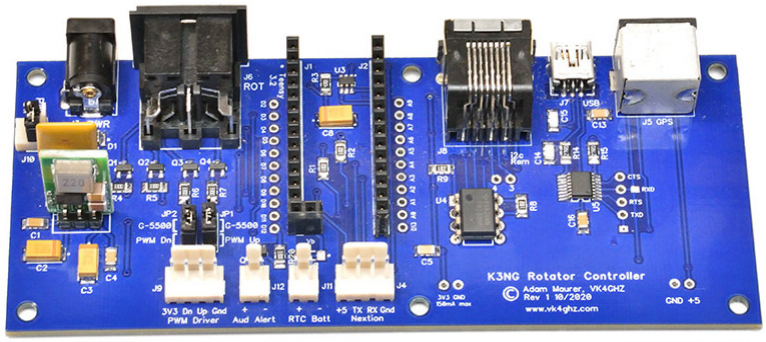
VK4GHZ Universal K3NG Rotator Controller Kit Notes

This K3NG based computer interface controller suits a Yaesu G-5500 dual azimuth elevation controller and also accommodates various other configurations, such as a azimuth only rotator along with a linear actuator for elevation.

Also features PWM derived speed voltage control output (ie; G-800DXA G-1000DXA, G-28000DXA), i2c remote sensors input via bus extender, a PWM interface for external PWM carrier driver board, and easy access to spare MCU I/O ports for future experimentation.



Pre-assembled and tested (factory Teensy 3.2 MCU removed after testing) and ready for you to complete the integration into your own system requirements.

Skill level required: Intermediate - Advanced

- **Arduino IDE/Teensyduino familiarity**
- **Programming your own Teensy MCU via USB**
- **Programming your own Nextion via microSD card or USB/FTDI**
- **Soldering interface lead connectors & wires**
- **Mounting Nextion & board in your own enclosure**

Features

- PCB 132 x 55mm, M3 mounting holes
- Accommodates Teensy 3.2 MCU (not supplied)
- Nextion (not supplied) touch screen HMI interface
- Computer interface via Teensy's USB-micro port
- Generic rotator control with CW/CCW/Up/Down outputs
- Yaesu G-5500 compatible with CW/CCW/Up/Down control
- Yaesu G-800DXA (and G-1000-DXA, G-2800-DXA) PWM speed voltage output for soft start/stop
- Azimuth & Elevation analogue potentiometer input
- PWM motor driver for linear actuator elevation control
- i2c extender for remote sensors via RJ45 and cat5
- Piezo audible alert output
- Teensy RTC battery connection
- 4 x N.O. generic push-button switch inputs with pull-ups
- GPS serial data pass-through (genuine FTDI chip) to USB Mini-B for simultaneous PC time-syncing ability
- 7805 High efficiency DC-DC Buck Regulator
- Resettable 2.5A fuse

VK4GHZ Universal K3NG Rotator Controller Kit Notes

Typical Configurations

This universal controller can be used to suit a variety of implementations, such as;

- Azimuth rotator only
- Dual azimuth & elevation rotator (eg; G-5500)
- Azimuth rotator + elevation linear actuator

What's in the Box?

1 x assembled and tested controller board (Factory Teensy removed after testing)
1 x 8-pin DIN connector (connects to rotator)
1 x 4-pin mini DIN connector (connects to GPS)
3 x Polarised 2-pin connectors (connects to audible alert piezo, RTC battery backup)
1 x Polarised 4-pin connector (to PWM Driver)
1 x 2.5mm DC plug (+13.8V power)
1 x RJ45 plug (to remote i2c sensors)

What's Needed to Finish This Off?

Teensy 3.2 MCU (requires programming)
Nextion HMI (requires programming)
Enclosure & mounting hardware to suit your own circumstance
Wires and cable to suit your own circumstance

VK4GHZ Universal K3NG Rotator Controller Kit Notes

MCU Selection Notes

Whilst many capable microcontroller modules are suitable, the powerful **Teensy 3.2** microcontroller from PJRC was chosen due to its small form factor (similar size Arduino Nano), and being a plug in solution. PJRC MCUs are assembled in the USA, not China.

Teensy 3.2	Arduino MEGA 2560	Arduino Nano
Cortex M4 72MHz 32-bit MCU	ATmega 16 MHz 8-bit MCU	Seriously, Forget about it!
256 kB FLASH	256 kB FLASH	
64 kB RAM	8 kB RAM	
2 kB EEPROM	4 kB EEPROM	
ADC 12-bits used 787 uV / step resolution	ADC 10-bit 4.9 mV /step resolution	
3 Hardware Serials	4 Hardware Serials	
Small sub-board form factor	Large form factor	

⚠ **Teensy 3.2 EEPROM accommodates 16 Satellite TLEs for stand-alone satellite tracking**

Teensy 3.2 purchasing suggestions (some suppliers provide header connectors, but not soldered to board)

Direct from PJRC (USA)
https://www.pjrc.com/store/teensy32.html

Sparkfun (USA)
https://www.sparkfun.com/products/13736

Adafruit (USA)
https://www.adafruit.com/product/2756

Arduino.cc Store (USA)
https://store.arduino.cc/usa/teensy-3-2-usb-development-board

Core Electronics (Aus)
https://core-electronics.com.au/teensy-3-2.html

Robot Gear (Aus)
https://www.robotgear.com.au/Product.aspx/Details/1052-Teensy-3-2-32Bit-processor-with-USB

Little Bird (Aus)
https://www.littlebird.com.au/products/teensy-3-2-cb69a1de-a135-4b0d-a569-5f537f5e6c9c

Hobbytronics (UK)
https://www.hobbytronics.co.uk/teensy-v32

Nextion Enhanced purchasing suggestions

Direct from iTead (not always the cheapest)
https://www.itead.cc/display/nextion.html

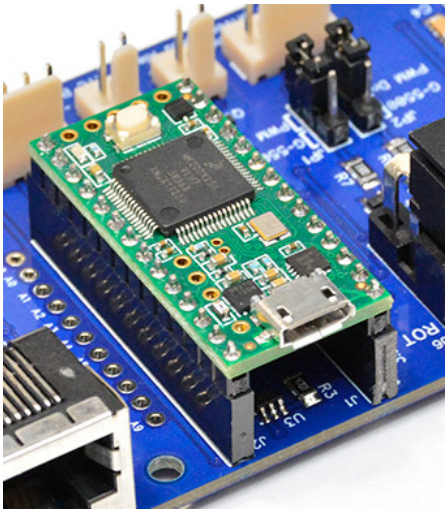
Banggood
https://www.banggood.com/search/nextion.html?from=nav

AliExpress
https://www.aliexpress.com/wholesale?catId=0&initiative_id=SB_20210127215039&SearchText=nextion

VK4GHZ Universal K3NG Rotator Controller Kit Notes

Teensy 3.2 Programming & Orientation

Insert your Teensy 3.2 MCU module as follows;



⚠ **USB connector is towards PCB rear edge**

Teensy USB port becomes main interface connection to computer for rotator control & tracking.

Teensy can be programmed stand-alone before being inserted.

If programming after insertion, disconnect Nextion during programming, as your Teensy USB programming port may not be able to provide sufficient current for everything. (?)

Can I use another MCU?

No, this board is designed to use a Teensy 3.2.

Teensy 3.2 I/O Summary

Physical Pin	I/O Pin	K3NG Reference	Pin Function
4	D2	-	*spare*
5	D3	3	CW output to NPN open collector
6	D4	4	CCW output to NPN open collector
7	D5	5	Up PWM or Up output to NPN open collector
8	D6	6	Down PWM or Down output to NPN open collector
9	D7	7	RX3 (Serial 3) Data from Nextion
10	D8	8	TX3 (Serial 3) Data to Nextion
11	D9	9	RX2 (Serial 2) Data from GPS
13	D11	-	*spare*
14	D12	12	Audible Alert to Piezo
16	A0	A0	Azimuth Analogue Volts In (adjust your rotator for 3V3 max)
17	A1	A1	Elevation Analogue Volts In (adjust your rotator for 3V3 max)
18	D16/A2	16	Remote CW input (This pin pulled up - take low to activate CW)
19	D17/A3	17	Remote CCW input (This pin pulled up - take low to activate CW)
20	D18/A4		i2c SCL to P82B96 Buffer Transceiver
21	D19/A5		I2c SDA to P82B96 Buffer Transceiver
22	D20/A6	20	Remote Up input (This pin pulled up - take low to activate Up)
23	D21/A7	21	Remote Down input (This pin pulled up - take low to activate Down)
24	D22/A8	-	*spare*
25	D23/A9		Az Speed PWM to SN74LVC1T45 Buffer (converts 3V3 to 5V)

VK4GHZ Universal K3NG Rotator Controller Kit Notes

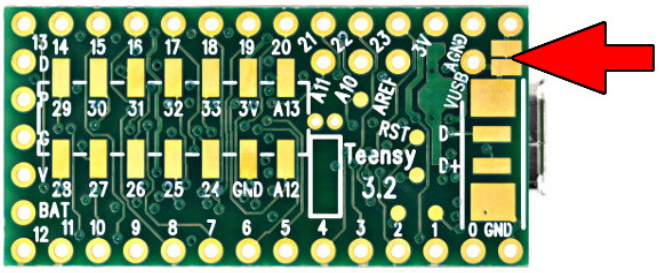
Cutting Teensy 3.2 V_{USB} Link

If the Teensy USB lead is connected to a PC and 5V is present (PC may even be 'off') and the V_{USB} link is not cut, Az and El meters on a G-5500 will deflect FSD even when the controller board is off

This happens because voltage from the USB line is appearing on the controller's 5V rail.

The USB 5V line and the controller's 5V rail should be isolated by cutting the VUSB link on the under-side of the Teensy 3.2. Use a sharp utility knife the break the fine trace linking these two pads.

Verify with a DMM continuity check that link has been broken between both pads.



Cut track in here to isolate V_{USB} from V_{IN}

Once the V_{USB} link has been cut, the Teensy must be inserted into the controller board and controller board powered up when programming Teensy via USB lead.

Also refer to page 15 - Fixing the TERRIBLE G-5500 +13V Supply Rail

Arduino file settings for Nextion

To use this controller board with a Nextion, the following lines must be enabled/configured in the K3NG code before compiling and uploading to the Teensy 3.2:

rotator_features.h

#define FEATURE_NEXTION_DISPLAY

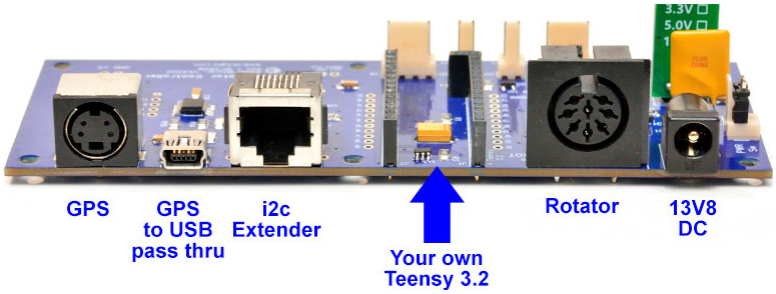
rotator_settings.h

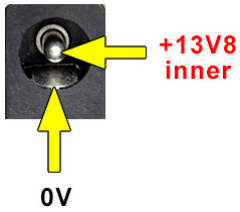
#define nexSerial Serial3

#define NEXTION_SERIAL_BAUD 115200

VK4GHZ Universal K3NG Rotator Controller Kit Notes

Rear Connections

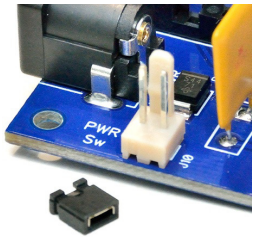




J3 – DC Power

⚠ **Observe polarity** Requires nominal 12 VDC. Inner pin is positive:

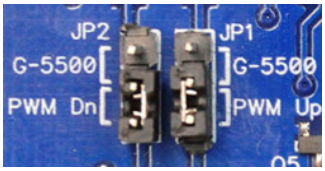
J10 – Power switch



To use your own SPST power switch, remove the shunt, and solder switch wire to a supplied 2-pin polarised plug.

Leaving the shunt in place will allow you to remotely turn this board on and off.

JP1 JP2 - Elevation Jumpers



Choose between Up & Down control signals appearing on J6 pins 5 & 4 (ie; G-5500 etc), or divert to J9 for external PWM motor controller (ie; linear actuator).

You need to configure rotator_pins.h file to suit your own system.

⚠ **Do not confuse Teensy digital pin reference and J6 pin references**

Example – for G-5500 Simple Up/Down switching

```
/*----- elevation pins -----*/
#define rotate_up 5
#define rotate_down 6
#define rotate_up_or_down 0
#define rotate_up_pwm 0
#define rotate_down_pwm 0
#define rotate_up_down_pwm 0
#define rotate_up_freq 0
#define rotate_down_freq 0
#define rotator_analog_el A1
#define button_up 20
#define button_down 21
```

Example - for external PWM Up/Down control

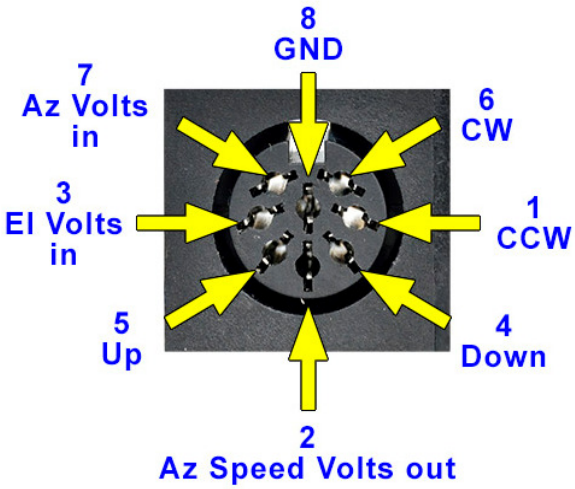
```
/*----- elevation pins -----*/
#define rotate_up 0
#define rotate_down 0
#define rotate_up_or_down 0
#define rotate_up_pwm 5
#define rotate_down_pwm 6
#define rotate_up_down_pwm 0
#define rotate_up_freq 0
#define rotate_down_freq 0
#define rotator_analog_el A1
#define button_up 20
#define button_down 21
```

Rear Connections

J6 – Rotator Port

CCW, CW, Up and Down outputs are open-collector NPN transistors switching to ground.

Use the supplied 8-pin DIN connector to prepare a shielded multi-core lead to your rotator as follows:



For your own reference, note the wire colours in the chart below;

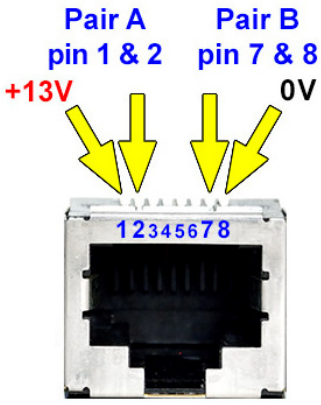
VK4GHZ J6 Pin	Function	My wire colour	G-5500 Ext Control	G-800/1000/2800 Ext Control
1	CCW		4	2
2	Az Speed Volts		-	3
3	El volts		1	-
4	Down		5	-
5	Up		3	-
6	CW		2	1
7	Az volts		6	4
8	GND		8	5

⚠ **For other rotators, check your rotator manual for connection details**

VK4GHZ Universal K3NG Rotator Controller Kit Notes

Rear Connections

J8 – i2c Remote



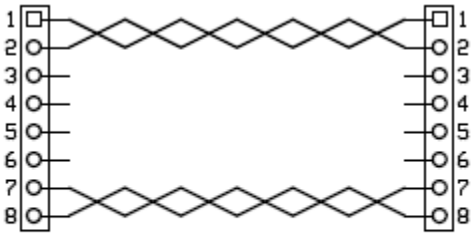
⚠ Observe polarity

A variety of remote sensors using the i2c bus can be used with this controller board.

Texas Instruments P82B96 bus transceiver is fitted to this board, and must also be used at the remote end. https://au.rs-online.com/web/p/buffers/8122662

Distance limitations will depend on cable capacitance, but 30m is easily achieved using regular cat 5 cable.

RJ45 Pin	Function
1	+13V
2	SCL Data
3	*spare*
4	*spare*
7	SDA Data
8	GND

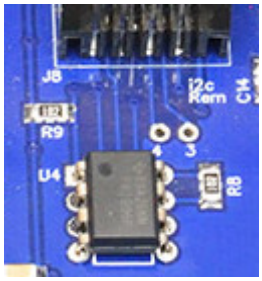


Main – Remote Interconnect
2 x Twisted pair

RJ45 pins 3 and 4 appear on PCB pads if another pair to the remote unit is required.

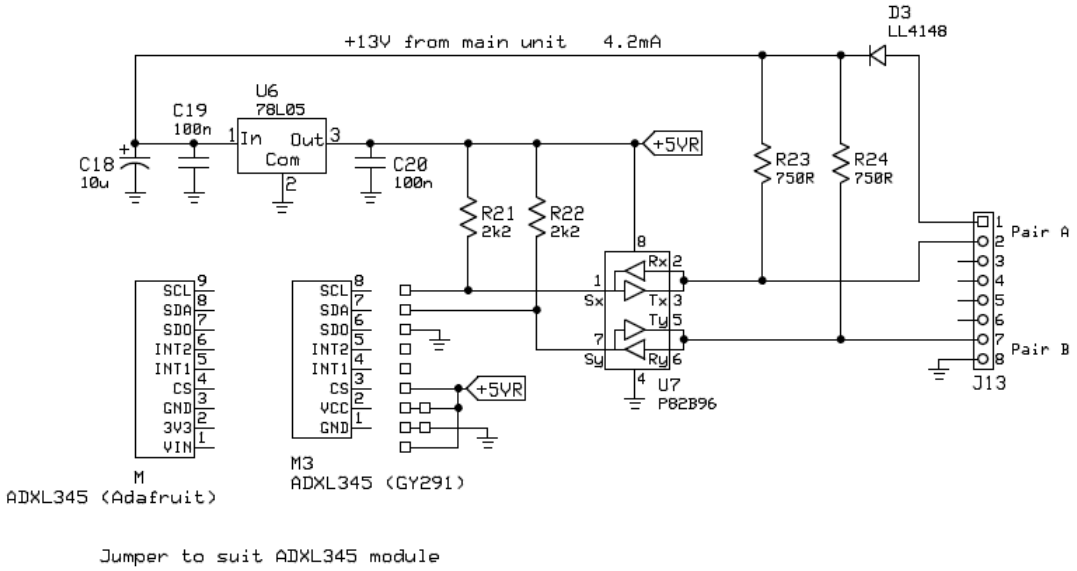
RJ45 pins 5 & 6 are not implemented.

Note a shielded RJ45 is fitted to the PCB if you wish to use implement shielded cable and connectors. RJ45 shield connects to PCB GND.



Example ADXL345 i2c Remote Elevation Sensor

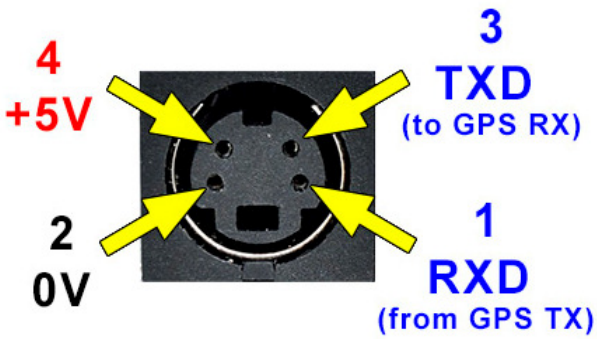
+13 V is fed up pin 1, GND is pin 8. Note terminating resistors required either side of P82B96. Remote i2c sensors will require a local 5V (or 3V3) regulator to suit, implemented like this;



VK4GHZ Universal K3NG Rotator Controller Kit Notes

Rear Connections

J5 - GPS Port



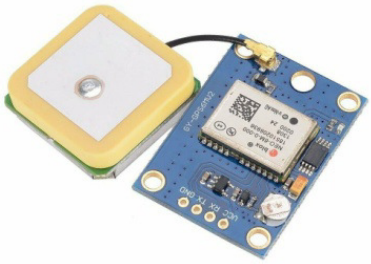
⚠ **Observe polarity**

Serial NMEA GPS data can be fed to the Teensy 3.2 for accurate time keeping purposes.

Using the supplied 4-pin mini DIN connector, prepare a lead to connect to your external GPS module as follows:

Ordinary 4-core alarm cable is ok for several metres.

GPS Suggestion



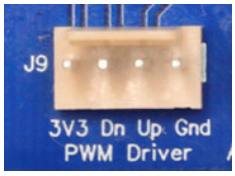
Low cost (AUD$18) UBlox NEO6M based modules available on ebay:

NEO6M modules are sensitive enough to use indoors, but not the basement!

J7 - GPS Pass thru

Use a standard USB Mini-B lead to provide simultaneous time keeping of your PC.

J9 – PWM Driver



⚠ **Observe polarity**

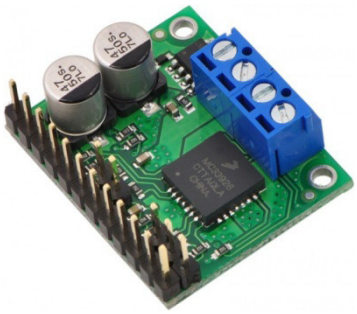
This connector provides 3V3, two PWM control signals and GND.
Intended for UP and DOWN control of a linear actuator.

Configure rotator_pins.h file to suit.

PWM Driver Suggestion

MC33926 Carrier Board is ideal for loads up to 5A, and will drive a 1500N 12V linear actuator with ease.

https://core-electronics.com.au/mc33926-motor-driver-carrier.html



VK4GHZ Universal K3NG Rotator Controller Kit Notes

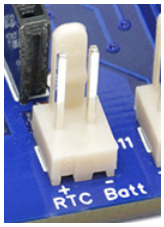
Front Connections

J12 – Audible Alert

⚠ **Observe polarity**

Connect your external piezo buzzer using supplied 2-pin polarised connector.

J11 – Teensy 3.2 Real Time Clock (RTC) Battery



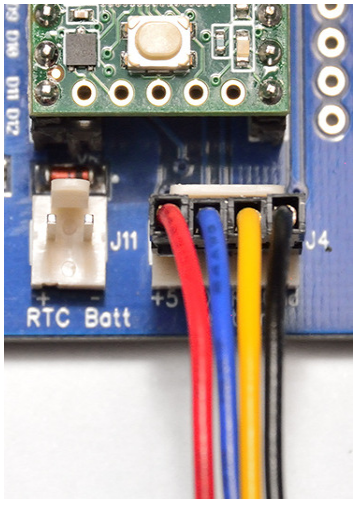
⚠ **Observe polarity**

Use supplied 2-pin polarised connector for an external 3V battery RTC power backup.

Note:
As of this documentation date, Teensy RTC firmware support is not currently implemented, but this hardware will accommodate if/when this happens.

J4 – Nextion HMI

Connect your own enhanced Nextion as follows.



⚠ **Wires connect in the same order as they connect at the Nextion**

Red = +5V

Blue = Nextion TX

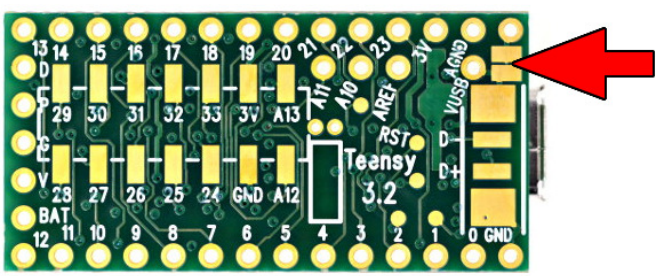
Yellow = Nextion RX

Black = GND

Cutting Teensy 3.2 V_{USB} Link

If the Teensy USB lead is connected to a PC and 5V is present (PC may even be 'off') and the V_{USB} link is not cut, Az and El meters on a G-5500 will deflect FSD when the controller board is off because voltage from the USB line is appearing on the controller's 5V rail.

The USB 5V line and the controllers 5V rail should be isolated by cutting the VUSB link on the under-side of the Teensy 3.2. Use a sharp utility knife the break the fine trace linking these two pads.



Cut track in here to isolate V_{USB} from V_{IN}

⚠ **If manually editing the standard rotator_pins.h file, configure as per above**

Pre-configured rotator_pins.h file available from

https://vk4ghz.com/product/vk4ghz-k3ng-rotator-controller/

Teensy 3.2 Firmware

K3NG provides free official firmware from Github

https://github.com/k3ng/k3ng_rotator_controller

Use the IDE of your choice to configure the settings, pins, and features and program the Teensy 3.2

For casual users, the free Arduino IDE is suggested

https://www.arduino.cc/en/software

Advanced MCU enthusiasts may prefer the free Microsoft Visual Studio (Community Edition)

https://visualstudio.microsoft.com/downloads/

Either IDE will require Teensyduino from Teensy manufacturer PJRC be installed

https://www.pjrc.com/teensy/td_download.html

Nextion Firmware

VK4GHZ provides free firmware for 3.2", 3.5", 5.0" and 7.0" **Enhanced** HMIs

https://vk4ghz.com/vk4ghz-k3ng-rotator-controller-system/

⚠ **VK4GHZ firmware requires enhanced HMIs, not the cheaper basic HMI variant**

You are free to modify the Nextion firmware provided by VK4GHZ to suit your own requirements, however no support may be provided due to unforseen situations you may create – you need to know what you are doing!

Enclosure Mounting Suggestion

YouTube video where VK4GHZ mounts his 5.0" Nextion and Universal controller board inside an $8 ABS box

https://www.youtube.com/watch?v=aY0UyPOcEHY

VK4GHZ Universal K3NG Rotator Controller Kit Notes

K3NG Firmware Calibration

Once Yaesu controller maximum voltages have been set to just under 3.3 V, K3NG controller firmware calibration can be performed via the Arduino serial terminal (or terminal program of your choice, eg; Putty) or via the VK4GHZ Nextion 'RotorCalibration' screen.

K3NG Command Reference Wiki

https://github.com/k3ng/k3ng_rotator_controller/wiki/820-Command-Reference

Satellite TLE Uploading to Teensy via USB

Remember, you cannot use the Arduino serial terminal to upload TLE data – it will NOT work!

Terminal program Putty is suggested, as seen here https://www.youtube.com/watch?v=oFZq4j7RhY8

K3NG Project Community

Join others on the Groupsio Radio Artisan discussion group.

https://groups.io/g/radioartisan/topics

Remote Control Pins

Four Teensy 3.2 pins have pull-up resistors **to 3V3** that can be taken to ground for wiring to physical push buttons or for remote control interfacing to activate CCW, CW, Up and Down. Solder pads available on PCB.

Teensy Pin	Typical Function
D**16** / A2	CW
D**17** / A3	CCW
D**20** / A6	Up
D**21** / A7	Down

Configure rotor_pins.h to suit your wiring. Eg;

```
/*----- azimuth pins -----*/
#define rotate_cw 3
#define rotate_ccw 4
#define rotate_cw_ccw  0
#define rotate_cw_pwm 0
#define rotate_ccw_pwm 0
#define rotate_cw_ccw_pwm 0
#define rotate_cw_freq 0
#define rotate_ccw_freq 0
#define button_cw 16
#define button_ccw 17
#define serial_led 0
#define rotator_analog_az A0
```

```
/*----- elevation pins -----*/
#define rotate_up 0
#define rotate_down 0
#define rotate_up_or_down 0
#define rotate_up_pwm 5
#define rotate_down_pwm 6
#define rotate_up_down_pwm 0
#define rotate_up_freq 0
#define rotate_down_freq 0
#define rotator_analog_el A1
#define button_up 20
#define button_down 21
```

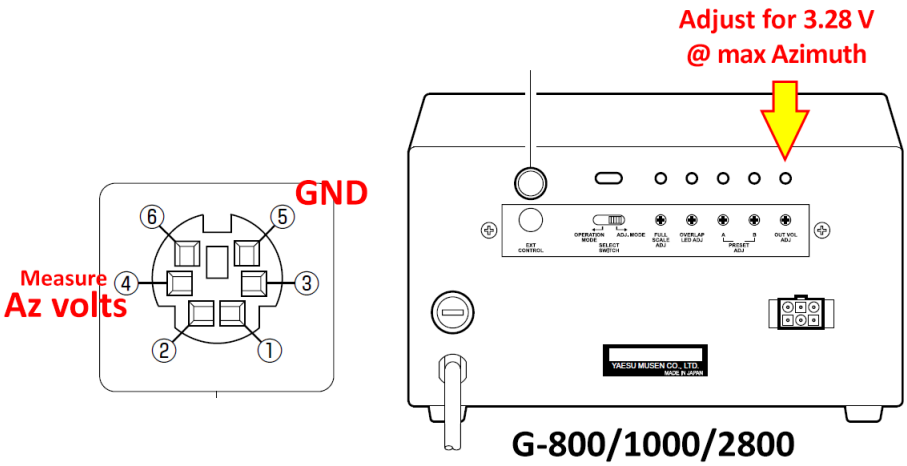
⚠ Before First Use – Potentiometer Feedback Voltage Adjustment

Whilst most Teensy 3.2 inputs are 5 volt tolerant, your rotator azimuth and elevation potentiometer outputs need to be trimmed for 3.3 volts absolute maximum output to suit the Teensy's 3.3 V environment.

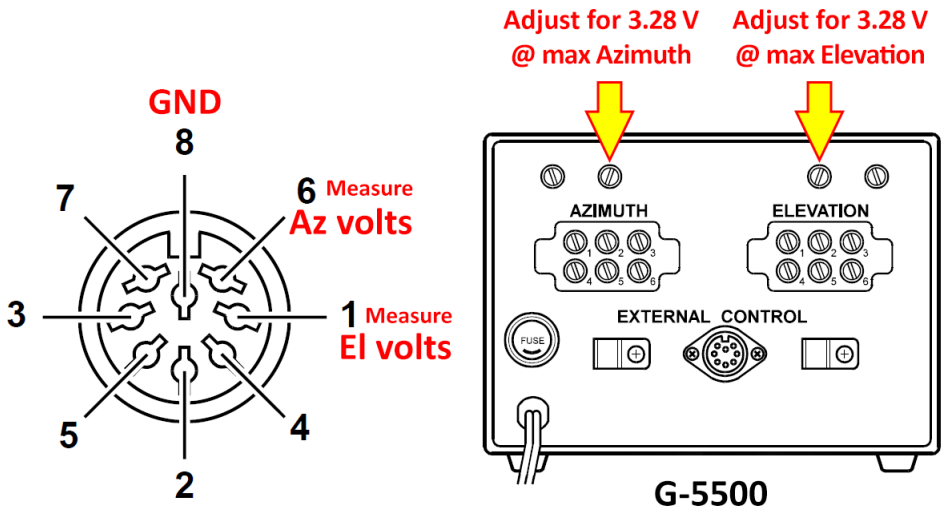
Analogue to Digital Converters (ADCs) will saturate at 3.3 V, therefore potentiometer feedback voltages exceeding 3.300 V will not register and incorrect Az and El readings will result.

Hint: Set outputs to a maximum of 3.28 V (slightly under 3.3 V) to allow for +/- system variations.

Example - Yaesu G-800DXA/G-1000DXA/G-2800DXA Controller Adjustment



Example - Yaesu G-5500 Controller Adjustments



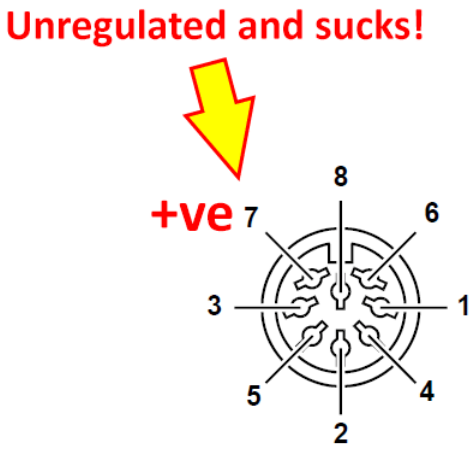
⚠ For other rotators, refer to your own rotator manual

⚠ G-5500 Before First Use – Fixing the TERRIBLE +13V Supply Rail

The +13V rail going to pin 7 of the External Control connector is unregulated, and drops significantly when motors are energised. This is largely due to Yaesu fitting a 20 ohm 5W wire-wound resistor (R1010) in line with this supply rail.

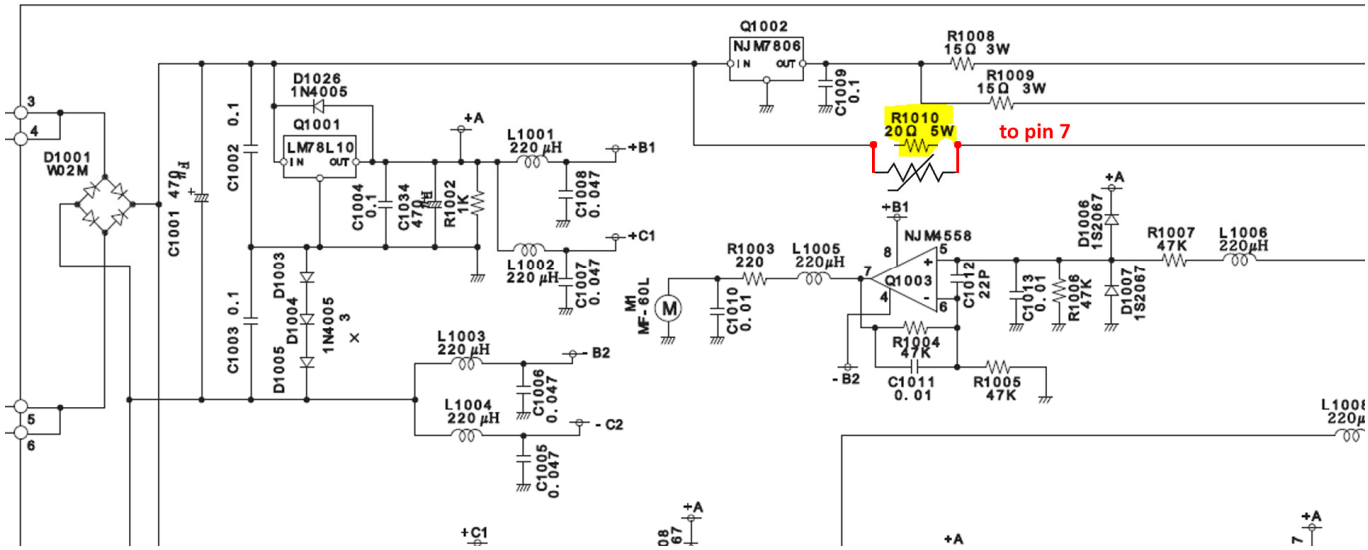
Voltage drop is noticeable when using a 5.0" Nextion, and the system might repeatedly reboot over and over, especially when a motor command is given. You may be OK if using a 3.5" Nextion that has a lower backlight current requirement.

Pin	Function
6	Provides 2 to 4.5 VDC corresponding to 0 to 450 °
1	Provides 2 to 4.5 VDC corresponding to 0 to 180 °
4	Connect to Pin 8 to rotate left (counterclockwise)
2	Connect to Pin 8 to rotate right (clockwise)
5	Connect to Pin 8 to rotate down
3	Connect to Pin 8 to rotate up
7	Provides DC 13 V to 6 V at up to 200 mA
8	Common ground



G-5500 External Control

In order to supply a reliable voltage rail for external equipment R1010 should be removed from circuit.



Options:

You can either move the orange wire going to pin 7, **or** replace R1010 with a resettable fuse.

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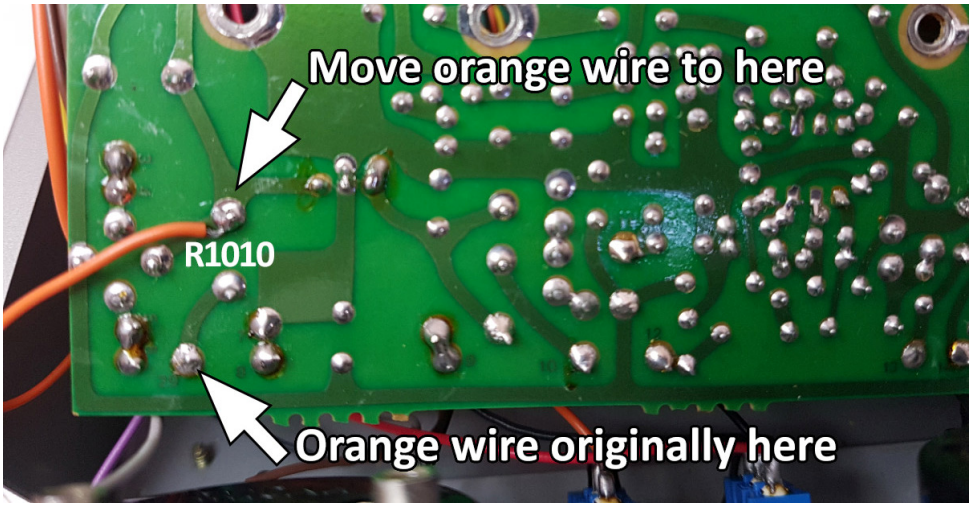
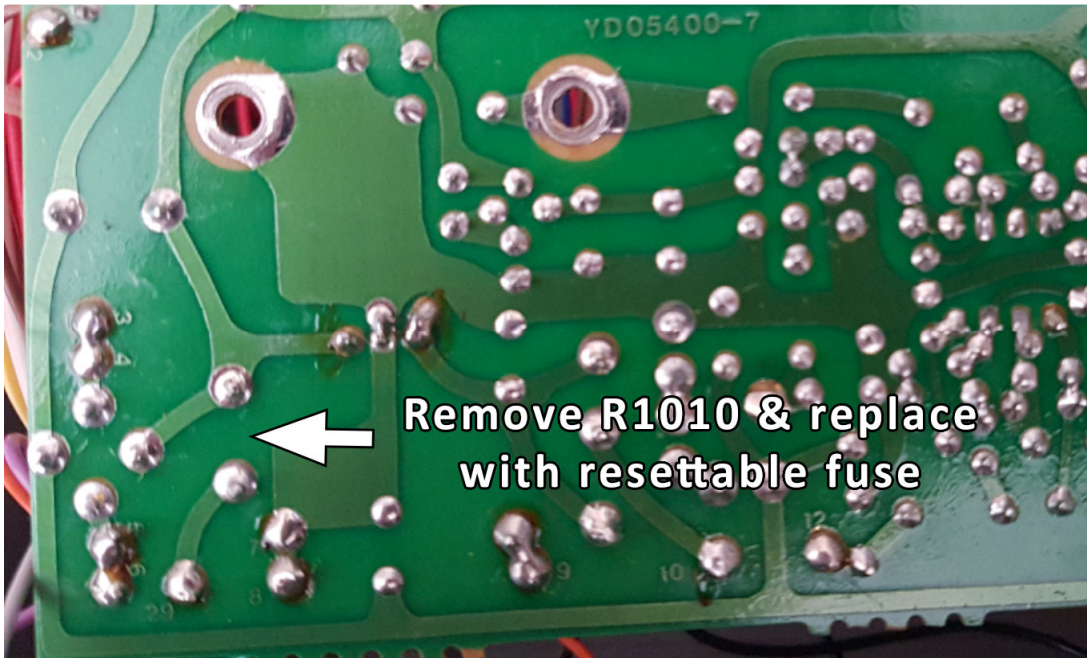
Option 1 – Solder Side Access Required

Relocate the orange wire (goes to Ext Control connector pin 7) from after R1010, to before R1010, as follows;



Option 2 – Solder Side Access Required

Remove R1010 and fit a resettable fuse in its place on the components side.



This is the best option.

You eliminate the resistor's voltage drop, and still have accidental short-circuit protection.