

# Chip-EC Howto

2018-02



Figure 1. The Chip-EC carrier board ( with no mezzanine)

< The information here is pertinent to Chip-EC 1B. Contact Tech Support for Chip-EC-1A compatibility information >

The “Chip-EC” is a small controller which implements many *Output Devices* that move actuators, when the Chip-EC is connected to the Overdrive Control Computer (“CC”). Overdrive software settings pertaining to an “EC” affect the Chip-EC and Stack-EC alike.

The current revision of the Chip-EC (“CEC”) has support for the following:

- 12 PWM outputs for RC Servos  
(RC Servo power pads allow a separate power source to be connected)
- 8 CAN motor drives
- Inter-EC (CAN) bus, which can connect up to 6 Chip-ECs together
- 2nd Serial port for communication with peripheral serial devices
- 3rd serial port compatible with RS485/RS422/RS232 (optional)
- 16 digital IO, configurable as inputs or outputs  
(36 channels available via a digital output mezzanine)
- Eight 12-bit analog inputs
- Two quadrature Encoder inputs
- Serial port for connection with the Control Computer
- Four status LEDs
- 16 bit DAC and ADC mezzanines may be added
- A serial RS422/RS485/RS232/TTL mezzanine may be added

Some of the features above can be enabled/disabled by the manufacturer, contact tech-support for details. Typical applications are described in this document.

The Chip-EC main controller is a 60 MIPS Freescale DSC microcontroller. A DCDC Mezzanine circuit board adds power regulation. Although a single Chip-EC itself is a 16 channel device, it can control up to 64 channels of motion by relaying channel data to other ECs on the inter-EC (CAN) bus.

RC servos are controlled at 60Hz, over a 4096 position range of 1520usec +/- 620 usec. This yields about 120 degrees of movement on most devices, though wider angle servos can be obtained. The center position of 1520 microseconds is the same as that of a Futaba radio receiver. RC Servos from Futaba, HiTEC, MAXX, JR, and Airtronics have been tested to comply with this range.

A mezzanine for RC servos provides:

- line-drivers logic-levels for long distance transmission
- PWM crosstalk reduction via curve-shaping
- static discharge protection
- output stage replaceability
- short-circuit protection
- RC servo style connectors

With its RS485 serial mezzanine, the Chip-EC can also control DYNAMIXEL servos.

Chip-EC's support a variety of third party servo amplifiers, or 'drives', via the CAN bus, utilizing CANOpen protocol. See also the PID-servo Howto in the Overdrive documentation. At present up to 8 CAN drives may be added, but more can be supported - contact tech support for details.

*Warning: The Chip-EC is static sensitive and may be damaged if its pins are touched without taking static dissipation safety precautions. It is recommended to leave the Chip-EC in any manufacturer heat-shrink packaging.*

## **Logic Power**

### Input Voltage vs Current consumed

12V	110mA
9V	140mA
7.2V	160mA
5V	220mA
4.3V	250mA

The figures above are power into the Chip-EC's onboard DC-DC converter. Though the current required reduces, the converter becomes slightly less efficient as the input voltage gets higher.

As low as 4.3V is required to power ChipEC DC-DC converter so that, when using batteries, longer run-times can be achieved.

It is recommended to use separate power (or at least separate regulators) for the Chip-EC logic versus Rcservo power. This prevents current surges caused by motors from interfering with the Chip-EC logic.

## **PWM Mezzanine & Servo Power**

The Servo Power "+V" on the RC-servo mezzanine is isolated from any other circuit, this power goes directly into the twelve servo connectors. The 12x3 Servo Connector may be mounted in different ways: "inline" at a right angle to the board, perpendicular to the board, over, or under the board.

Right-angle "Inline" : The pin closest to mezzanine board is GND, the middle pin is +V, the bottom pin (closest to Chip-EC main board) is signal (see diagram at end of

this document).

Note that this pinout is different from versions of the Chip-EC prior to version 1A. Perpendicular to PCB: The pin closest to the right edge of the mezzanine board is GND, the middle pin is +V, the left pin (furthest from edge of board) is signal. Additionally, observe where the power traces connect from the through-hole pads to the Servo Connector pins.

Power can also be supplied either directly to the servo connector pins, as is frequently done with RC radio receivers, or at the solder pads next to the PWM bus.

Don't connect RC-Servo GND to the Chip-EC GND externally. The two are already made common on the PWM circuit board.

Each Chip-EC with a PWM mezzanine supports 12 RC servo channels. Pairs of channels can draw current simultaneously, namely, these channel pairs: 1+7 2+8 3+9 4+10 5+11 6+12. This doubling of current draw may make the supply voltage droop momentarily. So the maximum instantaneous current required of any single Supply or Battery can be double that of a single servo.

Its best to allocate channels such that two high-current functions are not in one of the channel-pairs listed above. Power consumption is, of course, relative to the load on the mechanism which the servo drives.

When power to RC servos comes on and there is no signal (Ramped down), servos move a bit momentarily, then "relax". This is the servo circuitry itself, initializing. To avoid this, Ramp up RC servos at power on, then ramp down. Subsequent Ramping will not move the servos if they are not being pulled by a load.

## **"Inter EC" (CAN) Bus**

This "IEC" bus is the wiring on which CECs talk to each other, and talk to other devices like PID motor controllers (CAN drives).

Wiring and connectors should be daisy-chained in a linear fashion, like Christmas-tree lights, not in a star topology. Each connector on this bus contacts the same signals in parallel. Termination is required on both physical ends of the Inter-EC bus - use two 120 ohm resistors across the two wires. If small gauge wire is used, termination resistors can be crimped into the connector with the wire (insulate the protruding resistor leads). Chip-ECs version 1A and above have a surface-mount termination resistor R13 on the bottom side of the board. This resistor may be removed if termination is not needed at a given board. All Chip-ECs must have a common power GND in order to communicate on the IEC bus.

Technical details : communications on this bus is usually 500kbps and is transmitted in accordance with CAN (Controller Area Network 2.0) specifications. Devices such as PID servo controller drives, which use CAN, may be added to this bus.

Chip-EC versions prior to version "1A" cannot communicate on the IEC bus with a newer Chip-EC 1A and above. It is also not recommended to mix Chip-EC 1A with Chip-EC 1B on the inter-EC bus.

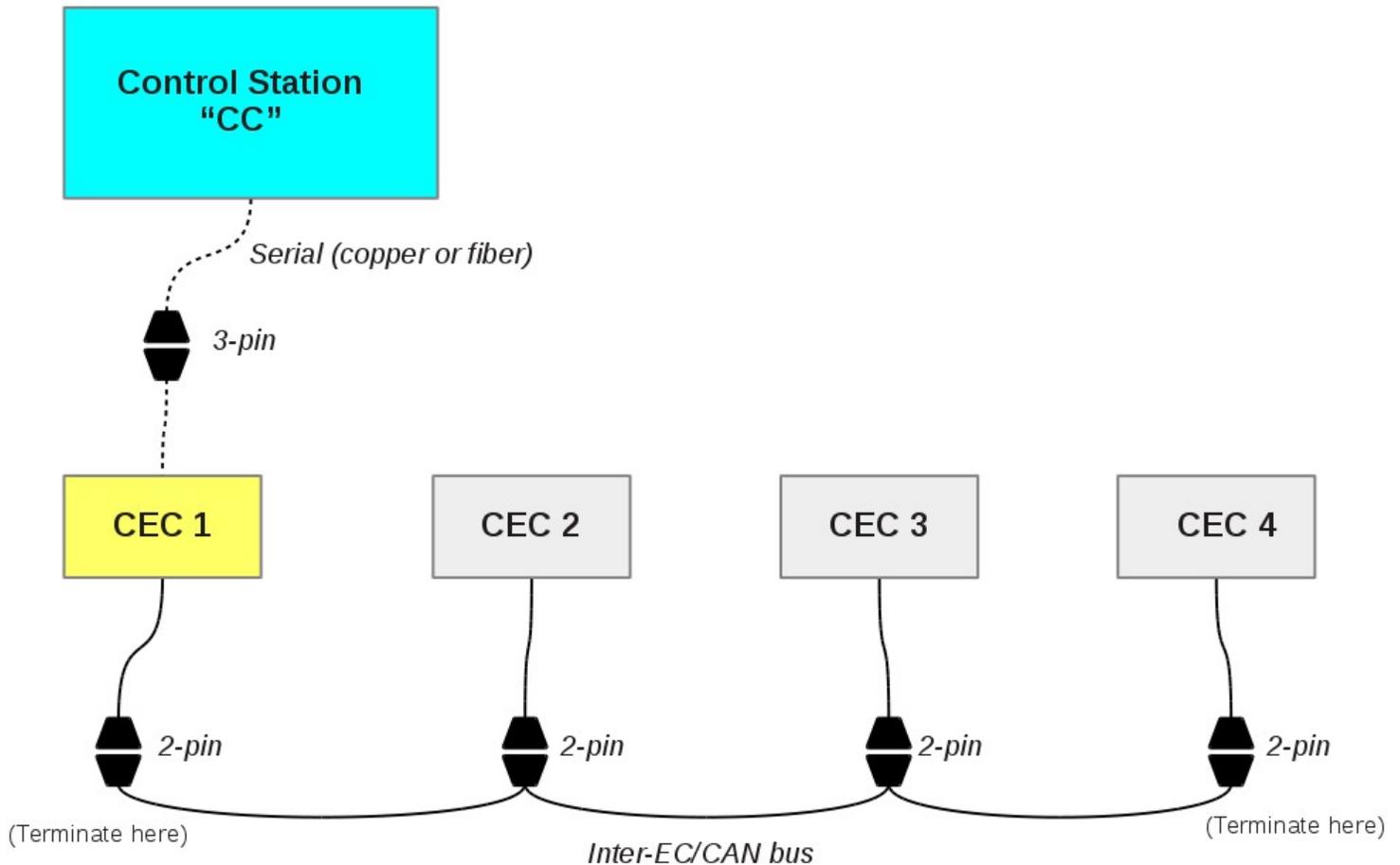


Figure 2. Topology of four Chip-ECs with PWM on the inter-EC bus, for 48 channels of RC-servo control

## Wiring

The Chip-EC logic wiring uses Molex SL contacts and crimps. Part numbers are on the Chip-EC pin out sheet at the end of this document.

On the PWM mezzanine, both 18 AWG Belden and Alpha wire fit the Servo Power pads next to the PWM servo connector, the positive voltage pad is marked with a "+". There is a lot of inherent heat-sinking in the wire and servo connector, so a large soldering iron tip must be used. Solder the wires quickly, with significant heat.

## PWM Channel Allocation

There are 12 Output Devices in a PWM Chip-EC. These are allocated sequentially as may be seen on an freshly created Output channel list on the Output Channel page of the Overdrive GUI. If all OutDevs are of type RCServo, the first OutDev on the list is the first RCServo on the first Chip-EC, The second OutDev on the list is the second RCServo on the first Chip-EC. The thirteenth OutDev on the list is the first RCServo of

the second Chip-EC, and so forth. Be sure to assign the proper device type ("Rcservo" versus Hydraulic etc) to each OutDev in Overdrive software.

At present the maximum number of RC servos supported on the Inter-EC bus is 64, using 6 Chip-ECs.

Each Output Channel ("OC") in the system is mapped 1:1 with an Output Device ("OD") of the same number. OD's represent the real world actuators which reside out at the ECs. Each OD has a type, like "RCServo" "Hydraulic" or "PID-Servo", which you can set on the OD tab of the OC page.

A Chip-EC can control up to 12 PWM RC-servos and up to 16 CAN PID-Servos. You must choose which type of OD to use. If say, OD1 of a CEC is of type PID-Servo, no signal will be output on the CEC's RCServo pin 1.

Example with two CEC's :

The OC list on the OC page is configured this way :

OC1 -> OD1 (RCServo)  
OC2 -> OD2 (PID-Servo)  
OC3 -> OD3 (RCServo)  
OC4 -> OD4 (PID-Servo)  
OC5 -> OD5 (RCServo)  
OC6 -> OD6 (RCServo)  
OC7 -> OD7 (RCServo)  
OC8 -> OD8 (RCServo)  
OC9 -> OD9 (RCServo)  
OC10 -> OD10 (RCServo)  
OC11 -> OD11 (RCServo)  
OC12 -> OD12 (RCServo)  
OC13 -> OD13 (PID-Servo)  
OC14 -> OD14 (RCServo)

On the Inter-EC bus, you have three PID-Servo controller units set to id2, id4 and id13.

OC1 will drive RCServo 1 on the first CEC.

OC2 will drive PIDServo id2, and RCServo signal 2 on the first CEC will be unavailable (since OD2 is of type PIDServo).

...

OC13 will drive PIDServo id13, and the first RCServo signal of the second CEC will be unavailable.

OC14 will drive RCServo 14, the second Rcservo signal of the second CEC.

Note that although you can graphically re-sort the OC list on the OC page, this does not change any mapping, it is merely visual. OC1 is still mapped to OD1, and OD1 is still mapped to the same real-world actuator as it originally was.

## **ID and Flashing**

One Chip-EC is the master, it has an ID of 1. This is the only unit which communicates with the Control Computer via a serial connection (copper or fiber).

Unique, sequential Chip-EC IDs (1-6) must be set for Chip-ECs to talk amongst themselves on the inter-EC bus. When flashing an ID, shut down all other Chip-ECs and connect just one at a time to the CC serial port or CAN port.

### *CAN Bus Flashing:*

Plug the Chip-EC into a CAN bus connected to the CC CAN port and turn it on. Make sure that the Chip-EC is the only device on the CAN bus. Open the Overdrive Control Panel, and click 'ChipEC'. The ChipEC configuration application will display properties of the connected Chip-EC, such as device type and ID number.

To change the ID of the Chip-EC, choose a new ID, and click 'Apply'. The yellow LED will turn on to indicate that flashing has occurred and that the device should be rebooted. To confirm that the ID assignment succeeded, turn the Chip-EC off, turn it back on, and watch the red LED. The red LED should indicate the ID, every 2 seconds. If you don't have access and can't see LEDs, click 'Connect' on the Chip-EC Configuration application and the new ID should be displayed, then Cancel.

### *Serial Port Flashing:*

Plug the Chip-EC into the CC serial port and turn it on. Once a connection is established, highlight that CEC on the EC page of the GUI (it should have a green icon on the list), click the "Assign EC ID" button. Depending on how long it takes for the Chip-EC to flash itself, it may generate communications warnings, or it may lose connection with the CC altogether. This is harmless.

The yellow LED will turn on to indicate that flashing has occurred and that the device should be rebooted. To confirm that the ID assignment succeeded, turn the Chip-EC off, turn it back on, the red LED will indicate what the ID is every 2 seconds. If you don't have access and can't see LEDs, click 'Connect' on the Chip-EC Configuration application and the new ID should be displayed, then Cancel. Note that Chip-EC's with an ID other than 1 will stop attempting to contact the CC *after* they have been contacted by a Master on the Inter-EC bus.

Chip-EC's with IDs greater than 1 will take longer to connect to the CC when first turned on; they also attempt to connect less frequently (this may be seen by looking at the fiber). This staggered connect timing helps multiple ECs to connect to a single CC when in Broadcast mode.

A boot delay can be flashed from the EC page, the EC will delay up to 25 seconds before contacting any device on any of its communications buses. This can be configured for CEC 1 only.

## LEDs

When the CEC first boots all three LEDs may illuminate for a fraction of a second.

The Green LED flashes at  $\frac{1}{2}$  the communications frequency. It signifies that the CEC is communicating with something on either the serial or the Inter-EC bus.

The Red LED blinks to indicate the CEC ID. It blinks like a grandfather clock: one blink means an ID of one, two blinks means an ID of two, etc. A pause of 2 seconds takes place between IDs. This is the ID that was flashed into the Chip-EC. <Note: A number written on capacitors on the board is a serial number, not the ID of the Chip-EC>

A Yellow LED indicates either a flashing operation or an error. It should not remain illuminated under normal circumstances.

The blue LED will blink at half the rate of serial communications on the second serial port, if that port is used, in some applications the blue Led will blink at half the rate of communication with CAN devices.

## Ramps

Overdrive "Gain Ramps" tell a Chip-EC to make servos power down their motor driver stage, though the servo logic stays on. This causes most types of servo to "relax" so the servo motor no longer holds position. This is valuable for power savings and servo longevity. Note that a ramp causes a Chip-EC to turn on/off RC servo signals when the ramp input is within 1% of the end of its range, which is different from the gradual gain effect a ramp has on analog actuators, like Hydraulic or PID Servos. PID servos implemented through a driver card, like the AMC series, may be gradually gained to/from zero-gain by a ramp. All servos on a common Chip-EC may not necessarily ramp up together. An individual servo will ramp up independently of its neighbors if it is in a different OutChan Group with a different ramp.

Certain RC servos (see list below) do not power down their driver stage when signal is removed. Thus, one cannot ramp down these servos like others. That problem can be mitigated with an "Mswitch" board. Each Chip-EC drives its last digital output bit "DIGOUT-8" along with the first servo's Ramp. So this bit will be high (3.3V) when the first servo's ramp goes high, and low (0V) when the first servo's ramp goes low. Driven by this output, the "Mswitch" can be used to turn servo power on and off. See the schematic "Servo-power-switch-CEC.png" in this documentation. The circuit can additionally have a turn-on delay of about 400 milliseconds, to insure that the Chip-EC has fully booted and initialized servo positions before servos get turned on.

\* Some RC Servos which do not Ramp down: HiTEC HS5735MG, HiTec HSR5995TG

If you use the Servo Power Switch ("Mswitch") circuit for RC servo power, there is no need for manual or "channel 9" power switches. When the Chip-EC Ramp or logic power goes down, all RC servo power is completely cut off by the Mswitch.

Note that RC Servos which are ramped down when servo power is switched on may “hunt” once as they power up, causing them to move slightly, then relax. This is caused by the design of the servo electronics itself, it is not caused by the Chip-EC. If this is undesirable, ramp-up before switching on servo power so servos go to known positions, then ramp down once it is on.

## **Digital In/Out**

The Chip-EC normally has eight Digital Inputs, which are 3.3V CMOS logic, but are tolerant of 5V TTL/CMOS signals. This can be expanded to 16 channels, contact tech support for details. The inputs are positive logic such that connecting a Digital input signal to PWR-COMMON asserts a logical “0”. Digital inputs are pulled high by internal pull-up resistors, so in some applications there is actually no need to supply positive voltage to them for a logical “1”. The signals are available as through-hole pads on the main board on the “DI” connector. See pinout and picture in the sections which follow.

The Chip-EC typically has eight digital outputs on the “DO” connector, but up to 16 outputs can be enabled via a configuration procedure. These channels overlap with PWM channels so Output Channel one may be either PWM or a digital output, but not both. The Digital outputs are 3.3V CMOS logic, which can source and sink 8mA.

A Chip-EC can be configured during manufacturing to be one of the following types, which have differing DIO features:

### *12 channel PWM “classic” Chip-EC :*

If the Chip-EC is configured to be a 12 channel PWM device, digital outputs are not used except for outputs 7 and 8 which are implemented as Ramp bits, as described in the “Ramps” section above.

### *12 channel PWM Chip-EC with Telemetry:*

A Chip-EC with Telemetry typically implements eight digital inputs plus eight 12-bit analog inputs. This can be expanded to 16 digital input channels, contact COI for details.

### *Chip-EC with DIO:*

The Chip-EC has a total of 16 DIO channels which can be configured as described above.

Note that a digital output device mezzanine can be added to the Chip-EC which provides a total of 36 channels of Digital output. When this mezzanine is applied the device is called a “DIOD”. See documentation of this device elsewhere in the Overdrive documentation.

## **Quadrature**

The Chip-EC has two quadrature ports for incremental encoder input. These are normally single-ended TTL/CMOS signals, but support input voltage levels up to 15 volts. Contact tech support for details on enabling these ports.

## **PID Servo Drives**

When CEC 1 boots, it scans the Inter-EC CAN bus for servo controllers, though most servo drives announce themselves and will be detected whenever they boot. When controlling PID servo drives, the topology is similar to that of Figure 2 above, where the drives would appear on the CAN bus in the place of the (grey) CECs. See the PID-Servo Howto in this documentation for details.

Since digital servo controllers may take time to boot, the CEC can be programmed to wait for a delay, up to 25 seconds, before scanning the IEC bus and subsequently connecting to the CC. Use "Set EC Delay" on the EC page for this.

Currently a maximum of 16 PID servo controllers per Chip-EC are supported. This number can be expanded, contact technical support for details.

## **Analog Outputs**

The Chip-EC can output up to eight analog voltages in the range +/-10V. The addition of an output mezzanine called the "MDAC" is required.

## **Analog Inputs**

The Chip-EC has eight 12 bit analog inputs on its mainboard, which can be turned on through a configuration operation, contact tech support for details.

For higher resolution analog input, the Chip-EC can be outfitted with an eight channel, 16-bit analog mezzanine called the "MADC-16" (see picture of this mezzanine at end of this document). Both the onboard 12 bit and the 16 bit inputs can be used at once for a total of 16 channels of analog input. When the board is configured and used as input-only it is called a Digital Input Device or "DID" - see the "DID howto" elsewhere in this documentation.

## **Telemetry**

While the CEC is normally an *output* device, it can also send analog and digital data back into the Overdrive system. "Telemetry" is the process of transmitting remote measurement to a local computer. A Chip-EC can be configured from the "EC" page of the GUI to be device type "Chip-EC with Telemetry". The Telemetry Device, or source, is configured from Telemetry Channel page. CEC telemetry can be 12 or 16 bit data depending on whether the 12 or 32 bit communications protocol is chosen though CEC configuration. The maximum number of telemetry channels is 64.

### *Analog Input Telemetry*

There are eight 12-bit Analog Input channels available on the CEC board, as seen in the chart below. Power for sensors to be read by the Analog Input should come from the 3.3V analog supply provided on this connector. See "Chip-EC Connector Layout

& Pin Identification diagram” below for pinouts. In general do not put voltages higher than 3.3V into analog inputs, though the hardware absolute maximum allows up to 3.7V.

"CEC w/Telemetry" - See telemetry channel how-to for details

Telemetry Device "Channel Number"	CEC Pin Name	Telem Device "Bits"
1	"DI" input port (bits 1 - 8)	8 bit int
2	read-back "DO" output bits	8 bit int
3	Unused	
4	Unused	
5	ANA1	16 bit int
6	ANA2	16 bit int
7	ANA3	16 bit int
8	ANA4	16 bit int
9	ANA5	16 bit int
10	ANA6	16 bit int
11	ANA7	16 bit int
12	ANA8	16 bit int

### *Digital Input Telemetry*

There are typically 8 Digital Input channels, "DIN1" through "DIN8", although the Digital output "DO" connector can be programmed to provide another 8 channels of digital input for a total of 16. Contact tech support for this feature. See diagrams below for pinouts.

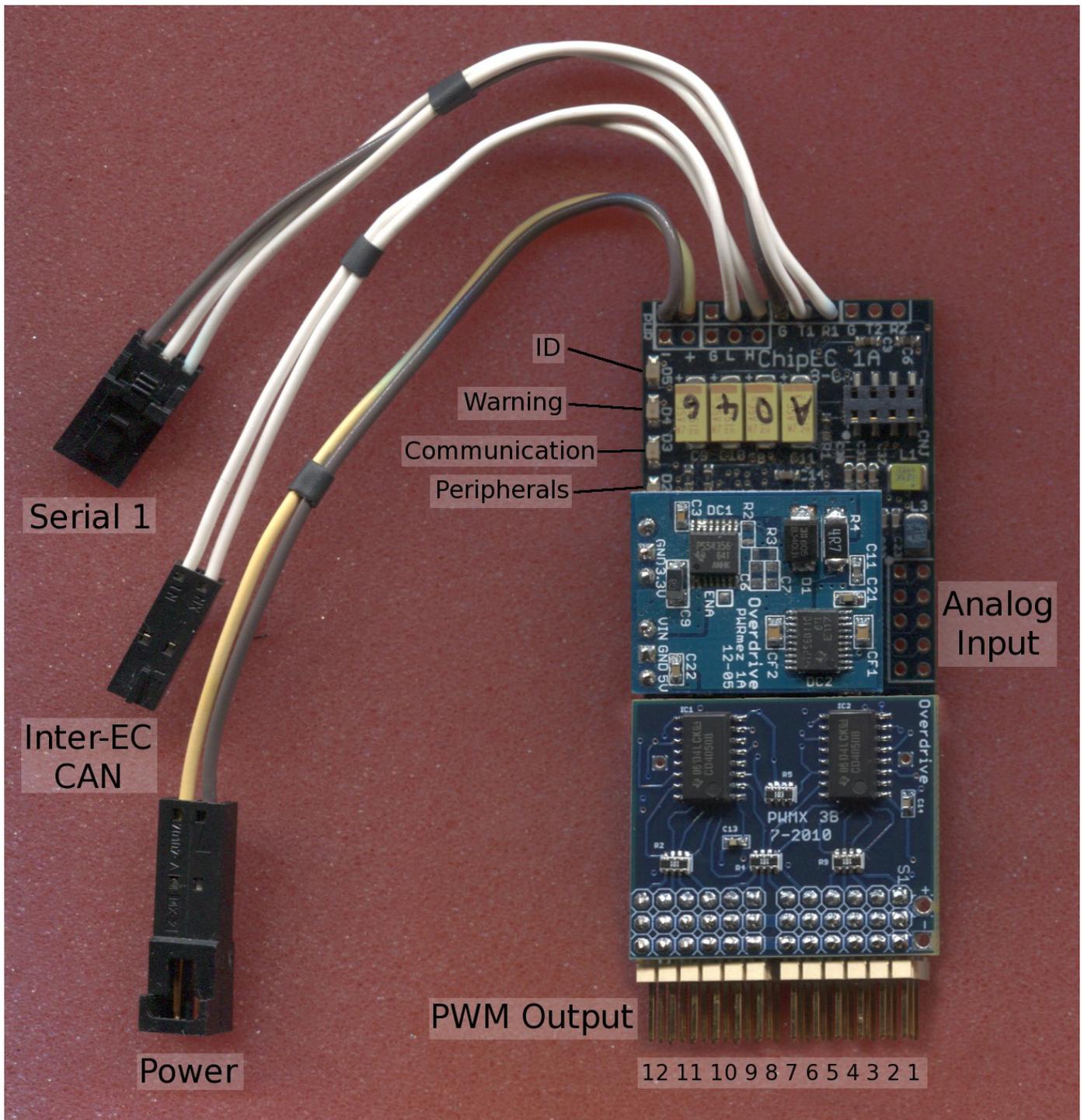


Figure 3. Chip-EC Connectors and Cabling including the PWM mezzanine (version 1A depicted)

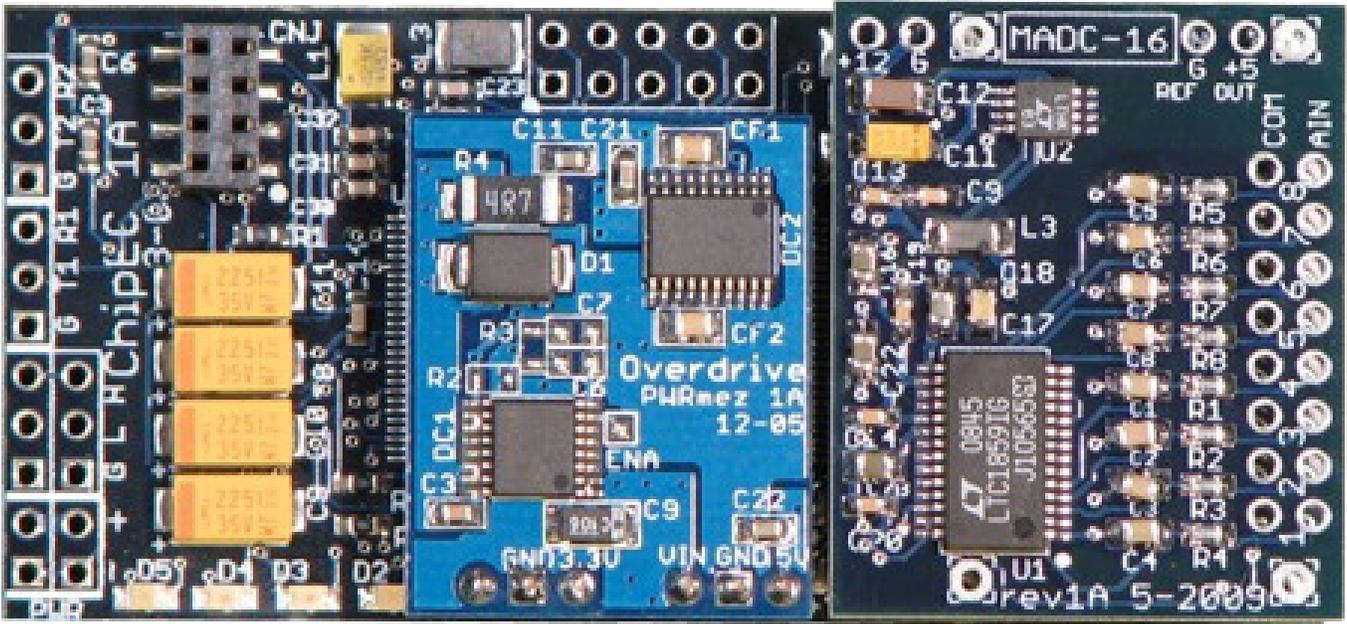


Figure 4. Chip-EC 1A plus MADC-16 Mezzanine

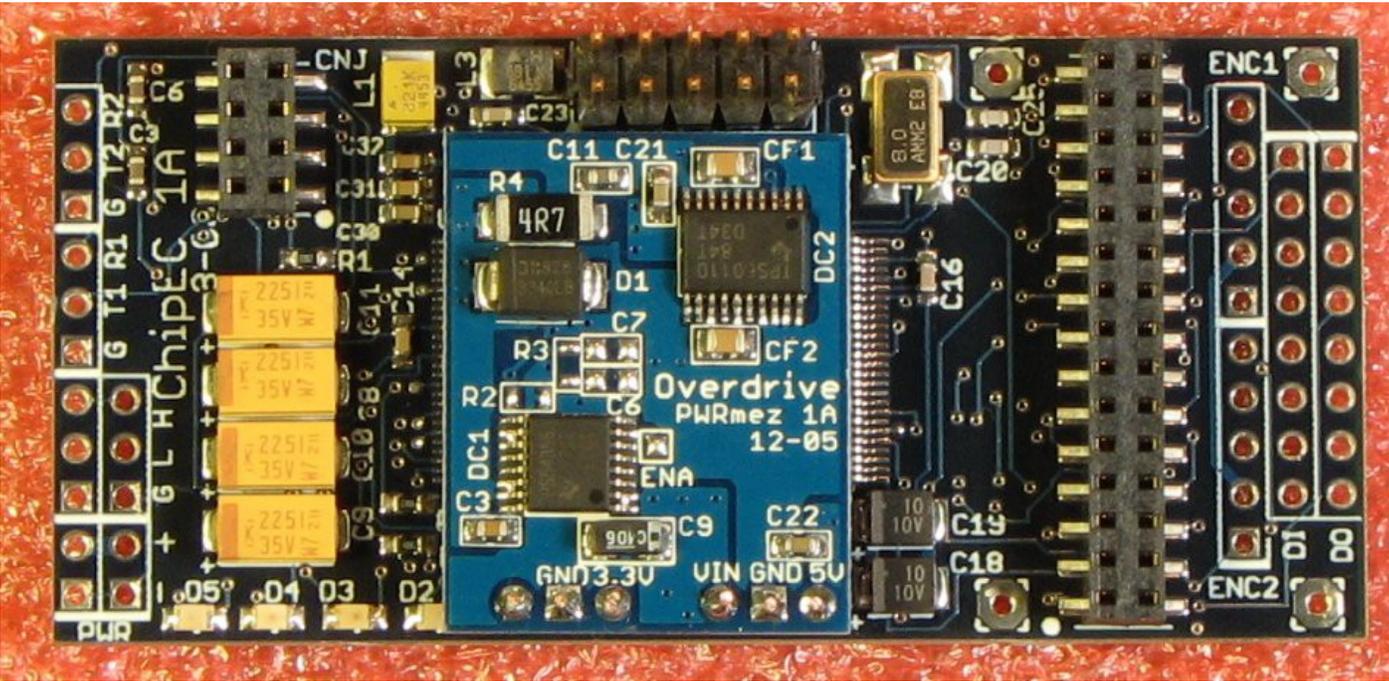


Figure 5. Chip-EC 1A Without Mezzanine

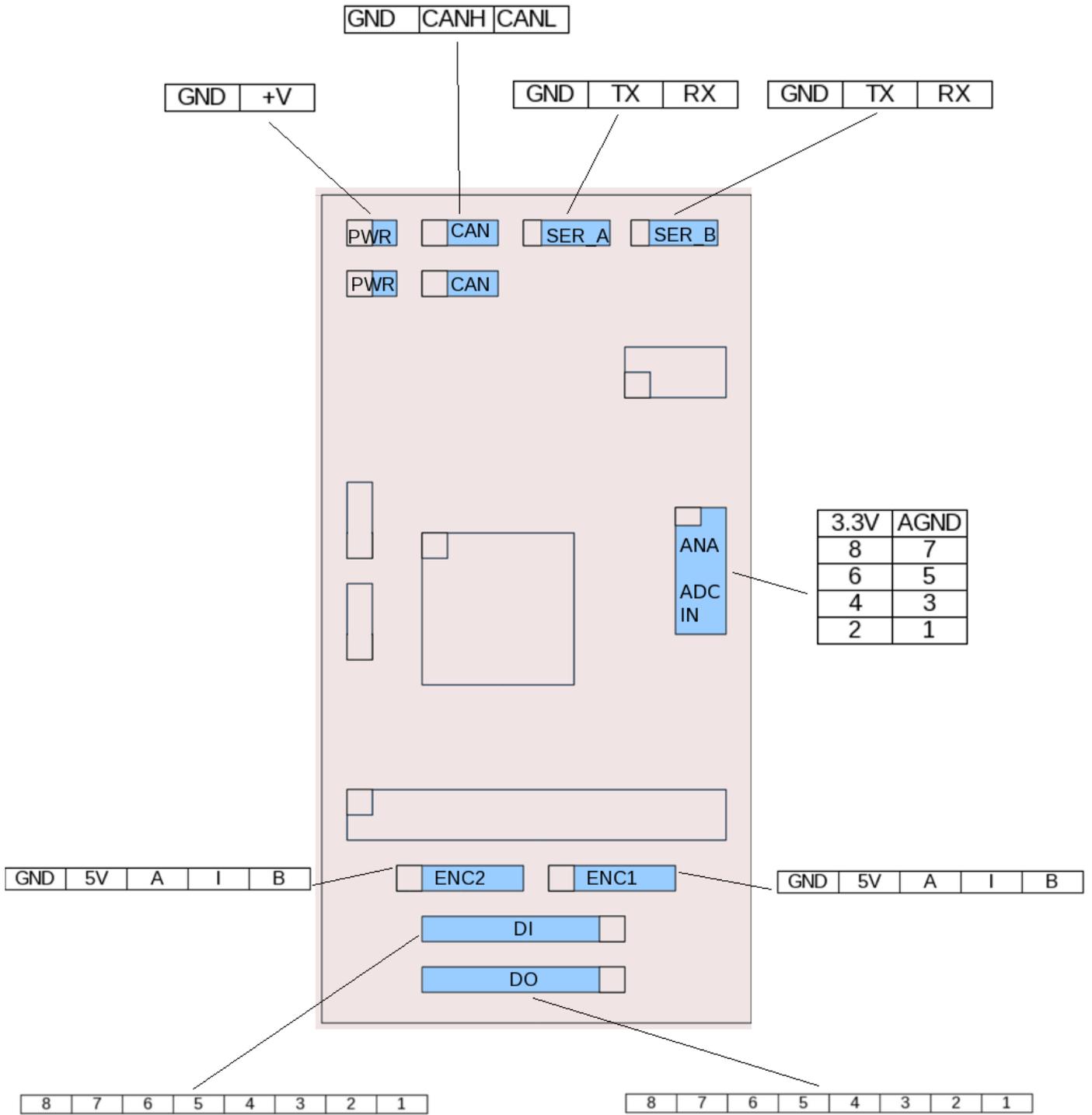
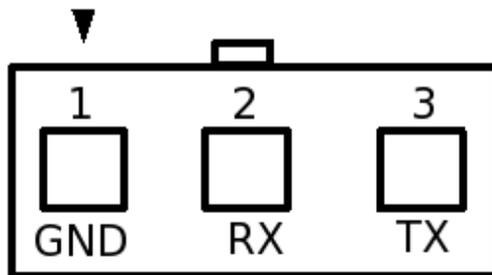


Figure 6. Pin descriptions & physical layout of the Chip-EC

# Chip-EC Pinout - rev 3 8/2005



## Color Code

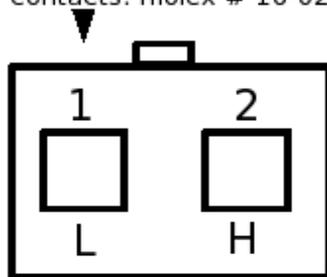
Gnd	Black
+7 to 12V	Yellow
Signal	White

## Serial

### Female - Front View

Female molex connector #50-57-9403  
(mates with male molex #70-107-0002 )  
contacts: molex # 16-02-1125

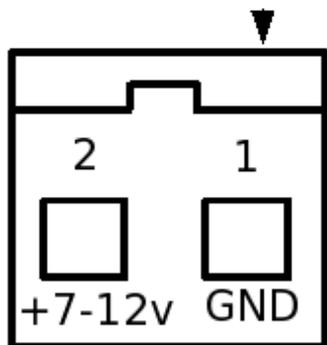
Note: Pin one indicated by arrow on top of connector



## Inter-EC Bus

### Female - Front View

Female molex connector #50-57-9402  
(mates with male molex #70-107-0001 )  
contacts: molex # 16-02-1125



## PWR

### Male pins - Front View

Male molex connector #70-107-0001  
(mates with female molex #50-57-9402 )  
contacts: molex 16-02-0115