

Operating CNC & Laser Machine Everywhere using IoT

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ABSTRACT

Computer numerical control (CNC) is programmed code that represents instructions for precise movements to be carried out by machines. Indirectly, this code defines how to automatically create, produce, or transform a virtual object into a real one. Laser GRBL is one of the best Windows GCode streamer for DIY Laser Engraver. Laser GRBL can load and stream GCode path to Arduino, as well as engrave images, pictures and logo with the internal conversion tool. *grbl* is a fantastically simple and economical g-code interpreter and CNC stepper motor controller for the Arduino, there doesn't seem to be much information on how an average or new Arduino user should interface with it or how it works internally.

KEYWORDS: CNC machine, IoT, lasergrbl, grblcontroller

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1. INTRODUCTION

The internet of things (IoT) is a computing concept that describes a scenario where everyday physical objects are connected to the internet and can identify themselves to other devices or processes, via an IP address. IoT is significant because an object that can represent itself digitally becomes something greater than the object by itself. No longer does the object just relate to the process; it now connects to surrounding objects and database data, permitting "big data" analytics and insights. In particular, "things" might communicate autonomously with other things and other devices, such as sensors in manufacturing environments or an activity tracker with a smart phone. IoT has evolved from the convergence of wireless technologies, micro-electromechanical systems, micro services and the internet.

CNC machine introduction

Milling machine is the process of cutting and drilling material (like wood or metal). A milling machine, regardless of whether it's operated manually or through CNC, uses a rotating cylindrical tool called a milling cutter. It is held in a spindle and can vary in form and size. Like most conventional mechanical CNC machining processes, the CNC milling process utilizes computerized controls to operate and manipulate machine tools which cut and shape stock material. In addition, the process follows the same basic production stages which all CNC machining processes do, including:

- Designing a CAD model

- Converting the CAD model into a CNC program
- Setting up the CNC milling machine
- Executing the milling operation

The CNC milling process begins with the creation of a 2D or 3D CAD part design then the completed design is exported to a CNC-compatible file format and converted by CAM software into a CNC machine program which dictates the actions of the machine and the movements of the tooling across the work piece. Before the operator runs the CNC program, they prepare the CNC milling machine by affixing the work piece to the machine's work surface (i.e., worktable) or work holding device (e.g., vise), and attaching the milling tools to the machine spindle. The CNC milling process employs horizontal or vertical CNC-enabled milling machines—depending on the specifications and requirements of the milling application—and rotating multi-point (i.e., multi-toothed) cutting tools, such as mills and drills. When the machine is ready, the operator launches the program via the machine interface prompting the machine to execute the milling operation.

Once the CNC milling process is initiated, the machine begins rotating the cutting tool at speeds reaching up to thousands of RPM. Depending on the type of milling machine employed and the requirements of the milling application, as the tool cuts into the work piece, the machine will perform one of the following actions to produce the necessary cuts on the work piece:

1. Slowly feed the work piece into the stationary, rotating tool
2. Move the tool across the stationary work piece
3. Move both the tool and work piece in relation to each other

As opposed to manual milling processes, in CNC milling, typically the machine feeds moveable work pieces with the rotation of the cutting tool rather than against it. Milling operations which abide by this convention are known as climb milling processes, while contrary operations are known as conventional milling processes.

Raspberry pi

Arguably the most popular single board computer (SBC). Easy to get started with because basically every problem is documented. Add a computer with an OS to practically anything Support for a vast array of peripherals (thanks to the Linux kernel). USB devices, networking, displays, cameras, audio etc.

The **Raspberry Pi** is a series of small board computers developed in the United Kingdom by the Raspberry Pi Foundation to promote teaching of basic in schools and in developing countries. The original model became far more popular than anticipated, selling outside its target market for uses such as robotics. It does not include peripherals (such as keyboards and mice) or cases. However, some accessories have been included in several official and unofficial bundles.



The first two models were developed by the Raspberry Pi Foundation. After the Pi Model B was released, the Foundation set up Raspberry Pi Trading, with Eben Upton as CEO, to develop the third model, the B+. Raspberry Pi Trading is responsible for developing the technology while the Foundation is an educational charity to promote the teaching of basic computer science in schools and in developing countries.

According to the Raspberry Pi Foundation, more than 5 million Raspberry Pis were sold by February 2015, making it the best-selling British computer. By November 2016 they had sold 11 million units, and 12.5m by March 2017, making it the third best-selling "general purpose computer". In July 2017, sales reached nearly 15 million. In March 2018, sales reached 19 million.

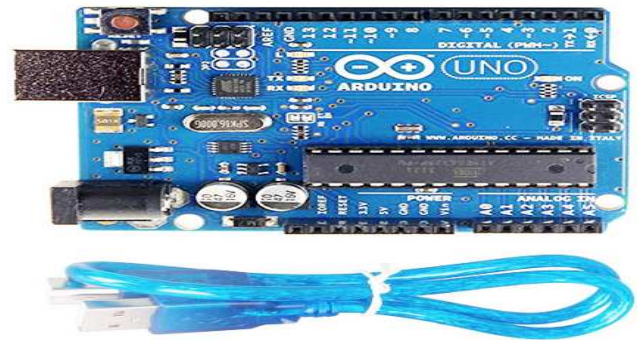
Most Pis are made in a Sony factory in Pen coed, Wales. Some are made in China and Japan.

GRBL

Grbl is a free, open source, high performance software for controlling the motion of machines that move, that make things, or that make things move, and will run on a straight

Arduino. If the maker movement was an industry, Grbl would be the industry standard.

Most open source 3D printers have Grbl in their hearts. It has been adapted for use in hundreds of projects including laser cutters, automatic hand writers, hole drillers, graffiti painters and oddball drawing machines. Due to its performance, simplicity and frugal hardware requirements Grbl has grown into a little open source phenomenon. In 2009, SimenSvaleSkogsrud (<http://bengler.no/grbl>) graced the open-source community by writing and releasing the early versions of Grbl to everyone (inspired by the Arduino G-code Interpreter by Mike Ellery).



2. TERMINOLOGY

GRBL CONTROLLER

grbl is a fantastically simple and economical g-code interpreter and CNC stepper motor controller for the Arduino, there doesn't seem to be much information on how an average or new Arduino user should interface with it or how it works internally. So, here's a shot at filling that gap. (As of this writing, grbl versions are master 0.6b and edge 0.7b)

The first thing that people should know about grbl is that it is designed to be simple and barebones. It is not a complete solution for all CNC milling, but it is rather it seems to be intended as a starting point for anyone building a 3-axis cartesian-type mill, router, laser cutter, 3d printer, etc. It started as a stripped down and general-use port of the ReprapArduinoGCode Interpreter, which is more geared for 3d printing only.

Grbl works primarily through the Arduino serial port interface and needs a constant stream of g-code commands sent via a computer or some other means. Grbl accepts and processes single g-code blocks followed by a carriage return, ignoring gcode comments and block delete characters. It returns an 'ok' or 'error:X' message when it has processed the block and is ready for more information. A simple ruby script for g-code streaming is supplied in the code base for reference. Python scripts also work very well for streaming grbl g-code, but ultimately it's up to the user in how to interface with it.

To get an idea how grbl works internally, there are essentially two programs running concurrently on grbl. The main program reads the serial port for g-code commands, parses them, then passes it to an acceleration/feedrate planner, and finally places the event into a ring buffer (max 5 blocks for 168 and 16 blocks for 328p Arduinos.) The other program is interrupt driven and works in the background. It controls the stepper motors and sends step pulses and

direction bits to the stepper driver pins. It sequentially processes through the ring buffer events, FIFO-style, until it is empty.

For the most part, the main program will continually accept new gcode blocks as quickly as it can be processed as long as there is room in the buffer. If the buffer is full, the grbl will not send a response until the interrupt program has finished an event and cleared it from the buffer. For streaming, this means the user interface should always wait for an 'ok' or 'error' response from grbl before sending a new g-code block. Also, the data stream should be steady and uninterrupted to minimize the chance of 'data starving' grbl, aka emptying the buffer, which will cause unintended hiccups in the CNC movements.

As for external interfaces, there are only XYZ limit switches. Other features, such as pause/halt, variable speed reductions for proofing, homing cycles, real-time jogging or manual interface, are currently not supported or are in development. It should be noted that some of these features are left to the user to decide to add, mainly to stay with the vision of simplicity and portability. Canned cycles and tool radius compensation/offsets are not supported, but this may be handled by an external preprocessor that has yet to be written. Also, there is currently no protocol in querying or broadcasting the current status of grbl, as in the size of the ring buffer, distance to go on current block, and current position.

For all the cool stuff that grbl can do, there are also still some bugs that are being ironed out. G02/03 arcs are not supported by the acceleration planner and intentionally forces the ring buffer to empty, causing some short motion hiccups when the main program has to process a new g-code block to fill the ring buffer and weird accelerations coming into and out of an arc. Although, there has been a lot of development here to solve this problem recently and should be ironed out soon. The same could be said of the acceleration planner itself in terms of improving speed and robustness. G04 dwelling forces the ring buffer to empty as well, but doesn't really pose too much of an issue other than having to re-fill an empty buffer upon resuming.

Regardless of its minor 'issues', grbl has a lot of potential and creates a wonderful and economical introduction to a large potential audience of makers and DIYers into the world of CNC. Even then, the possibilities for other applications, such as expanding to 6-axis hexapods or robotics, are very exciting. Anyhow, for about 95% of things that any home user would want to do with grbl, it will work as is. For the other 5%, like precision machining or production, there is still a way to go, but it's getting there.

Laser GRBL

1. Connection control: here you can select serial port and proper baud rate for connection, according to grbl firmware configuration.
2. File control: this shows loaded filename and engraving process progress. The green "Play" button will start program execution.
3. Manual commands: you can type any G-Code line here and press "enter". Commands will be enqueued to command queue.

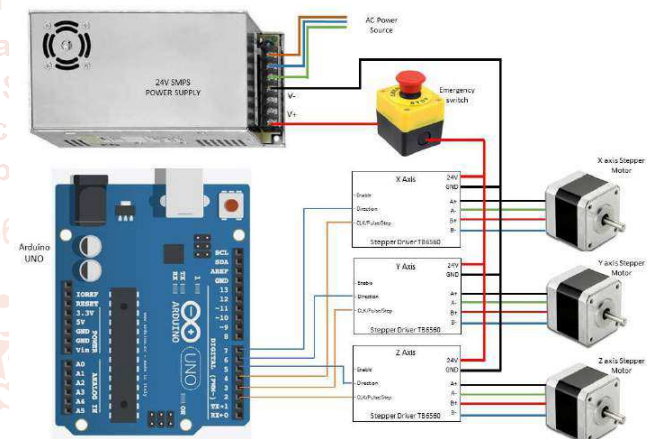
4. Command log and command return codes: show enqueued commands and their execution status and errors.
5. Jogging control: allow manual positioning of the laser. The left vertical slider control movement speed, right slider control step size.
6. Engraving preview: this area shows final work preview. During engraving a small blue cross will show current laser position at runtime.
7. Grbl reset/homing/unlock: these buttons submit soft-reset, homing and unlock command to grbl board. On the right of unlock button you can add some user-defined buttons.
8. Feed hold and resume: these buttons can suspend and resume program execution sending Feed Hold or Resume command to grbl board.
9. Line count and time projection: Laser GRBL could estimate program execution time based on actual speed and job progress.
10. Overrides status a control: show and change actual speed and power override. Overrides is a new feature of grbl v1.1 and is not supported in the older version.

3. PROPOSED METHODOLOGY

LASER GRBL

PWM SUPPORT

If your Laser does not support power modulation via ttl-pwm with S code, but only ON-OFF operation by M3-M5, please uncheck this flag.



All Laser GRBL features that require power modulation will be hidden, and laser control will be done only via M3-M5 instead of S command.

LASER MODE

Starting from GRBL v1.1 there is a new feature of GRBL called "Laser Mode". If you have "Laser Mode" enabled in your Arduino, all the G0 rapid movement will be executed with laser turned off.

If "Laser Mode" is enabled in your hardware please check this flag, so Laser GRBL will render G0 movement correctly, also with external generated gcode files.

PROTOCOL

LaserGRBL can connect via standard USB/Serial protocol but also via WebSocket or Telnet using a small WiFi module that acts as a bridge.

Read WiFi with ESP8266 for more information and instruction.

STREAMING MODE

- Buffered [recommended]: implement the “character-counting” streaming mode, as documented in grbl reference. Buffered is more optimized since it send more than one command to grbl/arduino queue preventing dead times.
- Synchronous: implement the “simple-send-response” mode. Synchronous send one command, wait for the complete execution and response (either ok or error) then send the next command.
- Repeat On Error: is the same of Synchronous but add the feature to repeat command if grbl report error (max 3 times). Some time could be useful with electrical noise on USB/serial line.

THREADING MODE

Laser GRBL claim to be faster than any others gcode streamer. Unfortunately not all hardware support all this speed. If you experience issues with your controller you can set slower modes.

- [Slow] StatusQuery = 2000, LongSleep = 15, ShortSleep = 4
- [Quiet] StatusQuery = 1000, LongSleep = 10, ShortSleep = 2
- [Fast] StatusQuery = 500, LongSleep = 5, ShortSleep = 1
- [UltraFast] StatusQuery = 200, LongSleep = 1, ShortSleep = 0
- [Insane] StatusQuery = 100, LongSleep = 0, ShortSleep = 0

GRBL CONTROLLER**Preparing**

- Power up Arduino and shield
- With motor off, manually position milling bit over origin (0,0) on the work piece. The origin is the intersection of X and Y on your CAD drawing.
- Start Grbl Controller
- Select COM port and open

Adjusting

- Choose appropriate step size (start with 1)
- Press the Z down button, the milling bit should move down towards the work piece 1 mm. The Z jog speed can be adjusted in menu Tools -> Options
- Repeat until the the bit is almost touching
- Turn on motor
- Press Grbl Controller's Reset button to zero the Arduino Grbl code

Sending G-code

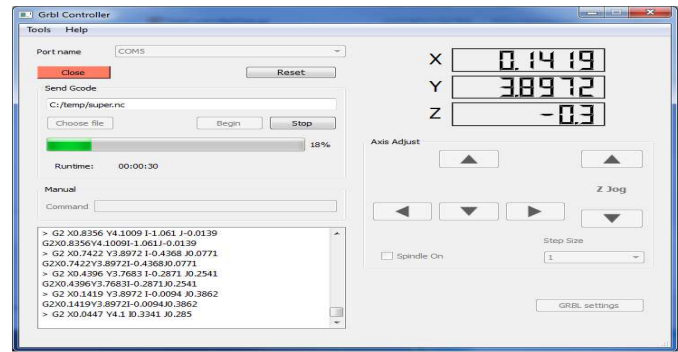
- Choose Send GCode radio button
- Open desired file, usually .nc
- Press Begin. If for some reason there is a long, slow traverse, the controller may time out. Increase timeout value in Tools -> Options

Finish

- Turn off motor when milling is complete

Emergency

- Press the Reset, Stop or Close button on Grbl Controller – the steppers should stop within a second or two. If not, power off your shield

**4. LITERATURE SURVEY**

The expansion in the fast development of innovation altogether expanded the use and usage of CNC machines yet is costly. This paper examines the outline viewpoints and mach inability investigation of low cost CNC machine cum engraver which is fit for 3-axis synchronous operation with less complexity. The additional Bluetooth highlight makes the machine more easy to use to work utilizing a cell phone separated from USB. The lower cost is accomplished by interfacing standard PC with microcontroller based CNC framework in an Arduino based embedded system. After the completion of machining, experimental trials to define machining parameters were held. The purpose of the Self-Guided CNC project is to construct a functional CNC type machine capable of tracking lines on and object to guide the armature in cutting the piece correctly. The device would be capable of functioning independent of off-board computers for both operation and determining cutting paths. The goal is not only high-precision cuts but also design and plot.

Nowadays with a digital control it's become more and more useful to use such machine tools with simple a coded software. This paper will present the design and fabrication of Laser Powered 3-axis computer numerically-controlled (CNC) machine which comprise the use of a graphical user interface (GUI) and Arduino micro-controller to produce pulse-width modulation (PWM) outputs in order to run the stepper motors that will be used in this work. A simple mini 3-axis CNC is previously used precisely surfaced designed for snapping of wood, plastic sheet and thin sheet of metal alloy by using a rotating drill bit which its accuracy is much lesser than using a lesser cutter techniques this machine tool is portable and it's controlled by computer (PC). Design and Fabrication of mini CNC with works pace of 130mm x 130mm using a precision Stepper motors that combined with belt & pulleys help in moving the axis smoothly on linearity bearings that increases a more precisely results obtained.

Downward trend in laser technology price and increase of the accuracy achieved has allowed it to acquire a new dimension in recent times. This paper proposes, with a practical approach, focusing on the RF field, the use of an innovative low-cost laser technology as part of the practical syllabus of an Advanced Electronics Prototyping Techniques course or similar.

It provides with conceptual understanding on industrial manufacturing limitations while studying different materials engraving, professional software suites and PCB Exposure, in contrast with the expensive CNC milling methods typically used, an alternative cheaper laser engraving technique.

G-CODE

draw a text file or design a circuit layout by the CNC plotter firstly the files need to be converted into G-Code. G-Code is a set of instruction that contains number of X, Y, Z, coordinates depending on the file. G-Code instructs X axis of the machine to travel from X1 to X2 points with a specific speed and same is true for Y axis, but for Z axis the coordinates are fixed because only vertically up & down movements are involved.

5. Advantages

- Operate from various locations using IoT
- Picture engraving with grayscale conversion
- Picture engraving with dithering conversion
- Image vectorization
- Perfect cut with Laser GRBL
- Custom buttons
- Faster Image Import
- Grayscale conversion parameters

6. CONCLUSION

Thus from our system, the user can control COMPUTER NUMERICAL CONTROL Machine & laser machine from various locations using IoT. Using this system the small scale Industries can make huge profit since they are controlling the machines from remote locations. we hope that in future using the same technology many applications Can be developed to controle various other machines.

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