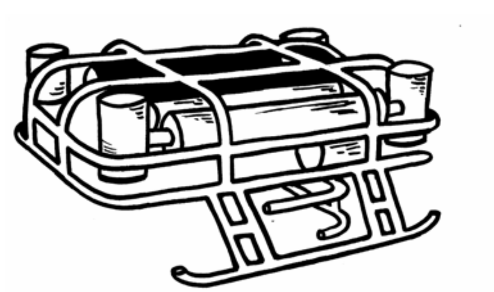
SPACE COAST TITANS

Technical Report

Brevard Community College

2004 ROV Team

Palm Bay, Florida



The Titan II

SPACE COAST TITANS DOCUMENTATION PORTFOLIO

Brevard Community College

Space Coast Titan's ROV Team

Palm Bay, Florida

A documentation portfolio submitted in partial fulfillment of the 2004 MATE Center/MTS ROV Committee ROV Competition for High School & College Students

Space Coast Titans ROV Team Participants

Faculty Advisor:	Susan Phillips	Professor of Biological Sciences
Team Members:		
	Billy Fried,	Science Education, Team Captain
	Richard Scully,	Electrical Engineering/Marine Sci
	Evie Touchton,	Elementary Education
	Tyler Acevedo*	General Education
	Janice Harker*	Physical Therapy
	Ryan Watkins*	Technology Education

(Students not attending competition)*

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ABSTRACT

Brevard Community College's Space Coast Titans have entered the 2004 MATE ROV Competition for High School & College Students open category. The mission is to perform several scientific tasks such as depth, distance and temperature measurements, fluid sampling, and recovering artifacts. To accomplish this mission, The Space Coast Titans have redesigned and retrofitted their second ROV, the Titan II. Six students from Brevard Community College have employed modern material science, personal skills, and industry standards along with knowledge from their mentors to develop the machine that they have today.

The Titan II was developed to be versatile, strong and smart. Its strength lies in the aluminum tubular frame, stainless steel manipulator, and sheer size and girth of the six thrusters. Although Titan II was designed for a competition in a shallow, chlorinated, freshwater environment, it has flown in the waters of the Florida Keys to a depth over 6.5 meters and proved itself capable. The Titan II's digital pulse width modulation controls, measurement sensors, and built-in-system diagnostic capabilities show it is not only strong, but also smart.

In addition to the many qualities the Titan II has to offer, perhaps the most remarkable feature is the entire machine can be broken down into its smallest components with three Hex wrenches and the pull of several quick release pins. Given these qualities, the Space Coast Titans expect the Titan II is a machine that every judge, competitor, and ROV employing company would want on the deck of their most trusted vessel.

PHOTOGRAPH OF COMPLETED ROV

Starboard Side and Bow View

Port Side and Bow View

Port Side and Aft View

Starboard Side and Aft View

Note: These photos include some mock up parts to replace those in final processing.

BUDGET

Event Budget for 2004 BCC-ROV Team

Expenses (Zero Actual Cost indicates items donated)

Total Budget	**$8500.00**	**Total Expenses**	**Estimated**	**Actual**
			$10,712.01	**$8,338.33**

	Estimated	**Actual**
ROV Control System		
Jameco	$50.87	$50.87
Omega	$193.00	$193.00
Seacon	$600.00	$0.00
Case	$300.00	$267.00
Tether Wrap	$120.00	$0.00
Digi-Key	$1,010.00	$1,140.82
LAST MINUTE RESERVE	$900.00	$900.00
Tecel	$249.00	$249.00
Totals	**$3,422.87**	**$2,800.69**
ROV Video		
Cable	$150.00	$0.00
Color (4) (AS)	$600.00	$595.96
Monitors (4) (Extreme)	$800.00	$545.28
Totals	**$1,550.00**	**$1,141.24**
Travel		
Airfare (3 x $217)	$651.00	$650.10
Car	$300.00	$267.32
Mileage (166 x .29)	$48.14	$48.14
Tolls/Parking	$120.00	$120.00
ROV Shipping	$820.00	$0.00
Meals	$258.00	$258.00
Totals	**$3339.14**	**$2485.56**

	Estimated	**Actual**
Tools		
Slurp Gun	$60.00	$60.00
Actuators	$900.00	$900.00
Lexan/Plexi	$100.00	$44.66
Starboard	$100.00	$49.99
Hydrophone	$200.00	$20.00
Software	$250.00	$45.00
Totals	**$1,360.00**	**$1,074.65**
ROV Propulsion		
Drive Motor (1)	$190.00	$0.00
Lift Motor (1)	$100.00	$0.00
Totals	**$290.00**	**$0.00**
ROV Ballast System		
Foam	$100.00	$100.00
Resin	$50.00	$50.00
Totals	**$150.00**	**$150.00**
Misc.		
Misc. Hardware	$250.00	$336.19
Graphics work	$100.00	$100.00
Ribbons/Plaques/Trophies	$150.00	$150.00
Photocopying/Printing	$100.00	$100.00
Totals	**$600.00**	**$686.19**

ELECTRICAL DESIGN AND SCHEMATIC

The Brevard Community College ROV team, along with their mentors, decided that the control system is far too complex to overlook any part of the schematic. For this reason we have attached it as an appendix. (See Appendix A.) We apologize for the volume of this report, but trust you will understand as you decipher the attached schematics.

The Brevard Community College 'Titians' ROV control and data acquisition system is comprised of three major sub-systems: The CONTROLLER Unit, the POWER Unit, and the ROV Unit. An optional personal computer may be added to actively monitor command and sensor data while the ROV is deployed or simulate ROV control for demonstrate and educational purposes when dry docked. At the heart of each of the three sub-systems is a PIC16F877 microcontroller manufactured by Microchip Technology, Inc.

The PIC16F877 was chosen because of several key functionalities:

The program and data memory utilize CMOS FLASH/EEPROM technology, which can be written to under program control utilizing a boot loader program. This means that the micro controller can be programmed through the serial communications port without direct access to the circuit and the program software will not be lost when the power is removed. At any time, on the surface or at depth, the system can be loaded with new program software.

- The PIC16F877 contains 8 analog-to-digital converters for reading environmental transducers such as depth or temperature sensors, and linear position sensors such as joysticks.
- The PIC16F877 contains up to 24 digital I/O signals. As inputs, these signals are used to read various control switch positions. As outputs, these signals send data to the CONTROLLER LCD display, control relays and H-Bridge motor controls.
- The PIC16F877 contains a fully programmable USART (Universal Synchronous Asynchronous Receiver Transmitter). This is the standard serial communication system utilized in personal computers. This allows the ROV System to readily communicate with any standard PC for software programming or data / performance monitoring of the entire system. This serial communication system is also how the three major sub-systems communicate data and commands between each other.

The Microchip PIC family of microcontrollers has available 'C' and BASIC programming compilers such as the PROTON family of BASIC compilers from Crownhill Associates. This allows for accelerated code composition as well as easily readable and alterable software programming.

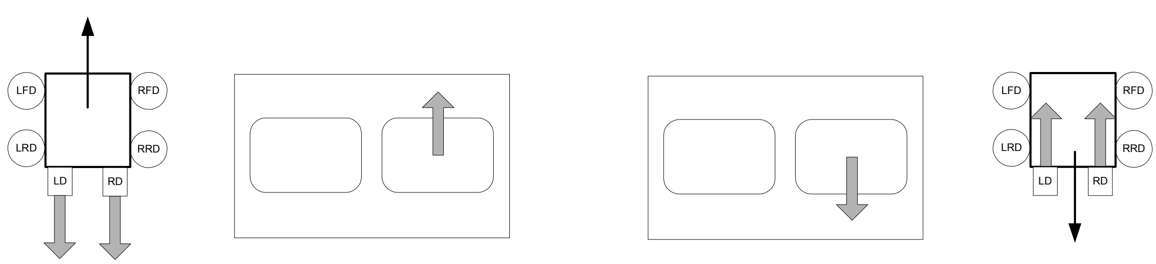
Each of the three sub-systems are designed for a specific function:

- POWER Unit: This unit is the master power and communications control unit of the system. It contains the H-Bridges, which are devices used to control the speed and direction of the various propulsion and linear actuator motors. It also acts as a network hub by requesting and directing control and sensor data between the three sub-systems.
- CONTROLLER Unit: This is the hand held device that contains the axis control joysticks with offset trims, the sensor and control data Liquid Crystal Display (LCD), and the function select/control switches.
- ROV Unit: This is the system within the ROV itself and is responsible for collecting measurements from the various sensors and reporting these measurements to the other sub-systems such as the CONTROLLER LCD or the optional personal computer.

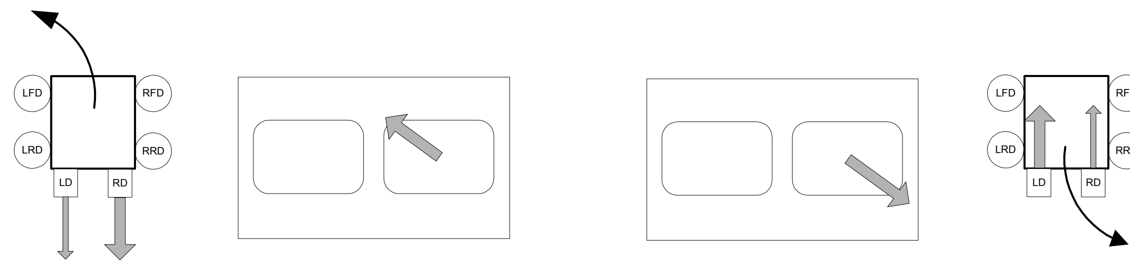
CONTROLLER UNIT

The CONTROLLER Unit was built from a standard RC molder's 4-axis joystick control box. The analog interface and RF transmitter circuitry was removed and replaced with digital microcontroller circuitry. A 16x2 LCD display module and additional function switches were also added. The CONTROLLER Unit's function is to interpret the analog joystick, trim, and function switch positions and convert the positions into numeric digital control data by the microcontroller. This digital representation of the controls position is transmitted serially to the POWER Unit for motor and linear actuator control.

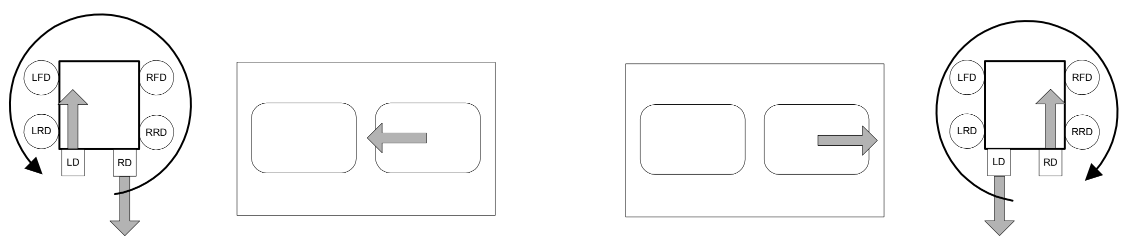
The control of the left and right horizontal thrusters is accomplished by the right joystick, which produces two independent analog voltages from the x-axis and the y-axis. This voltage is proportional to the position of the joystick. The analog voltage from the joystick is measured by the microcontroller and divided into 256 digital units – 0 = full reverse or full left, 127 = neutral (stop), and 256 = full forward or full right. Straight horizontal motion forward and reverse is interpreted from the y-axis. When the y-axis position is greater (forward) or less (reverse) than 127 (neutral) and the x-axis (turn) remains neutral, the left and right horizontal thrusters are powered equally and proportional to the joystick position which produces a straight line of travel either forward or reverse.



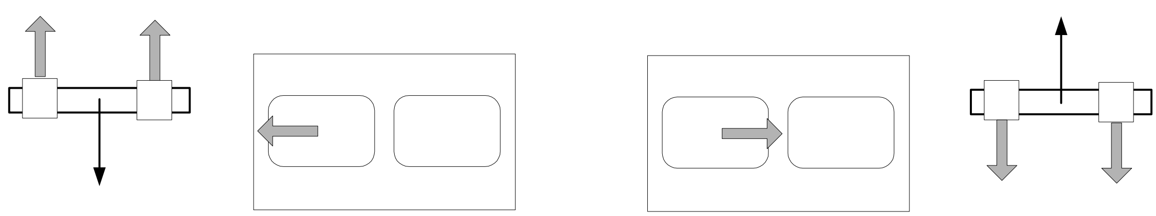
Turns are interpreted from the x-axis for direction and y-axis for speed. Turns are accomplished by reducing the thrust of the horizontal thruster on the inside of the turn arc proportional to the x-axis joystick position. This reduction of thrust causes the ROV turn towards the side of reduced thrust while maintaining a forward or reverse horizontal movement.



A pivot maneuver is interpreted when the x-axis (turn) position is greater (right) or less (left) than 127 (neutral) and the y-axis (forward/reverse) remains neutral. Pivots are accomplished by producing equal horizontal thrust but in opposite directions. To make a right pivot, the left horizontal thruster is forward and the right horizontal thruster is reverse. The speed of the pivot is proportional to joystick position from neutral.



The left joystick x-axis analog voltage accomplishes the control of the four vertical thrusters. This voltage is proportional to the position of the joystick. The analog voltage from the joystick is measured by the microcontroller is divided into 256 digital units – 0 = full down, 127 = neutral (stop), and 256 = full up.   The direction and amount of thrust determined from the joystick position is applied equally and simultaneously to each of the four vertical thrusters.



Shifts in the ROV center of gravity (pitch & roll) caused by sample collection is corrected through the use of offset trim controls (potentiometers). Each of the four vertical thrusters has an independent offset trim control which produce an analog voltage, independent of the vertical joystick, that is measured by the microcontroller then converted into digital units. The purpose of the offset trim control is to independently reduce or increase the amount of thrust of each of the four vertical thrusters in order to control pitch & roll while maintaining proportional vertical movement with the vertical joystick. When the ROV becomes heavier in a particular center of gravity quadrant, say the left front for example, the left front vertical thruster power may be increased by 10% in order to level the ROV. When the joystick position indicates a 50% thrust in the up direction the left front thruster will actually be producing a thrust of 60% while the other three thrusters will be producing 50% thrust. This will cause the ROV to ascend at 50% power rate while maintaining a level attitude about the center of gravity.

Various linear actuators are controlled by the left joystick y-axis and function switches similar to the thruster controls by converting the analog data from the joystick and function switches into digital units and transmitted to the POWER unit.

The LCD display has a contrast control and scroll switches to display sensor, active system and diagnostic data. Depth and temperature measurements may be displayed in various units such as Celsius, Fahrenheit feet and meters respectively. Joystick and trim positions can be displayed independently or cumulatively with joystick position including trim offset. The display may also be programmed to display any data required for program or system debugging.

ROV UNIT

The ROV Unit contains microcontroller and analog signal conditioning circuitry which is used to collect, digitize, and transmit data from the pressure gauge to measure depth and the temperature sensor. The digitized data is transmitted to the CONTROLLER Unit LCD display or the optional personal computer. The pressure and temperature sensors produce analog voltages, which are proportional to their respective stimulus. This voltage is then amplified for digitization by the microcontroller's analog-to digital converter. This raw digitized data is then processed through algorithms that convert the measurements into real world units such as degrees Celsius or meters of depth. The unitized measurements are then transmitted through the tether data communications cable to the other sub-systems via a full duplex differential signal capable of transmitting will over 4000 feet or 1200 meters.

POWER UNIT

The POWER Unit is the master control of the ROV system. It provides the interface to the power supply and power distribution to the other sub-systems. It contains the H-Bridges, which control the speed and direction of the thruster and linear actuator motors. It acts as a communications hub for routing data and control signals to the other sub-systems.

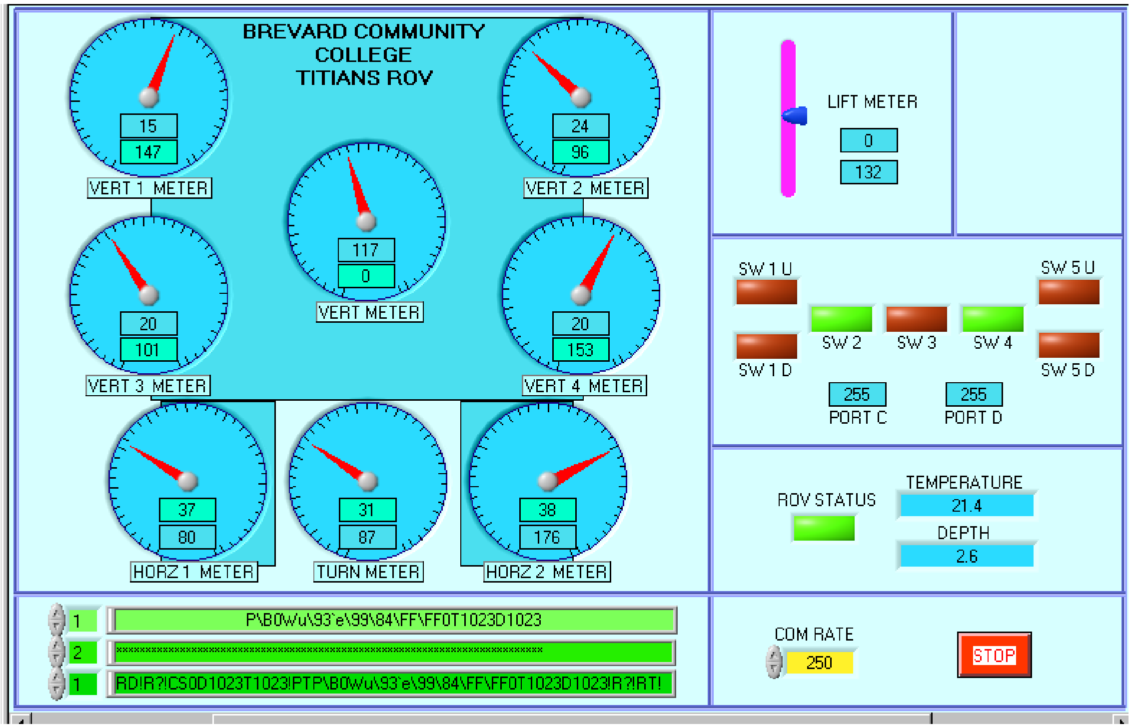
Power for the ROV system is applied and distributed through the POWER Unit. The ROV system requires +12 and +24 VDC in order drive all the electronic functions and motors. This power may be derived from storage cell devices such as batteries or from rectified AC power supplies. The thruster motors require +24 VDC, and the linear actuators and power relays require +12 VDC. The +12 VDC is further internally regulated down to +5 VDC in order to power the digital microcontroller logic, H-Bridges, and communications circuitry.

The POWER Unit contains eight H-Bridges to control each of the six drive thrusters, two horizontal and four vertical and two H-Bridges which are multiplexed through power relays to control the four linear actuators which power the fluid sample, lift and other mechanical actions. An H-Bridge is an electronic switch device that has the ability to electronically reverse the polarity of the applied power to DC motors, which in turn cause the motor to switch rotation direction. It also is capable of pulsing the applied power to the motor, which affects the speed of rotation. If you pulse the power to the motor at one second on, one second off (50% on 50% off) the motor will run at half of its full power speed. The speed and direction control functionality of the H-Bridge allows for precision maneuverability in confined spaces as well as station holding in currents.

System communication is accomplished utilizing two industry serial communication standards – RS232 and RS422. RS232 is a single-ended system where by a single wire is used for transmission to a device and one wire is used for reception. It is also full duplexed which means that data can be sent and received at the same time. It is the standard used by personal computers and is reliable only for short distances, around 50 ft at the maximum data rate. RS232 is used for sending data between the CONTROLLER Unit and the POWER Unit because of the short distance of 20 feet between the two units. RS232 is also used for data transfer between the POWER Unit and the optional personal computer, which may be added to actively monitor command and sensor data.

RS422 serial communication standard was implemented for the tether communication between the POWER Unit and the ROV unit. When transmitting data over long distances single-ended methods are often inadequate. RS422 differential data transmission (balanced differential signal) offers superior performance in most applications and is rated for distances in excess of 4000 feet. RS422 is also full duplexed and uses a pair of wires to transmit and a pair of wires to received data. The wire pair offers better immunity to electrical noise and static than does the single wire RS232.

OPTIONAL PERSONAL COMPUTER



The ROV system has a PC program that allows the monitoring of the control and sensor data utilizing graphical interfaces such as dial, slide, and alphanumeric indicators. This program can be used while the ROV is on a mission to collect and store data from the sensors as well as monitor the activity of the system performance. It can also be used as a visual aid to demonstrate how the CONTROLLER Unit's control data is interpreted by the POWER Unit and applied to the H-Bridges to regulate the amount of thrust generated by the thrusters.

DESIGN RATIONALE

A well-crafted tool must be designed and manufactured with the ability to withstand any job placed before it. Although Titan II was designed around the mission at hand for the *2003* competition, it is indeed a stout, durable, powerful, smart, and ocean worthy machine capable of being retrofitted in order to withstand any job placed before it. Given the typical work environment a submersible ROV must operate in, it must be able to withstand and adapt to the severe elements that occur while operating both on the service and at depths, the severe pounding on a boat deck, in the bed of a truck, during the sale at the static technical and industry conventions, and on the occasional workbench. As you will see, Titan II can do all of this and more.

The powder coated aluminum frame is the backbone of Titan II that each other system relies on to be efficient. The extruded pieces of symmetrically bent pipe are comprised of ~ 11.3 linear meters which give a positive buoyant force of ~ 3 kilograms and can withstand several hundred kilograms of pressure. The high tensile and sheer strength, combined with the low density it possesses, gives it the ability to take a blunt strike and not have more than a mar to show for it (which, for the most part, can be polished and buffed out). The frame is also positioned in a way to lend an infinite number of mounting points for all of our other equipment. The aluminum tubing has a smaller drag coefficient than flat bar and a more aesthetic appeal.

The forklift style manipulator that is now mounted can be removed with the push of a button that is countersunk into the two tracks. These tracks can also facilitate the mounting of cable cutters, a pipe alignment tool, samplers, torches, additional sensors, or cameras.

The six thruster housings are comprised of aluminum pipe with Delran inserts, as well as stainless steel shafts. These motors are placed on all four corners mounted to the static buoyancy tubes, and independently controlled. This adds control and stability. The thrusters used for horizontal operations are mounted to the aft end of the dynamic ballast tubes directly behind the bulkhead. These thrusters are identical to the assembly of the vertical thrusters. The thrusters produce enough horsepower and torque to lift and carry approximately a mass of 22 kilograms (dry weight).

The entire design is centered on a forward and aft clear plexi-glass bulkhead that is removed with eight quick release pins. This allows all systems of the video, thruster, and three manipulators to be removed from the frame to facilitate easy access to all components for maintenance purposes. Every main structure on the machine is also designed to be multifaceted.

PROJECT CHALLENGES

Team Challenges:

- Team member priorities
- Personality conflicts (too many chiefs; not enough Indians)
- Scheduling
- Procrastinating members
- Personal skill and knowledge levels
- Keeping design within our skills
- Keeping purchases conformed to BCC's accounting rules and regulations
- Getting group censuses on how to perform all seven tasks

Technical Challenges:

- Size Limitations i.e., fitting equipment for seven tasks onto a machine that will enter a 1-meter cavern and also be compact enough to fit our shipping budget.
- Acquiring the right part for the job i.e., lots of vendor problems including faulty specs, faulty parts, mistakes in cuts, parts being backordered, etc.
- Requirement of several different voltages i.e., motor can run on three different voltages for different levels of power requiring the logic control to handle three different voltages
- Limited choice of tools i.e., having to use a grinder instead of a hotwire to shape our foam and trying to find a facility with a lathe with a more stable chuck
- Using program compilers that did not have an up to date software patch
- Attaining communication protocol within our budget

Probably our major challenge this year was that we didn't have access to a machine shop. Instead, we had to work out of our advisor's garage with limited tools and an even more limited budget to buy the tools we needed. For us, this was like moving from a mansion to the ghetto! (No offense to our advisor who, incidentally, came up with this analogy.) But we did learn to appreciate the "simple things" in life. Consequently, we worked harder, longer and had to be more creative in "hand-crafting" the parts we needed.

Once again, our most rigorous technical challenge was overcoming our deficiencies in electrical engineering skills. Fortunately, one of our team members was an electrical engineering student who has been working as an electrical test engineer designing automated test systems for some time. This ensured the retrofitted Titan II had an up to date 'smart control' system, and gave the rest of the team members the opportunity to learn these much needed skills.

TROUBLESHOOTING TECHNIQUES AND EXAMPLES

TECHNIQUES

- Mock-ups, mock-ups, mock-ups!!!
- Sponsorships, sponsorships, sponsorships!!!
- Brainstorming additional methods from our original blueprint
- Using “not quite the right tool for the job”
- Consulting industry professionals

EXAMPLES

Perhaps our biggest help in troubleshooting came from consulting our partners in industry. We have been fortunate enough to be in an area where there are many opportunities to seek out industry partners. The Titans are from Brevard County, Florida, home of the Kennedy Space Center (which employs some Video Ray technicians as well). In addition, Harbor Branch Oceanographic Institute is less than 50 kilometers to our south. This makes them both a valuable and reachable resource.

As always, our industry partners have been instrumental in helping us get the parts we need and think through design ideas. Since this is our third year, we have continued to increased community awareness and are continuously invited to speak and do ROV demos for various events. These outreach programs have proven to be a great source of networking for the team. We were very fortunate this year to be invited to speak about the ROV Competition and show off our ROV to the American Society of Quality. We were also invited to demonstrate our ROV at the Sally Ride Festival, the goal being to recruit young girls into technology. These were just two of many outreach programs the Space Coast Titans have participated in which, not only educate the public in submersible technology, but offer the team extremely valuable opportunities to share ideas and make many new contacts with local and national industry.

Some examples of our troubleshooting efforts include the following:

- After testing with two cameras and two monitors we felt the need to increase to four of each. Even with the widest field of view (92^0), we were not able to obtain a satisfactory view for the pilot. And, although we purchased monitors that are capable of dual video input, we found it cumbersome and confusing to switch channels while flying
- After testing our buoyancy and stability in the water, we decided to change materials at several mounting points from dense polymers to shelled foam in order to increase overall efficiency.

LESSONS LEARNED & SKILLS GAINED

- ***"If it can happen it will…and always before the show!"*** *Tyler Acevedo*
- ***"…always work within your limits so you are not left stranded if someone quits and resources are deleted and no matter how much people promise, it is extremely difficult to find someone completely dedicated to a project that is on a voluntary basis."*** *Billy Fried*
- *"…* ***don't promise to do more than you can do.."*** *Ryan Watkins*
- ***"I have learned a lot about ROVs, machining, materials, and electronics to name a few. It has been a lot of hard work but as I see our ROV come together it makes it worth the time and effort!*** *Janice Harker*
- ***"This project has opened my eyes to marine technology and given me ideas of what I can do to advance the technology of undersea robotics and exploration. I have learned how to design and implement robotic control systems. I did not realize, sharing the skills I have learned through my work experience, and working with teachers and other students on a project of this magnitude would be so gratifying.*** *Richard Scully*
- ***"Being on this team has been an experience unlike any other. Before I was a member, I knew nothing about Marine Technology, ROVs, or the tools in which to build one. I now have a greater knowledge and appreciation for the subject and, hopefully, after receiving my teaching degree, I will be able to implement this knowledge into a classroom of my own."*** *Evie Touchton*

FUTURE IMPROVEMENTS

- Digital telemetry
- On-board power dispersion
- Articulating manipulator
- Enhanced on-board harness

ROVS AND MARINE SANCTUARIES: HOW ROVS ARE CURRENTLY BEING USED TO EXPLORE AND UNDERSTAND OUR NATIONAL MARINE SANCTUARIES

ROVs are being used to complete the dreams many people have had for years: to go to the bottom of the sea and to be able to go there less detected by native life forms than we can in a SCUBA rig. ROVs are not only great observation vehicles but, in the right conditions, outperform a human diver. ROVs are used by biologists, fishermen, and industry to observe, take samples, and perform tasks otherwise dubbed impossible or too unsafe.

For example, in the Monterey Bay of California, ROVs are being used for a multifaceted project. Since hydrocarbons are at the base of the marine food chain, one of the most interesting properties of this site is the presence of large amounts of hydrocarbons near, what is believed to be, a mud volcano. An ROV was used at Smooth Ridge (Figure 1) to take push core samples.[1]

Seismic surveys have been done for decades in order to get a picture of the sea floor's surface, as well as what is tens of thousands of feet into the sub-floor. It was originally done with gunpowder and dynamite and, still is, in other countries and in U.S. shallow inland waters. However, when it comes to deep-water surveys, engineers have been using seismic air blasts to generate the sound.

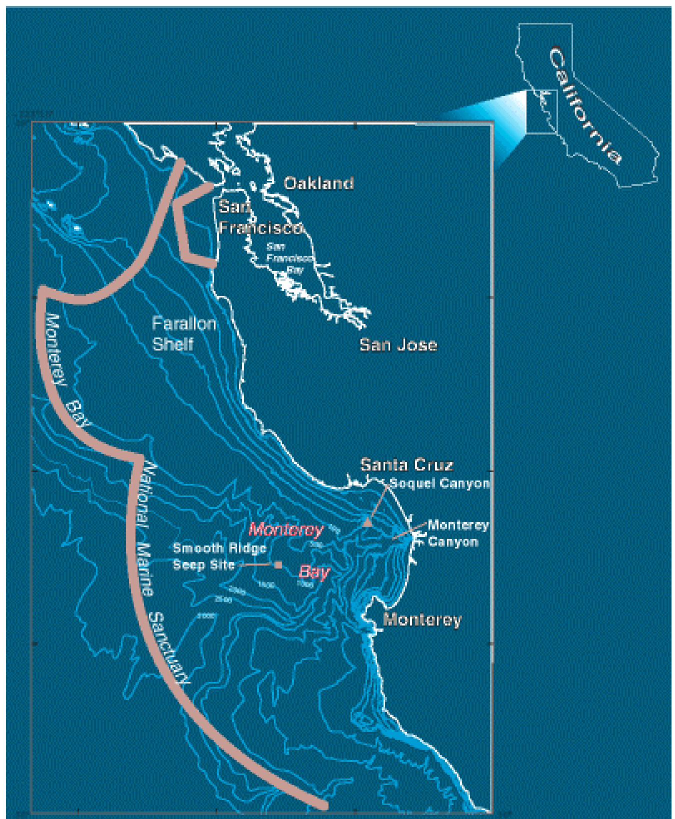


Figure 1: Topographical map of the Monterey Bay National Marine Sanctuary.

[1] http://walrus.wr.usgs.gov/hydrocarbons/index.html

With this, Oceaneering surfaced, once again, as the world's pioneer. British Petroleum has contracted them for a series of experimental surveys. These surveys still use air gun blasts. However, they are experimenting with the sensors. Instead of a surface array of sensors, engineers are trying to use sensor nodes that are placed on the ocean floor by ROVs and store the seismic data after the source vessel has shot transect lines over them. This method just began a month or so ago, so the future is still unclear. So far, it looks promising.[2]

Surveys are also used to identify the history of life. In 2002, the National Marine Sanctuary Program facilitated a monitoring side scan survey mission. The hope was to find samples and measurements that would prove pertinent to the local and regional issues of our oceans. The project was run in conjunction with NOAA's Center for Coastal Monitoring and Assessment and ran a course from the Channel Islands National Marine Sanctuary to the Olympic Coast National Marine Sanctuary. ROVs were used to help take the measurements and samples.[3] The mission was a success!

Remotely Operated Vehicles are being used more every year for observation of reefs and the inhabitants that live on them. Although ROVs are increasing in size to accomplish larger tasks, there is an ever-increasing need for smaller, less intimidating "eyeballs" for simple observation and crevice penetration. [4]

As submersible technology continues to develop, the need for commercial divers is becoming more obsolete. Our team learned first hand how competent ROVs are at accomplishing human tasks during a recent trip to the Florida Keys. We stopped at a local dive shop to try to solicit a free slurp gun for our ROV. Ironically, the owner, who was once a commercial diver, had been replaced by an ROV. Unfortunately, he didn't appreciate the irony in the situation and we, in return, literally "paid the price!"

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[2] http://geocet.net/

[3] http://www.oceanexplorer.noaa.gov/explorations/02quest/sanctuaryquest.html

[4] http://commdocs.house.gov/committees/resources/hii51770.000/hii51770_0f.htm

ACKNOWLEDGEMENTS

The Space Coast Titans wish to express sincere appreciation to our sponsors for their contributions to this project. In addition, we'd like to give a special thanks to Susan Phillips, our faculty advisor, for her valuable input in the needs and ideas of this project. We also wish to thank Brevard Community College for continued team support.

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Brevard Community College Environmonental Club
Contact: Susan Phillips **Phone:** 321-433-5289 **Donation:** cash

Brevard Community College
Situated on Florida's Space Coast, BCC has four integrated campuses – in Cocoa, Melbourne, Palm Bay and Titusville – an aerospace program at the Kennedy Space Center and a Virtual campus. BCC's diverse 25,000+ student body is made up of high school graduates, business professionals, retirees and everyday people who are university-bound, seeking new career paths or simply following a love of learning. More details about BCC can be found by clicking on this link. http://www.brevard.cc.fl.us/

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Crownhill Associates is a UK-based company that specializes in design, manufacture and supply of electronic goods and services, operating internationally within the electronics and telecommunications sector.
Contact: Lester Wilson **Donation**: PIC basic compiler
Web-site: http://www.crownhill.co.uk/about.php

Dictaphone is a leader in voice activated technology.
Contact: Bob Greene **Phone**: 321-259-4524 **Donation**: Machine shop time
Web-site: cableorganizer.com

Ecoes Consulting Incorporated has programs including, but not limited to, listed species research, inventory, and habitat assessment, environmental education, wetlands, professional training and certifications, protected species visual and acoustic observations, and monitoring programs for offshore oil and gas industry support.
Contact: Mary Jo Barkaszi **Phone**: 321.635.8477 **Fax**: 321.635.8449
Donation: Use of Dolphin Ear hydrophone **Web**: http://ecoes.net

The Firestore is a supplier for all firefighting needs.
Contact: James Witmer **Phone**: 800-852-6088 **Fax**: 888-335-9800
Donation: Discounted goods **Web**: http://www.firehelmet.com/

Forward Minds Incorporated is a software development and integration consulting firm. We specialize in the design and implementation of highly interactive public web sites to support communities of experts and professionals.
Contact: David Finley **Phone:** 877.441.0602 or 866.855.4932 **Fax**: 801.607.7315
Donation: Photo-editing, possible future web-site development/hosting, and epoxy foam.
Web: http://www.forwardminds.com

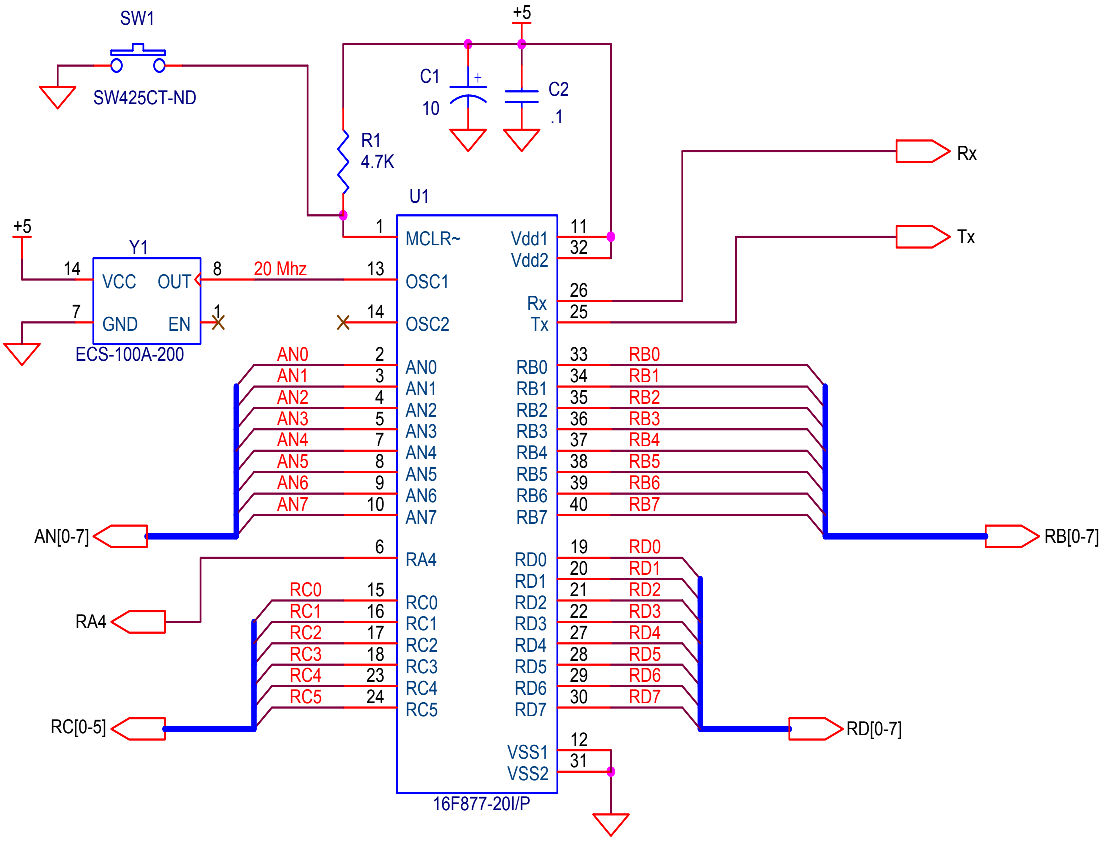
The GeoCet Group combines extensive experience, both in ecological research and offshore environmental compliance. The GeoCet Group provides total industry support, including marine mitigation services, certified offshore protected species observers, and unique training and educational programs for the energy related marketplace. Whether your business is decommissioning, blasting, or geophysical acquisition, GeoCet can provide you with a reliable and cost-effective compliance program. **Contact**: David O'Hare **Phone**: 281-325-1080 **Fax**: 281-325-1088
Donation: Cash **Web**: http://geocet.net/

Moonlite Courier Worldwide & Same day Express have provided on-time, expedited, accurate courier and messenger services to everyone from our valued Corporate Customers to our cherished "Average Joe".
Contact: Sam Gillani **Phone**: 212-473-6785 **Donation:** Shipping
Web: https://www.moonlitecourier.com/

SeaCon Brantner is one of the largest manufactures of underwater connectors in the world.
Contact: Glenn Pollock **Phone**: (619) 562-7071 **Fax**: (619) 562-9706
Donation: Underwater connectors **Website**: **http://www.seaconbrantner.com/**

APPENDIX A: ELECTRICAL SCHEMATICS

ROV UNIT SCHEMATIC



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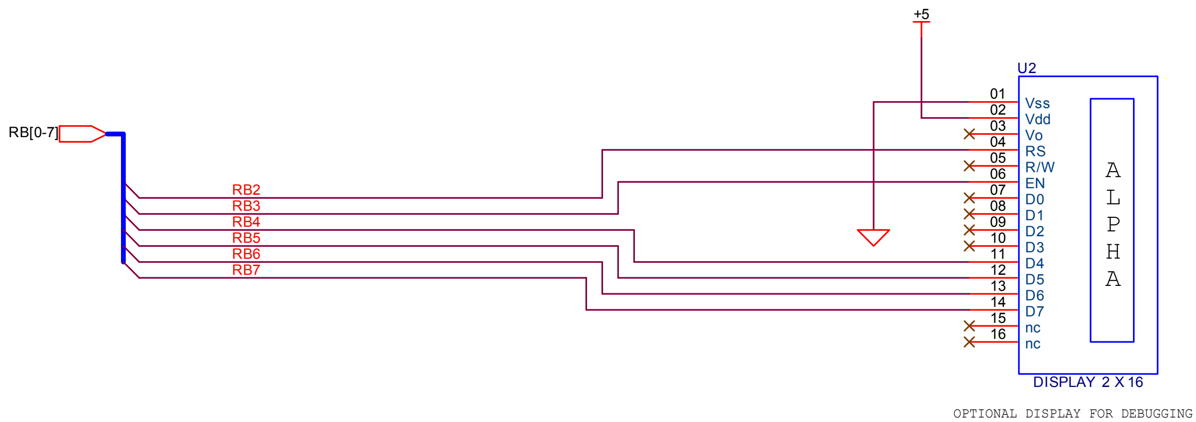
Size: A	Document Number: <Doc>	Rev: R2
Date: Friday, June 11, 2004	Sheet 1 of 7	



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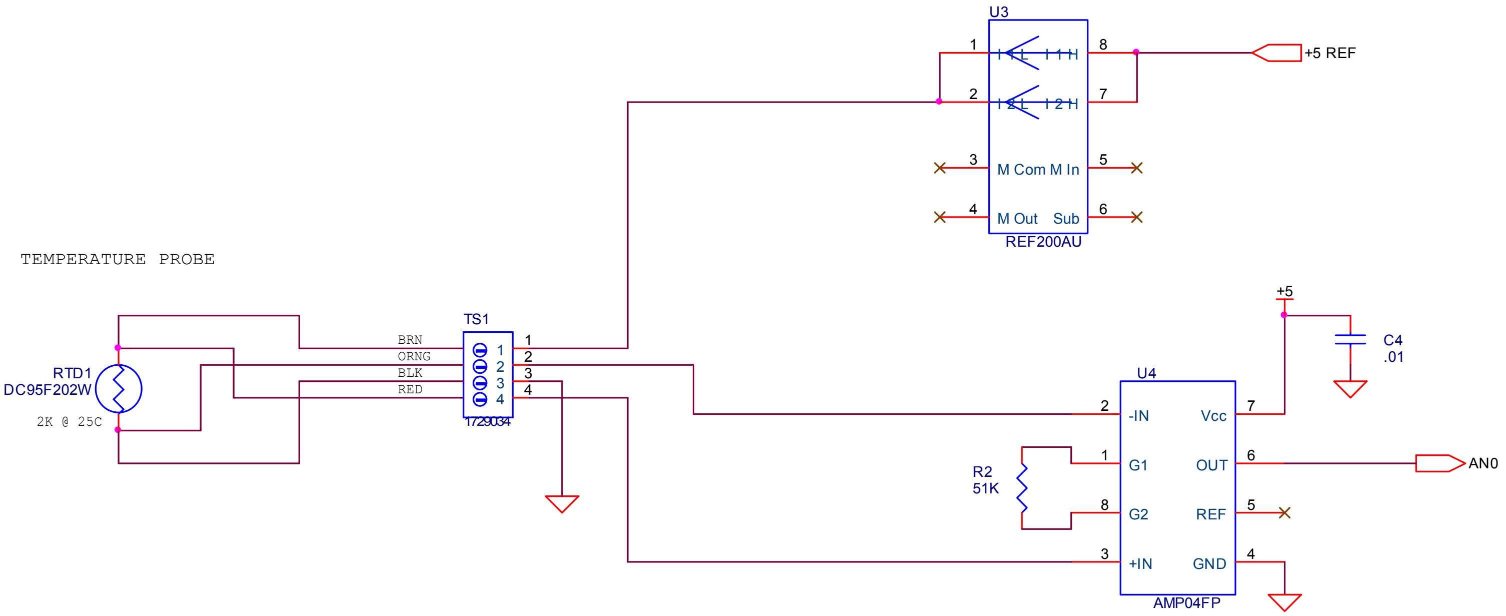
Size A	Document Number <Doc>		Rev R2
Date:	Friday, June 11, 2004	Sheet 2 of 7	



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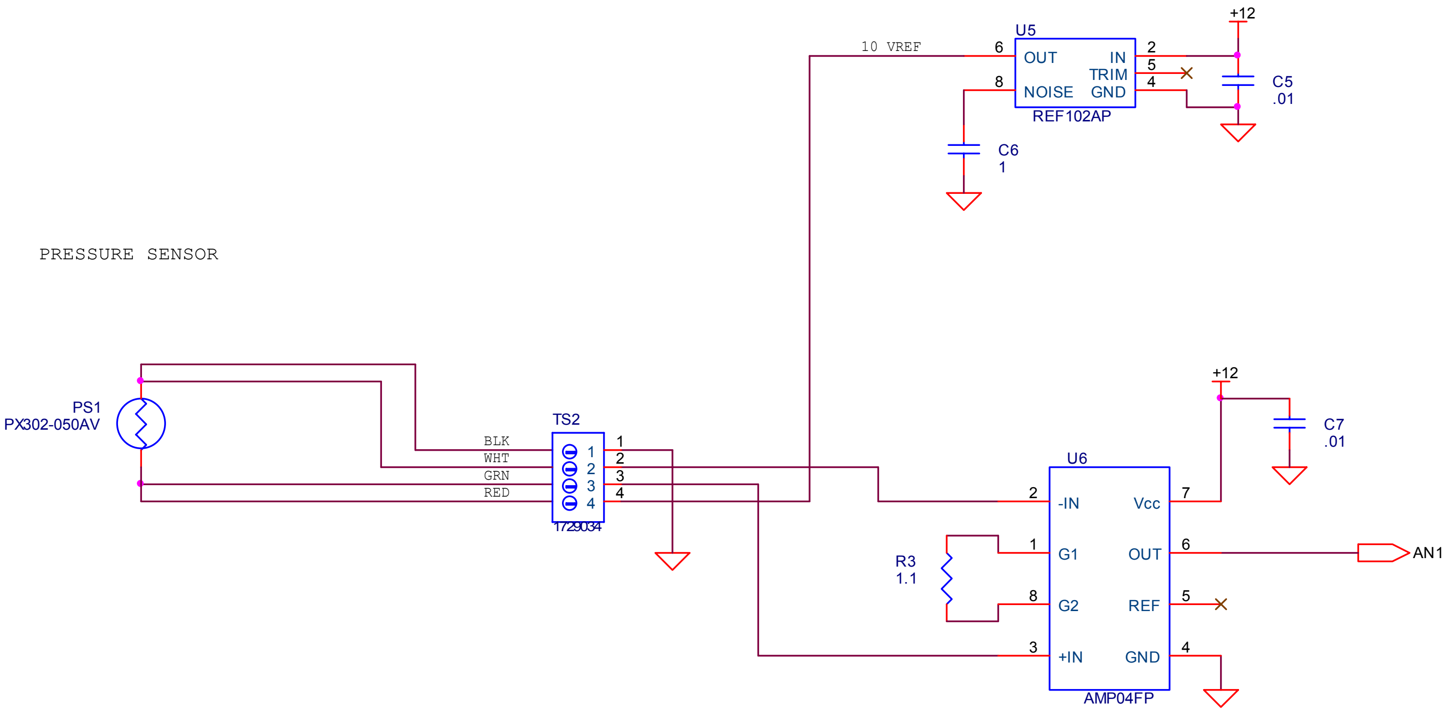

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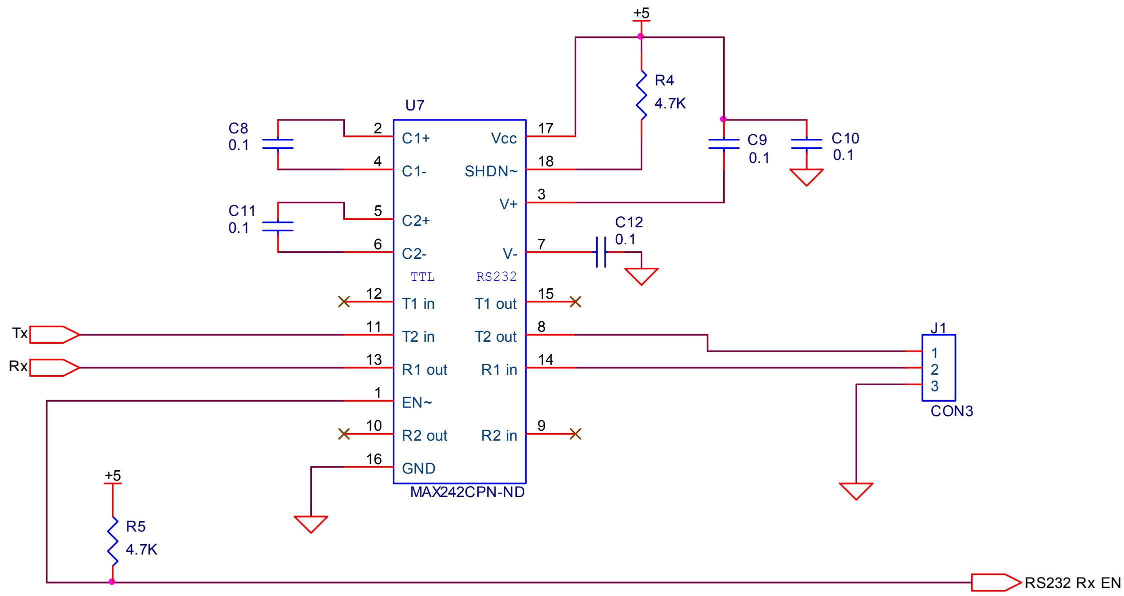

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Size: A	Document Number: <Doc>	Rev: R2
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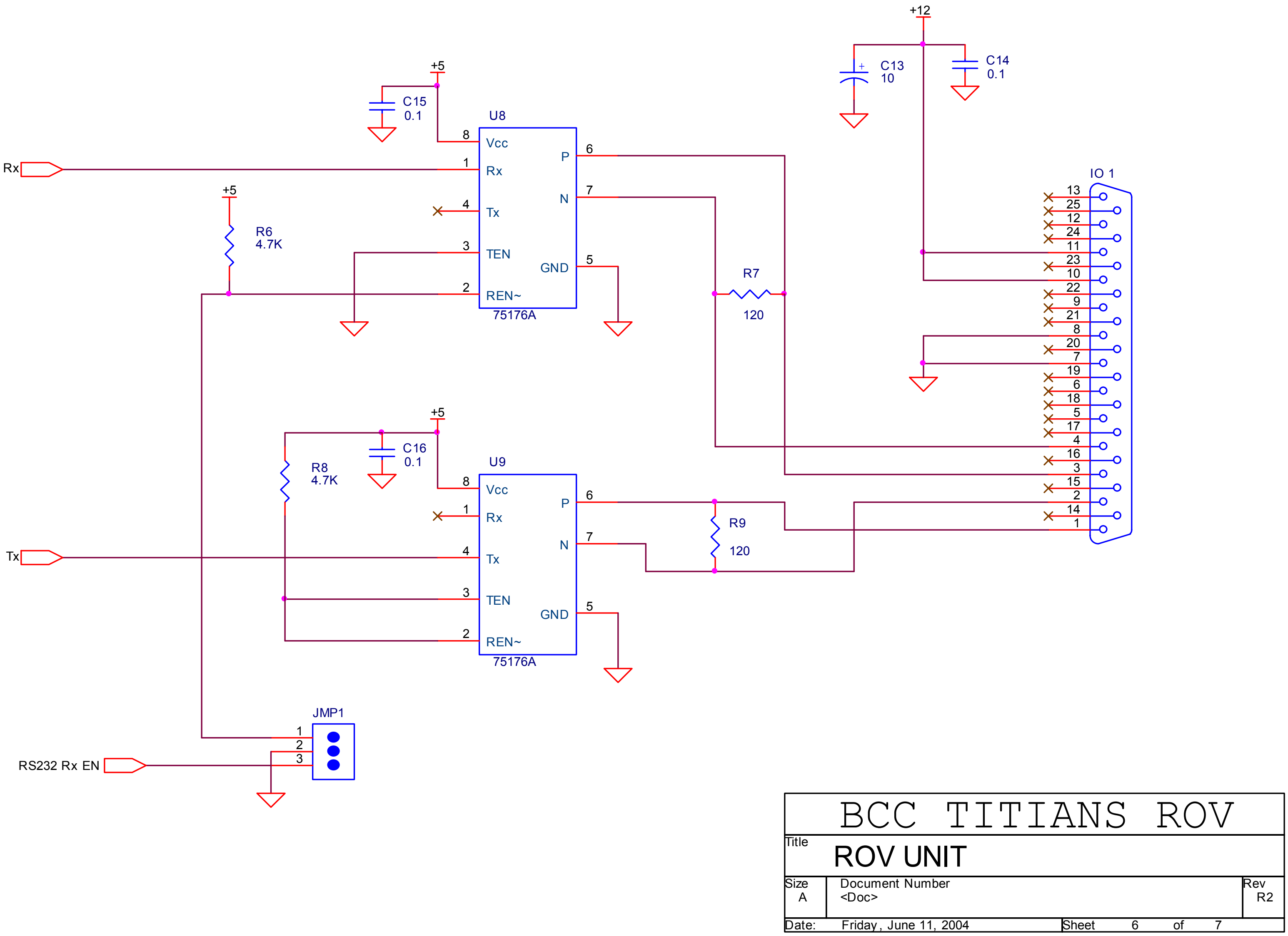
+12
C13
10
C14
0.1
+5
C15
0.1
U8
Vcc
Rx
Tx
TEN
REN~
P
N
GND
75176A
Rx
R6
4.7K
R7
120
IO 1
+5
C16
0.1
U9
R8
4.7K
Vcc
Rx
Tx
TEN
REN~
P
N
GND
75176A
R9
120
Tx
JMP1
RS232 Rx EN
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ROV UNIT
Size
A
Document Number
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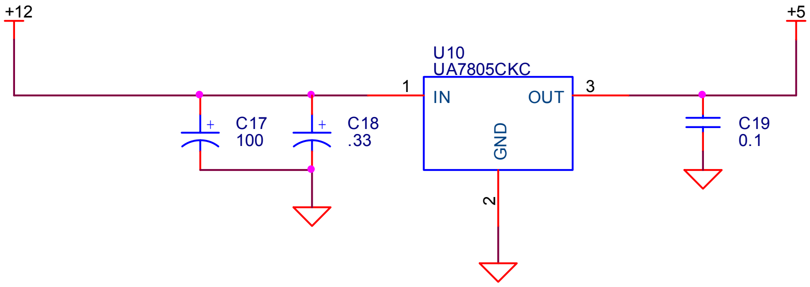
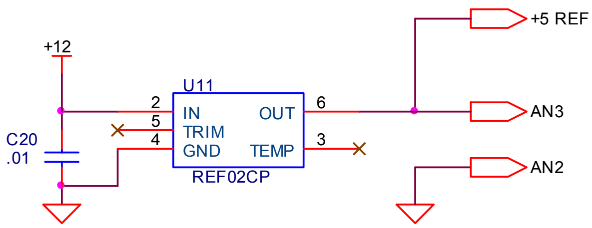
Rev
R2
Date: Friday, June 11, 2004
Sheet 6 of 7





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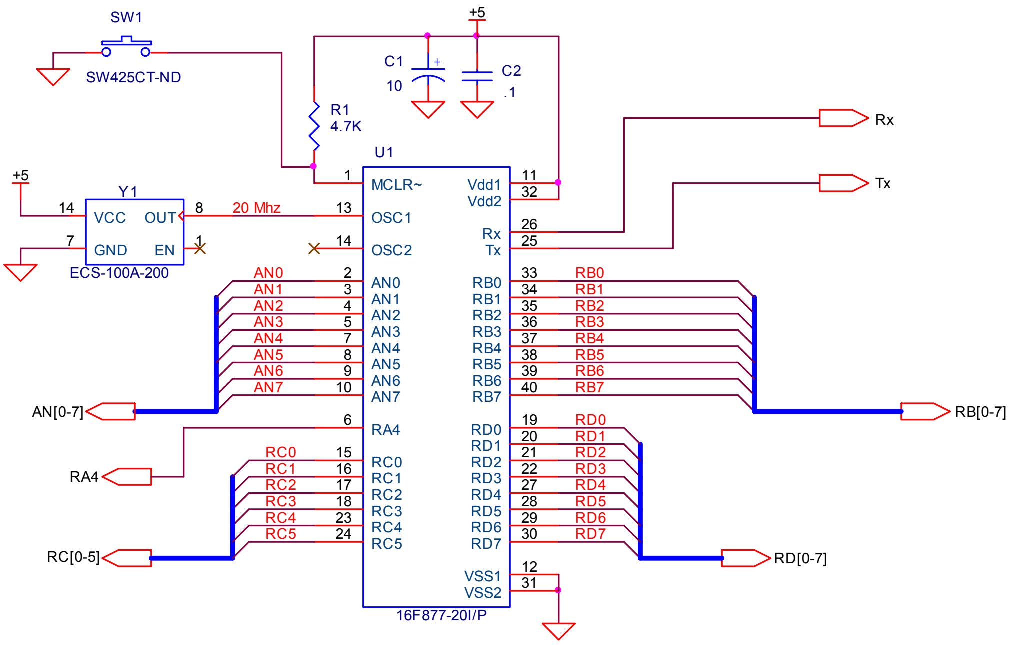
Size: A	Document Number: <Doc>	Rev: R2
Date: Friday, June 11, 2004	Sheet 7 of 7	

CONTROLLER UNIT PCB SCHEMATIC



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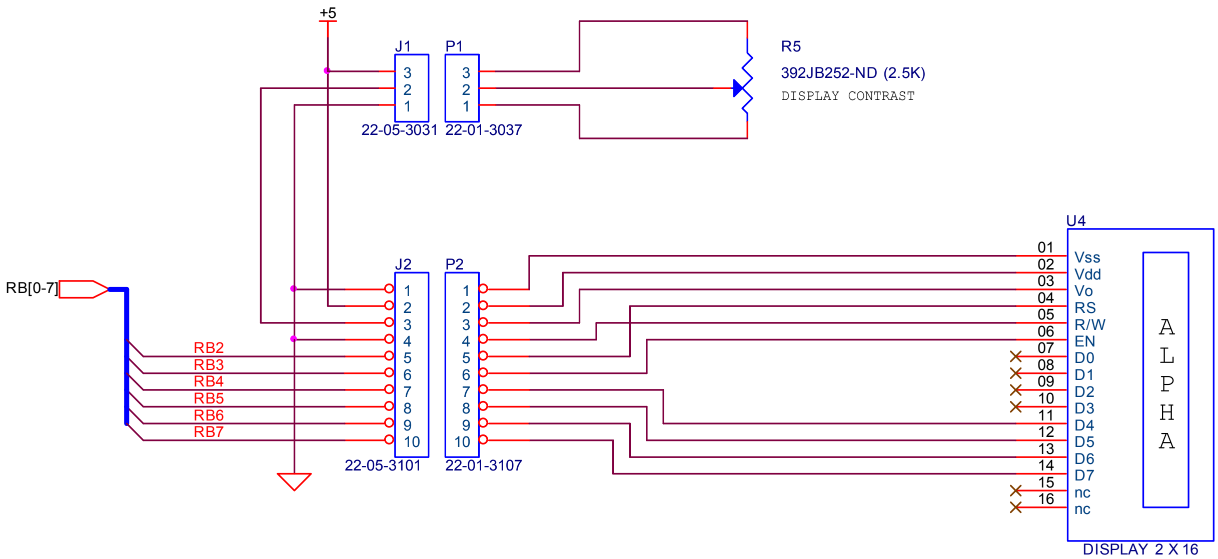

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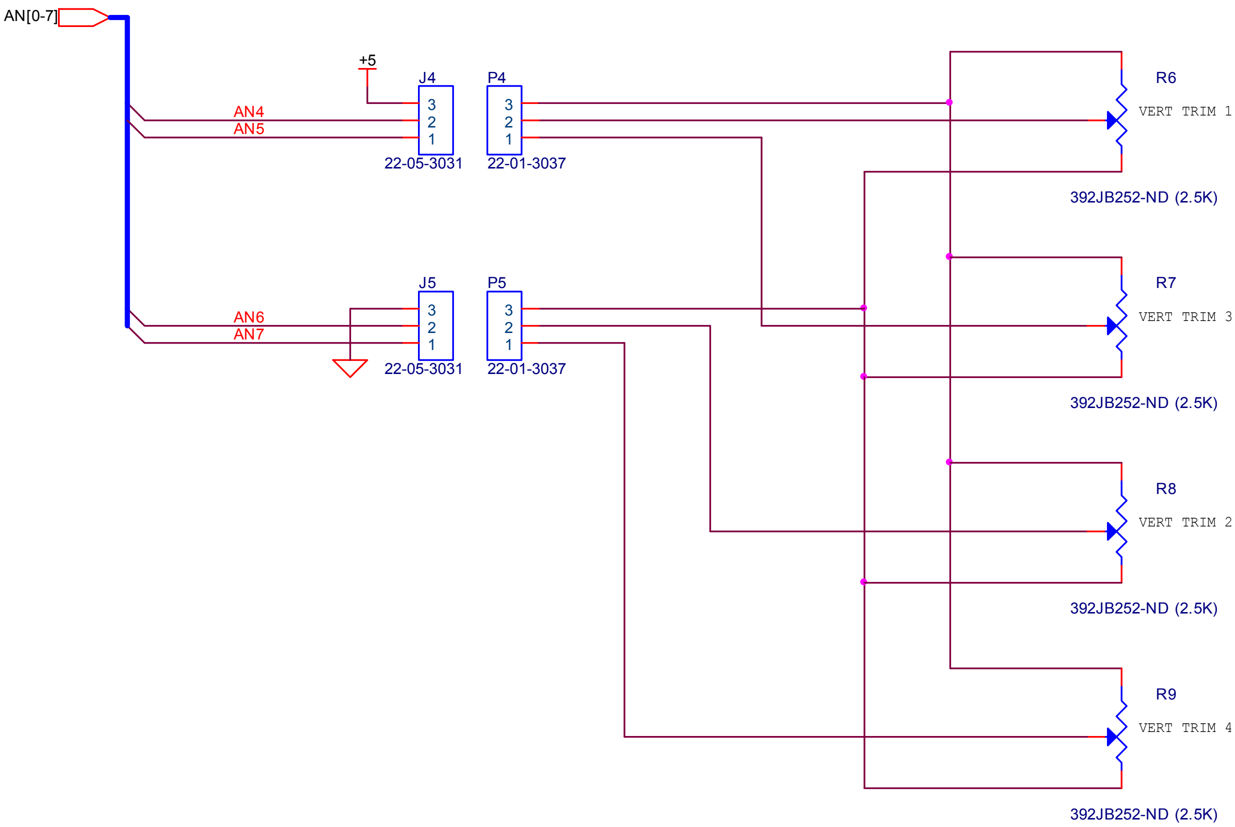
Size: A	Document Number: <Doc>	Rev: R2
Date: Friday, June 11, 2004	Sheet 2 of 7	



BCC TITIANS ROV

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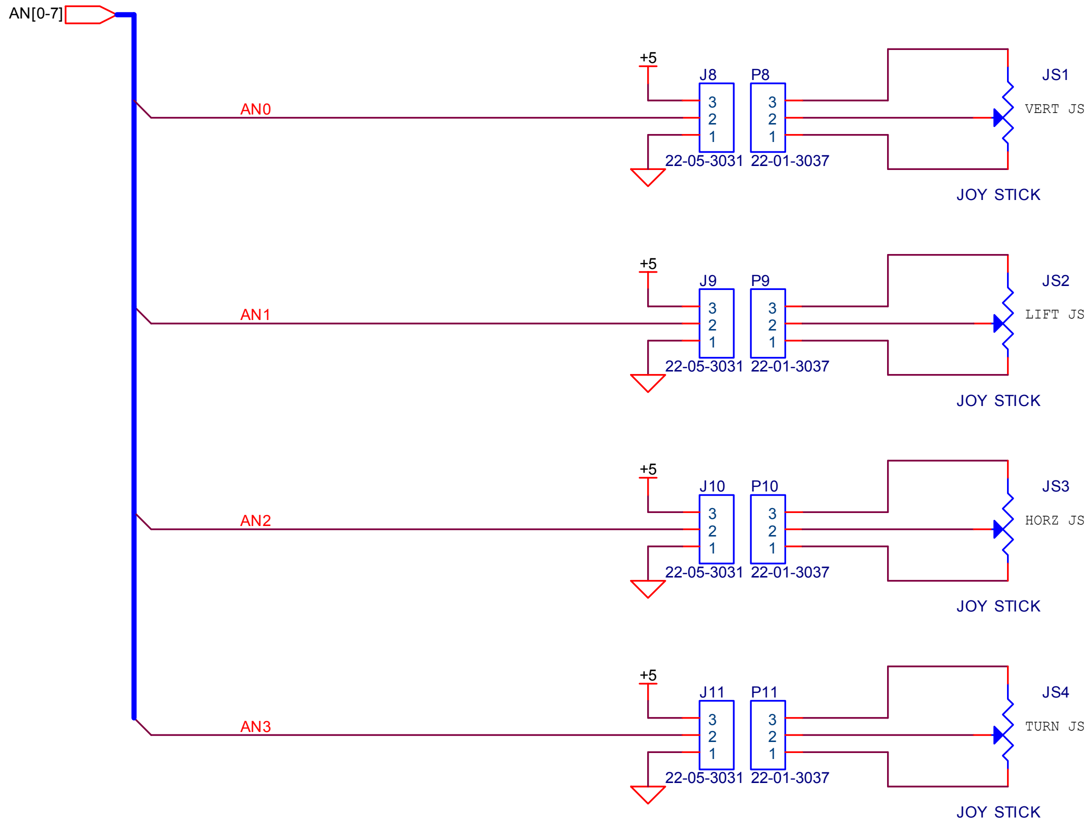
Size A	Document Number <Doc>		Rev R2
Date:	Friday, June 11, 2004	Sheet 3 of 7	



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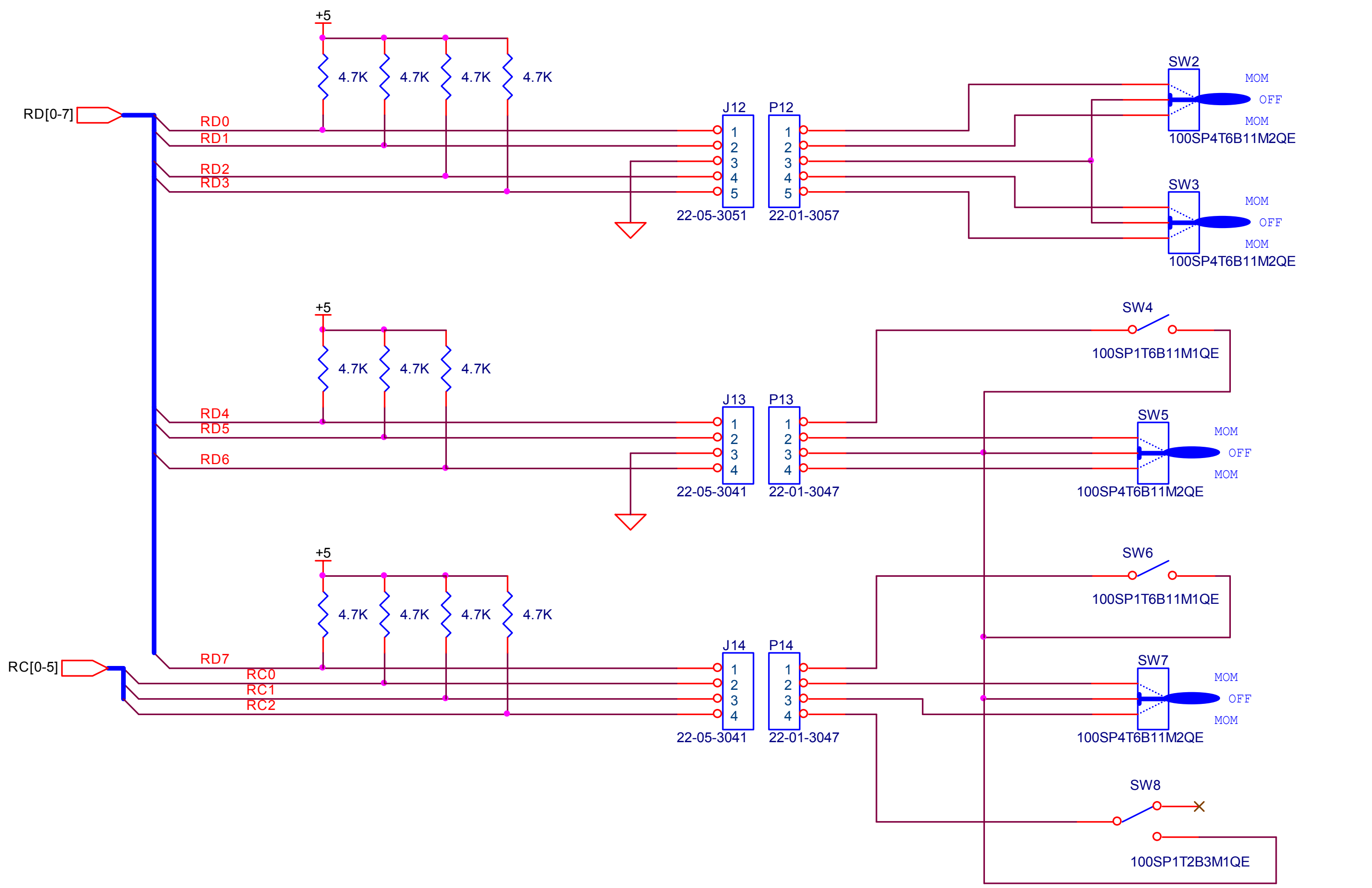
Size A	Document Number <Doc>	Rev R2
Date: Friday, June 11, 2004	Sheet 4 of 7	



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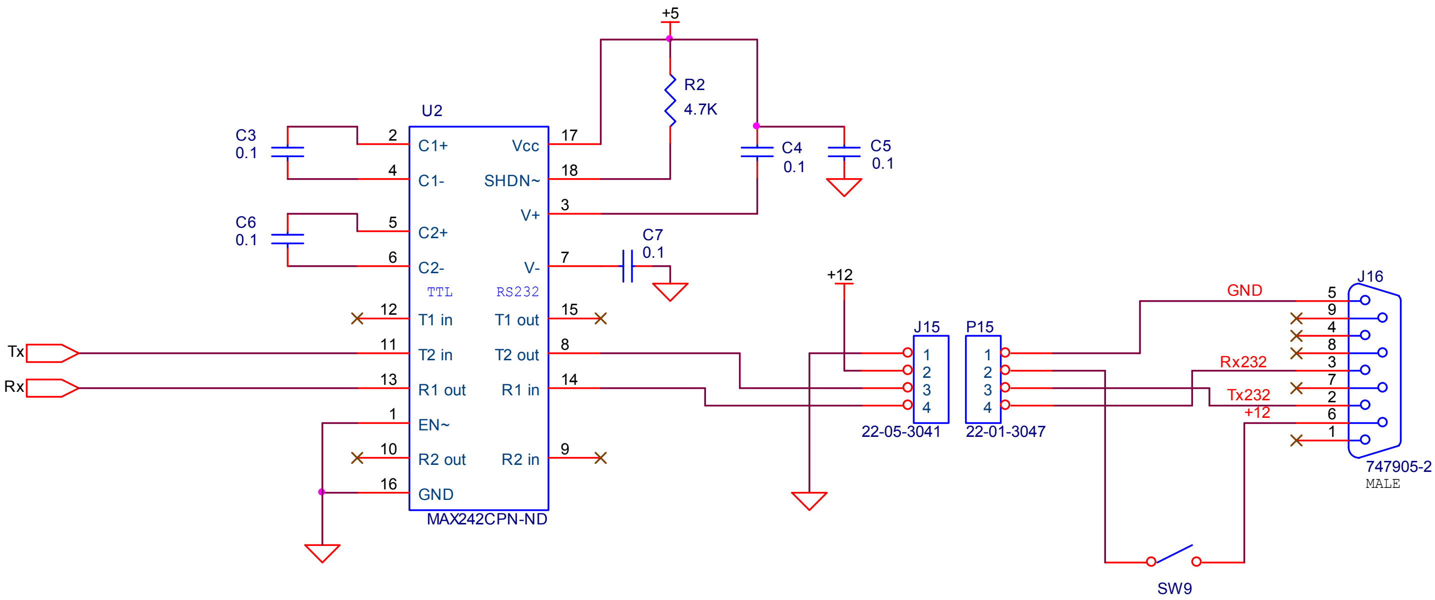

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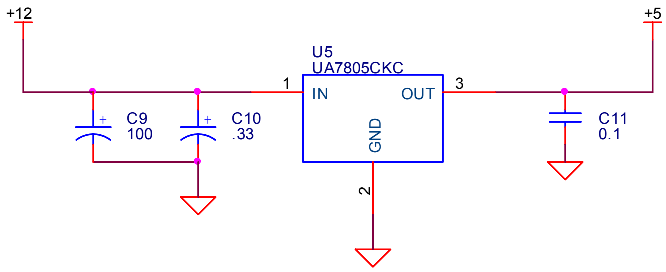

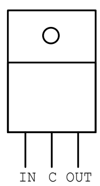

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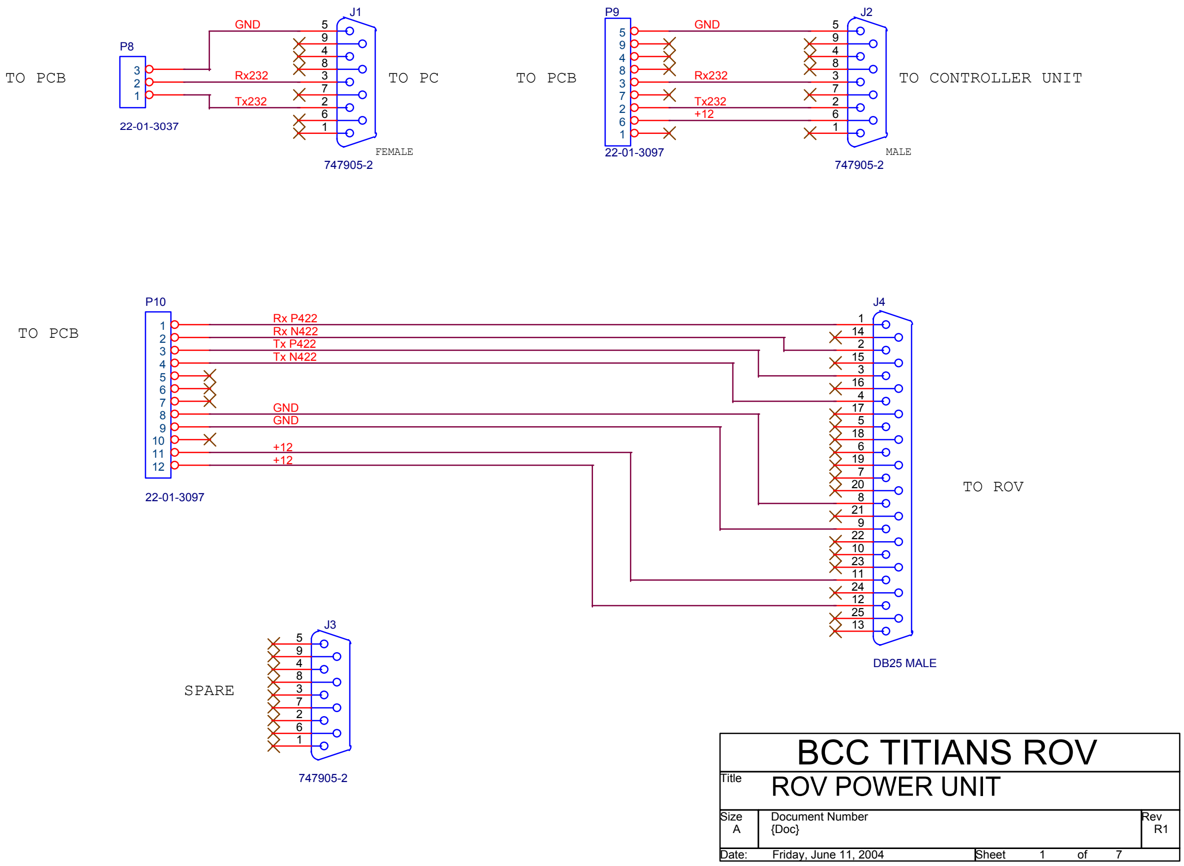
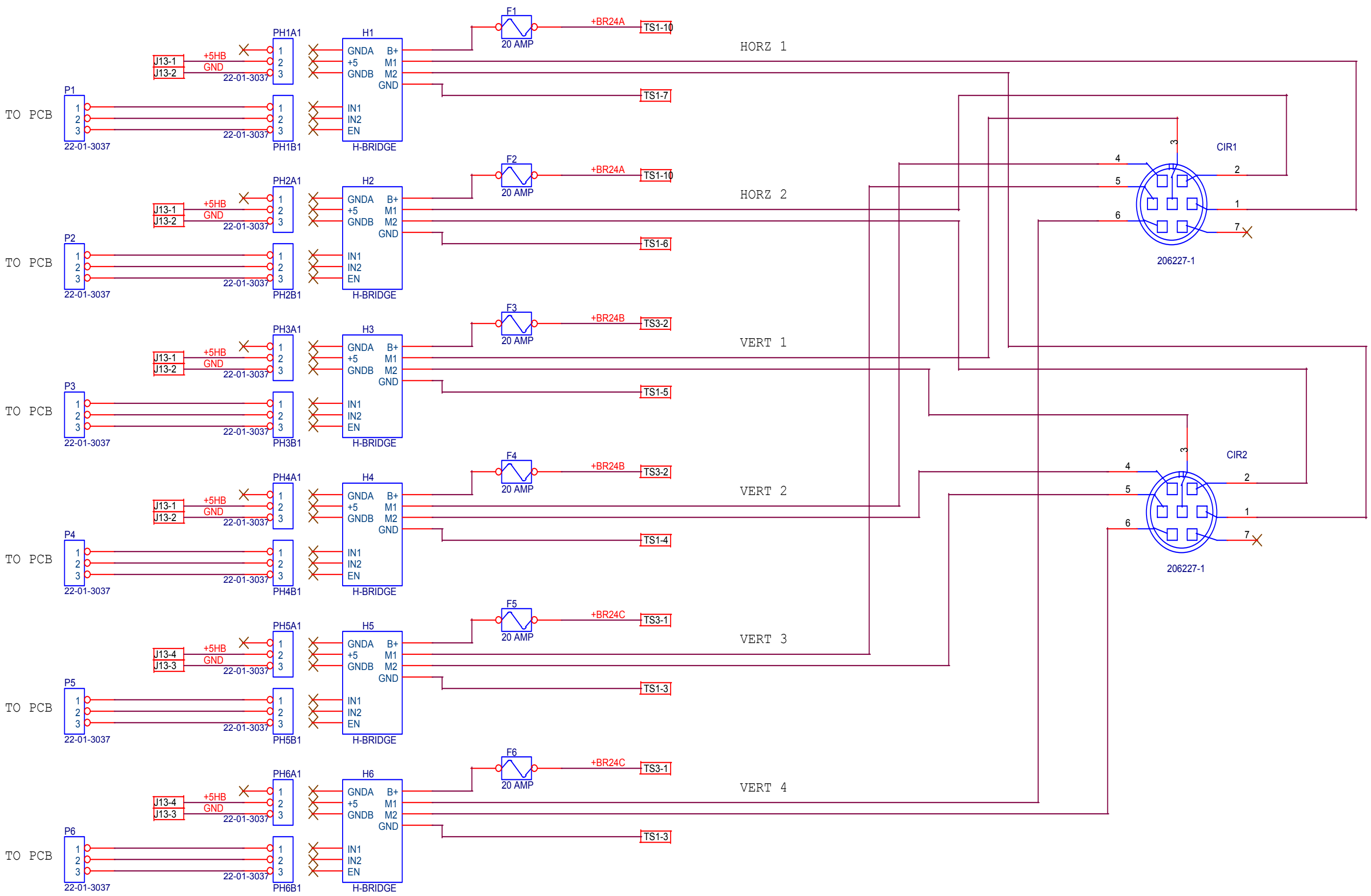
Size: A	Document Number: <Doc>	Rev: R2
Date: Friday, June 11, 2004	Sheet 7 of 7	

POWER UNIT CHASSIS SCHEMATIC





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Size B	Document Number {Doc}	Rev R1
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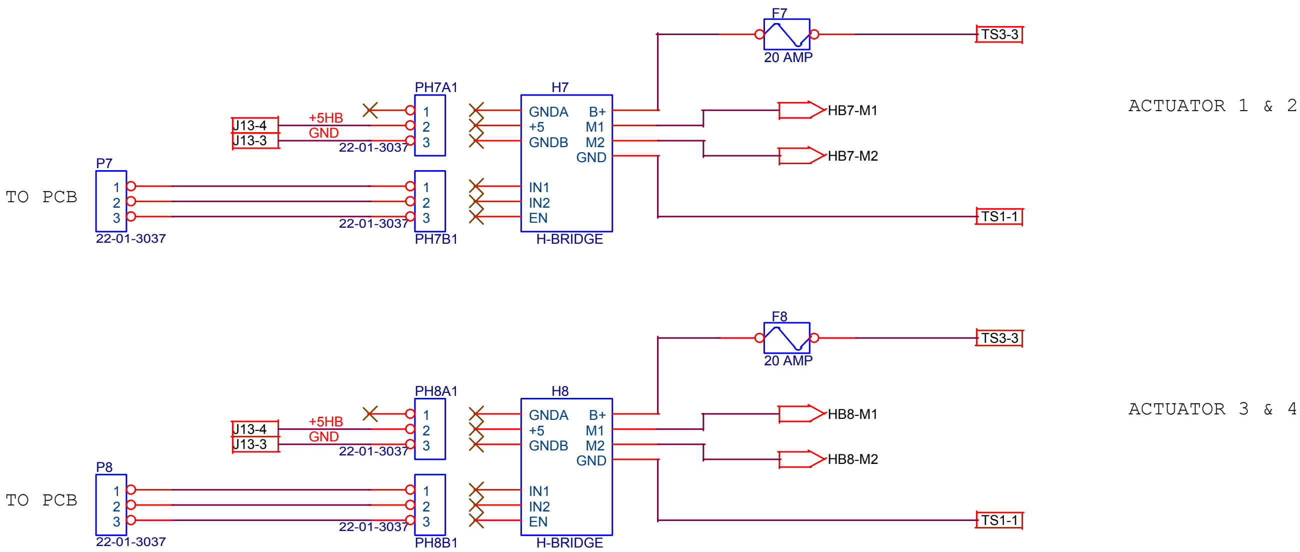

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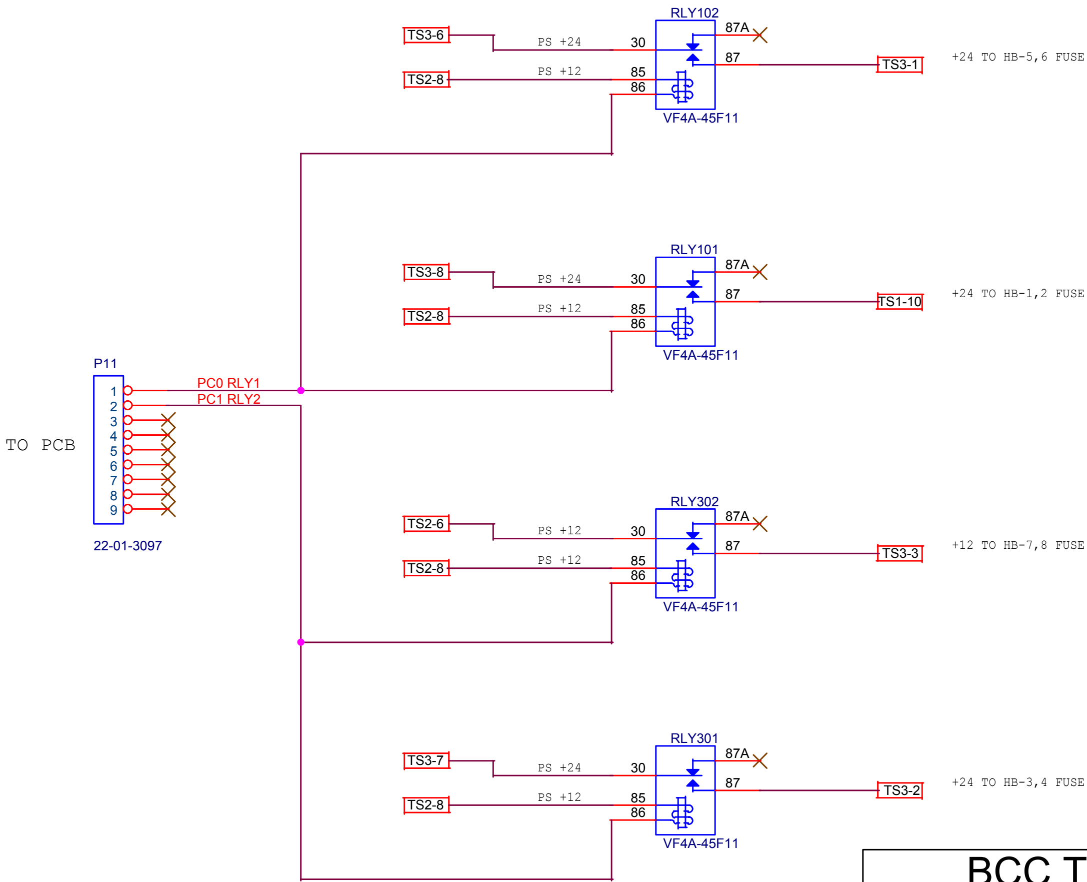
Size A	Document Number {Doc}	Rev R1
Date: Friday, June 11, 2004	Sheet 3 of 7	



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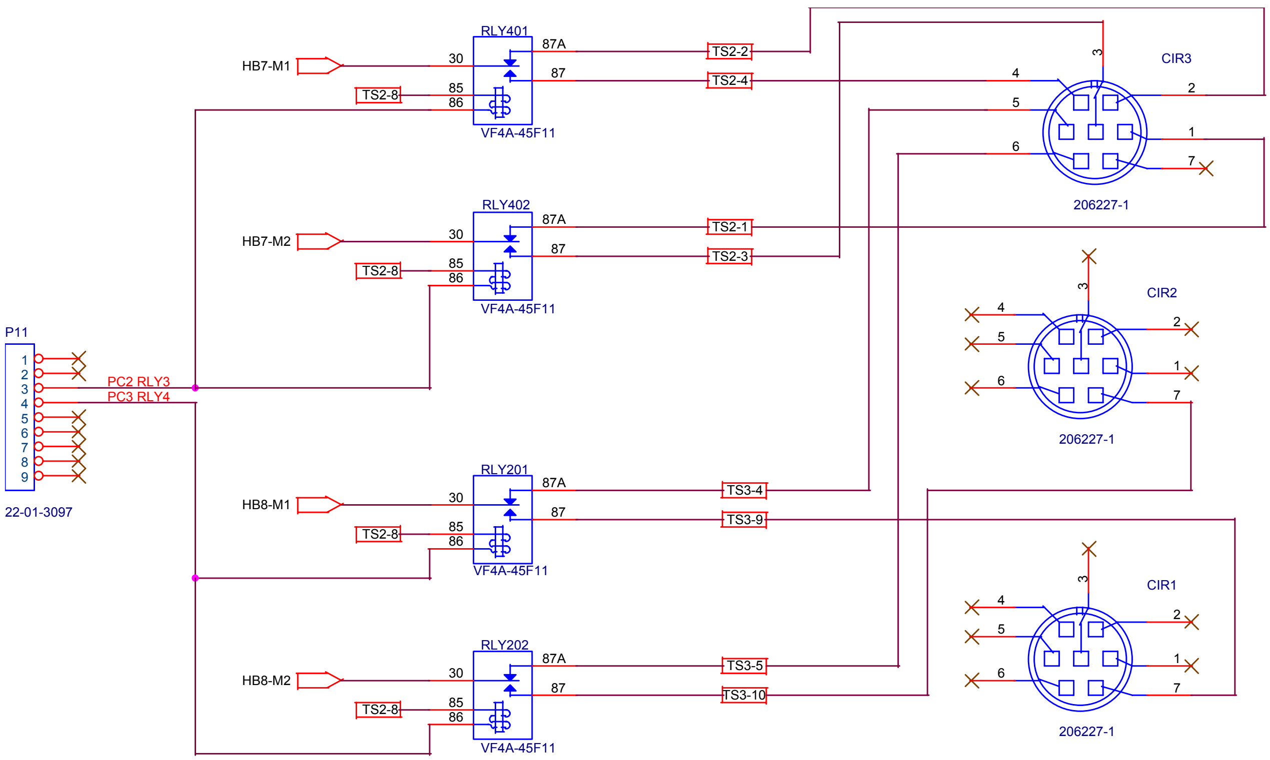
Size A	Document Number {Doc}	Rev R1
Date:	Friday, June 11, 2004	Sheet 4 of 7



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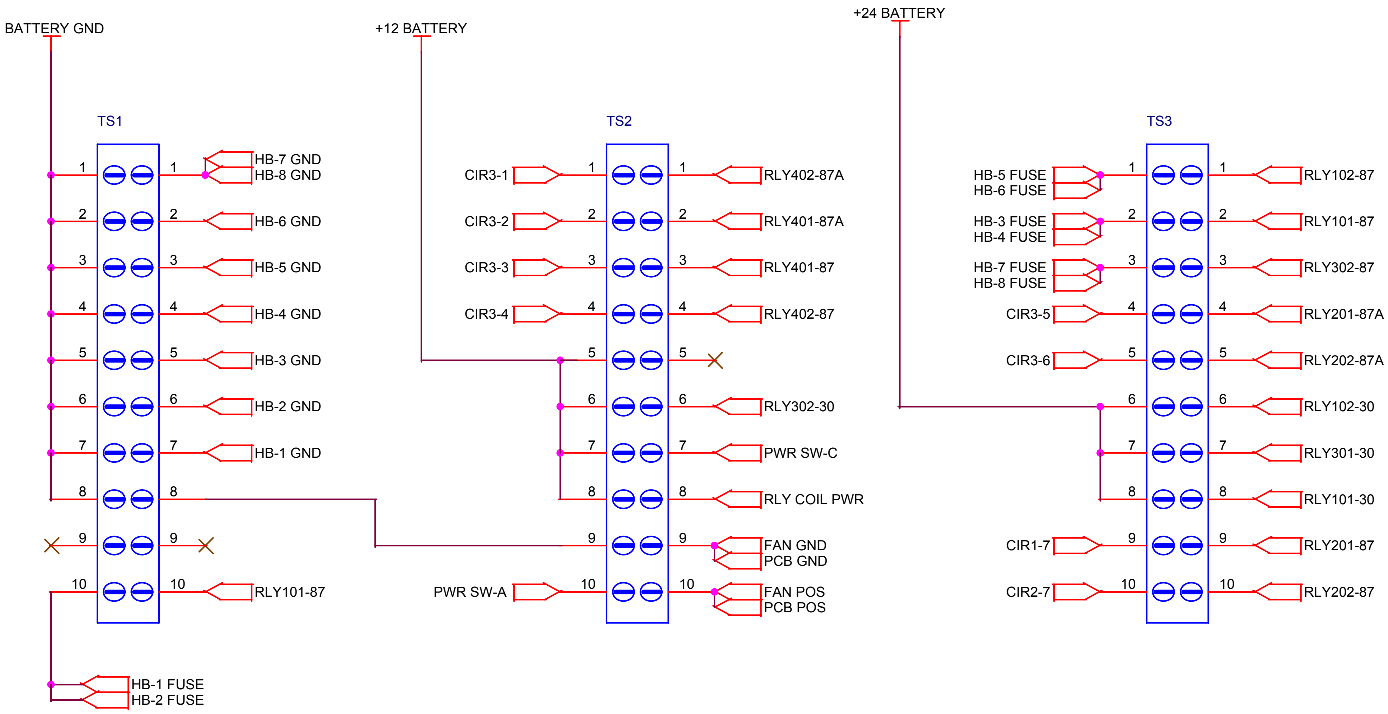

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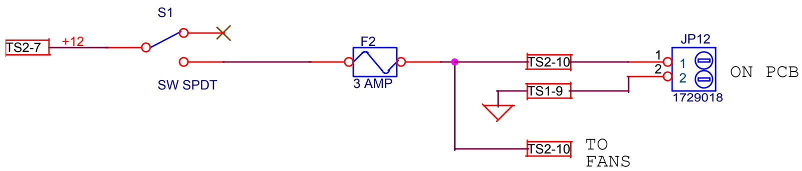

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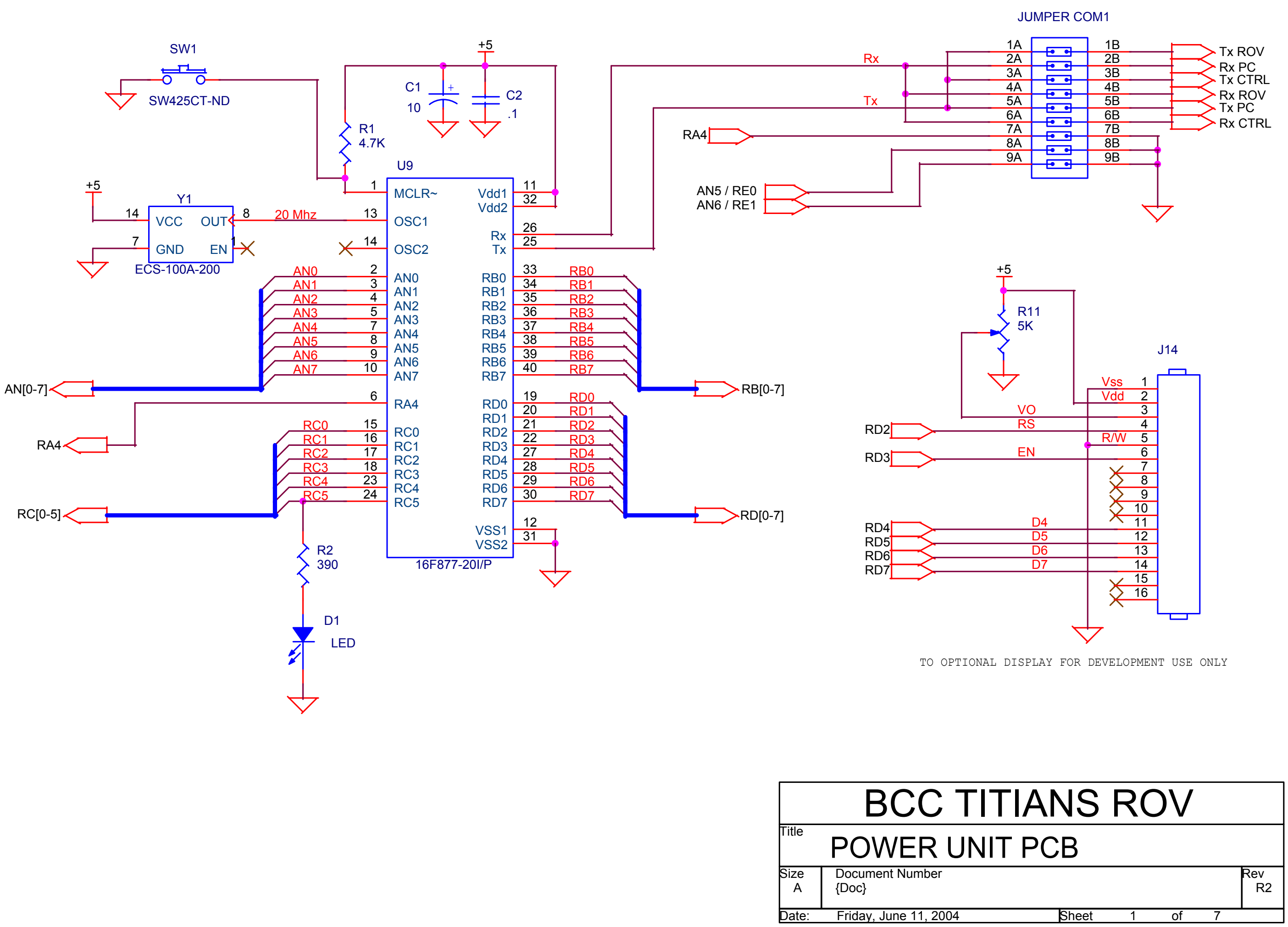
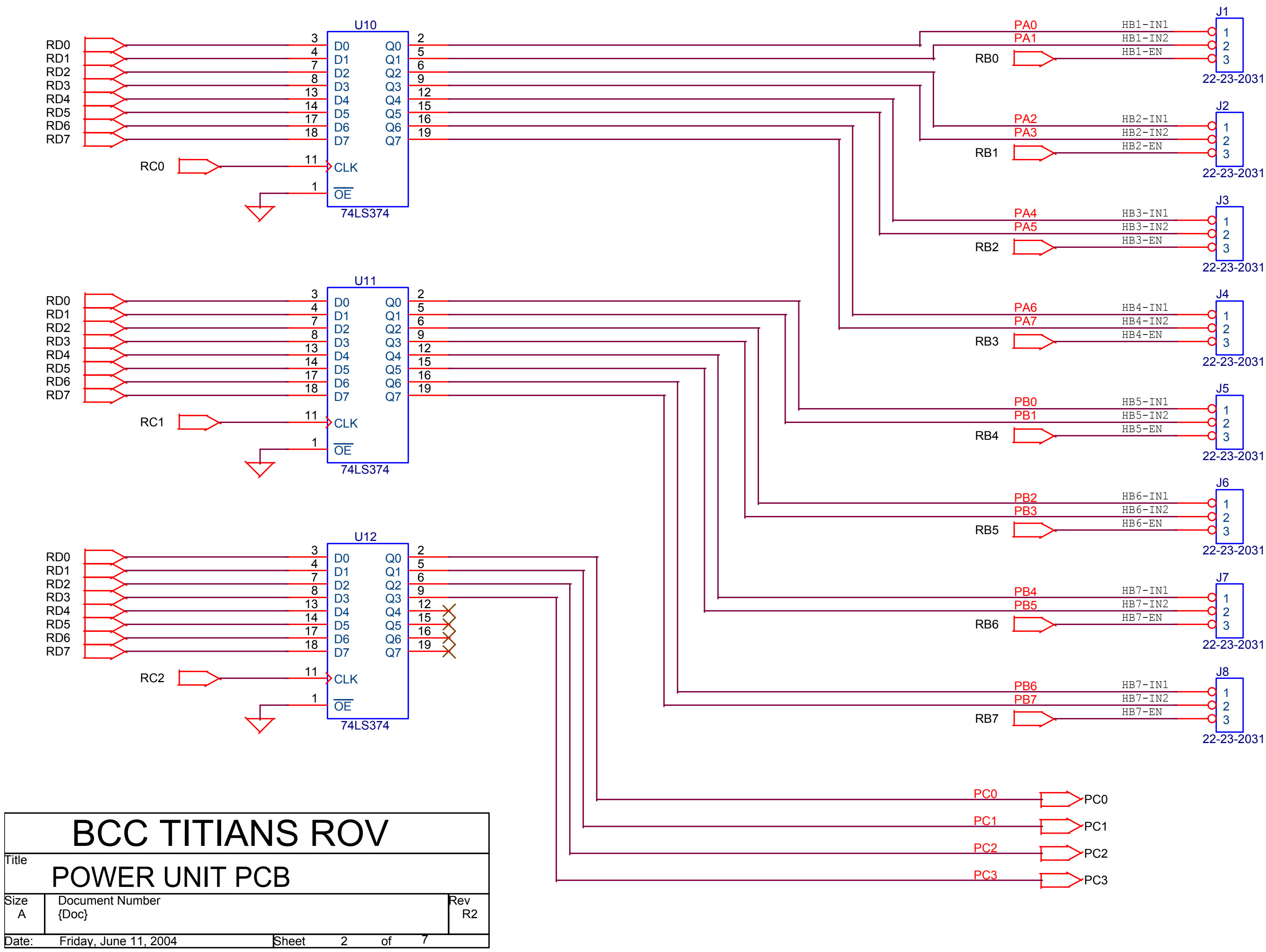
Size A	Document Number {Doc}					Rev R1
Date:	Friday, June 11, 2004	Sheet	7	of	7	

POWER UNIT PCB SCHEMATIC

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U11
U12
74LS374
RD0
RD1
RD2
RD3
RD4
RD5
RD6
RD7
RC0
RC1
RC2
D0 D1 D2 D3 D4 D5 D6 D7
Q0 Q1 Q2 Q3 Q4 Q5 Q6 Q7
CLK
OE
PA0 PA1 PA2 PA3 PA4 PA5 PA6 PA7
PB0 PB1 PB2 PB3 PB4 PB5 PB6 PB7
RB0 RB1 RB2 RB3 RB4 RB5 RB6 RB7
HB1-IN1 HB1-IN2 HB1-EN
HB2-IN1 HB2-IN2 HB2-EN
HB3-IN1 HB3-IN2 HB3-EN
HB4-IN1 HB4-IN2 HB4-EN
HB5-IN1 HB5-IN2 HB5-EN
HB6-IN1 HB6-IN2 HB6-EN
HB7-IN1 HB7-IN2 HB7-EN
J1 J2 J3 J4 J5 J6 J7 J8
22-23-2031
PC0 PC1 PC2 PC3
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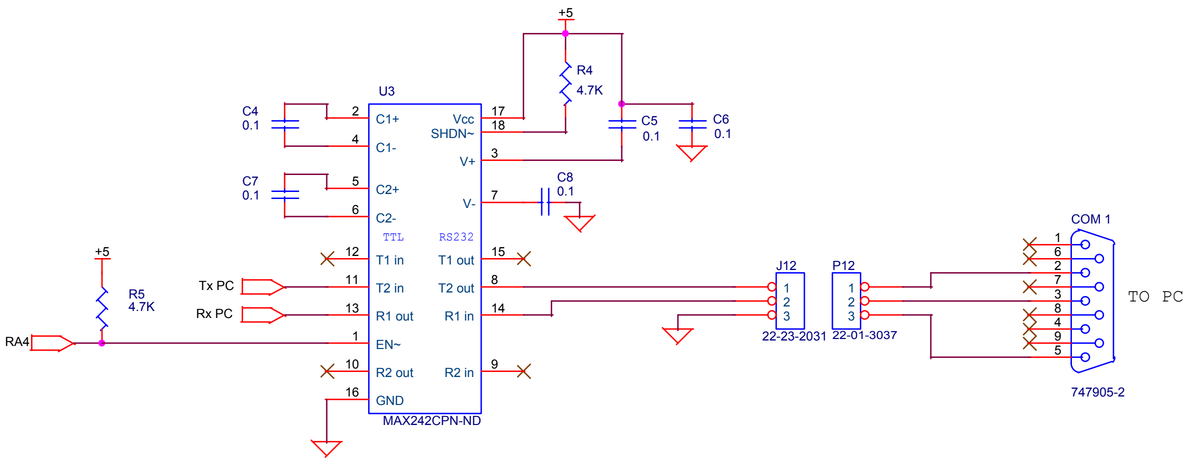
Title
POWER UNIT PCB
Size A
Document Number {Doc}
Rev R2
Date: Friday, June 11, 2004
Sheet 2 of 7



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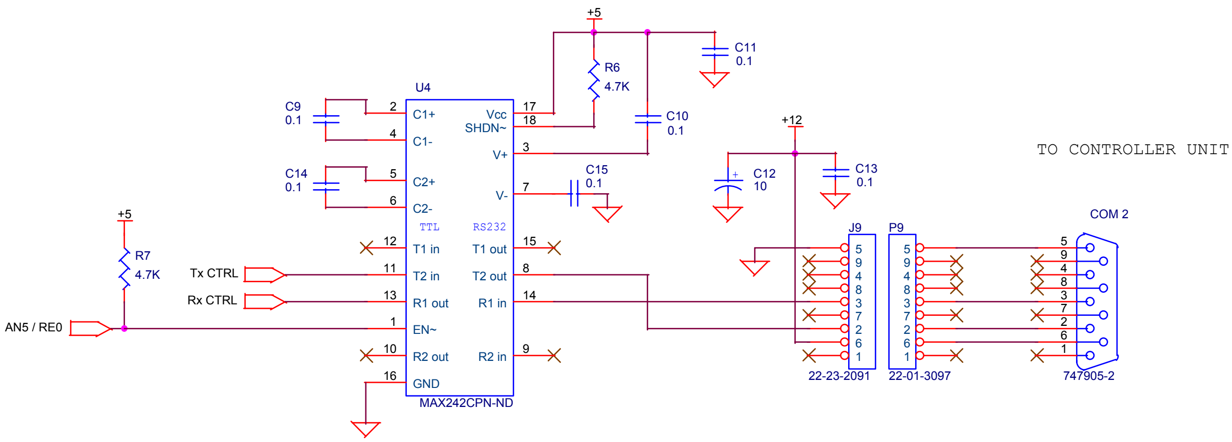
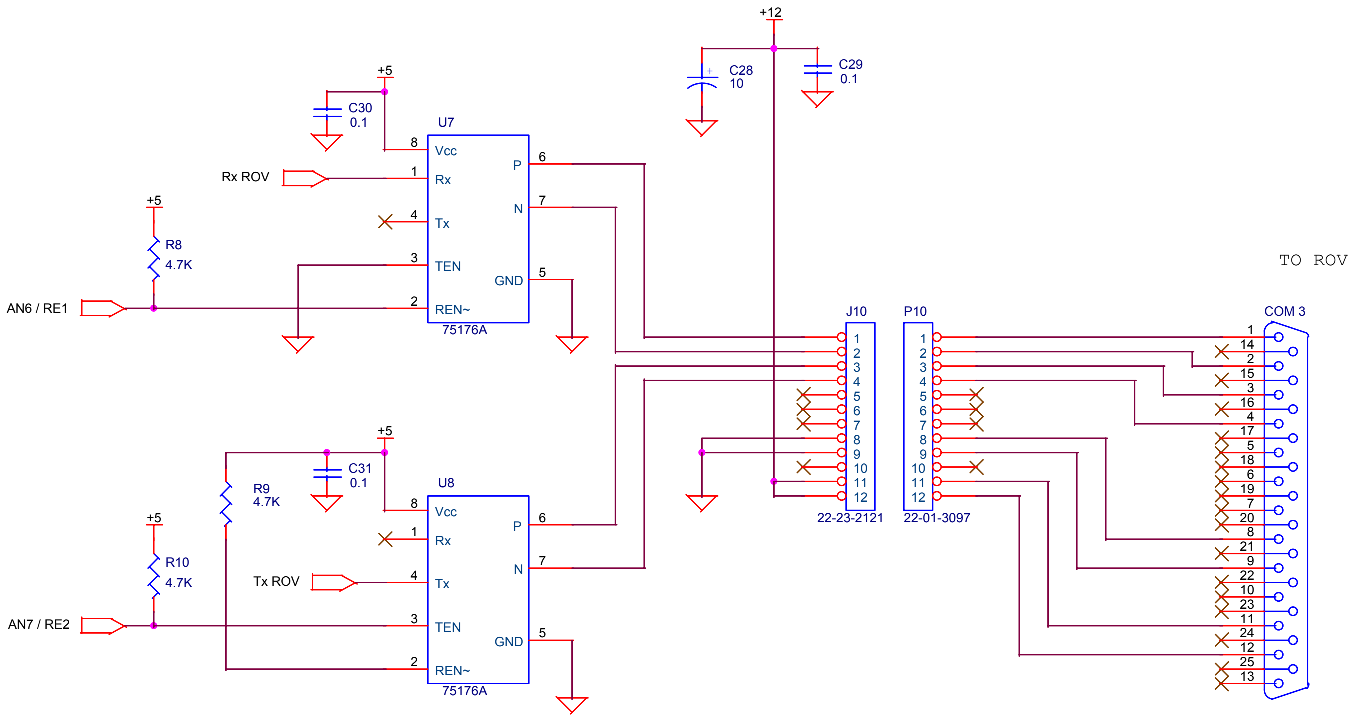


BCC TITIANS ROV

Title: POWER UNIT PCB

Size	Document Number	Rev
A	{Doc}	R2

Date: Friday, June 11, 2004 Sheet 4 of 7



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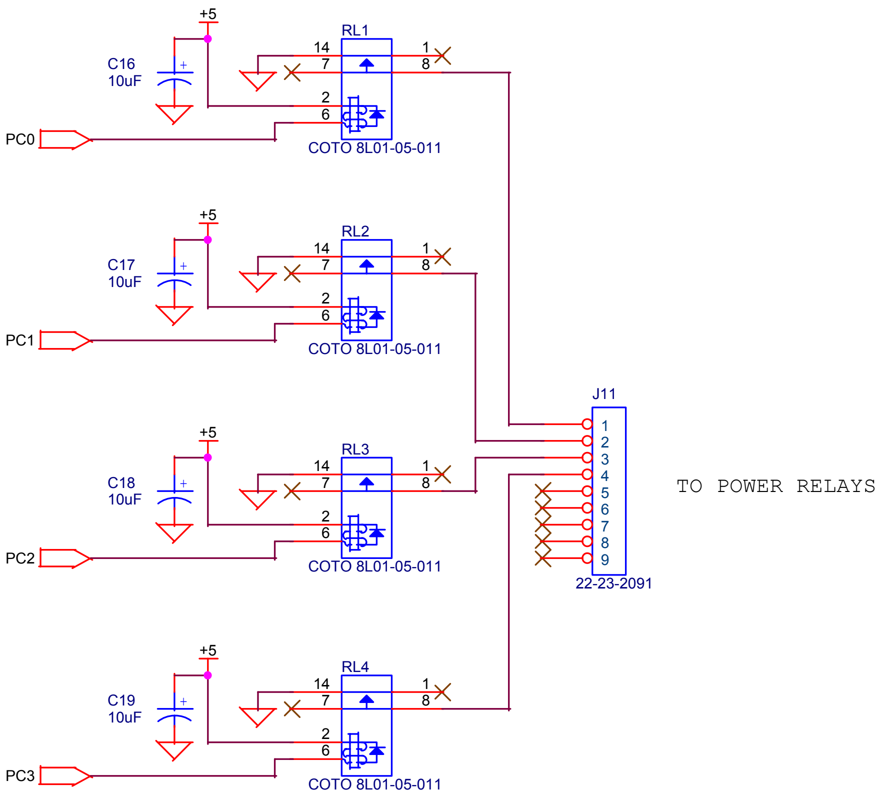

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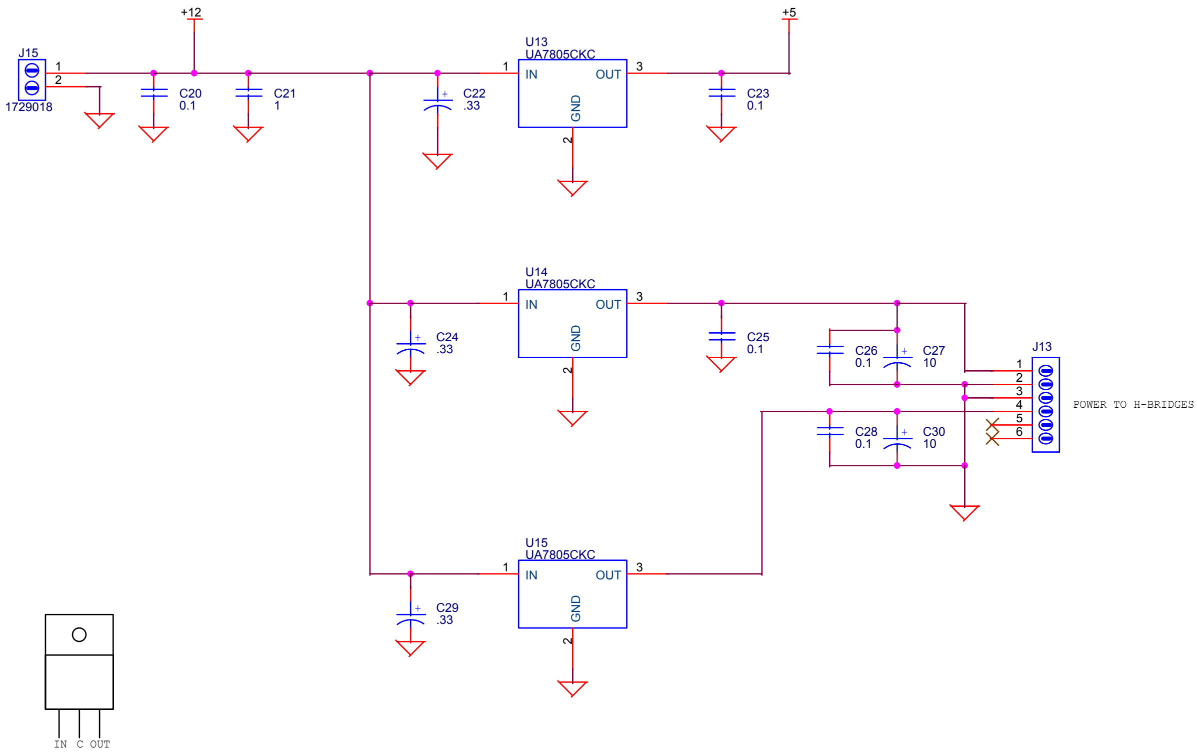

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