EXCITRON
C O R P O R A T I O N

ExROS -- Excitron Robot Operating System

These notes are additional details about ExROS and general operation of our new X Controllers. Our plan is to merge these notes into the X Controller Manual.

ExROS is the fastest and smallest real-time Operating System for Robotics, CNC (Computer Numerical Control), Motion Control, Automation, motorized products, and Machines.

Timing for commands and responses are in predictable millionths of a second, giving ultimate performance and speed of motors. Compared to other sluggish systems, response is immediate and without latency. Thus ExROS is the one and only true Real-Time system in the world.

6 modes for motion control:
- CNC/Gcode System (if set as GOD or Master), use d, l, v, G etc. serial commands for 100s or 1000s of gcode files.
- Motion Profiles with 17 profiles and using C, W, S, N, t, (,), G etc. serial commands.
- Onboard Joystick runs 4 different sets of 3 Profiles (2 Profiles if not memory upgrade), and center push runs 1 Profile. Once running, the center push stops the motor.
- Input Profile Mode runs 3 Profiles if enabled and pin is low.
- Automatic Home at power-up runs Profiles, option to auto-repeat makes the Controller stand-alone.
- Driver Mode for step and direction pulses from another Excitron controller, external controller or PC.

Easily change between Motion Profiles and CNC/Gcode System modes by typing "Q".
Default at reset can be set to either Motion Profiles and CNC/Gcode System by setting the CNC command in the "c" menu.
Useful commands I, J, (,), X, x, c are common to both Motion Profiles and CNC/Gcode System.
ExROS has special CNC gcodes for using the pin modes of the Motion Profiles, useful for sensors and limit switches.

Built-in Joystick gives you instant motor running, CW or CCW, speed adjustment, saving your new speed, and stopping--all without any PC or external switches. Great for jogging and precise 3 Profile movements. You can set the exact motion you need since the Joystick motion is configurable.
For X86 & X110 motors:
      J045 runs Profiles 18, 19 & 20
      J135 runs Profiles 21, 22 & 23
      J315 runs Profiles 24, 25 & 26
      J225 runs Profiles 27, 28 & 29
      JCEN runs Profile 30

For X28, X35, X39, X42, X57, X60 motors:
      J045 runs Profiles 12, 13 & 14   (Profiles 12 & 13 if not memory upgrade)
      J135 runs Profiles 15, 16 & 17   (Profiles 14 & 15 if not memory upgrade)
      J315 runs Profiles 18, 19 & 20   (Profiles 16 & 17 if not memory upgrade)
      J225 runs Profiles 21, 22 & 23   (Profiles 18 & 19 if not memory upgrade)
      JCEN runs Profile 24

If running, JCEN stops the motor. This is true for any running, not just the Joystick and thus functions as an emergency stop. These Joystick Profiles are pre-configured for manual motion, you can change the values. The time delay is set to +00500 msec to give you time to release the Joystick. If t=-00500 msec, then the secondary Joystick button feature of speed up/down would occur before you could release the switch.

CNC/Gcode system
GOD is the supreme MASTER controlling up to 65 total Master/Slaves. One Master per CNC serial loop, and rest are Slaves, see CNC_Gcode_System.pdf.
GOD, Master, and Slaves can be named A, B, C, D, E, X, Y, or Z, each must be unique. ExROS automatically configures the Slave quantity for true Plug-n-play. You can physically add or remove Slaves Controllers, if Power is off to the Slave, without making any configuration changes. Your CNC gcode must change, of course. Excitron offers 2 sizes of X Controller computer memory: standard and upgrade.

The maximum number of Gcode lines per file is limited by the available RAM. This limit is 780 lines for standard X Controllers, and 1,600 with the memory upgrade. The total flash size for storing Gcode files is ~5,930 lines, and 26,000 with the memory upgrade.

You can read your external Gcode file into the Controller by: Typing 'r' then a filename containing 1 to 24 chars (characters "space" thru "~" is allowed), and the enter key.

   Type each line, example G00 Y+2300, followed by LF Linefeed (ctrl-J). CR carriage return/enter (ctrl-m) is optional.
   The order of CRLF or LFCR does not matter, but the LF is mandatory.
   Your external program, such as Realterm, must have a 10ms time Line delay, and 0 delay for each character.
   Send your Gcode file. If using Realterm, click on the Send tab, set the character delay to 10 or so, and then select
your file in the Dump File to Port window.

Axis step numbers are up to 6 digits, limited to ±262,142, but are more than enough.

Feedrate is half-steps/second, up to 5 digits, limited to 16,383 steps/second. You can have more than 1 Feedrate per line:

   A Feedrate followed by an Axis applies for that Axis only. Ex.: G00 Y800 B770 F2400 Z540   applies to Z only.
   A Feedrate at the end of the line applies for all 8 Axis'. Ex.: G00 Y800 B770 F2400   is sent to all 8 Axis',
   regardless of how many slaves are connected.
   Feedrates are module 8 (divided by 8 and truncated), examples:
   1000, 1008, 1016, 2024 are stored without truncating.
   1002, 1005, 1007 are stored as 1000, this will not affect your motion.

Pause is up to 5 digits, limited to 2,047, each unit is 1 millisecond, max is 2.047 msec. If you need a longer pause just add more Pause lines.

Gcode filenames may contain 1 to 24 characters, including space, !"#$%&'()*+,-./, numbers 0-9, :;<=>?, caps A-Z, [\]^_`, a-z, {|}~. This is superior to Windows. A space cannot be the 1st filename character. @ is not allowed because that will reset your controllers.

Previous i, h, r and some other commands are now capital letter commands.

You can directly communicate with any Slave by the ^ transparency command, then type any Slave letter (Master is ignored) to talk to it. End this transparency command by typing _.

Change active Gcode line*. Higher level Sequencer* lets you run several Gcode files in sequence. You may select the first Sequence file to run at power ON.

Dual serial ports for faster response, versatility, and exceptional motion control:
   CNC serial port is the 3 pin header located on the rear of the motor next to the 4 pin power header.
   USB serial port is located on the side of the Controller. Important--this serial port is not USB, it is 3.3 volt TTL logic.

Sweet and simple "I" for information. Controller system variables are now viewable and set in the "c" menu with each command. Use "c" menu for viewing and changing system values. Note that Driver mode does not display d in the prompt.

Concerning your current Motion Profile:
   o Typing (or) for single stepping
   o Any values you changed, ex.: N=0004200, are automatically saved when:
      • View all Motion Profiles with the v command.
      • Quit to the CNC/Gcode System.
   o The previous U command is no longer needed, and is deleted. The last execution of G, g, or S is saved when you type v or q.
   o If you push the Joystick or activate 3 Input Profiles by making an input pin go low, your changed values are not saved. If you
   o really wanted to save your changes, then re-type them, and type v or Q to save them.

Brake value is now 0 to 100, where 100 is 100% of rated amperage.

DC-DC voltage convertor using PWM (pulse width modulation) from 12 to 28 volts down to the motor voltage of 3-4 volts. Future--measures power supply voltage and automatically adjusts amperage and torque to remain the same. Excellent for swapping different power supplies, and for battery power, where the voltage drops. Extremely low energy used in standby, as low as 0.08 ua (0.00008 ma). Running energy use, not counting the motor, is 4 ma.

Selectable motor running torque from 10 to 150% of rated current.

Automatic damping at end of running for 2 seconds maintains motor shaft position and smoothes power supply current. You may run the motor immediately without waiting 2 seconds. When the damping period is finished, the Brake action is turned ON, if you have a non-zero Brake value.

Selectable Brake value from 10 to 100% of rated current, for locking the motor shaft. Brake value is independent of running torque.

Change speed on-the-fly by Joystick, switch J45 degrees speeds up, switch J315 degrees slows down. By pushing switch J215 while running, you can save the new speed as a global default speed. This new speed applies for all Motion Profiles, disregards any previous set Vsps, and is saved after power is off. You easily over-ride this global speed by changing any Vsps in any Motion Profile.

Repeat is a true repeat from 0 to 65,535, and is one less than previous Au Controllers, example:

      R=00000 will run once and not repeat

      R=00002 will run once then repeat 2 more times

      The 5 digit repeat quantity remaining is sent to the serial port.

Note: if you use 'g' for reciprocal motion the motor will oscillate back and forth repeat + 1 times; if you use 'G' then the Motion Profile runs in one direction repeat + 1 times.

Future--@ sends the Axis address and waits for another character:

  If not @, performs a hardware reset.

  If 2nd @, clears Autohome, Autohome repeat, and IPM then hardware resets the controller.

Best viewing with RealTerm is:

- o Display tab: Display As = ASCII (2nd one), Terminal font = Lucida Console (fixed width) and size = 8 or 9, Scrollback = 2000 or higher.
- o Port tab: Baud = 115200, Parity none, Data Bits = 8, Stop Bits = 2, Hardware Flow = none.

Controller serial port transmitted characters have 2 stop bits; this helps the sluggish poor response of Windows. Best if you select 2 stop bits in your PC program, but 1 stop bit works ok. Echo of serial port characters is always ON, except CNC commands on CNC serial port is OFF automatically. For easier connection, the baud is fixed at high speed 115,200. If you select the output of '()' serial characters, by c menu and Out=1, then '(' and ')' characters are only sent to the USB 3.3v serial port.

Your motor and Controller are safeguarded with a temperature limit of 77°C (170°F). If temperature is > 70 degC, then the controller pauses 1 second then resets. The sign-on message displays temperature repeatedly until the controller cools down.

Pin command sets the input pin and mode command (separate command now) sets the input logic for the pin. Pins and Modes are not verified while entering values, you must enter only valid values, invalid pin or mode values are ignored when you run the motor.

User k ADC value is 8 bits. The analog signal on pin IN2 is internally divided so that 8 bits are compared to the user value. Home counter for life cycling applications, up to 10M, triggered each time a sensor goes low on In2.

Input pins for Input Profile Mode (IPM) and pin modes are sampled every 2 msec. Your input signal must be longer than 2 msec. If IPM is enabled for a pin, then that pin going low will trigger the running of 3 Motion Profiles. IPM on In2 is analog only, and triggers 3 Motion Profiles when the input voltage value is less than your k specified value in Profile #06.

All input pins are protected to +-100K volts, and has EMI filtering above 50 mhz.

Future: Driver Mode uses Step and Direction input pins to step the motor. These pins are interrupt driven and are precise to within 0.2 microsecond. This very high accuracy gives you 100X better stepping than any PC based program, even a 4 Ghz PC. The Step minimum pulse width must be more than 4 usec. Driver Mode uses the current Motion Profile values of Break, Torque, msec, pin, mode, and k. Other values are ignored. Therefore you MUST make msec=+00000 or you will

lose steps. Suggest you always use Motion Profile #01 and make msec=+00000 because #01 is the default at power-up reset.

You enable Driver Mode by typing c then ~ then d then 1. Your value is saved automatically. When Driver Mode is enabled, input pins In2 and In3 are disabled for pin modes and IPM. Therefore only use Driver Mode is that is your distinct intention.

Most mechanisms have some play (backlash), examples:
- gears have .001-.008" of backlash
- timing belts have an initial stretch up to .100", depends on load
- leadscrew nuts have 0-.030" play, note that Excitron's nuts have zero play

For top performance, it is very important that the stepper motor remains in magnetic sync with the Controller's power pulses, and to take up the mechanical play before accelerating. Example: your motor starts stepping and it can be running at 500-900 steps per second before the gears physically engage, causing a huge increase of torque that stalls the motor. Almost no one is aware of this banging backlash situation.

Since 2002, Excitron Controllers eliminate stoppage due to backlash, by stepping at a slow rate until the backlash is taken up. This feature is built-in. In the c submenu, use the F command to set how many First Steps to run at very slow speed, when the motor starts stepping. First Steps is pre-set to 003, you may change this to 000-255. We recommend values of 002 to 010; 000 minimizes run time, but the motor may stall for reasons stated above. The F steps quantity is now included with N, the total number of steps. Legacy Controllers did not include First Steps in the total step count, and now the older f command is no longer necessary. Future firmware will automatically measure play and adjust the F steps so your motion is optimized.

The little x command displays the ±position. If in Motion Profile Menu, the single ±position is shown. If in Robot/CNC Mode, all 8 axis ±positions are displayed.

Be aware that mechanical switches bounce on/off for 10 to 40 msec. Excitron controllers automatically take care of switch bounce for you. However, if you have a Motion Profile set up with less than 50msec time delay, and/or you have less than 10 motor steps, then pushing a switch may cause unintentional motion. Unless you are tuning for extremely high performance, always use t=±00050 as a minimum.

Controller LED is hardware ON and is not software controlled. The LED brightness is a relative indication of activity and milliamps used. The energy consumed by this LED is actually zero, due to a novel circuit.

Quad storage scope on 4 analog-to-digital channels. Control data input with these commands:
- Channel select 0, 1, 2, or 3:
  - 0 is internal temperature
  - 1 is In2
  - 2 is In3
  - 3 is external +Vs power supply voltage
- Multiple input pin selection allows more than 1 pin for action.*
- Gain from .5 to 64X, input is power of 2, 0 = 1X, 1 = 2X gain, 7 = .5 gain. Example: you want gain of 3, then you type 2.
- Number of samples: 0=64,1=128,2=256,512,1024,2048,6=4096(32A4U=3840),7=7950. input is power of 2 (with offset of 6)
- Offset value--subtracted after Gain is applied.
- Time interval 0-9, input is power of 2.
- Command input is power of 2,

Remote high speed 12 bit analog-to-digital measurements are sent by serial port for your analysis and evaluation. The conversion speed is Time interval for samples and is adjustable from 1.0 to 500 msec, with up to 1 mhz*. Number of samples can be 64 to 3,840, or 7,940 with memory upgrade. Usually you should ignore the first sample. Scope clears RAM memory; any gcode RAM file is erased.

Interesting notes:
Single stepping with (and) commands changes motor direction in the current Motion Profile. Know that if you then type q or v, your new direction is saved, thus over-writing the existing direction, but step number is not affected.

Supported Gcodes, all are modal and incremental, not absolute:

F is Feedrate 244-16,383 hsps, individually applied if precedes an Axis letter, or globally applied if at end of line.

G00 rapid movement, treated as G01 since Feedrate is modal
G01 linear interpolation movement*
G02 arc CW*, 2 axis letters then I & J, ex: X300 Y-120 I-200 J900
G03 arc CCW*, X,Y = finish point, I,J is relative to X,Y

M03 Spindle ON CW*
M04 Spindle ON CCW*
M05 Spindle OFF*
M06 pause until '~'
M07 Mist Coolant ON*
M08 Flood Coolant ON*
M09 Mist Coolant OFF*
M10 Flood Coolant OFF*
M30 EOFILE

N codes send pin and mode commands to an Axis, applies only to last Axis
N00 pin =0 (no modes)
N01 pin =3 & mode =12
N02 pin =3 & mode =13
N06 acceleration low*
N07 acceleration hi*

P Pause 0-2.047 sec

T Tool 0-6, use only as reference--no action is taken

* means future.

Enjoy!   Feel free to contact us at info@excitron.com.

…make it a great day!

Excitron's Engineering Team