Steel sheet laser cutting machine

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PLEASE NOTE: I'm really not competing to win the laser, a t-shirt would be fine, thanks.I saw the competition and thought it would be fun to show off my system.INTRODUCTION. The general idea of this CO2 laser system is that a beam is directed down to a part for cutting. The part sits on a computer controlled platform which moves the piece around the stationary laser beam. Cutting is acheived by passing the beam through a focusing lens. A focused beam exits through the bottom of a cutting head nozzle. Gas, such as oxygen, is fed into the side of the chamber below the focusing lens. This gas exits the nozzle along with the beam and the laser beam/oxygen combination serves to vaporize the steel for cutting.Click here to see it cutOne thing that I discovered when making this system is that purchasing the laser was the easy part; many other systems are required to be on-line in order to achieve anything useful with the laser. To give you an idea, this is a comprehensive diagram describing the basic components of a CNC laser cutting system.This is a picture organizing many of these components around the central control unit and includes other sub components such as the motors, encoders, solenoids and flow sensors.Assume for now that you have a really great laser, and these main components are handled:Laser head and power supplyOpticsControl unitCNC table and power supply.ComputerCooling systemsWhat other systems have to be on-line in order to have a cutting operation? ElectricalTwo 110VAC 20 amp lines were run to operate ancillary equipment, a 220VAC 20 amp line services the laser power supply, a 220VAC 20 amp line services the chiller outside of my house, and another 110VAC 15 amp line runs room lighting.It was also useful to make boxes like this that have 110VAC entering into them and also had relays system that could be driven by TTL levels to run various appliances like ventilation.VentilationA ventilation system has yet to be installed in the work area. This will be required to remove fumes and reduce smoke that will contaiminate the optics inside the beam delivery system. The laser has the capability to cut a number of different materials like wood and plastic. Ventilation will be essential to remove the fumes produced by these materials.Gas LinesThe laser cutting system can use either oxygen or nitrogen depending on the cutting application. This required that a couple tanks get installed and I ended up mounting the tanks up off the wall. This is to conserve floor space so I can cut larger sheets of metal. The brackets came from the welding supplier. The plastic chameleon has a couple magnets embedded in it for sticking to the tank.Here's a pic of the gas set up. Here is another.Support ArmThe laser head needs to be suspended about 48 inches away from the nearest wall. Another design criteria was that it has to be able to change the height of the laser along the z-axis. A CAD drawing was put together, and I bought a pile of channel iron, angle iron, and flat stock then went to work with my chopsaw. Note the lag bolts attaching the angle iron to wall and floor.Here's the support.block_diagram.pdf This be that laser. My system is based the Coherent G-100, an RF excited sealed industrial C02 pulsed laser. It consists of 100 watt laser resonator and solid state RF amplifier integrated into an all aluminum enclosure. The RF amplifier provides pulsed RF power to the laser to ionize the CO2 gas mixture in the tube. A modulation signal applied to the laser head controls the output pulse width and period. The amplifier produces 3000 watts of RF power.Average power range 10-100 watts.Peak effective power: 250 watts.Input power: 48 volts DC at 50 amps.Weight: 35 pounds.Cooling requirements: 2500 watts, water based.DocumentationOriginal price: $27,000.The Coherent web site.DC Power Supply. The power supply was specifically designed for the G-100. It is air-cooled and digitally controlled. The supply produces 48VDC at 50 amps and requires 220VAC input.Control systems. The G-100 has a DB25 connector that supplies control and input modulation signals to the RF amplifier and supplies status information from the amplifier. This allows monitoring of the temperature, duty cycle, and supports digital control of the overall power output of the laser. I purchased a large CNC table on ebay for $500.The table was probably made in the 90s. It has a total of 18 inch movement in X and Y directions. The lead screws have a .25inch pitch. The motors that came with the table were too old to be used, and some new servos were retrofitted.The servos also came from on ebay.Their specs are the following: 37.51 Oz-In/A 25.0-30.5 V/KRpm Motor Terminal Resistance .75-1.02 Ohms @ 4A. Maximum Terminal Voltage 60V Maximum Continuous Speed 2100 RPM (No Load) Maximum Peak Torque 1500 Oz-In. Maximum Peak Current 44.5A Maximum Continuous Stall Torque At Max Motor Temp 300 Oz-In. Maximum Continuous Current 8.9AUS digital motor encodersencoders were used to detect the position of the motor relative to turns of the lead screw.The new motors were so large that they dont fit the nema 34 sized system on my table.At Stock Drive ProductsStock Drive Products, they have piles of cad drawings, pdf files specifying pulleys and belts, and a straight-forward ordering system. I had to make an educated guess about the length of the belts, so using the data from the sdp site I put the geometry of the motors, pulleys and ballscrews in autocad and figured out the number of teeth required for the correct length belt.After getting the anticipated position of the motor the motor mounts were designed and plans were sent off to a machinist:...who made the parts out 3/8th inch aluminum plate.The CNC table also needed to have a rack added that would support parts that are getting cut by the laser. The rack has to be level, because the distance from the laser that can develop the power density to cut metal can only vary by a less than a millimeter. The first tablefirst table was machined aluminum, very flat, and served as a good platform for the rack. The rack was made of 3/4 inch aluminum bar stock. Its held together with threaded rod. Aluminum tubes were cut 1 3/4 inch for spacers.I tried putting neodymium ring magnetsneodymium ring magnets attached with small bolts in on each bar.The neodymium rings came from ebay. If you search on neodymium you'll get a million hits. Nice stuff, but you cant machine it, so the ring variety was purchased for easy bolting.Next generation tableI went to a newer version of the table that supports parts to be cut by the laser more effectively. It was constructed with 12 power hack saw blades. The dimensions of the blades are 24 inches long, two inches wide and 1/16th of an inch thick. They have 4 teeth per inch. The table was constructed by running two foot long, 1/4 inch threaded rod through the holes at the end of the blades. One and a half inch long spacers were placed between each blade.The only other construction item was the bracketsbrackets that were placed in the assembly to bolt the blade-unit to my cnc table. The brackets were cut by my table and folded into the a C-shape. Its nice to have a system that can help build itself.The main picture is the table made of the blades. Here is anotherHere is another, holding up a piece of stainless steel. The t-shaped brackets staying flat on the table have bolts that project down and wing nuts bring up a part below the table to hold down the steel.In my previous set up, when the laser passed over the part getting cut in the areas where the bars contacted the part, it would splash in funny ways producing problematic cuts. In the new system the point of contact to the part is relatively small, when the laser passes over where the supporting table there's no splashing. The tips of the points on the blades are machined well enough they form a nice flat surface. Once assembled together with the threaded rod they are very ridged and dont flex in left to right or up and down directions. The blades came from ebay and cost about $100 total. The laser has a cnc table that moves parts around a stationary beam source.A table of this size required building fairly large power supply to drive the table's servos. This documentationdocumentation describing power supply formulary says that two servos requiring 10A should never exceed 2 * 10 * 67%, or 13.4A.The manufacture Plitron sells toroidal transformers. They have some useful technical notes. To calulate the desired transformer voltage I used the formula: (68VDC/ 1.4) = 48.6 VAC. However, when I constructed my power supply I used a formula supplied by Plitron which uses a slightly different method of:(68VDC + 2) * 0.8 = 56 VAC.Using this required that I make the modification described below. But since I went with a 55VAC toroid I went with a 13.4A * 55VAC = 743 VA rated toroid transformer. I purchased plitron transformer 117042201, with two 55v secondaries @ 9A each, $139.73. See plitron's toroidal ratings.At this amperage and using the formula ((80000 * I) / V) I estimate I would need around ((80000 * 18) / 68) = 21167 uF filter capacitor. I purchased five Model#: 3VTLM153M80V, 15000uF, 80V electrolytic caps on ebay and I'll wire two in parallel. I also purchased 4, 25 Amp 200 Volt bridge rectifiers,$4 each.CAUTION: the capacitors in the supply store a lethal charge after powering up. The resulting discharge has the potential to be very unsafe. This is typically experienced when you're just hooking the thing up to the rest of circuit and comes in the form of a firecracker-sized explosion. This is primarily a problem with the power supply is not hooked up to anything and its best to keep the output terminals shunted when not in use. Fortunarely the manufacturer of the Gecko drives provisioned for removing the energy stored in the caps and the overall is system is much safer when the Geckos are connected to the supply. Knowledgable designers should consider adding circuitry that will safely discharge across a power resistor; although I have not been able to get advice on exactly what that circuitry would look like.The suply employs a full wave bridge circuit and put into a canibalized Sun harddrive enclosure. Its a nice box that comes with fans and a 5VDC power supply. Most wiring was done with 14 guage wire, terminals, and screw-down terminal blocks. After completion I looked at the voltage on my osciloscope and there was absolutely no ripple. Over-voltage repairThe plitron transformer produced too much voltage. I used the formula from their site. I recommend the formula for the transformer rating of:VDC = 1.4 * VACThe voltage is 79vdc. Lowering the voltage of the transformer required that I remove some wraps from the Plitron torroid. I drilled out the epoxy core on the drill press in about ten minutes. The heat shrinkable wrapping around the windings completely prevented the epoxy from entering any windings. After chipping out the remaining epoxy block I removed the heat shrink wrap. The secondaries wires were very accessable and I didnt have any problem unwinding them.I went with about 5 windings first prior to testing. I carefully checked for shorts between any of the exposed wires. (Its a bit of an act of faith that the enamel around the wires will prevent any shorting but it does the job.) After checking as much as I could, I hooked up the transformer and measured the voltage. The first time the voltage the wasnt even close. I unwrapped some more, eventually got to the right voltage, trimmed the secondary wires, soldered new connectors and put heat shrink tubing around solder joints.Heatshrinkable sheet was wrapped around the donut. I didnt like that result but left the sheet on, and followed up with lots of wraps of electrical tape. I popped the transformer back in the power supply enclosure and I'm operating at the right voltage. power_supply_design.pdfSheet metal cutting requires a power density of 106 watts/in2 (source: Mike Klos @ laser mechanisms)Converting to millimeters, that's 1550 watts/mm2. (using equation: 1in2 = 645mm2)A 100 watt laser can achieve a power density of 1550 watts/mm2 in a spot size that is 0.6452mm2A spot size that is 0.6452mm2 has a diameter of of .28mm or 280 micron (using area = pi * (d/2)2)280 micron! If I can deliver 100 watts to a spot of 280 micron, I should be able to cut metal. That's too easy.Why? Well, how big a diameter can I expect with my optics? The information on my beam diameter varies. I have read it goes anywhere from 1.6 to 2.3 mm.At 1.6mm, if I have a 3x beam expander I get 4.8 mm, which will be 103 micron using a 1.5 inch focal length(equation: diameter = .013 * M2 * (fl/D) where M2 is equal to 1, and D is diameter of incoming beam. See this site.If I substitute in an M2 of 1.5, I still get a diameter of 150 micron. So according to calculations I should be able to deliver a power density needed is 106 watts per square inch.Note: I'd like hear from anyone who could verify that 106 watts per inch is the power density I need.Note: the reason I bought the microscope was to be able to measure in micron -- hopefully I can use it to check my beam diameterRomos gave me some excellent feedback on my post about beam sizes. He points out that the expected beam size can be taken from this table for the G100:Distance From Laser (mm) vs Beam Diameter (mm) 0 mm distance = 1.9 mm beam diameter250 mm distance = 2.9 mm beam diameter500 mm distance = 4.7 mm beam diameter750 mm distance = 6.7 mm beam diameter1000 mm distance = 8.7 mm beam diameter1500 mm distance = 12.9 mm beam diameter2000 mm distance = 17.2 mm beam diameterIn his case, the focal lens from the laser dinstace is 500 mm. So, without any beam expander I have...(assume that M2 = 1.5)diameter = .013 * 1.5 * (38.1/4.7) = 0.158mmThe distance to my beam expander is 33cm, so using that chart the beam size will be about 3.5mm when it goes into the expander. The beam expander is 3 times the original size so the beam will go to 10.5mm.Based on the equation:diameter = .013 * 1.5 * (38.1/10.5) = 0.071mmThis is a great spot size. The problem will be my depth of field. This is based on the formulas shown on this site: of field is the distance range that an object can be placed in front of the lens and still get cut. The forumula for depth of field isDOF = 2.5 x wavelength x (focal_length / beam_diameter)2for the G100 laser it calculates to:DOF = 0.027 * (focal_length / beam_diameter)2The optics for the laserThe beam delivery system is composed of a bend mirror, a processing head, a cut quality enhancer and circular polarizer, and a beam expander. In order to attach the cut quality enhancer to the G-100 two adaptors were machined out of aluminum (1, 2). The cut quality enhancer improves the shape of the G-100 beam, and the circular polarizer prevents the beam from reflecting back into the laser head. Both parts came from Laser Mechanisms. The cutting head was manufactured by Haas LTI.The principal of the cutting head is that the beam enters the top of the head and is directed to a focusing lens that is found in the center of the cutting head cavity. A focused beam exits through the bottom of the cutting head nozzle. Gas, such as oxygen, is fed into the side of the chamber below the focusing lens. This gas exits the nozzle along with the beam and the laser beam/oxygen combination serves to vaporize the steel for cutting.The optics for the laserThe beam delivery system is composed of a bend mirror, a processing head, a cut quality enhancer and circular polarizer, and a beam expander. 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First set up a system to mark circles or edges of your beam path with cross hairs in the center of scotch tape.The place your targets on the beam path. If the item that gets the tape can be threaded into place it makes it easy to mount the target.Using this system, I started with a target on the cut quality enhancer, and then moved on to the elbow that points the beam towards the floor. The elbow has allen head screws that allow you to microadjust the mirrors in the beam. This took a little while to figure out the impact of changing these screws and where the beam lands, so for a while I would take to shots on one piece of paper, and view the where the beam moved after making a change. After I got the hang of this, I went back to the targetting system to adjust the beam as best I could to be on center.The cutting head has a nozzle on it with a port that is roughly half a millimeter in diameter. If the beam is not exactly on center, it gets reflected off the side when it comes out of the nozzle and forms a characteristic pattern that looks like this.Another alignment method I used to cure this problem was to remove the nozzle, and shine a short pulse on thermally sensitive paper. The issue is to carefully adjust the beam so that it produces the same spot shape with and without the nozzle to ensure it is going directly through the port of the cutting head. A friend also recommended that acrylic works as an alternative to the thermal paper.Height adjustment.Here is a nice picture of laser beam height adjustment. The issue is that the beam forms a waist and the most power of the laser occurs at the minimum waist diameter. The sweet spot of the beam waist can be placed in path of the beam by adjusting the height of the cutting nozzle.To find the best height for minimum beam diameter, I used the thermally sensitive paper and looked at the beam diameter as a function of height. The markings on the card are based on 100ths of an inch are relative; they do not reflect the actual distance of the focusing lens to the paper. What you can see from this experiment is that the beam size gets smaller down to a distance of 650ths of an inch and then starts to increase in size.I would not claim that is a good method to determine the beam diameter. I dont know if there is a way to determine what the beam size is, however, it was still interesting to look at the spot under the 100x microscope. This is a picture of my smallest possible spot on the thermal paper. The microscope was focussed on the stainless steel below the paper. You can see burnt edges around the hole. The burns are not a result of reflection as shown here, at least they dont occur like this repeatedly. It seems more like the results of a heat flare coming off of the beam.This is the underside of 1/8th inch thick plywood which was cut at 10% power levels on the laser. The kerf width is roughly 200 micron as well. Blessed are those that use Eagle Schematic software.The Gecko drives and the USC board are nice, but the laser controller also has some custom electronics that measure the states of laser itself, generate a pulse width modulated signal, and report an E-stop to the Unversal Stepper Controller. The schematic of the custom electronics was generated using schematic software. The laser measurement was based on circuitry specified by the laser manufacturer. The states of the laser were fed into a "Just A Minute" or JAM circuit (original schematic). The JAM circuit was originally designed for a game show situation, where multiple contestants can hit a switch, when the switch is thrown a light goes on indicating who hit the button, and the rest of the contestants are locked out. Perfect for my application, because if any of multiple states go low I want to register which system went low, lock out other inputs, and then flip the E-stop toggle of the USC board. The custom board also has a PWM circuit which is based on a programmable timer that feed into a binary counter and magnitude comparator combination. There's also a section on the circuit that debounces the push of a button and then toggles a D-type flip flop. This receives power from an unswitched power supply, when the user hits the pushbutton it turns on a solid state relay that powers up the remaining circuit. The schematic epitomizes the I/O problem posed by the laser controller. There are over 120 different lines from connectors going to limit switches, encoders, geckos and the USC board. All lines were led into one of four 30 pin female headers. This was good way to go because it reduced any soldering or other types of direct connections between components -- basically all connections between components were handled by linking between header pins using wire wrap. This has several advantages: 1) it is an overall reduction in soldering -- soldering is fine but its harder to disconnect -- connections are made by crimping wires onto pins and then inserted into the header 2) The "logic" of how lines are linked is managed in software as described in the next section -- this avoids mechanically looking at a header block from the geckos and deciding which wires have to be soldered to the pins leading to the encoders. 3) Overall, it reduces the spagetti of the circuit. Dont get me wrong, the spagetti is still there, but its centralized into four main headers. Readers may not want to go with this strategy, but one thing I strongly recommend is to avoid making hardwired connections between components. Be sure everything is connected by easily disconnected plug ends -- hardwired leads soldered directly between components make it really hard to pull the components out of the box when problems arise.View circuit...Wire wrap is a beatiful thing.Eagle supports exporting the schematic as a net list and a pin list. These files were used as input to a perl program which was also given the locations of all the parts on a wire wrap board, which then listed all the wire wrap connections required to make the board. The program also creates a drawing that shows the location of the chips on the wire wrap board. There are significant advantages to mapping out the entire network of connections in a net work connection file. The main thing is that its faster. You arent looking at much except the names of the pins on the wirewrap board, wiring those pins together, and then checking for continuity with a audible tester. This is in contrast to a situation where you have your components on one side of the board, you're looking at those, looking at a circuit diagram, then flipping the board over, picturing the location of the IC pins in your mind that are now on the other side of the board, and then connecting things together. I've now gotten into the habit of always translating the circuit I'm working on into pin to pin connections. The other advantage I see with having a listing of wire wrap connections is if I experience problems with the circuit in the future -- imagine just having a circuit diagram and a completed wire wrap board in your hands. Debugging the circuit -- looking for breaks, testing chips -- is very time consuming. With a list of wire wrap connections you can order the list to give all the connections for one single IC, and rapidly check those connections.The wire wrap was performed using a slit-n-wrap tool purchased from Digi-key; a few points about this process:If you havent done slit-n-wrap, dont compare it to other methods. Slit-n-wrap takes a little getting used to, but you can end up making a pretty high quality product. Frankly I thought it was fun.Dont use pre-stripped wire wrap tools because they only allow you to make two connections. Slit-n-wraps let you make as many connections as you want on one wire.Get an audible continuity checker. You must check for continuity -- when it works wirewrap is a very solid connection but around 10 percent of the connections will fail and have to be redone. The audible continuity checker is a lot faster.Being able to rapidly unwrap wirewrap is essential. Radio shack part number 276-1570 is a cheap wire wrap tool that absolutely should not be used do wire wrap with slit-n-wrap wire, however; it is a great device for unwrapping. Digikey also sells unwrap tools but they are over-priced. Unwrapping using the radio shack tool is a matter of pushing the tool over the wirewrap post, bearing down on the wrapped wire, and turning in the opposite direction. This loosens the wire enough to then be pulled off with your fingers.I purchased my wire wrap boards on ebay by searching on "AUGAT" "WIREWRAP" and or "WIRE WRAP". Augat wire wrap boards are absolutely the best. Their original cost is astronomical but fortunately many have been appearing on ebay for garage-sale prices.My board had over 400 connection points and I would definitely use wire-wrap if I had do it again. On the other hand, now that I debugged my circuit I could just have a board shop make a PCB for around $100. :-) The website has links to places that make PCBs.veiw boardThinking outside of the box included thinking how to work outside of the box.Previous motor controllers that I've made have had one serious flaw -- all the components were mounted directly into their enclosure. This made circuit repair, as well as installation and removal of all components very inconvenient. For this controller, I started by mounting all the components on a plywood board. The board has rubber feet and makes it much easier to service all the parts on my bench. The board sits a recycled computer case, which also has a hole on the side for a fan. The fan points directly over the gecko motor drivers. This laser cut connector plate was made by first designing the plate using dimensions of connectors found in documentation obtained from digikey. The resulting DXF file was sent to Arts who produced the plate by laser cutting 1/8 inch thick plywood. Ironic that I am out-sourcing to other laser shops to do something I hope to eventually do in my own basement. The wires leading to the connector plate form something that I refer to as the neural network, an extensive collection of wires and connectors that hook to all the internal components. Once the neural net is connected to the internal components the plate faces outside of the enclosure, and is slightly recessed to allow all the cabling connectors to be protected from getting banged around.Assembled system...InstallationI ordered a PCB from fab express. The board cost only $65.This board was mounted on the outside of the enclosureThe strategy of this PCB is that it has an AVR chip right on it, this allows me to set in two different power settings manually. There is an input to the board that selects these two preset values, and based on the values five outputs are pushed onto another chip on the wire wrap board that handles selecting the pulse width set to the laser. The completed controller box was closed up and put on the shelf.On shelfIf you look at the diagram you can see there a lot of inputs and outputs to the controller. This creates a problem because you end up with a lot of cables to manage. I have a friend who used to wire phone closets. He suggested doin' it like the phone company and making spools made of posts projecting off the wall. This was very helpful because it keeps the excess wound up and the cables stay off the floor. Its also nice because there will be some excess length to the cables which will be helpful in a situation where some of the hardware gets moved to a new location. The cable expert and I lay over 100 feet of between the controller to the CNC table.The cabling...Observe the loops of wire going around these spools in the picture above. The controller joins some other components on the shelves. That was pretty much the complete layout of the system, the following is a video showing the motion control system.I want to make a metal cutting system too. What would you have done differently? Are there ways that I could save time by buying OEM components?Well there are some things that I would have done differently to be sure, but I dont think it would mean that would have saved time. The main reason is cost. There arent any systems that I know of that are in my price range. Another way to say it is, most OEM solutions are incredibly expensive.Most of the mechanical parts of the system like the physical CNC table, the chiller, the frame supporting the laser were very easy. This is fun and not very time-consuming. Perhaps the biggest technical hurdle was that I put my laser support system together using a welder which some people may not have.The optics were pretty much bolt-together parts and I dont think there would have been much time to save there. There are some optics that are specifically designed for the laser itself which would allow you to just take the optics out of the box, connect to the system, and you are ready to go. I was lucky to get my optics from ebay and other sources for fairly cheap, but it was not an instant solution. I would still go with the used parts solution again.Electronics. Now, this was hard for me. You need to have motor drivers, some laser controls, limit switches and emergency stops. Putting this all togethe under one integrated system was a very large amount of work. I dont know of a commercial system that works for my laser, even an expensive one, so I had to make all that circuitry myself. I used a lot of TTL logic, and to be certain I would never do that again.So one thing I definitely would do differently is this. I would use microcontrollers. I would have liked to have all inputs and outputs of electronic/electric connections going into a board handling TTL signals, relays, and connections for external limit switches, and then put the logic of the overall system together with microcontroller software. On the other hand, if you want to save some time it would be best to find an alternative to making the electronics your self.House wiring. There was a lot of wiring I had to do myself, which was fun but also a lot of work. You could definitely save time (not money) to have someone else do that.There are examples on ebay of complete laser cutters with enough power to cut metal. They are very expensive, and also require wiring ventilation and cooling pretty much similar to what it would be like if you had a shop with a really large milling machine. But that still might be a way to be cutting metal without taking a lot of your time.So the short answer to your question is this: unless you want to spend $50,000 I think you'd have to do most of it yourself.Can I cut brass?No. I cant either. The industry would love to cut brass and they aint figured it out either. I gather it's a problem due to the heat transmission of brass and copper. It spreads out its heat over the area of the cut too effectively. If you cant concentrate the heat on a particular area, the metal doesn't get obliterated. Steel is a lovely and cooperative metal.I have a glass laser that delivers 100 watts of power, can I cut steel too?Probably not. Its really hard to tell what power my laser actually delivers. The ambigiuity is because the product literature says that they modulate the output. The laser sends out higher bursts of energy that probably exceed 100 watts. The total delivery of power integrated over time is 100 watts. But according to the manual, they claim that by peaking the delivery over short bursts that it actually develops intermittant delivery of 250 watts. I dont know if its really doing that -- I do know that other lasers (e.g., YAG) also work on the principle of quick bursts that deliver much higher power. If you have a sealed glass laser, it delivers continuously, and it doesn't do this burst trick that the Coherent does. That's not to say you cant get some cutting power. Maybe you could cut stuff that's 0.005 inches, or better. The key, as you may very well know, is to think about your optics. If you really want to explore the issue you have to read and understand: your goal is to get a tight beam, and a DOF that is thicker than the object that you want to cut. If I was in your shoes one place I'd do some research is to find out what power density is required to cut metal. I was told over the phone by Coherent guy (hey better than an incoherent one) that it is 106 watts/in2 for steel. But there's a chance that he's wrong. Once thing I know, is that I can control my power output with electronics going to the laser. When I take that down to 50% of the max, it still cuts, maybe not as well but it still cuts. It suggests to me theres still hope for the glass tube guys.What else do I need to cut?You must have a functioning cutting head, that delivers oxygen that flows through the nozzle. You also need a cnc table running the part around underneath the nozzle.How much did it cost?Its rude question but...total estimated cost is about $15k or so. The laser itself was $6500, I bought a cnc table for $500, and the optics were another $2500. A chiller from ebay cost me $500. There were lots of other incidental costs like a lot of electronics, motors, motor controllers, 220 volt wiring, cooling and ventilation. The biggest operational cost is oxygen. A tank of oxygen is $55 and can easily be used up in a weekend. The operational cost of electricity is negligible. The stainless is pretty cheap, around $1 a pound.Then there's time. The project took 2 years, but if I had to do it again it could get done in about 6-12 months.I was thinking earlier today about all these CNC machines when all of a sudden I looked over at my printer and realised that with a few modifications it might be made into a basic CNC.I dont think this approach works. The problem is lateral thrust.If your printer is buzzing along, try putting your hand in the way of the movement, you'll see that even a bit of resistance will prevent most of the electromechanical gizmos from moving. Now think about instead of that printer head on a little gantry system, you've substituted in a cutting tool like a small dremel.You can imagine that you'd have problems with the printer mechanics moving a cutting tool in wood, but you also have problems just with forward inertia. If the heavy cutting tool is moving in one direction, reversing that movement quickly will wont happen perfectly, it will try to reverse, some belt or gear or stepper will slip a little. (If you clamp your fingers on small steppers when they are moving, they just stop.)Since most systems of that kind lack feedback about the exact position of the gantry after that slip happens you dont have a good relationship between what the computer is treating as an x-y position, and what's actually happening on the printer. this'll screw ya up.but, some cutting tools offer little or resistance, like a laser beam being moved around by flying optics, or really really fast cutting tools (like a high speed bit in a dental drill). so then all you have to do is deal with the forward-reverse inertia problem. there are other applications, like if you're spraying paint or something, that would also have no resistance. also if you're cutting something really soft. but be advised I used to have a balsa wood cutter and there aint no way a printer could handle pushing a bit through that with any accuracy.so for cutting tools, you want to have something stronger than a printer. be advised though, if you want to make something it just aint that hard. there's steppers and pulleys and belts and drivers and premade systems galore, just gotta make a little investment. search ebay using the term "linear actuator" or "xy table" or "cnc table", at least some of those searches will show something cheap.the other way to think of it is go ahead and buy a plotter on ebay and hack it up, they have all the parts in there. you either hack the existing driver, or get a cheap motor driver board and connect the motors to that. its incredibly instructive to see how a system works. it wont handle moving a cutting tool but its still very instructive. I started by getting a laboratory robot that moved around small liquids, was really good for showing basic principles.so it just boils down to how much lateral force a cutting tool needs, and the forces involved when redirecting movement of the cutting tool. my guess is that in most cases you could just clamp your finger down on the motors that are moving your printer and you could stop the movement. to be sure, the older printers and the larger format plotters might have a chance. the other option would be to use the mechanical parts from an old system and swap in bigger steppers.Can your laser cut thru your finger. That'll leave a mark.No. This laser cant cut through a whole finger. One reason is that co2 lasers cant penetrate through water, which is what meat mostly is made of. The other reason is because of divergence, the power density of the beam drops off very very quickly as it leaves the cutting nozzle. Its the molecular equivalent of shooting at a target with a shotgun that's a mile away.I have succeeded in cutting a disk of approximately 1/4 diameter off the tip of my finger though. Hurts like heck but it cuts while it cauterizes, so there's no bleeding. These are various items I have made with the laser. MVI_1825.AVI

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