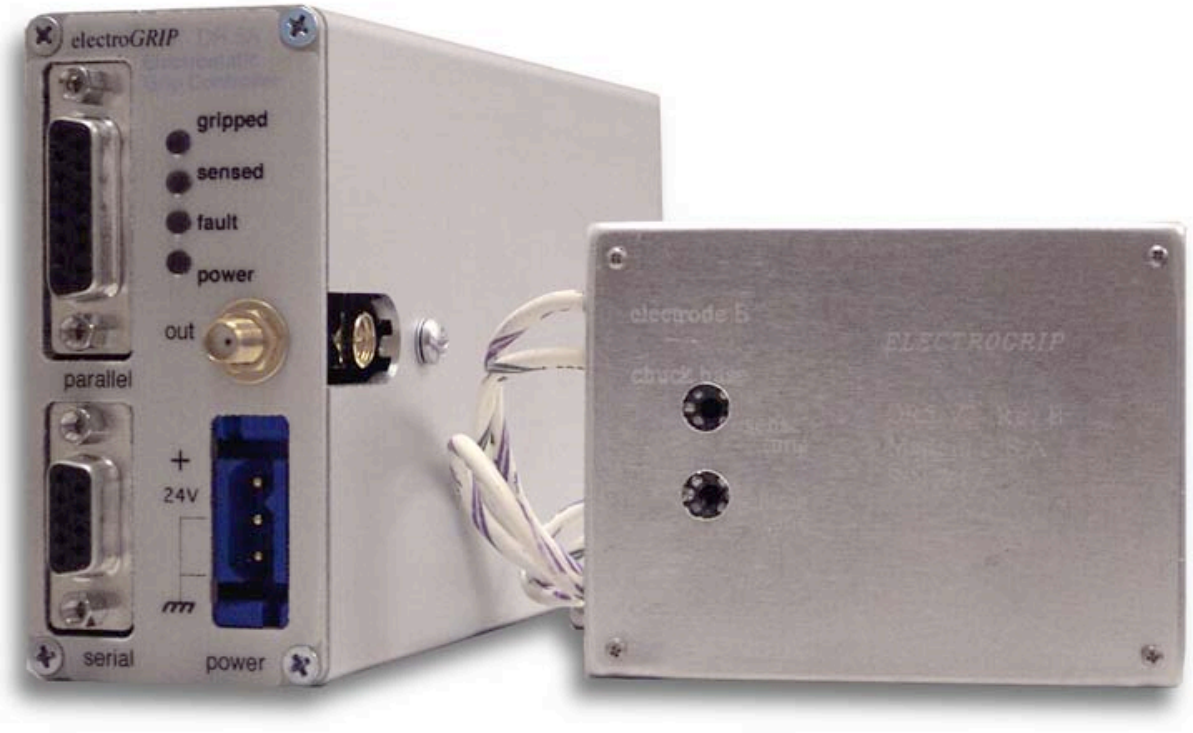
INSTALLATION AND OPERATION MANUAL

ELECTROSTATIC

DRIVER

DR5



ELECTROGRIP

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LIABILITY. Although all care is taken to ensure stated, safe, and reliable performance, Electrogrip can not be held liable for any direct or consequential damages arising from the use or abuse of this equipment. Detailed descriptive, hazard and use data is provided with each unit. Proper operating and safety procedures must be followed and reasonable care must be taken by the user to avoid hazards.

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All warranty replacement or repair of parts shall be limited to equipment malfunctions which, in the sole opinion of Electrogrip, are due or traceable to defects in original materials or workmanship. Malfunctions caused by abuse or neglect of the equipment are expressly not covered by this warranty. One particular such abuse is accessing, attempting to read, or reading the drive unit microcode.

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For additional assistance, contact Electrogrip or its authorised agent.

ELECTROSTATIC DRIVER

DR5

This manual refers to Electrogrip Model DR5 Electrostatic Drivers
using DR5A v12 and DR5V v612 software with serial numbers 5400 and higher

for use with
Electrostatic Chucks and End Effectors
compatible with
System Controller GC2

Revision _5.1_ April / June 2005

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OPERATIONAL SAFETY

INPUT POWER, INTERLOCKS

Before applying power to the DR5A unit, ensure that your power input voltage is appropriate. The allowable input voltage range is 18-35V (nominal 24V) dc, 3A maximum. An optional power pack available from Electrogrip permits ac line voltages to be employed. The DR5 driver is protected against internal faults and reverse polarity power input with a self-resetting "fuse" element and is filtered against rfi emissions.

Two **interlocks** are provided to assure safety since the DR5V unit outputs reach high voltages. Both are provided on the DB-15 parallel port connector.

One interlock is absolute, since opening it interrupts the main power to the DR5. Restart is then slowed by the microprocessor startup sequence. This interlock is shipped internally bridged by a jumper on the DR5A unit, visible in the open space to the side of the male SMA output connector. If this jumper is removed, the absolute interlock connections on the DB-15 connector must be made to permit power-up. An emergency-off switch would control this interlock.

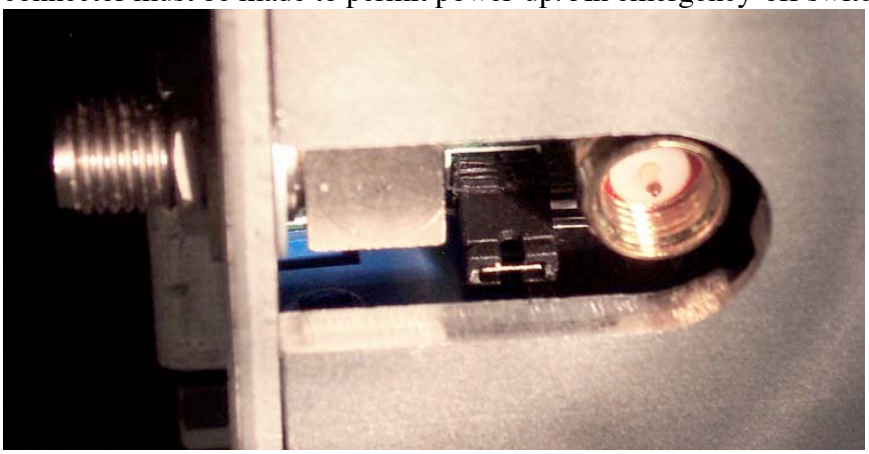


Figure 1. DR5A unit; detail view of absolute interlock jumper.

The second software interlock permits setup of sense levels, communications, and all other system checks except for high voltage output. An interlock switch closure or signal from a control computer must be provided to enable the high voltage DR5-V unit output. This interlock must be arranged to cut high voltage output when driver output terminals may be exposed. For example, high-voltage access plates should actuate a switch in this interlock line.

HIGH VOLTAGE CAUTIONS

Operation must be in accordance with instructions given here and with normal safety practices for high voltage systems.
VOLTAGES of up to **20,000VDC** ACROSS THE OUTPUT TERMINALS are present.
Maintenance and servicing must be done by qualified personnel only.
This device generates high voltages when the absolute (drive power) and software (high voltage) interlocks are enabled.
These high voltages are present on the outputs during wafer grip and **after** wafer release.
HIGH DC BIAS and RF POWER VOLTAGES ARE PRESENT ON THE OUTPUT CONNECTIONS WITH RF-POWERED CHUCKS.

GENERAL INFORMATION

DESCRIPTION

The Electrogrip DR5 Electrostatic Driver comprises two basic units; a DR5V high voltage module, and a DR5A control and power module, connected via an SMA coaxial cable and various styles of isolating or nonisolating coupler, as required by the application.

Figure 2. DR5A control and power module, with DR5V high voltage output module.

The DR5V contains computer-controlled high-voltage low-current power supplies for charging electrodes of electrostatic gripping systems. Such systems are used to hold delicate substrates for semiconductors, liquid crystal displays, thin film heads, etc. Bipolar or monopolar output voltages from <±100V to ±10kV are available. The DR5A and DR5V Driver set is used in conjunction with electrostatic chucks and robot end effectors and interfaces directly with the Electrogrip GC3 Gas Controller for electrostatic temperature controlling chucks. Operation is controlled through a parallel or serial interface. There are no manual switches. Setup programming may be performed using a computer terminal or the Electrogrip DS1 Handheld Terminal.

A data scanner - I/O module can be connected to the DR5V for isolated multi-channel telemetry of gripper parameters and for drive of low-power actuators or sensors. Examples of monitored parameters would be pressure, temperature, and substrate current flow. This module operates on the SPI™ high-speed peripheral interface bus system.

[SPI is a registered trademark of Motorola]

The DR5 driver is extensively filtered on both inputs and outputs to minimise the corrupting effects of rf radiation and pickup. The completely separated design of the DR5 components permits extreme levels of isolation between the DR5V gripper electronics, and the DR5A control and power module. The DR5V contains the computer-controlled substrate sensing and chuck powering electronics, and is mounted close to the electrostatic gripper for the best substrate sensing accuracy. If potted (an available option), it may be mounted in room-temperature vacuum chambers due to its small size, metal case, absence of electrolytic capacitors (hence low outgassing and long life), and low power consumption of about 300mW. Communications and power are transmitted between the DR5V and DR5A modules using ferrite core transformers or rotary couplings. Light or microwave beam communication and powering may be used for higher isolation levels.

An example of remote mounting would be if the DR5V module were mounted at a robot end effector, using rotary motion, linear motion, and vacuum feedthrough power couplers between it and the DR5A. In this case, 3 or 4 chained couplers transmit signals between the units; no direct connection between the DR5 modules is required. Such couplers are approx. 25mm diameter and would mount concentrically with joint bearings. Couplers of smaller size such as 15mm diameter are available for more constrained applications.

Because the DR5V chuck drive module is isolated, it is possible to mount it inside or directly underneath an rf chuck, maintaining the DR5V at rf potential. This eliminates the need for rf filters between a chuck and its drive, and permits operation over a wide frequency range without filter changes. A BD5 coupler, or a DR5VI unit combining the DR5V output unit and a coupler, is normally required for rf applications.

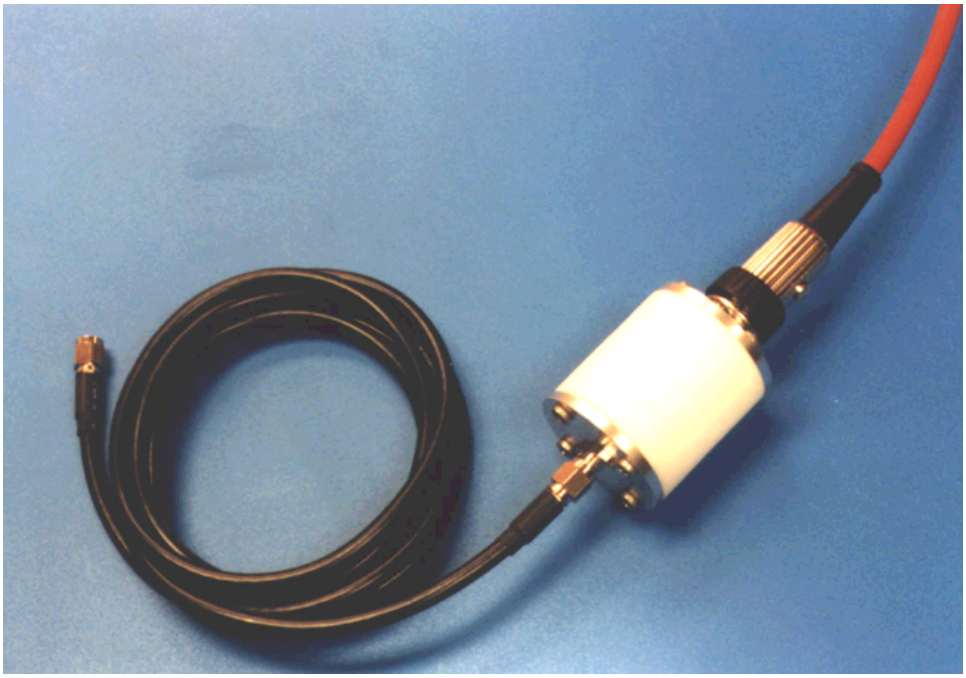


Figure 3. BD5 coupler for rf applications.

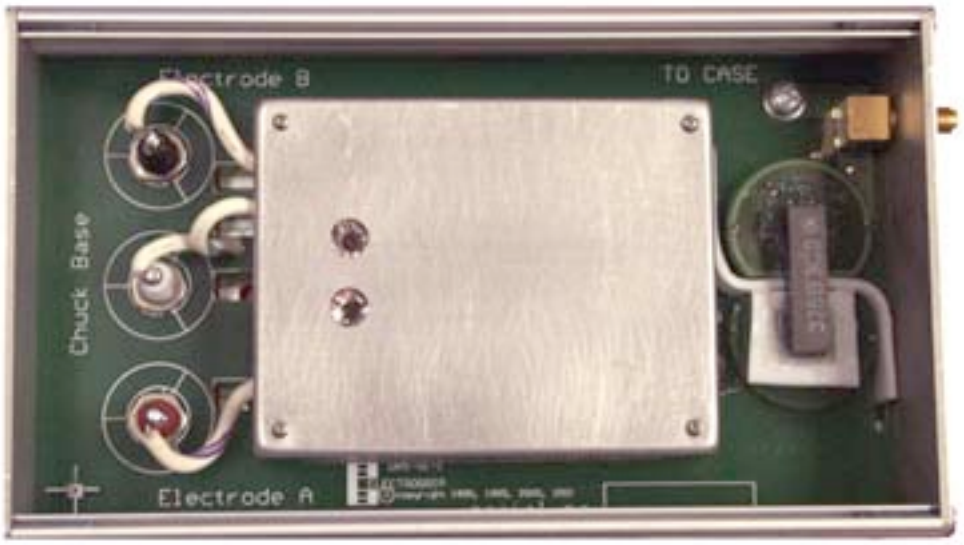


Figure 4. DR5VI rf chuck drive unit with integrated DR5V and coupler; interior view. A fan may be installed at the bottom right hand side for higher output voltage, high duty factor units.

The DR5V high voltage output unit generates symmetric bipolar outputs which may be used to drive monopolar or bipolar grippers. The rate of change of these voltages is controlled to attain the highest operating speed while maintaining low across-wafer voltages to avoid device damage. Substrate position relative to the gripping device surface is sensed through accurate capacitance measurement on one of the electrodes. This position is output via both a logic on/off signal denoting substrate presence, and serial data strings providing a numerical measure of the wafer location. Control outputs and inputs, some of which are user-definable, are provided to assist safe and reliable robotic operation of the entire system incorporating the electrostatic gripper.

Charge buildup on gripper surfaces which would otherwise yield unreliable grip and release of substrates is negated and even extracted by the DR5 using patented adaptive grip and release routines. Option and parameter values can be entered for the level and style of this charge control, permitting optimal control with a wide variety of chuck surface types.

Electrogrip's adaptive charge control system uses rapid, high-sensitivity substrate-chuck capacitance measurements based upon an approximately 1MHz sensing signal. Because of this high frequency, glasses and semi-insulating GaAs substrates can be sensed with similar sensitivity to that available from more conductive substrates such as Si or doped GaAs. The high inherent sensitivity is most effective if lead lengths between the DR5V and the gripper are kept short to minimise environmentally induced sense signal variation. The 1MHz internal DR5 operating frequency can be altered upon special order if chuck or gripper rf excitation is anticipated in the 1MHz range, to avoid unpredictable sense and logic system interactions.

The DR5 driver software performs automated self-calibration functions which assist both with rapid installation, and with compensation of long-term drift effects.

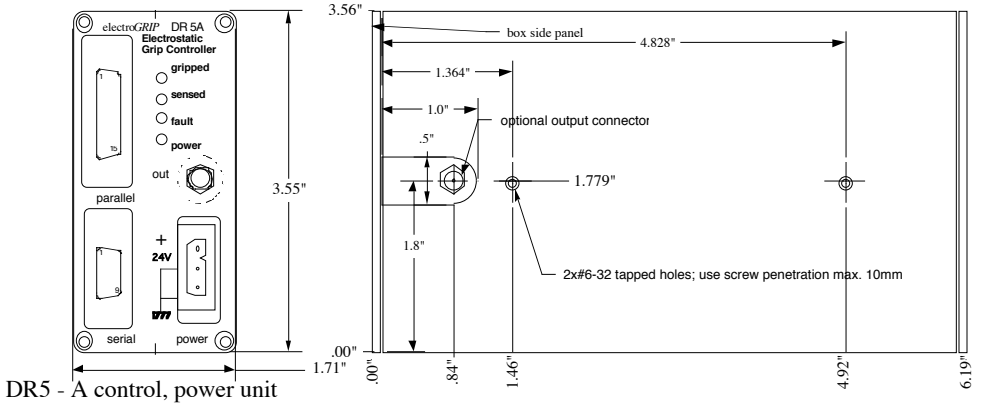
For charged particle lithography and electron beam inspection systems, DR5 drivers permit substrate sense signals to be turned off during wafer grip, as a user-programmable option.

Earlier DR5 models used an 8MHz sense signal, for which some tuning was required. These later 1MHz units automatically compensate for any wiring, chuck style, or chuck size.

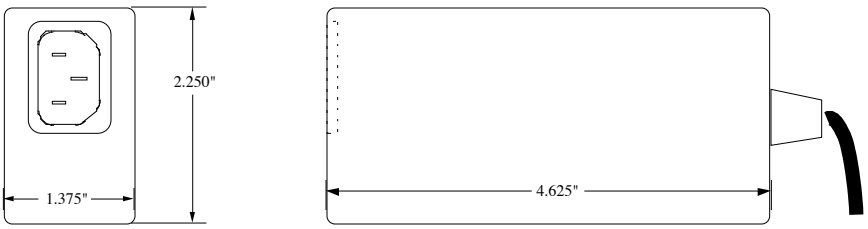
PANEL LAYOUTS

Fig. 5. DR5A connector panel and side mounting face.

The DR5A may be mounted in a controls rack remote from the gripper assembly, or close to the gripper such as on the side of an rf shield enclosure. In the latter case the mounting face male SMA connector would be used to connect to a coupler, thence to the DR5V unit. Mount hole positions match those of the Electrogrip BD2 and BD3 Bias Decoupler. Dimensions are shown below for the DR5A and for its optional available power pack with universal ac line voltage input.



DR5 - A control, power unit



DR5 pwrpack1

Fig. 6. ..... DR5A control, power unit and DR5 pwrpack1 dimensions.

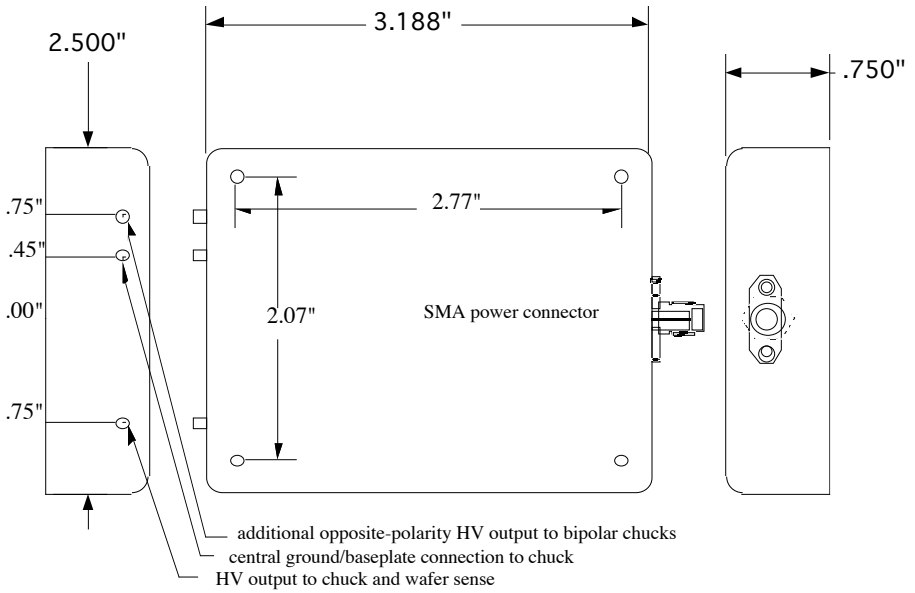


Fig. 7..... DR5V case dimensions with optional SMA connector on side.

The DR5V is available as a free unit (Fig. 7), in the DR5VI case (Figs. 4, 8), or in a chuck body, and may be powered from a side SMA connector, from free wires soldered on bottom face terminals, or through a magnetic coupling on the bottom face.

Output electrode high voltage and gripper baseplate connections are made using flexible silicone-insulated wires. For critical UHV systems such as EUV chucks, other more compatible materials are provided with an approved low-outgassing potting material. In case of monopolar chuck drive, use the high voltage wire labelled as a wafer sense connection (lowest wire in the above Fig. 7). For multipolar chucks connect each alternate electrode to one of the high voltage outputs, forming in practice a bipolar chuck. Substrate presence is monitored over all of the chuck electrodes in a bipolar or multipolar chuck, but is more sensitive to substrate movements over the electrode directly connected to the sensing wire.

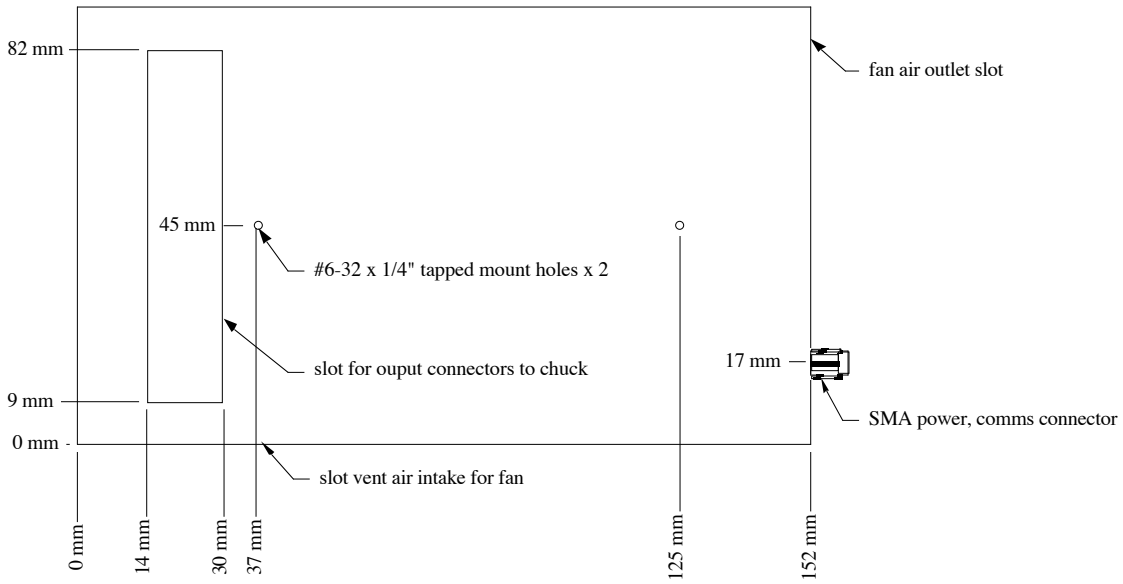


Fig. 8 DR5-VI case connection diagram

INSTALLATION

INTRODUCTION

This section of the manual describes initial setup and operation of the DR5 driver.
Additional information required for setup will be found in the following section for connector pin wiring, in the programming section, and in your chuck / end effector instructions.

UNPACKING

In your package you should find:

(i) Driver unit DR5A
(ii) Power connector components for DR5A
(iii) DB15M connector for rear panel control and interlock connections
(iv) SMA connector cable, 2m length. Other lengths may be obtained through cable joints or special order; and
(v) Either • Driver unit DR5V with power coupler BD5 or similar;
or • DR5VI unit with integral power coupler;
or • DR5V unit mounted into a chuck, with integral power coupler.

INSTALLATION TOOLS

You will require the following items for installation:

(i) Attachment hardware for mounting DR5 into rack or other enclosure.
(ii) Interlock cable from • switch on high voltage wiring enclosure;
OR • computer interlock line (hi for safe, lo for open / unsafe).
This cable connects to the interlock pin(s) on the DB15 connector.
(iii) Modem cable from DR5 serial output to terminal or computer,
OR Electrogrip DS1 handheld terminal with its connection cable;
(iv) Optional absolute interlock wiring, taken to the DB15 connector (see Operational Safety section Fig. 1, and Connection diagram Fig. 10).
(v) Capacitance meter with 2 / 20nF ranges (possibly required for wiring, chuck debug).

MOUNTING, CONNECTIONS

(i) Mount DR5A and DR5V. Ensure system input voltage is in correct ~24V range for DR5A, and that DR5V is connected to gripper electrodes. The interlock jumper in Fig. 1 must be removed or left in place at this time, depending on your interlocks.
• For all types of grippers or chucks, the DR5V should be mounted rigidly and close to the chuck for best sensing stability. The coupler provided with your unit may be isolated if a motion or rf interface is required; or nonisolated if no isolation is required, and is mounted in between the DR5V and DR5A. The DR5VI integrates the coupler and DR5V. An SMA cable connects the coupler and DR5A.
• For rf chucks using a DR5VI, the VI unit must be attached to a side of the match network/rf shield enclosure under the chuck. Chuck electrode lines must be connected to the red and black sockets; the chuck baseplate (rf) to the central white socket.
• An unenclosed DR5V unit must be attached on an Al metal baseplate, thence to an rf electrode connected to the base of the chuck, with a BD5 coupler connected between the DR5V and an SMA cable going to the DR5A. The DR5V can operate over an internal temperature range of 0-60°C at full rated output. Temperature monitoring is performed through a telemetered temperature sensor in the DR5V case.

(ii) Attach SMA cable from DR5A output to the DR5V coupler.

SETUP

(i) Connect the Electrogrip DS1 handheld terminal or a terminal emulator to the serial port connection on the DR5A.
(ii) Ensure that the interlock jumper in Fig. 1 is in place, or that the interlock connection

required is bridged (DB15, pins 11 and 12).

(iii) DO NOT yet attach interlock wiring on DB15 connector pins 4, 5. This enables setup without high voltages present.

(iv) Plug in the DR5A power cable. This energises all but the high voltage output.
• Check that a single dot is shown (earlier models had two dumps of parameter settings). With HV interlock disabled, this will be announced. When the HV interlock is enabled, there will be a "wait" signal for system self-calibration and zeroing, as shown in the Programming section of this manual.
• If there is no output, after about 20 secs the DR5A should display a "V unit not responding" message with the DR5A software version number. The SMA cable connections should be checked.
• If messages are seen, then the power LED goes out, look for a power short in the DB15 connector, causing the internal DR5A self-resetting fuse element to open the power line.

OUTPUT VOLTAGE LEVEL CHECK
The output level setting should be checked to avoid chuck destruction.
The voltage BETWEEN the outputs is DOUBLE the single-channel values described.

(i) **Disconnect** the red and black wires to the chuck from the DR5-VI or DR5-V output.

(ii) Observe the high voltage output monitor numbers on the main menu display; Va80b80 means Va is 80, Vb is 80. In our display format, 80 is central and means outputs are zero.

(iii) Enable high voltage. Fault light should turn off. A "deadband setting" process begins, then the unit is ready for action. Va, Vb should be between 7F and 81.

(iv) Cause grip, either using the parallel port wires or with Control-G on the terminal. If the wafer sense light is out, the options should have been set to enable grip even without a wafer present.

(v) Check the Va and Vb levels shown on the terminal screen. The outputs are shown as VaXXbYY where "XX" and "YY" are hexadecimal numbers. The higher number is positive, and may be either Va or Vb. The lower number is negative.
[For the earlier DR5-V3 versions one bit was ~40V, and for the DR5-V2 versions (with max. 5kV output one bit was ~80V]. In current versions, one bit is calibrated to indicate 100V with approx. 2% full scale accuracy. Thus for current DR5V units:

Va/Vb		Output
88 / 78		≡ ± 0.8kV
90 / 70		≡ ± 1.6kV
A0 / 60	≡	± 3.2kV
B0 / 50		≡ ± 4.8kV

(vi) To alter the output voltage, set the parameter "MaxOutVoltage" to the required value in hexadecimal volts and wait for it to stabilise. Some imbalance in output voltage may be observed between the two channels, and is normal if in a 10% range. Higher imbalances may indicate output leakage currents which should be eliminated. The DR5V controls the average output voltage to be correct within 2 digits, up to its output current limits.

(vii) Interlock check: With the correct output level obtained on the Va and Vb display, break the interlock connection. Check red Fault light is on, "interlock open" is displayed and that the system restarts. Observe that a Va80b80 (zero output voltage) display results.

(viii) Reconnect the red and black wires to the chuck. Close the interface enclosure and re-enable the high voltage interlock.

SUBSTRATE SENSE SETUP
(i) Observe the wafer sense light on the front panel. This light will go on when a substrate is on the gripper, and off when the substrate is taken off, after adjustment of settings.

(ii) You should at least see that the "Sense" level (on the top line of the serial display output) changes when the substrate is put on and off, confirming connection to the gripper. The least significant digits of the sense signal will exhibit noise; this is normal.

If you do not observe some change with substrate location, check the wiring by disconnecting the DR5 from the chuck cables. Measure capacitances between each gripper electrode and the gripper baseplate. For this a meter with a capacitance range of 20nF or less will be adequate unless a very large chuck (for example, an LCD panel chuck >1m on its sides) is tested. Roughly equal capacitances on each connection of a bipolar chuck should be seen relative to the baseplate, and this capacitance should change when substrates are placed on the gripper face.

(iii) The sense signal number shown on the "Main Menu" display is a shortened and filtered version of the sensing 1MHz oscillator frequency. The level of shortening from the raw value is determined during the "Learn Wafer" process.

- The raw sense frequency in Hz can be output one time by pressing "P". It is displayed as a hexadecimal number with a point (separating integral from fractional values).

- Press the space bar to toggle on or off a continuous hex display of sense values;
  (a) Shortened in 4 digit format, and;
  (b) Raw in 8 digit format of 5 digits, point, 3 digits (Hz).

(iv) Follow instructions given in the "ADJUSTMENT AND PROGRAMMING" section to "Learn Wafer" sensing levels.

OTHER TESTS
(i) Refer to chuck/end effector instructions for other tests required.
(ii) Confirm that the **interlock** is working; and that **parameter** and **option** settings are correct for your application.

OPERATION

INTRODUCTION

This section describes the DR5 driver panel indicators and connectors. It also provides typical wiring diagrams.

CONTROL PANEL

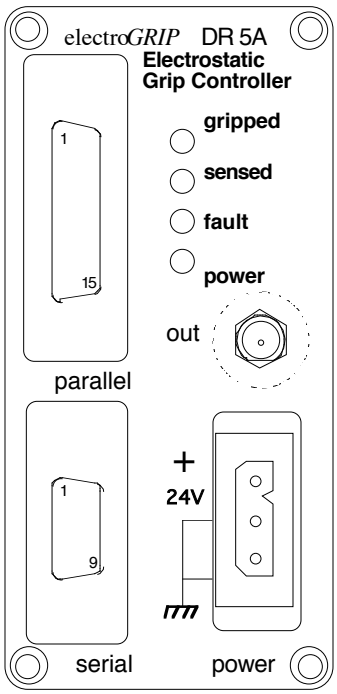


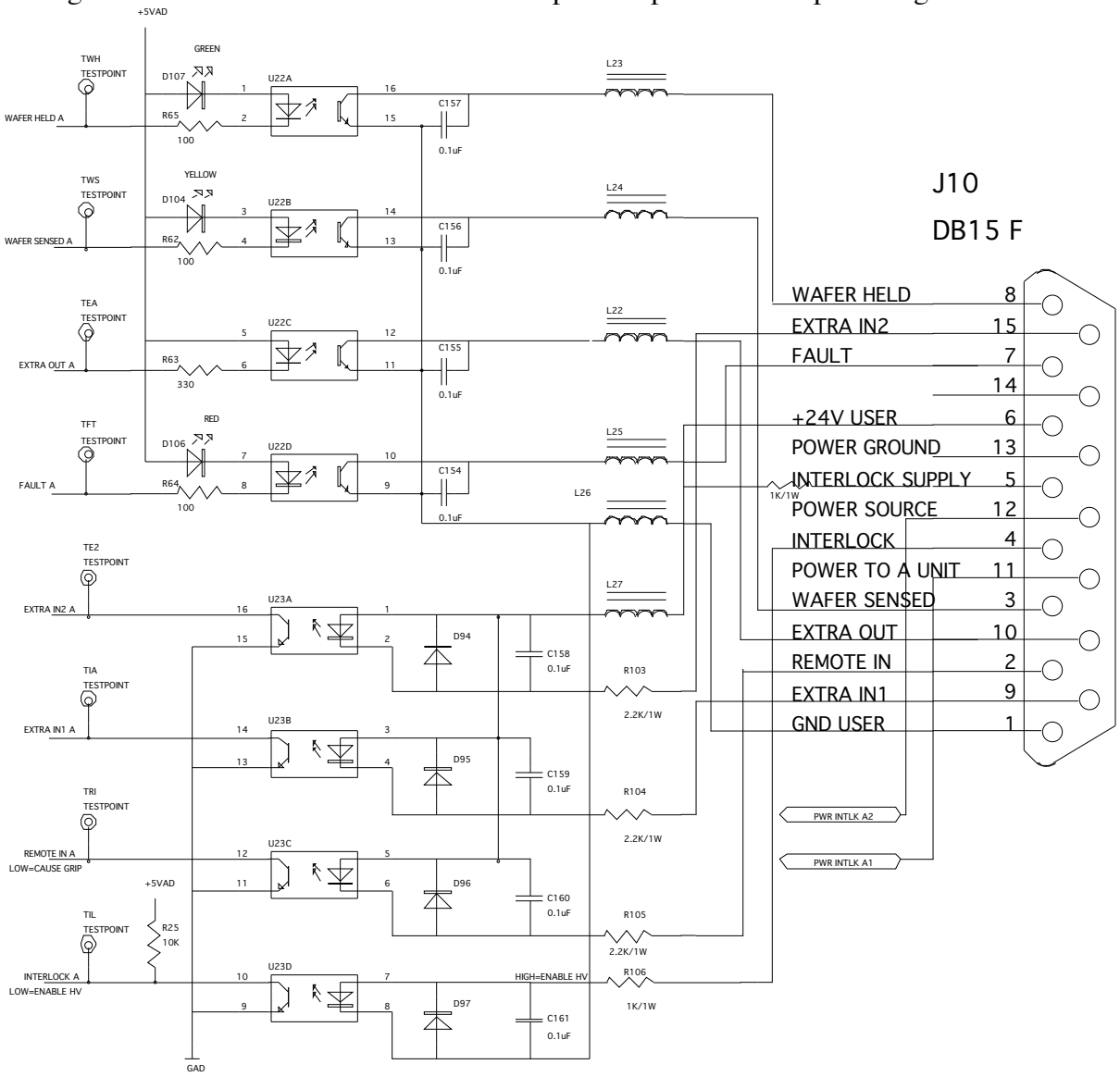
Fig. 9 DR5A control panel

POWER indicator: Lit when input power connector is energised and absolute interlock enabled.
FAULT indicator and output: Energised when "Interlock" input on parallel port pin 4 is low. Disables high voltage output and pulls parallel port pin 7 low when energised.
SENSED indicator: Lit when substrate is present on gripper. Causes low "Wafer Sensed" output on parallel port pin 3 when substrate causes a gripper capacitance rise.
GRIPPED indicator: Lit when wafer grip operation is complete. Off when wafer release operation is complete. Causes low "Wafer Held" output signal on parallel port pin 8.
POWER connector: Dc input power, 24V nominal. Allows case grounding via this connector.
OUT connector: Coaxial SMA female (shown) or SMA male recessed (on side of cabinet). Connects to DR5-V through a DR5-VI or BD-5 or other coupler device. Provides power and communications link to DR5-V.
PARALLEL port connector: DB-15 female. All lines except for the two "Pwr Intlk" absolute interlock pins 11 and 12 are opto-isolated. All outputs are opto-coupler open collector outputs and inputs are opto-coupler LEDs. Logic outputs are open-collector pulldown to Chassis Ground, 80V max. rating.
Inputs are ~2.2kΩ pulldown except for the Interlock (pin 4) which is ~1kΩ pull-up to pin 5 or driven from a logic input; and operate over a range of 5 to 30V.
Input and output circuit power must be provided on pin 6 by the user and could be provided by jumpering to pin 12 unless an isolated +5V to +24V power supply is desired. If this jumpering is chosen, the pin 1 control ground must be connected to the power ground, pin 13.
SERIAL port connector: DB-9 female. NOT isolated from case or power input circuits.

CONNECTIONS

PARALLEL PORT

Wiring is shown below. Refer also to the description of pin use in the preceding subsection.



Parallel Port Connections:

Short pins 11,12 via wire loop or main system safety power NC interlock switch (if present).
If J4 jumper (visible in side slot) is installed, pins 11,12 need not be shorted.
Connect pin 6 to logic power (+5V to +24V), 1 to logic ground to enable parallel port input control functions.
....*IF ISOLATION NOT REQUIRED*; connect pin 6 to power source (pin 12) and pin 1 to power ground (pin 13).
Short pins 4,5 via high voltage NC interlock switch to enable high voltage output; or take pin 4 high.
All outputs are OC pull down, 80V max., 16mA.
To grip using parallel port switching, take pin 2 low or short to ground; to release, take high or open circuit;
....*OR if option is set for pin 9 (EXTRAIN) control;* Grip, pin 9 high/OC; release, low or short to ground.

Fig. 10 Control, Interlock Parallel port connector pins

SERIAL PORT

Wiring to the Serial Port connector is shown below.

If daisy chaining is required to enable control of multiple DR5A units from a single serial line, the first unit must have pin 3 connected to the controlling computer's serial data output, and the final unit must have pin 2 connected to the controlling computer's serial data input. Intermediate DR5A units must have their data outputs (pin 2) connected to the next unit's data input (pin 3). Daisy chain communication follows the protocol described at the end of the "ADJUSTMENT AND PROGRAMMING" section following.

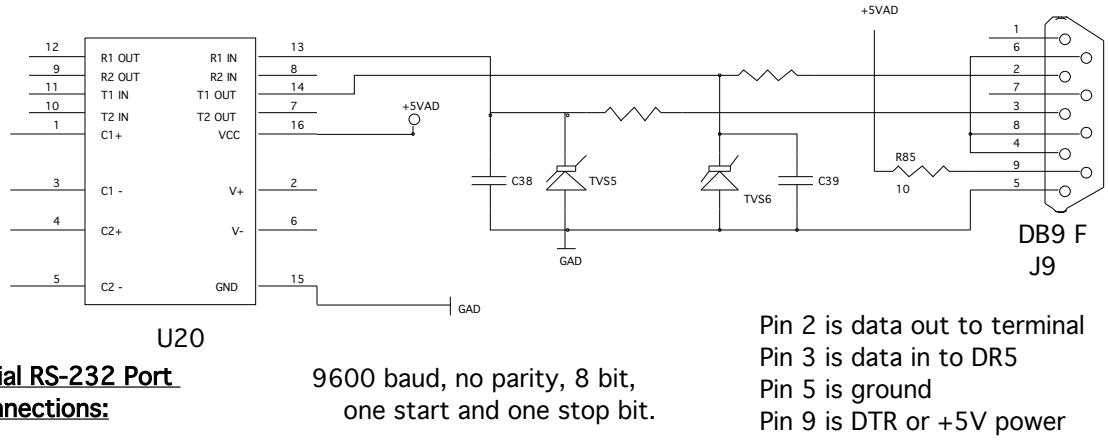


Fig. 11 Serial Port connector pins

DR5V ISOLATION, SPECIAL APPLICATIONS, TELEMETRY

Many coupling styles between the two electronic modules are possible, depending on the desired application, and are available from Electrogrip for nonisolating, rotary, vacuum-air, linear, high voltage, and rf isolation.

There may be a *direct connection* between gripper and control system in cases such as inspection stations where the gripper is in air, at ground potential. In such cases a *nonisolating coupling* device is used to provide impedance matching between the electronic units.

Isolation between the DR5-A control unit and the [gripper / DR5-V] combination is often desired for vacuum-air feedthroughs, rotary or linear motion couplings, and high voltage / rf applications. There may be several isolating couplers in the connection path. For example, a vacuum-air coupling followed by two rotary couplings may be required for a vacuum robot. A single isolating coupling is typically required for rf isolation. For the highest level of isolation such as for ion implantation voltages, an all-optical linkage can be used in place of the magnetic couplers shown in this manual.

The DR5-V unit is mounted in or near a gripping chuck or end effector. The low power dissipation and the absence of electrolytic capacitors permits operation in high vacuum. Units must be specially ordered for vacuum use since the metal case is completely potted and enclosed.

If telemetry is required for datalogging or for control of actuators, a Serial Peripheral Interface (SPI™) bus connection is provided which enables communication with a DAC / ADC or digital I/O chip, permitting low speed telemetry and control of signals such as substrate current, temperature distribution, relay control, pressure sensing, and gas flow. Isolated power and high speed optoisolators yield a telemetry system which is isolated from the local DR5V as well as from the remote DR5A. DR5 telemetry systems available now are; 1 channel, 12 bit analog output; and 8 channel 8 bit analog inputs, and must be special ordered.

[SPI is a registered trademark of Motorola]

ADJUSTMENT AND PROGRAMMING

INTRODUCTION

This section describes how parameters may be monitored and modified using terminal commands to a DR5 driver serial port.

Typical adjustments and parameter settings are:

- Wafer sense levels for wafer position;
- Maximum distance of wafer from gripper that permits gripping to occur;
- Ramp step time for control of wafer backside current levels;
- Release processing methods to minimise residual gripping forces;
- Control of grip performance in case of errors;
- Control of use of alternate types of wafer with different sense characteristics.

Additional functions performed include:

- Monitoring of system status; including power electronics temperature, output voltages and currents, internal drive voltage, and wafer sense signal;
- Full control of the unit on the serial line, permitting; grip, release, output zeroing;
- Storage of operating parameters in user-configurable memory;
- Rapid changeover of operating modes through "Load" and "Dump" functions;
- Learning and tracking shifts in sense levels and output zeroing during operation;
- Delays after grip and before release for sense signal switching (lithographic applications);
- Self-testing of driver functions (factory use only);
- History logging (factory use only);

USER INTERFACE FORMAT

CONNECTIONS

9600 Baud [no parity, 8 bit, 1 stop bit] or ["space" parity, 7 bits, 1 stop bit]. No flow control.
Use a "Modem" DB-9 computer cable / DS1 Electrogrip terminal with an RJ-11/DB9 adapter.

MEMORY TYPES

The DR5 driver contains three types of memory;
(i) program storage
(ii) RAM space for storage of current parameter values;
(iii) an electrically erasable EEPROM for long-term storage of adjustable parameters.
The following user interface information relates to EEPROM and RAM access only.

POWER-DOWN / LOW INPUT POWER ACTION

When "A" Unit is turned OFF, or when input voltage is too low;

```
A MODULE.LOW.12V
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POWER-UP ACTIONS

When the DR5 driver is first powered up it will:
(i) Start the high voltage generator if the high voltage interlock is enabled and zero output levels;
(iii) Display the main menu.

If the DR5V unit is not connected at any time, after about 20 seconds a text message shows;

```
V MODULE NO RESPONSE
ELECTROGRIP
DR5-A2v14(c)2001
```

This line shows the A unit software version.

MENU FORMAT, NAVIGATION

DR5 driver menus consist of four lines that contain numbers, words and questions, with some letters in words capitalised. These capitalised letters are keys for menu navigation.

-**Capitalised letters** in keywords represent keys that can be pressed to call the function or menu corresponding to that keyword.
- Upper or lower case characters are read identically.
-**Two dots** ".." following a menu item indicate that it calls up another menu which will give further choices.
-Because of space limitations not **all possible valid entries** are shown. E.g.:

(i) the X and ESC (escape) keys often cause return to the main menu;

(ii) the "space" key or "spacebar", except when the driver is waiting for numeric input, toggles operation of a "running sense monitor" which displays the DAC value, and both full and compressed sense signal levels. The driver will still take menu selections and mostly will return to the running sense monitor after carrying out other commands.

This sense signal display is turned off by:

- Pressing the spacebar;
- Exit to the main menu (pressing X or ESC);

NUMERICAL FORMAT, NUMBER ENTRY

All values are in HEXADECIMAL format, not DECIMAL. Numbers use base 16, not base 10, and the additional numerals required are letters. Hence allowable numerals are 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, and F. Single-byte (8-bit) numbers have the format 00 to FF (0 to 255 decimal), while double-byte numbers have the format 0000 to FFFF.

-**Numbers are output** with leading $ signs to denote their hexadecimal base.
-Numeric data for parameter adjustment can be **entered** using:

(i) Numbers (hexadecimal format); or

(ii) +, - (plus and minus) keys for fast one-digit changes to any of the parameters.

These changes affect RAM values only. Thus finish with a "Save" to EEPROM when correct parameter values are determined. This "Save" action will save the currently displayed parameter ONLY. Other parameters which have been changed but not individually saved will be lost upon power-down of the DR5 driver.

-To **abort a parameter alteration** in progress, press ESC (Escape) or some other non-numeric key (ie, other than 0-9 or A-F) BEFORE entering a number.

MENU FORMATS

MAIN MENU

This periodically refreshed menu is:

`DAC=$0200Sense=$9247`	*Output, Sense levels*
`(c)05ELECTROGRIP612`	*Software version, copyright*
`I+00-00 Va80b80  T20`	*Currents, Voltages, °C Temp*
`Set.., Dump, Load:`	*Main menu line*

DAC is proportional to the output drive voltage. 200 Hex represents zero output voltage.
Sense is a function of wafer height. The sense number rises as wafer height is increased above the gripper surface, after setup "learning" of the sense system performance.
I+ is the + channel current in μA (hex); **-** for the - channel. Unsigned.
Va, b are the A, B channel output voltages (hex); 80 is zero, higher numbers for positive output, lower numbers for negative output voltage. ±10kV output is typ. FF and 00 for 10kV-capable units (DR5V3 and higher).
T is the DR5V unit circuit board temperature. At room temperature reads 1C to 20 (hex), and at ~100°C reads 64 (hex). At 100°C, an alarm display will be shown every 4 Main Menu cycles, warning of overtemperature.

```
WARNING - HEATSINK
TEMPERATURE IS OVER
100 DEG.C. SHUTDOWN
IS IMMINENT!
```

S = Set.. Calls up another menu for calibrations and setup.
D = Dump (i) Lists all values in RAM, which can be captured and later down-loaded into a driver to give it the identical values of all set parameters and options.
(ii) Then dumps all values from EEPROM into RAM.
L = Load (i) Accepts a down-loaded file and stores it into EEPROM.The data transmission rate should be slowed down some-what because programming occurs in realtime. A delay between characters of 1/10th second yields safe timing.
(ii) Stores into RAM the new Loaded values.

SET MENU

The set menu is:

`Set-parameters.., or`	*detailed parameter setting*
`Options.., or learn-`	*control option setting*
`Wafer, Zero, Balance`	*auto adjust choices*
`or 'X' to eXit:`	*exit to main menu*

S = Set-parameters.., Sets numeric parameter values such as rates or time periods. All parameters may be set using this menu but the methods would be less straightforward than using the auto-setting procedures in the menus below.
O = Options.. Enables/disables control options and external control pins.
L or W = learn-Wafer Automatic setup for a new gripper or wafer type. It will prompt you to take the wafer off and put it back on. During this time it will do various internal calibrations and adjust the setting of the wafer presence indicator. The results are stored into EEPROM.
Z = Zero Zeros the high voltage outputs. Performed also during power-up and occasionally during operation. During normal operation including power-up the zero settings are not stored into EEPROM. However this menu selection will store zero values into EEPROM.
B = Balance Turns on an oscillatory output to assist in checking and balancing the bipolar drive.

SET-PARAMETERS MENU

This menu is:

```
this parameter is                    header line
1 Click= 100Vx$0005                  description of parameter
Next,Back,Alter,Save                 choice of action...
or 'X' to eXit:                      ...or exit to "main"
```

Second line Describes the parameter to be set, with its value being the last item on the line, following the $ (hexadecimal) sign.
See section "PARAMETER DEFINITIONS" for parameter descriptions.

N = Next or <ENTER> Progress to the next parameter. The list wraps around at the end and returns to the first parameter.

B = Back Go to previous parameter. The list wraps around from the list start, going to the last parameter.

A = Alter Modify this parameter IN RAM ONLY. To save to EEPROM use the Save command after modification in RAM.

S = Save Save the value of this parameter now in RAM to EEPROM.

OPTION MENU

The Option menu is of the form:

```
Do you want to
release, if sense is
lost during grip?                    3-line question
Y/N/ENTER? (now YES)                 3 possible responses
```

See the section "OPTION DEFINITIONS" for descriptions of the options.

Three lines ask a question which can be answered Yes or No.

Fourth line prompts for a reply and shows the current state. Enter Y for Yes, N for No, ENTER will leave the answer the way it was previously set and go to the next question.

ESC (escape) OR reaching the end of the option list returns to main menu.

B = Back Back will return to the previous question.

All options get **saved** into EEPROM as you respond to the questions. This will occur EVEN IF YOU ESCAPE out of the list.

OPTION and PARAMETER DEFINITIONS

OPTION DEFINITIONS

Do you want to release, if sense is lost during grip? Rf plasmas can shunt sense signals. Thus for rf chucks, answer NO to hold the wafer while wafer sensing is shunted by the plasma. Sensing will be regained after the plasma is turned off.

Do you want to see debug printouts?
Factory debug aid. You may be asked to energise this option to help us decode resetting problems. Answer NO in general.

Do you want to reduce voltage after grip? Reduces electrode voltages after grip has been attained, limiting charge storage in leaky chucks. Parameter settings determine the time at full voltage and the final reduced voltage.

Do you want to go to zero volts after release? After substrate release has

been attained, electrode voltages are ramped to zero. See the Option below.

Do you want to discharge after release? Relates to electrode voltages going to zero, in above Option. N will ramp steadily, Y adaptively extracts dielectric charge while a substrate is resting on the gripper.

Do you want to use the measured AMP DLY findings? N uses EEPROM parameter value, Y measures value during grip (normal setting).

Do you want to use RELFRACT with sense rather than volts? If N, compares release electrode voltage levels with desired fractional value; if Y, compares release sense levels with desired fractional sense change (resting - grip) value.

Do you want to use the optimized gripping polarity? N will grip according to choice in below options. Y will measure and choose polarity for strongest substrate grip.

Do you want to alternate the gripping polarity? N will use a constant grip polarity, Y alternating (preferred for leaky dielectrics).

Do you want to operate without a wafer sense? Y permits gripping even without a substrate being sensed on the gripper; used for tests.

Do you want to use the EXTRAIN1 signal to grip when high? Y causes parallel port pin #9 (see page 14) to act as a reversed polarity grip/release signal; i.e., grip when pin #9 is high. Pin #2 and the front panel grip/release switch are not active if this option is chosen.

Do you want the EXTRAOUT high when IWARN is met? Y causes pin #10 of the parallel port (see page 14) to go high for at least 30ms when either A or B high voltage output microampere current level meets or exceeds the "I WARN" parameter in the EEPROM SET-PARAMETER settings (see pages 18, 22). Transient currents will thus be registered if the DR5 is polled more frequently than every 30ms.

Do you want to zero when sense is lost after release? Y causes the output high voltages to be zeroed after release, 2 seconds after wafer sense is lost. This assists with chuck surface discharge using plasma or an ioniser.

Do you want a no-wafer signal on the EXTRAIN1 input? Y will force the sense light to go out when EXTRAIN1 is high. Used in cases where sense signals are very small (eg with a very small chuck, and insulating substrates) to reset the sense levels after raising each wafer.

Do you want to turn off sense while gripped? Y causes the sense signal to be turned off while the wafer is held, when the grip command is still active. This can assist with lithgraphic and other applications where the ac noise from the sensing circuit is a problem.

Other options will be added in later versions of the software and you may have custom options for your installation.

PARAMETER DEFINITIONS

Typical numerical values for the parameters are shown below, following the $ (hexadecimal) sign. Single byte variables contain two digits; Double byte variables 4 digits. Some sense values are four bytes (8 digits) long. Single byte variables are shown with a / divider mark between them.

Variables able to be set by user

*MaxOutVoltage=	$0800	Voltage at each output. Double this level appears between the outputs.
Rel Tmax 0.1s	$00C8	Nominal release time; set this to 40 (decimal 64) for 6.4 secs. Controls accuracy of release; longer times yield higher accuracy. If set to zero, causes a simple ramp to zero volts instead of release.
*Amp Delay (ms)	$0100	System time constant. Normally set by program unless Option is so set.
*I Warn/TrpFrac	$2002	Microamp level for warning outputs if "EXTRAOUT" option is set / "Sensed" output trip fraction. Larger TrpFrac values yield trip points closer to the chuck surface.
*RednTime/Ratio	$4003	Time (0.1s increments) before reducing grip voltage to a lower level / Decimal (1 to 9) of grip voltage that is reduced by (03 falls by 30%)
/GrpRmpT 0.1s	$0002	Time to complete a grip ramp, in 0.1 second increments
*Relrpt/Relfrac	$0403	Release ramps permitted while release volts or sense level diff > (grip voltage or sense level diff÷relfrac). / Relfrac.
*RelRmps/RlxMul	$0202	RelRmps = 0 with ReleaseMethod = 1 yields no continued release search RelRmps = 1-F yields longer continued searches for larger numbers / RlxMul not currently used.
*/Init Rel.step	$0014	/ Voltage step size/5 used in release search ramping. 14 yields 100V.
*/ReleaseMethod	$0005	/ 0 older ramp search, 1 point search, 2 successive approx'n, 5 peak.
*OutRider Optns	$0001	/ Serial DAC, ADC, control etc. telemetry board option setting.
*EXCEL P1 ADDR	$011E	debug use only
*EXCEL P2 ADDR	$8200	
*VSMult/S16tvty	$0000	Multiplier for HV effect on sense /4-digit sense place in 8-digit sense
*Deriv/SFN Mult	$0002	Used in Release Method 5
*DschrgD0.1sA/B	$0000	Discharge delay time, 0.1 s. units - from end of release to its report. /B parameter internal use only.
*VoltSnsDacDevn	$0000	DAC bits for voltage start of correction of HV effect on sense
*DacSlowHi/Mid	$0000	Used in Release Method 5
* /DSlLow	$0000	Used in Release Method 5

Variables set under program control during operation

*Off-On Diff.Hi	$00B5	MSB's of raw sense difference betw. substrate off and on
*Off-On Diff.Lo	$B595	LSB's of above
*On-GrpdDiff.Hi	$0006	MSB's of raw sense difference betw. substrate on & gripped
*On-GrpdDiff.Lo	$D098	LSB's of above
*WfrGrpdSns.Hi	$0AC6	MSB's of lowest gripped sense level during Wafer Learn
*WfrGrpdSns.Lo	$0A94	LSB's of above
*SNS16NoiseLevl	$0A1C	Noise level of sense signal, set in Wafer Learn
*Options 'A'	$8090	General operation options, set in Option menu
*Options 'B'	$0899	
*RAW Min./Max.	$405C	Power supply levels for DR5V (factory setting)

SERIAL OPERATION AND EXAMPLES

User commands may be uppper or lower case.

SERIAL COMMANDS

DR5 SERIAL CONTROLS

KEY	PARAMETER SHOWN	OUTPUT [1st:2nd byte] DISPLAY
Cntrl-F	-	turn on/turn off (toggle) forced wafer sensing
Cntrl-G	-	commence gripping
Cntrl-R	-	release wafer
Cntrl-Z	-	zero output voltages
Cntrl-S	-	starts "quiet" mode
Cntrl-X	-	ends "quiet" mode
Cntrl-Y		Details of internal sense values
Cntrl-W	Sense levels exported without comms noise, in spreadsheet format	
P	Wafer sense level (raw & shortened forms on 1 line)	[MSB : LSB], repeated
V	A, B output voltage	[V A channel : V B channel]
I	A, B output current, μA	[I A channel : I B channel]
T	DR5 main heatsink temperature, °C	[- : T]
U	DAC level (output drive)	[MSB : LSB]

```
User command            Response
-----------------------------------
Ctrl+F
                        Forced sense ON!
Ctrl+F
                        Forced sense OFF!
-----------------------------------
Ctrl+G
                        Gripping
------------------------
Ctrl+R
                        Releasing
                        Time to release = $0017
--------------------------------
Ctrl+Y
                        Wafer OFF=$4C000000
                        Wafer ON =$3C000000
                        Wfr  Gripd=$4E000000
                        TRIP32    =$40000000
                        N.WFR.BEND=$0A
                        GRP SNS FLT H.V XOUT   ( status of system)
                         NO YES  NO OFF LOW
--------------------------------
U -                     0200
P -                     000A03D5
I -                     0000
V -                      AA4E
T -                       --1E
--------------------------------
Ctrl+W - to be imported in EXCEL to see repeated sense values
                        =HEX2DEC("041DEAF6")/4096
-----------------------------------
```

SENSE SIGNAL SETTING; "Learn Wafer"

Typical session text:

```
- - - - - - - - - - - - - - - -
DAC=$0200Sense=$2F5F
(c)05ELECTROGRIP612
I+00-01 Va80b81  T1D
Set.., Dump, Load:          A "grip" command is made after power-up, here.
Power Setup Grip            The unit responds with a trial grip sequence
Please wait!
Not enough Power!           The A unit learns what power setting is needed for grip
High volt. limited!
Releasing                   A release is executed (v.3.00 only; others retain grip)
Power setup DONE 03              The power level (here, 03) stored in temporary
memory

DAC=$0200Sense=$2F65
(c)05ELECTROGRIP612
I+00-01 Va80b80  T1C
Set.., Dump, Load:

DAC=$0200Sense=$0000
(c)05ELECTROGRIP612
I+00-00 VaAAb4E  T1A
Set.., Dump, Load:s         Press "s" after power setting, above.

Set-parameters.., or
Options.., learn-
Wafer, Zero, Balance
or 'X' to eXit:w                 Press "w" or "l" to learn sense signal settings.

Take Wafer Off then press any key
or 'X' to eXit: d

Put Wafer On, press any key
or 'X' to eXit: s

Press a key to grip
or 'X' to eXit: e
Zeroing

Wait!
Zeroing

Off-On  Diff.Hi=$00B8
Off-On Diff.Lo=$F8AF
On-GrpdDiff.Hi=$0007
On-GrpdDiff.Lo=$FCB2
Base DAC Zero =$0ACA
Base DAC Relsd=$0A98
Snstvty/Snpout=$0A1C

Done.
```

- -

INDIVIDUAL PARAMETER SETTING

```
Set-parameters.., or
Options.., learn-
Wafer, Zero, Balance
or 'X' to eXit:S                          ...selecting Set-parameters

this parameter is
MaxOutVoltage=$07D0                       you can set the voltage
Next,Back,Alter,Save
or 'X' to eXit:N                          ...but go on to the next value
.........................
.........................                 (stepping through parameter list)
this parameter is
Relrpt/Relfrac$0402
Next,Back,Alter,Save
or 'X' to eXit:A
enter a HEX number: $0403                 here decided to enter a new value

this parameter is
Relrpt/Relfrac$0403
Next,Back,Alter,Save
or 'X' to eXit:+                          can also change with + and - signs

this parameter is
Relrpt/Relfrac$0404
Next,Back,Alter,Save
or 'X' to eXit:-

this parameter is
Relrpt/Relfrac$0403
Next,Back,Alter,Save
or 'X' to eXit:-

this parameter is
Relrpt/Relfrac$0402
Next,Back,Alter,Save                      If press "S" then saves this number
or 'X' to eXit:s                          to permanent memory
.........................
```

DUMP OF PARAMETER VALUES TO TERMINAL

```
DAC=$0800Sense=$8000
(c)05ELECTROGRIP612
I+00-01 Va80b80 0T00
Set.., Dump, Load:d

.HEX
*MaxOutVoltage=$0800
 *Rel Tmax 0.1s*$0064
 *Amp Delay (ms)$0190
  *I Warn/TrpFrac$2002
 *RednTime/Ratio$4003
 */GrpRmpT 0.1s*$0005
  *Relrpt/Relfrac$010F
  *RelRmps/RlxMul$0302
 *InitRelStp A/B$0306
 */ReleaseMethod$0005
 *OutRider Optns$0001
 *EXCEL P1 ADDR $0000
 *EXCEL P2 ADDR $0000
  *VSMult/S16tvty$0002
  *Deriv/SFN Mult$2014
  *DschrgD0.1sA/B$1E14
 *VoltSnsDacDevn$0000
  *DacSlowHi/Mid $3020
 *       /DSlLow$0010
 *Off-On Diff.Hi$0075
 *Off-On Diff.Lo$9D66
  *On-GrpdDiff.Hi$003A
 *On-GrpdDiff.Lo$25C4
 *WfrGrpdSns.Hi $8CE9
 *WfrGrpdSns.Lo $7C7C
 *SNS16NoiseLevl$004C
 *Options 'A'   $8080
 *Options 'B'   $03B5
  *RAW Min./Max. $60FF
.END
```

SERIAL DAISY CHAINING

Daisy-chained DR5A control units are addressed with single-digit hexadecimal numbers from 1 to F, permitting up to 15 units to be controlled on one serial line.

All commands to access any unit are preceded by an address command. No commands are global once addresses are assigned. All command types, including address commands, are echoed by each upstream unit, and address commands as well as the addressed unit's responses are echoed by each downstream unit.

Addresses are assigned dynamically at system setup and at any time thereafter using a ##n↲ command, where ## is the address assignation marker, n is a nonzero number between 1 and F sent from the control computer, and ↲ is a carriage return (ASCII 13). No line feeds are used. Each unit responds to this command by accepting the number n as its address, and sending on to the next unit a ##m↲ command, where m = n+1. The response from the final unit to the control computer is ##p↲ , where p = n+(no. of daisy chained units). Thus a typical startup sequence would be:

##1↲	from control computer
##3↲	reply to control computer from 2 units in a daisy chain.

Receipt of a ##n↲ or .HEX causes DR5A units to enter "quiet" mode and cease any outputs that may be in progress.

DR5A units are accessed by enunciation of an address, followed by commands as for single, unchained DR5A units. The command and response sequence may be of any length, and is terminated by the enunciation of another address. Addresses are enunciated by #n↲ where n is the address. Thus:

#1↲	[access unit with address 1]
[commands such as V, P, I, or s, o for setting options; and s, s for setting parameters, etc.]	
#2↲	[access unit with address 2]
[commands such as V, P, I, or s, o for setting options; and s, s for setting parameters, etc.]	
#0↲	[de-accesses all units]

The null address is 0, and turns off all responses from the DR5A units to serial line outputs. However it also enables DR5A units to act in non-polled mode and generate asynchronous status outputs. Thus when no new actions are being anticipated, the null address permits monitoring for fault or warning outputs. All such status outputs are preceded by a #n↲ where n is the address of the sending unit. Data collisions are possible, in which case the control computer may poll each unit to determine the sources of the signals.

DEBUGGING CHECKLIST

Observation	Possible causes
Wafer holding behavior:	
No gripping	Fault light on
	Gripper drive voltage not sufficient
	Gripper damage
	Arcing in leads to gripper
	Option setting must be changed to permit grip if no wafer present.
Poor releasing	Wafer sensing should be readjusted using learn-Wafer
	Suboptimal release parameters or method set in EEPROM
	Wafer being moved while release is in progress
Erratic with rf power	Chuck arcing due to high rf current
	Set Option to retain grip even though sense signal goes out during grip time due to rf plasma operation.
	Rf interference.
	Contact Electrogrip with details.
Drive unit behavior:	
Fault light on	Interlock on rear connector not activated
Power light off	No power input
	Absolute interlock not in place
	Shorted power in DB15 connector
	Internal DR5A power supply fault
Wafer sense not activated	See manual for sense learning of learn-Wafer.
	Check that wiring is connected; "Sense Level" as displayed repeatedly on serial line should change when a wafer is placed on and off a gripper. If this number does not change significantly, a wiring or driver fault is indicated.
Drive voltage not sufficient	Power to DR5V unit may not be sufficient. DR5A adjustment may be required.
	Set EEPROM parameters to correct output voltage level.
	Gripper/wiring excess current; or DR5 internal fault.
	Excessive DR5V temperature; high current will be also seen due to internal current leakage flow.
High current on output	Gripper/wiring leakage. May appear as transient high readings such as 04, 05 etc. higher than "normal" readings.
Overtemperature	Blocked DR5VI fan inlet/outlet; faulty fan; excessive high-voltage and hot operation.
Gripper faults:	
Gripper damage	Change, send in for repair / replacement.
Arcing in leads to gripper	Change, send in for repair / replacement.