



Nova Gen2 Hardware Integrator's Guide

Toro PN 161-7501 Revision A Release

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1 Scope and Purpose

The Nova Gen2 electronics unit described in this document is Toro Part Number 161-7460. The unit is depicted in the figure below.

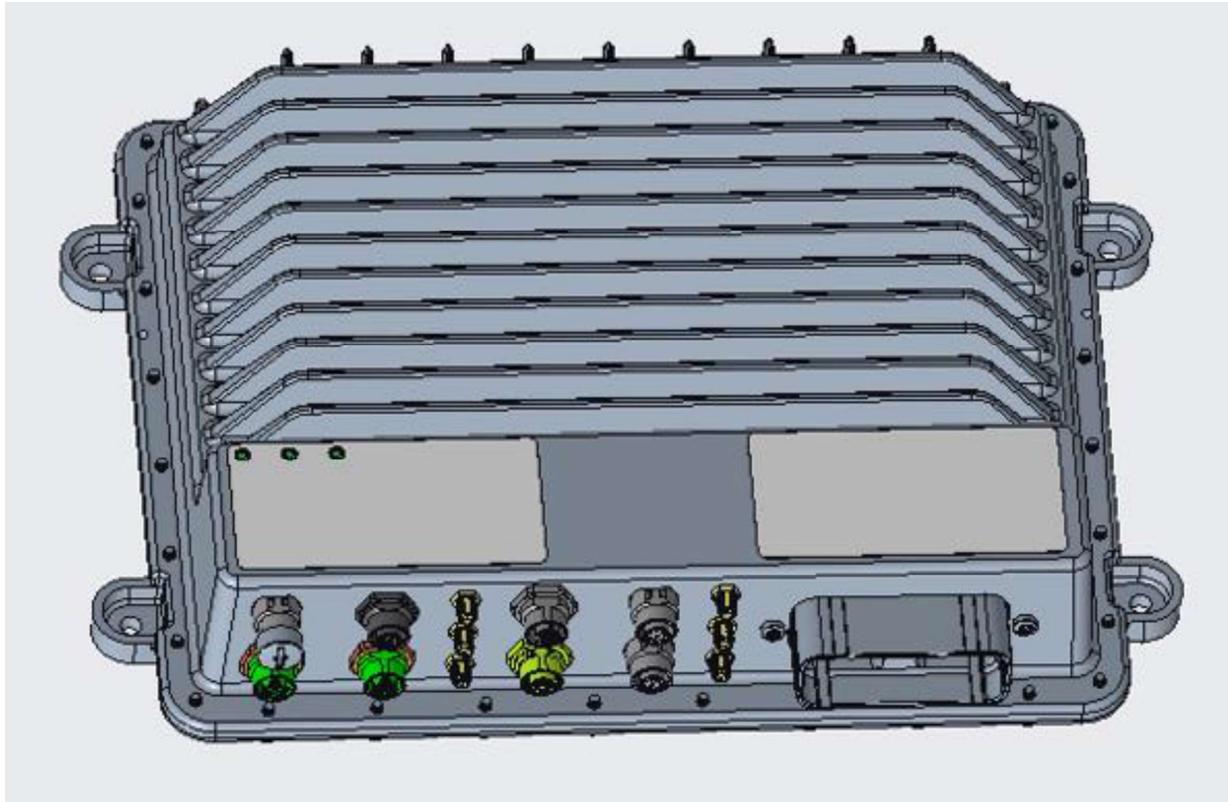


Figure 1 The external chassis/enclosure view of the Nova Gen2 electronics unit.

This document provides necessary information for engineers that are integrating the Nova Gen2 electronics into end-product equipment and machinery designs. As such, the document focuses on the external properties of the device, the external interfaces used to connect with other parts of the machine-level design, and on enabling the wireless connectivity features.

This document includes electrical specifications for providing power to Nova Gen2 electronics and for connecting peripherals to Nova Gen2 external power and data interfaces. This document also contains information on the antenna requirements when using the Nova Gen2 embedded radio modules and for complying with applicable radio regulatory requirements.

2 Nova Gen2 Hardware Overview

Nova Gen2 device is a set of computing and communications electronics in a ruggedized enclosure intended for use as a subcomponent of a larger machine-level design, specifically targeting use on mobile, outdoor power equipment. This device has a set of data communications and electrical power interfaces that can provide connectivity with a wide variety of external electronic sensors and other electronic controllers. The Nova Gen2 device performs sensor information processing, executes software-based machine control algorithms, exchanges data with other machine electronics controllers

and actuators, and provides wireless data communications connectivity to local area networks (i.e. WiFi) and wide-area networks (i.e. LTE Mobile/Cellular Data).

2.1 External Connections

The location of external connectors can be found in the drawings for the Nova Gen2 top-level assembly, Toro Part Number 161-7460.

Details of the electrical pinout of all external connectors is found in the detailed hardware description documents for Nova Gen2.

All the external connectors are Ingress Protection (IP) rated and designed to meet Toro's internal environmental hardening requirements.

3 Electrical Data

3.1 Absolute Maximum Ratings

12V POWER INPUT

- Input DC power is tolerant to +30V DC without damage (not operational).
- Input DC power is tolerant of Reverse Input voltage (not operational).
- Operation may cease during over-voltage and reverse polarity conditions but will automatically resume without circuit damage when voltage is returned to normal range.
- Input DC power current maximum is 12 Amps (with external power loads).

SIGNAL INPUTS

- GP signal inputs are tolerant between -6V and +30 Vdc relative to Ground.
- GP signal outputs not to exceed external voltage above +30Vdc or below -6Vdc relative to Ground.
- ON/OFF input is tolerant between +30 Vdc and Ground.
- RS232 inputs tolerant between -25 Vdc to +25 Vdc, outputs to not exceed -13.2 V and +13.2 Vdc.
- CAN High/Low tolerant to -26V dc and +26 Vdc relative to Ground, with internal over-voltage clamping.
Common mode voltage maximum -12V dc to +12V dc relative to Ground.
- Ethernet differential signals are magnetically isolated to 1.5 kV.

3.2 Recommended Operating Conditions (Input Power)

- Nova Gen2 input power is compatible with 12 VDC power systems, and operates over and input voltage range from 10Vdc to 18Vdc. Note that the low end input level is not currently compatible with sharing a 12V supply with an engine starter.
- Nova Gen2 outputs and signal interfaces are not isolated from the 12V input power and ground. All signal grounds are connected to input power ground.
- The Nova Gen2 aluminum chassis (i.e. housing) is electrically bonded to the system ground and power ground signals inside the Nova assembly.

3.3 Power Consumption

Without any external power loads (i.e., neither 12V or 24V outputs connected to anything),

0.8 Amps at 12.0V at with processors idle,
up to 2.5 Amps at 12.0V with full processor load and active data interfaces.

When external devices are powered through Nova, their load will directly contribute to the 12V input current consumption of the Nova Gen2 unit.

3.4 Interface Electrical Specifications

3.4.1 12V D.C. power outputs

Nova provides multiple switched 12V power outputs that are directly derived from the 12V input power and share in the input power ground (non-isolated). These outputs are rated to supply a maximum of 2.0 Amps total across the sum of the outputs, but additional testing could allow a rating up to 2.0 Amps each. Output Voltage will follow input power voltage.

There is no over-current protection on these outputs, thus these outputs should be fused to avoid exceeding the individual ratings of the series power elements: wires from Nova Gen2 outputs to the load, Nova Gen2 input current limits (see section 3.1), the power wires feeding the Nova power input, or the upstream power supply limits. A short on a 12V output will disrupt the Nova electronics operation unless externally protected to remove the fault.

3.4.2 24V D.C. power outputs

Nova provides multiple switched 24V power outputs that share ground connectivity with the input power and other external ground references. These outputs are rated to supply a maximum of 1.25 Amps each. Output voltage is regulated to $23.85V \pm 1.5\%$. Voltage converter efficiency is approximately 95%. The 24V outputs have over-current protection that protects against output shorts disabling the Nova internal electronics.

3.4.3 General Purpose Outputs

GP signal outputs are weak ($\sim 10mA$), constant-current, low-side drivers, created using an photo transistor but share power ground (no isolated input return). When desired to connect these output to a voltage sensing input, they should be connected to the input with a weak pull-up resistor that limits the output current sink to approximately 1mA (e.g., use a 12k Ohm or higher pull-up resistor to 12V for a 12V input).

While output Active: 0.2V at output (saturated), when sinking current limited to 1mA;
otherwise the voltage at the output pin will rise as needed to sink approximately $10mA \pm 20\%$.

While output Inactive: open circuit (external applied voltage not to exceed +30V dc).

3.4.4 General Purpose Inputs

GP signal inputs are current detecting with 1000 Ohm input impedance, a 1.2V forward drop at input pin, and no internal pull-up. These inputs must be driven high to activate, and can not sense switch to ground without external pull-up.

To drive input Active: apply external +5V to +30V (minimum 1.6mA, maximum 30mA)

To drive input Inactive: apply external open circuit or voltage between 0V and +0.5V.

3.4.5 Ethernet Interfaces

Nova Gen2 provides multiple external Gigabit Ethernet interfaces (1000Base-T), that should connect to external peripherals using Shielded CAT5a or CAT6 twisted pair cables in order to minimize EMC susceptibility at the system level. These signals are galvanically isolated from all logic and input power and ground. These interfaces provide auto negotiation and support auto MDI-X.

3.4.6 CAN bus Interfaces

Nova Gen2 provides multiple external CAN bus interfaces, capable of industry standard CAN and CAN-FD. These interfaces will operate with common mode voltage up to $\pm 12V$ and have additional ESD protection, but are not isolated from system ground and power.

These interfaces should connect to machine-level wire harness using twisted pair wiring for CAN High and CAN Low differential signals and should have a closely associated ground wire with the bus (minimally same endpoints connected to same wire harness grounds).

3.4.7 RS-232 Serial Interfaces

Nova Gen2 provides multiple industry standard RS-232 interfaces. These interfaces have additional ESD protection, but are not isolated from system ground and power. These interfaces should connect to the machine-level harness with a closely associated ground wire for signal return currents (minimally same endpoints connected to same wire harness grounds).

Output Voltage levels: at least ± 5.0 Volts

Input Voltage Threshold: $V_{in_positive}$ 2.4V maximum. $V_{in_negative}$ 0.6V minimum.

3.4.8 Radio-Frequency (RF) Interfaces

The three active RF connections on the Nova Gen2 assembly must be connected to the approved external combination antenna and are further described in the sections below.

The three RF SMA coax connectors (if installed) on the right closest to the larger 40-pin connector are not connected internally and should not have a cable connection.

3.4.8.1 *Qualified Radio Antenna(s)*

The only antenna qualified for use with the Nova WiFi/Bluetooth and LTE modem radios that has the required rugged and ingress protected housing is the following Combo-Antenna for LTE 4G MIMO (two identical antennas) and 2.4/5.0 GHz (single antenna)

- Manufacturer: 2J Antennas
- MPN: 2J6985Ba-183RG316-C20G_C20G_C115G, which is a custom variant of 2j6985Ba with RG316 coax
- Toro Part Number: 161-7450
- IP Rating: IP67,IP69

3.4.8.2 *WiFi-Bluetooth Radio-Frequency (RF) Antenna Interface*

The WiFi-Bluetooth RF interface to the external antenna has the following characteristics:

- Chassis Connector: Ref Des S1 (also called “WFBT1” on top label), type male SMA-RP (Reverse Polarity)
- Antenna Cable Connection: use the “Cable 3” per above antenna’s datasheet, which has the

Reverse Polarity SMA female end, and will only mate to this one location on Nova Gen2 enclosure.

- Conducted output power on 2.4 GHz band: up to 17 dBm typical at full-power. However, output power is reduced further for certain channels and operating modes to meet RF emissions requirements with the specified antenna.
- Conducted output power on 5 GHz band: up to 15 dBm typical at full-power. However, output power is reduced further for certain channels and operating modes to meet RF emissions requirements with the specified antenna.

3.4.8.3 LTE Modem Radio-Frequency (RF) Antenna Interface

The LTE Modem RF interface to the external antenna uses two coaxial connections. The top-left SMA normal polarity RF connector is used by the LTE radio for both Transmitting and Receiving.

- Chassis Connector: Ref Des S3 (also called “LTE1” on top label), type male SMA normal polarity.
- Antenna Cable Connection: use the “Cable 1” or “Cable 2” per above antenna’s datasheet, which have the normal polarity SMA female ends.
- Impedance: 50 Ohms nominal
- Conducted output power on 4G LTE bands: up to 23 ± 0.5 dBm maximum. However, output power is reduced further for certain channels and operating modes.
- Conducted output power on 3G HSPA+ bands: up to 23 ± 0.5 dBm maximum. However, output power is reduced further for certain channels and operating modes.

The other middle-left LTE Modem RF connector is for Receiving only.

- Chassis Connector: Ref Des S2 (also called “LTE2” on top label), type male SMA normal polarity.
- Antenna Cable Connection: use the “Cable 1” or “Cable 2” per above antenna’s datasheet, which have the normal polarity SMA female ends.
- Impedance: 50 Ohms nominal
- Conducted output power on 4G LTE bands: N/A (receive only).
- Conducted output power on 3G HSPA+ bands: N/A (receive only).

4 Form-Factor Specifications

4.1 Nova Gen2 Enclosure Specifications

The external chassis of the Nova Gen2 unit (Toro PN 161-7460) including mounting flanges and connectors) has maximum envelope of 13.86 inches width, 9.83 inches width, and 2.95 inches depth. However, significant additional clearance is required on the side of the chassis containing the interface electrical connectors to accommodate external cable connections. See drawings under the Nova Gen2 Toro PN 161-7460 for additional details.

4.2 Radio Antenna Size

The size of the specified combination radio antenna from 2J MPN 2J6985Ba-183RG316-C20G_C20G_C115G (Toro PN 161-7450) for use with the Nova Gen2 is 74 mm by 80 mm by 25.6 depth (excluding mounting and cables), with additional 20 mm depth extending through the mounting hole and 183 cm long attached cables.

5 Environmental Specifications

5.1 Temperature, Shock & Vibration, and Ingress & Exposure

The Nova Gen2 is ruggedized for use in outdoor mobile machine environments. The Nova Gen2 enclosure and specified external antenna have been tested to specific stress levels and performance criteria per Toro's internal specifications for electronics equipment. Integrators should consult the test reports to assist in determination of compatibility with specific machine environments and mounting locations.

5.2 EMC Emissions

The Nova Gen2 device has been tested for unintended EMC emissions in a standalone configuration and found to be well within the CISPR 11 limits for Class B devices from 0.15 MHz to 1.0 GHz. These results demonstrate that Nova Gen2 device could be integrated with end-product (machine-level) emissions regulations (FCC, IC, EU, etc) for industrial/commercial (class A) devices. However, these standalone results does not imply compliance with these regulations at the end-product (machine-level). Thus, additional emissions testing after integration is always required.

5.3 EMC Susceptibility

EMI IEC 61000-4-3 Radiated Immunity – meets performance criterion A at the test level 2 (3V/m).

5.4 ESD Tolerance

Meets the ESD Test requirements per ISO10605-2008

- o Unconnected, unpowered – Per ISO10605 Section 9.
- o Connected, powered – Per ISO10605 Section 8.

Additional Toro internal standard test results are also available.

6 Regulatory Information

6.1 Radios

The Nova Gen2 contains radios that are intentional radiators and subject to regulator certification requirements as described below.

6.1.1 WiFi-Bluetooth Radio

The Nova Gen2 unit contains a WiFi-Bluetooth radio that is a pre-certified module with approvals for US (FCC), Canada (IC), and Europe. This radio operates in the following frequency bands

- 802.11 b/g/n/ac, Bluetooth LE, BR, EDR-2, EDR-3 in band 2.412 GHz -2.472 GHz
- 802.11 a/n/ac in band 5.180 GHz – 5.825 GHz

6.1.2 LTE Mobile Cell Modem Radio

The Nova Gen2 unit also contains an LTE radio modem module that is pre-certified with approvals for US (FCC) and Canada (IC). This radio operates in the frequency bands

- LTE CAT 4 in Frequency Bands FDD B2[1900], B4[1700], B5[850], B12[700], B13[700], B14[700], B66[1700], B71[600]
- DC-HSPA+ in Frequency Bands B2[1900], B4[1700], B5[850]

6.1.3 Radio Regulatory Requirements

The presence of two co-located radio modules and the combination antenna, required that the Nova Gen2 unit also be tested for intended RF emissions in this new hardware configuration. Nova Gen2 in a standalone configuration with the antenna described above in section 3.4.8.1 (2J Antennas MPN: 2J6985Ba-183RG316-C20G_C20G_C115G), is filing for radio approval under the following identifications:

- FCC ID: OF7-NVG2
- Canada IC ID: 356A-NVG2

Nova Gen2 is always intended to be integrated into a larger machine. The machine-level integrator must comply with the following for the machine to comply with the existing Nova Gen2 approvals:

1. Nova Gen2 must be used with the approved combination antenna described above in section 3.4.8.1 (2J Antennas MPN: 2J6985Ba-183RG316-C20G_C20G_C115G) as a condition for these regulatory approvals. If a different antenna is needed in the future due to an incompatible machine-level requirement, then additional testing and certification is required with that hardware configuration, see FCC 15.21 requirements.
2. The Nova Gen2 unit is labelled with its own FCC/IC ID numbers, and, if the FCC/IC IDs are not visible when the module is installed inside another device, then the outside of the device into which the unit is installed must also display a label referring to the enclosed Nova Gen2 unit identifications. This label must state
FCC ID: OF7-NVG2
IC ID: 356A-NVG2
3. The machine (end product) must display the FCC Part 15 interference statement (FCC 15.19): This device complies with Part 15 of the FCC Rules and Industry Canada license-exempt RSS standards. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.
4. This device is approved as a mobile device with respect to RF exposure compliance. The mounting of the approved external antenna(s) used for this mobile transmitter must provide separation distance of at least 20 cm from all persons and must not be co-located or operating in conjunction with any other antenna or transmitter. Should the modem's antenna be mounted closer than 20cm from the human body or if there are adjacent RF transmitters, additional FCC/IC testing or analysis may be required to assure RF exposure compliance of the end product.
5. **IMPORTANT:** Modifications to this unit and approved antenna that are not expressly approved by this company could void the user's authority to operate this equipment (FCC section 15.21).
6. **IMPORTANT:** A finished machine-level product containing Nova Gen2 unit is required to comply with all applicable FCC and IC equipment authorizations regulations, requirements and equipment functions not associated with the Nova Gen2 radio transmitter module portions. Compliance for unintentional radiators (Part 15 Subpart B "Unintentional Radiators"), such as digital devices, computer peripherals, radio receivers, etc. must be demonstrated.

1. Note: This Equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.

- Increase the separation between the equipment and receiver.

- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.

6.2 Materials Regulations

All components in the Nova Gen2 assembly are intended to be RoHS / REACH compliant and analysis reports are available.

All items which form a barrier between the inside and outside of the housing, have a UL 94 flammability rating of V0 or better.