM

VM Operation Mode Setup	**VM**
High Speed Spot Measurement Trigger	**TV**
Measurement Channel Setup	**MM**
V Measurement Range Setup	**RV**
Averaging Mode Setup	**AV**

AFU

Search Mode Setup	**ASM**

NOTES

APPENDIX D

COMMAND SYNTAX LIST

AB
AIV ch#, output current, target voltage [, V compliance]
ASM search operation mode, search measurement mode [, feedback integration time]
search operation mode:
1: negative feedback search (initial)
2: positive feedback search
3: ramp wave search (greater than target)
4: ramp wave search (less than target)
search measurement mode:
1: search SMU V measurement (initial)
2: search SMU I measurement
3: search SMU V and sense SMU V or I measurement
4: search SMU I and sense SMU V or I measurement
feedback integration time: 0.5E-6 to 450E-3 (default: 5E-3s)
ASV ch#, search start voltage, search stop voltage [, ramp rate] [, I compliance]
ramp rate: 0.5 to 100E+3 (default: 500V/s)
AT hold time, delay time
AV averaging number [, averaging mode]
averaging mode: 0: Auto (initial, default), 1: Manual
AVI ch#, output voltage, target current [, I compliance]
BC
BDM detection interval [, V/I measurement]
detection interval: 0: Short (initial), 1: Long
V/I measurement: 0: V measurement (initial, default), 1: I measurement
BDT hold time, delay time
BDV ch#, output range, start voltage, stop voltage [, I compliance]
CA [slot#]
CL [ch#] [, ch#] [, ch#] [, ch#] [, ch#] [, ch#] [,ch#] [, ch#]
CM auto calibration
auto calibration: 0: OFF, 1: ON (initial)
CN [ch#] [, ch#] [, ch#] [, ch#] [, ch#] [, ch#] [,ch#] [, ch#]
DI ch#, output range, output current [, V compliance] [, compliance polarity mode]
compliance polarity mode: 0: Auto (default), 1: Manual
DO program# [, program#] [, program#] [, program#] [, program#] [, program#] [, program#] [, program#]
DV ch#, output range, output voltage [, I compliance] [, compliance polarity mode]
DZ [ch#] [, ch#] [, ch#] [, ch#] [, ch#] [, ch#] [,ch#] [, ch#]
END
ERC control mode, control value [, dry switching]
control mode: 1: Module Selector, 2: 16 bits
control value:
for control mode = 1: 0: No unit (initial), 1: SMU, 2: HVU, 3: HCU
for control mode = 2: 0 (initial) to 65535 (specified bits = LOWs)
dry switching: 0: on (default), 1: off
ERR?
FL filter [, ch#] [, ch#] [,ch#] [, ch#] [, ch#] [, ch#] [, ch#] [, ch#]
filter: 0: OFF, 1: ON (initial)

FMT output data format [, output data mode]

output data format:

1: ASCII data format with header; terminator (CR/LF^EOI). (initial)

2: ASCII data format without header; terminator (CR/LF^EOI).

3: Binary data format; terminator (CR/LF^EOI).

4: Binary data format; terminator (^EOI).

5: ASCII data format with header; terminator (,).

output data mode:

0: Source data is not output. (initial, default)

1: Primary sweep source data is output with sweep measurement data.

2: Secondary sweep source data is output with synchronous sweep measurement data.

***IDN?**

IN [ch#] [, ch#] [, ch#] [, ch#] [, ch#] [, ch#] [, ch#] [, ch#]

LOP?

***LRN?** type

LST? [program#]

MM measurement mode, ch# [, ch#] [, ch#] [, ch#] [, ch#] [, ch#] [, ch#] [, ch#]

measurement mode:

1: Spot

2: Staircase sweep

3: 1ch pulsed spot

4: Pulsed sweep

5: Staircase sweep with pulsed bias

6: Analog search

7: 2ch pulsed spot

8: Pulsed sweep with pulsed bias

9: Quasi-pulsed spot

NUB?

***OPC?**

OS

PA [wait time]

PDI ch#, output range, base current, pulse current [, V compliance]

PDM ch#

PDV ch#, output range, base voltage, pulse voltage [, I compliance]

PI ch#, output range, base current, pulse current [, V compliance]

POL ch#, output polarity

output polarity: 0: +, 1: -

PT hold time, pulse width [, pulse period]

pulse width: 100E-6 to 50E-3 (initial: 1E-3s)

pulse period: 0, 10E-3 to 500E-3 (initial: 10E-3s, default: 0)

PV ch#, output range, base voltage, pulse voltage [, I compliance]

PWI ch#, sweep mode, output range, base current, start pulse current, stop pulse current, number of steps [, V compliance]

sweep mode: 1: linear sweep (single stair), 3: linear sweep (double stair)

PWV ch#, sweep mode, output range, base voltage, start pulse voltage, stop pulse voltage, number of steps [, I compliance]

RCV slot#

RI ch#, I measurement range

***RST**

RU start program#, stop program#

RV ch#, V measurement range

RZ [ch#] [, ch#] [, ch#] [, ch#] [, ch#] [, ch#] [, ch#] [, ch#]

SCR [program#]

***SRE** bit

***SRE?**

ST program#; [command;] [command;] ... [command;] END
***STB?**
TI ch# [, I measurement range]
TM trigger mode
trigger mode:
1: XE & TRIGGER, 2: XE, 3: XE & External trigger signal, 4: XE & MM
***TST?** [slot#]
TV ch# [, V measurement range]
UNT? [mode]
VM ch#, VM operation mode
VM operation mode: 1: Grounded, 2: Differential
WI ch#, sweep mode, output range, start current, stop current, number of steps [, V compliance] [, power compliance]
sweep mode:
1: linear sweep (single stair)
2: log sweep (single stair)
3: linear sweep (double stair)
4: log sweep (double stair)
WM automatic sweep abort function [, output after sweep]
automatic sweep abort function: 1: OFF(initial), 2: ON
output after sweep: 1: Start value (initial, default), 2: Stop value
WNU?
WS [waiting mode]
waiting mode:
1: Continue if trigger was already received.
2: Wait for next trigger.
WSI ch#, output range, start current, stop current [, V compliance] [, power compliance]
WSV ch#, output range, start voltage, stop voltage [, I compliance] [, power compliance]
WT hold time, delay time
WV ch#, sweep mode, output range, start voltage, stop voltage, number of steps [, I compliance] [, power compliance]
XE

output range, or *measurement range:*

For Voltage Range	*For Current Range*
0: Auto	*0: Auto*
10: 0.2V range fixed	*11: 1nA Ltd Auto*
11: 2V Ltd Auto	*12: 10nA Ltd Auto*
12: 20V Ltd Auto	*13: 100nA Ltd Auto*
13: 40V Ltd Auto	*14: 1μA Ltd Auto*
14: 100V Ltd Auto	*15: 10μA Ltd Auto*
15: 200V Ltd Auto	*16: 100μA Ltd Auto*
16: 500V Ltd Auto	*17: 1mA Ltd Auto*
17: 1000V Ltd Auto	*18: 10mA Ltd Auto*
	19: 100mA Ltd Auto
	20: 1A Ltd Auto
	21: 10A Ltd Auto

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