by Erick Royer

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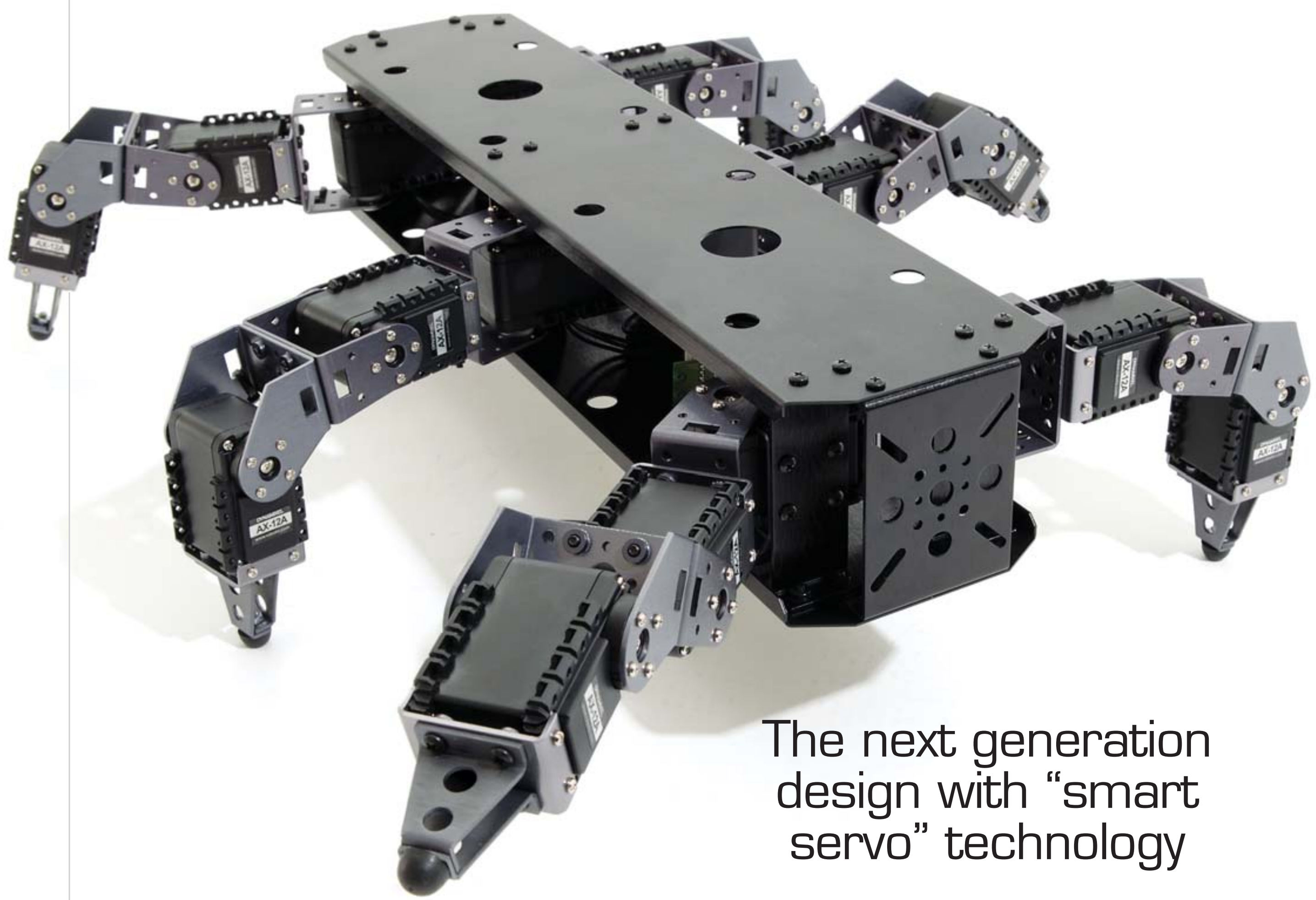
CrustCrawler AX12-18
Smart Hexapod



The next generation design with "smart servo" technology

There are two types of robots that really peak my interest; humanoids and hexapods. They have the ability for life-like movements with incredible precision and accuracy. While humanoid robots are designed to emulate the movements and reactions of human beings, the hexapods are modeled after insects. Insects have a much simpler nervous system than other animal species. Their complex behaviors are often attributed to only a few neurons traveling a very short pathway between the sensory input and motor output. The long-time study of an insect's walking behavior has been used to improve robot locomotion designs. I read a couple of studies online where scientists and biologists utilize hexapod robots to prove and test various hypotheses relating to insects. Many attribute the design of hexapods to spiders due to their life-like spider persona, but some of the early hexapod designs were actually been modeled after the cockroach.

FEATURES

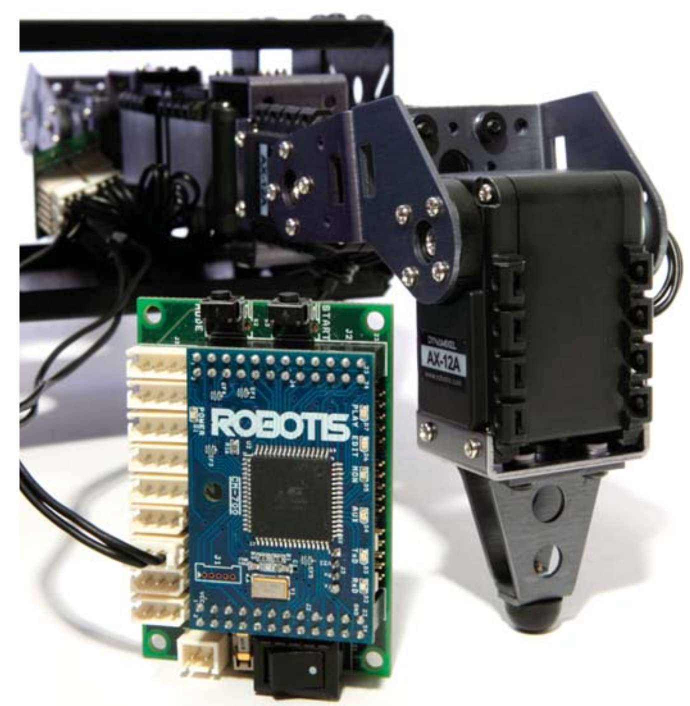
I've had the pleasure of working on a robot from Crustcrawler in a past issue; the AX12 Smart Arm, which was an extremely well built robotic arm that excelled in performance and accuracy. They recently released their new AX12-18 Smart Hexapod and I saw the video of it in operation on their website which left me totally amazed by what this robot can do. Check out the video at find.botmag.com/011251. The range of motion and functional abilities that the video demonstrated were amazing. Since the AX12-18 Smart Hexapod utilizes Robotis AX12 actuators, the controller and software possibilities for this robot are virtually endless.

Editor's Note: The video represents a large range of functionality and control for the AX12-18 Hexapod. It is a very good demonstration of all that can be done with this robot. The software and controller used for this demo is not provided or sold by Crustcrawler. This demo was provided by the Robotics and Neural Systems Laboratory at the University of Arizona.

What makes the AX12-18 Smart Hexapod unique from many other on the market is the use of "smart servo" technology that comes from the AX12A and/or AX18A actuators. These actuators overcome the poor torque/cost ratios and lack of feedback which is common in RC servo based hexapod robots. The extensive feedback nature of the AX series of actuators allows true kinematic walking routines to be easily implemented.

The AX12-18 Smart Hexapod features a power-optimized 3DOF (degrees of freedom) leg design with over 220 oz-in. of torque at each joint. The robot is completely constructed from high grade aluminum for maximum payload capacity and walking kinematic accuracy. The large upper and lower decks measure 16 in. by 3.5 in. with plenty of room to house the controlling electronics, power source and accessories. Each of the parts is beautifully finished with hard anodizing to offer maximum corrosion and scratch resistance. One of my favorite features that Crustcrawler uses on most of their robots is the integration of Pem nuts on all the brackets. This makes assembling the robot very easy with the only required tool being a Philips screwdriver.

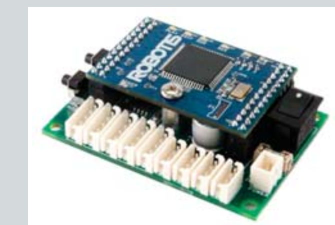
The servos operate over TTL RS-232 serial protocol and support communication speeds of up to 1MBPS, which makes them compatible with a variety of controllers on the market including the USB2Dynamixel adaptor, CM-5 programming bundle M-510 Controller, or the new CM-700 controller. Each actuator is assigned a unique ID allowing the controller to communicate directly with that actuator. The AX12's position, velocity, compliance, and torque can be set with a single command packet allowing the main processor to control many actuators with very few resources.



I am using the Robotis CM-700 controller to drive my AX12-18 Smart Hexapod. The controller is very robust and works well for standalone applications.

CM-700 CONTROLLER

The CM-700 is a new modular controller which is perfect for scratch builders and more advanced hobbyists who wish to work with a mix of Dynamixel actuators. The microcontroller, with dual bus handles both TTL (for the AX12 and AX18F actuators) and RS-485 (for the RX-64, EX-106, RX-28, MX-28, RX-10 and RX-24F servos) communication. It is designed to work with a daisy chain of similar servos or a mixture of AX-Series, RX-Series, or the EX-106+. The only limitation is that the input voltage must overlap the range of each servo used. It has an acceptable input voltage range from 7 to 27 volts.



In order to make use of the module you need a CM-700 SUB Board. The sub board manages the power with a battery/power jack and power switch. It features ports for 3- and 4-pin Dynamixel serial communication. There is a communication jack that is used in conjunction with a LN-101 USB interface to connect the CM-700 to a PC. This port can also be used with a wireless communication module such as the ZIG-110 and IR receiver. Lastly, there is a 5-pin peripheral device connection port that can be used to connect devices such as DMS, touch sensors, IR sensors and the like. Since the CM-700 will allow you to store programs on the board, there is a start and mode button used to activate motion programs.

The included RoboPlus Software suite allows you to assign an ID number to each actuator so you can assign various poses for each actuator. This software is not really suited for creating an independent controller to drive the hexapod. It is good for setup and testing but you will need to look into a more robust software package that will incorporate the use of a wireless controller, sensors, or whatever else your custom application might need.

The AX12 actuator is capable of precise control response with position and speed resolution programmed in 1024 steps. Feedback can be sent to the controller for angular position, angular velocity and load torque. It also features a status display LED which can be programmed to indicate errors, including high temperature, overload, over voltage, and low voltage conditions. These actuators are very modular in nature and there are numerous brackets on the market designed specifically for them, thus giving maximum flexibility to create custom robot projects.

ASSEMBLY

Once you have the opportunity to work with a Crustcrawler robot, you will understand my enthusiasm. First off, the fit and finish of the components that make up their robots is second to none. They use high-grade aluminum with a hard anodizing for all the parts and every component fits perfectly without any manipulation. Each kit is hand packed at the factory, so you can be sure that every last screw has been accounted for. However, it is still always a good idea to do an inventory of the parts before you begin. Starting on page three of the manual, there is a list with pictures of all the major components. One thing you will need that is not contained in the kit is some blue Loctite which you can get at any local hardware store or hobby shop.

There are a lot of small screws used in this kit. The screws for the frame are packaged in a zip lock pack from the factory. The smaller screws and nuts for the actuator connections come in the boxes with the actuators. I like to use either a magnetic tray or half of an egg container to keep my screws in while I am working so they are easy to grab and will not end up all over my work area.

Assembly begins by placing the nuts into the AX12 actuators. This is very easy to do, especially if you summon the aid of a pair of needle nose pliers. The nuts are too small to position with my large hands. All you need to do is simply align the nut with the slot in the actuator and gently press it in place. Just be careful not to apply too much pressure or you risk snapping off the plastic tab. There is an alignment indicator on the front of the round servo horn with a corresponding indicator on the case of the actuator. Be sure that the two marks are properly aligned before you begin the assembly.

The next step is to assemble each of the six legs. The manual does an excellent job of illustrating the proper configuration for each component. Each step is broken down into an assembly. Be sure to use Loctite on each of the screws as all the connections are metal screws to metal nuts which run the risk of coming loose during operation.

When it comes time to start mounting the brackets to the AX12 actuators, be sure to pay close attention to the layout and configuration of each component in the manual. You are building a left and right leg assembly at the same time so the locations of the screws and brackets will be opposite.

There is a plastic spacer and washer used on each bracket to connect the servo. These parts are located in the parts bag that comes inside the AX12 actuator box. There is a single larger screw among all the tiny screws and nuts in these bags. Be sure to remove them as they are used to connect this spacer to the servo horn.

GAITS–TYPES OF MOTION

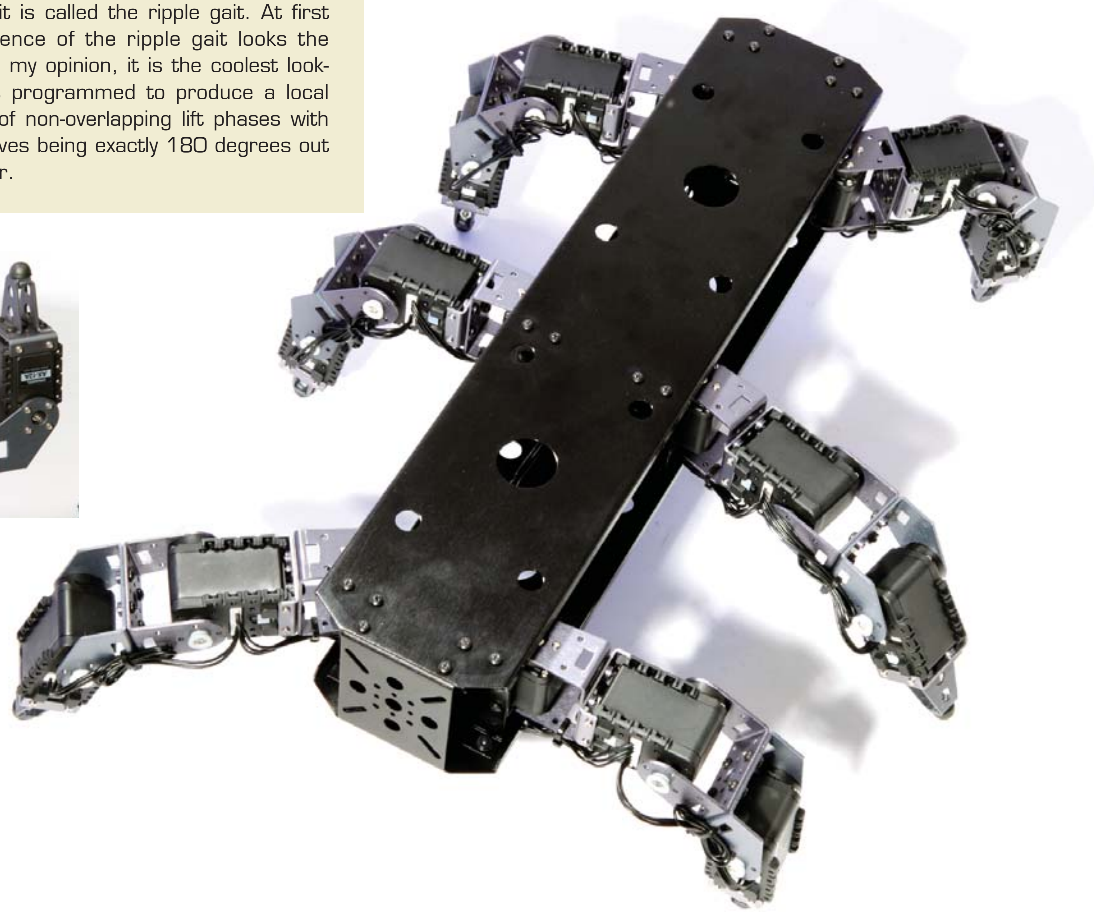
The method of a robot walking forward with legs is called a gait. There are several common types of gaits that hexapods use to allow the robot to move forward, turn, raise and lower, and even side-step.

The most common gait for hexapods is the tripod gait. It consists of linking the front and back legs on one side with the center leg on the opposite side, thus forming a tripod. For each tripod the legs are lifted, lowered and moved forwards or backwards in unison to create a walking motion. Since three legs are on the ground at all times, this gait is both statically and dynamically stable.

The wave gait is programmed so all the legs on one side move forward in unison starting with the rear-most leg and then the motion is repeated on the opposite side. The action is very similar to that of a centipede. Since only one of the legs is off the ground at a time with the other five remaining down, this gait produces the most stability for the hexapod. The downside of the wave gait is lack of speed. Since only one leg is moving at a time it is the slowest of all gaits.

The final common gait is called the ripple gait. At first glance, the timing sequence of the ripple gait looks the most complicated but, in my opinion, it is the coolest looking motion. Each side is programmed to produce a local wave that is comprised of non-overlapping lift phases with the two opposite side waves being exactly 180 degrees out of phase with one another.

Each leg has a rubber-tipped foot that supports the robot. The rubber is a great material because it dampens the impact with the surface and provides a solid grip.



There is a very important illustration on page 15 of the manual (figure 20) that shows the completed leg sets. The two rearmost leg sets (two and three) have the inner actuator mounting bracket on the bottom of the actuator whereas leg set one has this bracket on the top of the actuator. Be sure that you layout the completed leg assemblies in front of you as shown in this illustration to verify they are correct.

I attached the vertical brackets to the lower mounting deck first and then attached each leg assembly to the brackets. At this point I chose to wire up the servos before mounting the bottom deck.

WIRING THE AX12-18 SMART HEXAPOD.

Each AX12 actuator has two identical male connectors on the back of them. It is very important to note that the input port is located on the left and the output port is on the right. So beginning with the innermost actuator (the one that connects to the bracket on the deck), I connected a wire from the output port to the input port on the middle leg actuator, and then placed another from the output of the actuator to the input of the foot actuator. I repeated this step with each leg.

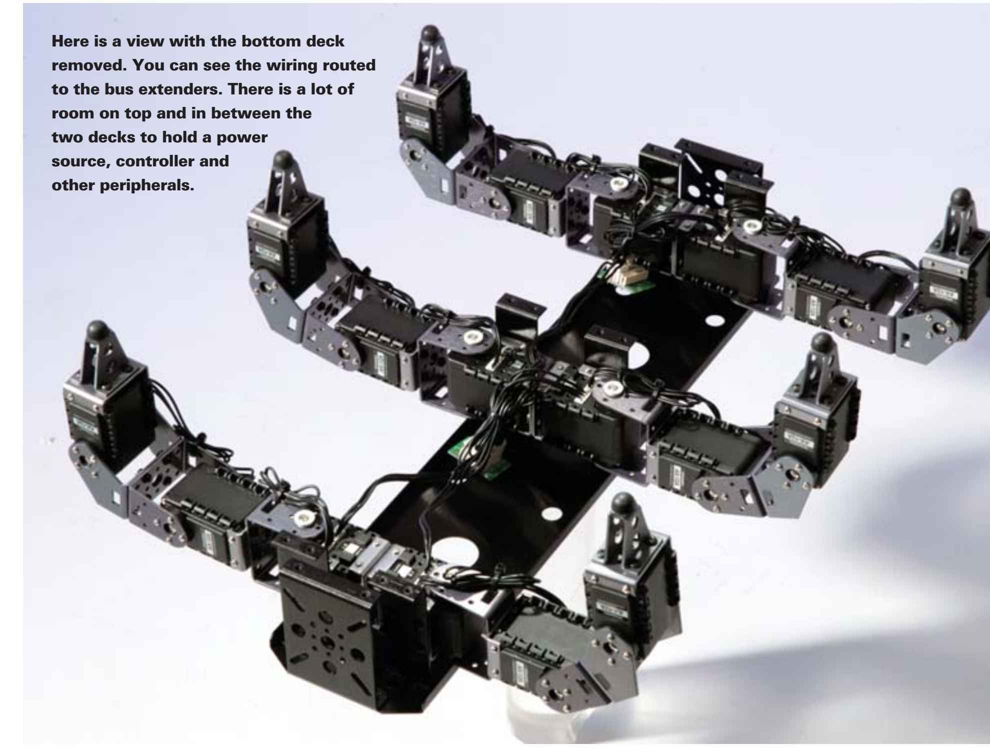
Editor's Note: Crustcrawler included a set of wires in the kit; however you will also need to use the wires that are included with each AX12 actuator. Be sure not to discard them with the boxes.

At this point a wire needs to be connected to the input on each leg. The kit comes with a pair of bus extenders, each containing six male connectors. I ran a wire from the input on the actuator for each leg to one of the connectors on this bus extender. I used one extender for the back four legs and one for the front two legs. Then I ran a single wire to connect the two extenders together. At this point, all that is needed was to connect the output of your controller to any empty jack on either bus extender.

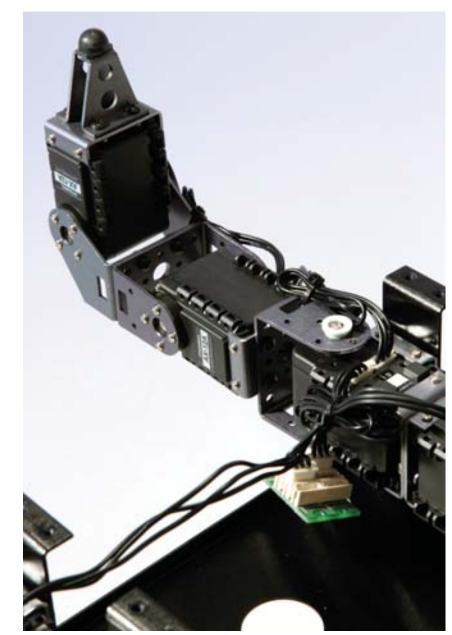
Once all the wires are connected, I used the included zip ties to neaten up the wiring fastening them to the legs so they will remain out of harm's way during operation. With the wiring complete, the last step is to install the bottom deck.

PROGRAMMING OPTIONS

Once the AX12+ Smart Hexapod is assembled, you will need to choose a programming method and controller to bring it to life. There are a lot of options, including the Robotis CM-5, USB2Dynamixel, Parallax Propeller board, any computer with a serial port, any controller that can communicate at 1mbps with a serial protocol, and just about any programming language—Software solutions can include Matlab, Simulink, C++ , SDK and other free sample code is also available from the Robotis support site at support.robotis.com. I am using the new Robotis CM-700 control module and RoboPlus Software to test the Hexapod.



Here is a view with the bottom deck removed. You can see the wiring routed to the bus extenders. There is a lot of room on top and in between the two decks to hold a power source, controller and other peripherals.



CONCLUSION

I really enjoyed assembling and testing the AX12-18 Smart Hexapod. You simply cannot ask for an easier kit to build. Everything fit perfectly and the instructions take any guesswork right out of the equation. I completed the hexapod in about two hours and spent another hour setting up the ID numbers for the servos and testing them with the RoboPlus software. In a future issue of ROBOT Magazine we will be covering various software applications that can help bring this hexapod to life.

If you are considering a hexapod robot, then you really need to consider the AX12-18 as there is very little on the market that can compete with the value and performance of this unit. Since they designed such a large upper and lower deck, you have the ability to mount just about anything you might need for an educational research application, or for a simulated industrial, military, or other hobby application. Visit find.botmag.com/011251 for more information and to watch the video. ◎

Links

CrustCrawler, www.crustcrawler.com, (480) 577-5557

Robotis, www.robotis.com

For more information, please see our source guide on page 89.