railDECOacc

DCC accessory decoder
User Manual

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Firmware references: v6.01 / PIC16F84A and v7.01 / PIC16F628A

> **Before connecting a turnout:** commission the decoder with its loads disconnected. Stored output states are restored at power-up, so a connected accessory may operate as soon as power is applied.

railDECOacc controls eight accessory outputs arranged as four pairs. Each pair can provide timed operation for suitable twin-coil accessories or continuous switching for suitable lighting and relay loads.

Project website: tren.enmicasa.net — RailPIC projects and model railway electronics.

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1. Overview & operating principle

railDECOacc is a stationary decoder for DCC accessory commands. It is intended for layout equipment, not locomotive motor control. A PIC receives the digital commands through an optocoupler and switches an eight-channel ULN2803A output driver.

Four accessory pairs

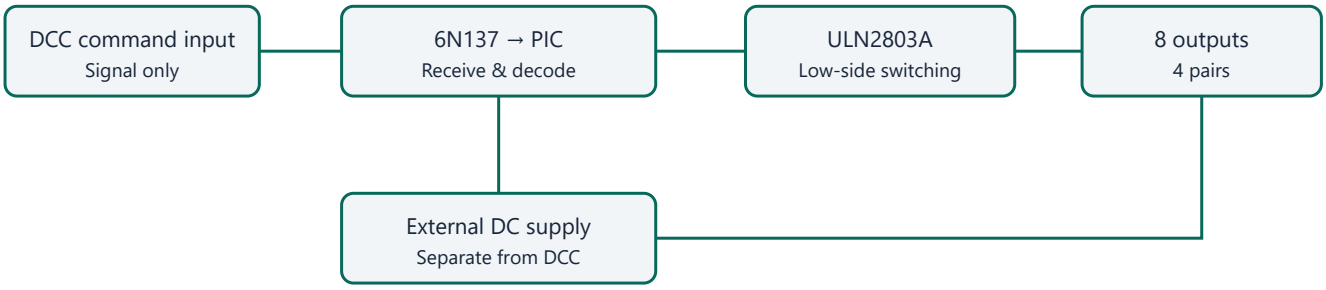
Outputs 1/2, 3/4, 5/6 and 7/8 form pairs 1–4. Each pair has two selectable sides and one shared timing CV.

Separate power

The DCC input carries the commands. An external DC supply powers the electronics and the accessories, so accessory current is not drawn through the DCC input.

Remembered state

The firmware stores output state information in EEPROM and restores it at power-up. This can restore lights and refresh turnout positions.



Timed and continuous operation

A non-zero timing value gives a nominal on-time in steps of approximately 10 ms. A value of zero disables the timeout for that pair: an activated output stays on until an explicit off command changes it. The two sides are not motor-polarity terminals and are not a servo interface.

There is no RailCom transmitter in this circuit. The programming LED provides local acknowledgement only; it is not a bidirectional data link or confirmation of a turnout's physical position. With the separate supply and isolated DCC input, the command station cannot read CVs through current acknowledgement.

2. Hardware & electrical safety

> **Never work on live wiring.** Switch off both the accessory supply and the DCC source before changing connections. Do not connect mains voltage to the board or its outputs.

Main components

Component	Role	Important detail
PIC16F84A / PIC16F628A	DCC decoding and timing	Requires the firmware intended for the fitted PIC.
8 MHz crystal	External processor clock	The firmware timing assumes this clock. Do not select an internal oscillator instead.
6N137	Optically isolated DCC receiver	DCC is a signal input, not the accessory power input.
ULN2803A	Eight low-side switching channels	Outputs sink current towards local ground; they do not supply a positive voltage.
78L05 regulator	5 V logic supply	Check regulator temperature and input-voltage suitability.
Programming LED and transistor	Local acknowledgement	The retained ACK circuit draws from the external supply, so its current change is not detectable at the DCC input.

Supply and load limits

The circuit reference marks the accessory supply **12 V DC** and the logic supply 5 V. Use a regulated, current-limited DC supply appropriate to your assembled board and loads, observing polarity. A voltage used successfully on another installation is not automatically a safe rating for your board.

The ULN2803A is commonly described as a 500 mA-per-channel driver. That figure is **not** a guarantee that eight channels can each carry 500 mA simultaneously. Package dissipation, duty cycle, voltage drop, board tracks, connectors and ambient temperature all matter. Check the actual manufacturer's data and the accessory's current demand.

A stalled or permanently energised coil can overheat even below the driver's headline current rating. Use suitable fusing/current limiting and accessories with appropriate protection. Firmware timing is not an independent safety cutoff.

Keep the power domains separate

Do not join a rail connection to accessory GND to "complete the circuit". The optocoupler provides signal isolation. Check turnout lamps and any shared wiring: an accessory with an internal lamp tied to a rail can unintentionally bridge the isolated power domains.

The load-driver clamp common must be connected as required by the board design, normally to accessory positive. The ULN2803A common pin is a clamp-diode connection, not its ground pin.

Known schematic issue: the retained ACK circuit

> **No command-station CV readback with the isolated, separately powered circuit.** The schematic retains a circuit intended to generate a DCC current acknowledgement, but its load is powered by the external supply. The resulting current change does not pass through the DCC input, so the command station cannot detect it. This is a hardware design limitation, not a command-station setting or a firmware timing problem.

CV writes can still be accepted, and the LED can show local acknowledgement. Firmware verify operations can also produce a visible LED response when a value matches, but they do not provide automatic CV reading by the command station. A programmer that requires a current ACK may report failure or stop its programming sequence even though an individual write was accepted.

For the separately powered design, the retained circuit must not be represented as a functioning DCC readback interface; at most, its LED is a local indicator. Providing current-based readback would require a hardware redesign that makes the acknowledgement load visible to the DCC source. Do not bridge the isolated power domains or change the board wiring to try to restore this function.

3. Connections & installation

Identify terminals from the markings and schematic of your actual board. The connector names below refer to the archived RailPIC circuit reference; do not infer physical pin order from the position of a connector in this table.

Connection	Role	Wiring
J1 / J7	DCC signal	Two connections to the DCC accessory bus or track signal. The two headers are wired in parallel in the circuit reference.
J6 / J8	External DC power	Accessory positive and GND. The two headers are wired in parallel; check polarity before connecting.
J5	Pair 1 / outputs 1 and 2	Two switched outputs and common accessory positive.
J4	Pair 2 / outputs 3 and 4	Two switched outputs and common accessory positive.
J2	Pair 3 / outputs 5 and 6	Two switched outputs and common accessory positive.
J3	Pair 4 / outputs 7 and 8	Two switched outputs and common accessory positive.

Twin-coil accessory

For a compatible three-wire, common-positive twin-coil turnout drive, connect its common to accessory positive and its two coil wires to the two outputs of a pair. Start with the shortest suitable pulse time and increase it only as required by the mechanism.

If the displayed turnout direction is reversed, swap the two coil wires with power off, or reverse the controller's logical direction. Do not swap supply polarity.

LEDs and steady loads

For an LED, connect accessory positive through a suitable current-limiting resistor to the LED anode, then its cathode to the switched output. With the output active, the ULN2803A sinks current. Size the resistor for the actual supply voltage and allow for the driver's voltage drop.

Use common-positive lighting assemblies. A common-negative signal cannot be connected by simply treating the driver as a positive-voltage source. For steady lighting, set the pair's timing CV to zero and send explicit on/off commands.

Output mapping at the PIC

Pair	Side A / output	Side B / output	Timing CV
1	1 · RB0 · PIC pin 6	2 · RB1 · PIC pin 7	515
2	3 · RB2 · PIC pin 8	4 · RB3 · PIC pin 9	516
3	5 · RB4 · PIC pin 10	6 · RB5 · PIC pin 11	517
4	7 · RB6 · PIC pin 12	8 · RB7 · PIC pin 13	518

These pair labels are accessory channels, not locomotive function keys F1–F4. Operate them with DCC accessory commands.

4. Programming the firmware

Installing the firmware requires a PIC programmer that supports the fitted device. Select the exact PIC in the programmer software and use the matching image. Do not rename or interchange the two HEX files.

Version / device	HEX filename	Configuration word
v6.01 · PIC16F84A	`DCCDECOMANOLO_V6_01.HEX`	`0x3FF6`
v7.01 · PIC16F628A	`DCCDECOMANOLO_V701.HEX`	`0x3F06`

Both images use the external 8 MHz clock with the watchdog enabled. Use the configuration supplied by the matching HEX rather than copying a setting from a different PIC.

Published firmware packages

- v6.01 package for PIC16F84A
- v7.01 package for PIC16F628A

The HEX checksums below identify the images documented here. Check the extracted HEX, not the ZIP container:

```
PIC16F84A · DCCDECOMANOLO_V6_01.HEX
db912d9178565a443b509d33b735033da5a3b9538e8a25c24a4cec9130eb0c8a

PIC16F628A · DCCDECOMANOLO_V701.HEX
6896258de05a6b5151f942d8356724f4f334d6124708a20408a6cf41d285a3b6
```

For example, in PowerShell:

```
Get-FileHash .\DCCDECOMANOLO_V701.HEX -Algorithm SHA256
```

Programming sequence

1. Disconnect the DCC input, external supply and all loads. Prefer a suitable programming socket/adaptor unless in-circuit programming has been verified for the board.
2. Read the PIC and save a backup, including EEPROM, before erasing it. This preserves your current CV settings and remembered outputs.
3. Select the correct device, open the matching HEX and enable programming of program memory, configuration and the EEPROM data provided in the file.
4. Program and verify all supplied regions. Do not substitute a blank EEPROM or an EEPROM image from a different version.
5. Disconnect the programmer and install the PIC in the correct orientation. Check the 8 MHz crystal and 5 V supply before applying power.
6. Perform the first-run tests with loads disconnected. Only connect a coil after output timing and startup behaviour have been checked.

ICSP reference for both 18-pin devices: VDD pin 14, VSS pin 5, VPP/MCLR pin 4, ICSPCLK/RB6 pin 12 and ICSPDAT/RB7 pin 13. The last two also drive accessory outputs, so attached hardware may load the programmer. This pin list is not approval for unverified in-circuit programming.

5. First run & output behaviour

Initial configuration in the documented HEX files

Setting	Initial value
Address fields	CV513 = 0, CV521 = 0. Configure an explicit address before layout installation.
Output-enable mask	CV514 = 255: all eight outputs enabled for commands.
Pair timing	CV515–518 = 10: approximately 100 ms per activation.
Identification bytes	CV519 = 0; CV520 = 0. The version is identified by the selected package, not these bytes.
Configuration byte	CV541 = 128. Leave it unchanged.
Remembered outputs, v6.01	`0x00`: no output initially selected.
Remembered outputs, v7.01	`0x80`: output 8 initially selected at startup.

> **The v7.01 image does not start with every output off.** Its initial saved state selects output 8. After normal use, both versions restore their own saved state. Disconnect loads during the first power-up and after reprogramming.

1. Inspect soldering, supply polarity, PIC orientation and driver orientation.
2. Apply the external DC supply with current limiting and no loads connected. Verify the logic supply is approximately 5 V.
3. Provide a valid DCC signal. Configure the decoder address and required timing CVs.
4. Use a suitable low-current test load to check each pair and both sides, including an explicit off command. Confirm actual pulse duration.
5. Power-cycle and check which outputs are restored. Do not assume they remain off while waiting for the first command.
6. Switch everything off and connect one real accessory at a time.

Timed operation

An on command starts the selected output and restarts its timer. A valid off command can turn it off earlier. Repeated on commands can extend energisation; the nominal CV duration is not a maximum under all command patterns.

Continuous operation

A timing value of zero removes the automatic timeout. Switching one side on does not provide a guaranteed interlock that turns the other side off. For a two-aspect signal, explicitly switch the unwanted side off before switching the desired side on.

Power-up and signal loss

Remembered state is restored to the outputs on power-up. For pulsed accessories this can refresh the stored position; for lighting it can restore the display. There are no physical position sensors, so the stored command is not proof that a turnout moved.

Do not rely on signal loss to turn a load off. The watchdog and output-memory logic are not an independent emergency-stop circuit. Switch off the accessory supply to guarantee removal of load power.

6. CV programming & addressing

A CV is a configuration variable stored in EEPROM. This decoder uses the accessory CV numbering **513–521 and 541**. These are not railDECOrc's locomotive or secondary-address CVs.

Programming methods

Method	Use	Important condition
Direct service-mode byte access	CV writes; verify instructions can produce a local LED response.	The controller must support CV numbers above 512 and sending writes without a detectable current ACK. Automatic CV reading is unavailable.
Paged service-mode access	Alternative CV write path; acknowledgement remains local to the LED.	Requires a compatible controller that can send the sequence without current ACK feedback. Do not substitute locomotive CV numbers or a guessed page value.
Accessory operations-mode programming	Addressed CV writes without moving the decoder to a separate programming setup.	Requires the accessory programming packet format supported by this firmware, not locomotive PoM.
Local acknowledgement	The programming LED flashes after an accepted operation or a successful verify.	No detectable current ACK reaches the DCC source in this separately powered design. There is no RailCom readback either.

The firmware requires repeated identical programming packets. Let a compatible command station generate the sequence; a single manually transmitted packet is not sufficient. Bit-manipulation programming is not documented as a supported method here.

Do not select automatic service-mode CV reading. This hardware cannot return the current ACK needed for it. Confirm writes through the local indicator and practical output checks, or inspect EEPROM with a PIC programmer when an exact stored value must be established.

> **Service programming is not address-isolated.** Connect only the decoder being configured. Keep its required external supply connected, but leave loads disconnected. Never connect the programming output to the accessory power terminals.

Address fields

The raw decoder-address format is `N = CV513 + 64 × CV521`, with CV513 containing the lower six bits (0–63) and CV521 the upper three bits (0–7). Do not write the entire displayed turnout number into CV513.

Many controllers show four consecutive turnout addresses per decoder. Under the common one-based convention, decoder address `N = 1` corresponds to turnouts 1–4, and `N = 5` corresponds to 17–20. Other controllers apply a numbering offset. Establish the mapping on a bench test before assigning layout addresses.

The stored initial address fields are zero; do not assume that this means "turnouts 1–4" on every controller. For first commissioning, set CV513 = 1 and CV521 = 0, then test the four pairs using your controller's documented numbering.

> **Address-isolation check:** commission with CV521 = 0 and verify that other decoder addresses do not operate the board. Before using higher address groups, explicitly test isolation; do not assume that changing CV521 alone guarantees a distinct decoder address.

After changing an address

For operations-mode writes, send each change to the address currently in use and expect the destination to change when the address fields change. For initial setup or recovery, service-mode programming avoids needing to know the old accessory address. Always verify the result using a harmless load.

7. CV reference

All values in this table are decimal. Defaults are taken from the EEPROM data in the documented firmware images.

CV	Initial value	Purpose
513	0	Lower six decoder-address bits. Use 0–63; see the address-isolation and numbering notes in chapter 6.
514	255	Output-enable mask. Bits 0–7 correspond to outputs 1–8; 1 accepts commands, 0 inhibits that output's command handling.
515	10	Pair 1 timing: outputs 1 and 2. Zero = continuous; non-zero = nominal 10 ms steps.
516	10	Pair 2 timing: outputs 3 and 4. Same scale.
517	10	Pair 3 timing: outputs 5 and 6. Same scale.
518	10	Pair 4 timing: outputs 7 and 8. Same scale.
519	0	Stored version-identification byte; protected against normal writes. It does not contain 6.01 or 7.01.
520	0	Stored manufacturer-identification byte; protected against normal writes. Do not assume the DIY identifier 13 is stored here.
521	0	Upper three decoder-address bits, 0–7. Higher-group isolation requires checking before layout use.
541	128	Stored accessory configuration byte. Leave at 128; it is not a user-selectable lighting mode or factory-reset command.

CV514 bit weights

Output	1	2	3	4	5	6	7	8
Bit	0	1	2	3	4	5	6	7
Weight	1	2	4	8	16	32	64	128

Add the weights of the outputs whose commands you want enabled. For example, 15 enables outputs 1–4; 252 enables outputs 3–8. The mask is **not an immediate all-off command**: it does not guarantee that an already active or restored output is cleared. Send off commands before disabling outputs, and disconnect load power for electrical isolation.

Timing values

`Nominal duration ≈ value × 10 ms`. Examples: 5 ≈ 50 ms; 10 ≈ 100 ms; 20 ≈ 200 ms; 50 ≈ 500 ms. The byte accepts 0–255, with zero reserved for continuous operation. Actual pulse duration depends on firmware operation and the command stream; measure it for a coil load.

Do not write unspecified CVs. No factory-reset command such as "CV8 = 33" is defined for this accessory firmware.

8. Configuration examples

Use a compatible **accessory** CV programmer. For first setup, isolate the decoder and use service mode with its external supply present and loads disconnected. Examples use the raw CV numbers, not zero-based EEPROM offsets.

A. Four timed turnout pairs

```
CV513 = 1
CV521 = 0
CV514 = 255
CV515 = 10
CV516 = 10
CV517 = 10
CV518 = 10
```

All eight outputs accept commands. Each pair has a nominal 100 ms on-time. Under the common one-based numbering convention, select turnouts 1–4; confirm the controller's mapping before attaching mechanisms.

B. A longer pulse for pair 2

```
CV516 = 20
```

Pair 2, outputs 3 and 4, now uses approximately 200 ms. The other timing CVs are unchanged. Increase coil energisation only if the accessory permits it; repeat commands may extend the pulse.

C. Continuous lighting on pair 1

```
CV515 = 0

Show side A:
  output 2 OFF
  output 1 ON

Show side B:
  output 1 OFF
  output 2 ON
```

Use the controller's accessory activate/deactivate commands. Continuous mode does not convert the pair into an automatically interlocked signal controller. A controller that only transmits brief activation pulses followed by off packets may need different settings for steady lighting.

D. Enable commands only for outputs 1–4

```
First send OFF to outputs 5, 6, 7 and 8.
CV514 = 15        1 + 2 + 4 + 8
```

Do not use this mask as a substitute for disconnecting a load during maintenance. To re-enable commands for all outputs, write CV514 = 255.

E. Move to decoder address 5

```
CV513 = 5
CV521 = 0
```

Under the common one-based convention, the four turnout numbers become 17–20. Other controllers can use a different offset. When writing by operations mode, account for the address changing after CV513 is written.

Keep a configuration record

Record the fitted PIC, HEX version, both address CVs, mask and four timing CVs, plus the controller's displayed turnout numbers. Note which outputs operate on power-up.

9. Troubleshooting & recovery

Symptom	Checks
No outputs respond	Check the separate DC supply, 5 V logic supply, PIC and firmware match, external crystal, DCC signal, address mapping and CV514. DCC alone does not power the loads.
An accessory moves at power-up	Output memory is restored at startup. The documented v7.01 image initially selects output 8. Test without coil loads after programming.
The wrong turnout number operates	Check raw decoder versus turnout numbering, controller offset, pair mapping and address isolation. Do not compensate blindly by changing CV521.
Other address groups also operate this board	Disconnect loads and isolate the module. Verify the fitted firmware and high-address filtering before connecting multiple decoders on the layout.
Lights go off immediately	Set the pair timing to zero, then check whether the controller is sending an off/deactivate packet immediately after on. Also check the mask and wiring.
Both sides of a steady pair stay on	Send an explicit off command to the unwanted output. Do not assume selecting the other side provides an interlock.
Coil or driver becomes hot	Remove accessory power immediately. Check timing is non-zero, repeated commands, stalled mechanism, current, supply voltage and simultaneous loads.
LED flashes, but programmer reports failure	The LED load is powered by the external supply, not the DCC source. Its current ACK cannot be detected by the command station. An individual write may have succeeded; check it locally or inspect the PIC EEPROM. Do not join the power domains.
Automatic CV reading always fails	This is a known limitation of the separately powered, isolated circuit. The retained ACK hardware cannot provide DCC current readback. Changing controller settings or retrying reads will not repair that hardware limitation.
LED does not flash	Check a compatible accessory CV packet and repeated writes. Verify LED polarity and its driver; a physical LED fault can hide an accepted command.
Output-enable mask does not switch a load off	The mask inhibits command handling rather than forcing all outputs low. Re-enable the output if necessary, send off, then set the intended mask. Disconnect power for a guaranteed stop.

Recover an unknown address

Disconnect all loads and other decoders. Use an isolated service-mode setup that supports accessory CV numbers and sending writes without current ACK feedback, then rewrite CV513/CV521. If service programming is unavailable, read and back up the PIC using a programmer, then reinstall the matching documented image including its EEPROM.

Reloading the HEX restores its initial EEPROM contents, including its startup-output state. There is no documented CV reset shortcut. A DCC reset packet is part of service programming and must not be confused with a factory reset.

> **Stop when a load behaves unexpectedly.** Remove accessory power and investigate with a harmless test load. Do not use repeated turnout operations as a diagnostic for a suspected wiring or address-isolation problem.

10. Acknowledgements & references

Thanks to the modelling community

RailPIC thanks all the railway modellers who have helped over the years by building boards, testing ideas on their layouts, sharing experience, reporting problems and offering practical advice. Their generosity and enthusiasm have made these projects possible.

The accessory firmware credits **Dean Probst, Mike Bolton, G. Ising and Stefano Curtarolo**, with its technical roots in the MERG DCC work. Their decoder and programming contributions are gratefully acknowledged.

The RailPIC project history also acknowledges **Le monde du DCC** as a circuit reference and **Paco Cañadas** for contributions through his model railway electronics designs. The RailPIC adaptations and output-memory behaviour build on this wider body of shared knowledge.

Thank you also to everyone who contributed in less visible ways: a careful test, an encouraging message, a useful question or a willingness to try a circuit on a real model railway.

Project and technical references

- tren.enmicasa.net — project website.
- RailPIC accessory decoder project page — project description and published firmware packages.
- MERG — Model Electronic Railway Group.
- Paco's model railway electronics website.
- NMRA S-9.2.2 — configuration-variable definitions. This manual retains the accessory CV numbers used by the documented firmware.

Refer to the manufacturer's documentation for the fitted PIC, ULN2803A, optocoupler and regulator when checking electrical limits. Component ratings do not by themselves certify the assembled board.

Scope of this manual

This manual describes the two published firmware images identified in chapter 4. Their HEX checksums and initial EEPROM data have been checked against the stored files and the packages currently downloadable from the project website. This is not a claim of new physical testing, a complete firmware audit, or NMRA certification.

Before installation, confirm the fitted board revision, supply/load limits, practical controller numbering and address isolation on the installation.

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