working voltage V_{input}, connect the motor (without loads on its shaft) to the appropriate battery — the same that will be used in combat — and measure I_{no_load}. Note that the value of I_{no_load} does not depend much on V_{input}. However, it is always a good idea to measure it at the working voltage. If you have an optical tachometer (which uses strobe lights, such as the one in **Figure 1**), you can also measure the maximum no-load motor speed ω_{no_load}. A cheaper option is to attach a small spool to the motor shaft, and to count how long it takes for it to roll up. For instance, take 0 meters or 30 feet of nylon thread. The angular speed in rad/s will be the length of the thread divided by the radius of the spool; all this is divided by the measured time (the thread needs to be thin, so that when it's rolled up around the spool the effective radius doesn't vary significantly).

- Attach the motor shaft to a vise grip, hold both the motor and the vise grip well, and connect the battery. Be careful because the torque can be large. The measured current will be I_{stall}, associated with the circuit resistance $R_{system} = R_{battery} + R_{motor}$, so $I_{stall} = V_{input} / R_{system}$; then, calculate $R_{battery} = (V_{input}/I_{stall}) - R_{motor}$. Do not leave the motor stalled for a long time; it will overheat and possibly get damaged. Also, take care not to dent the motor body while holding it (for instance, with a C-clamp) as shown in **Figure 2**.

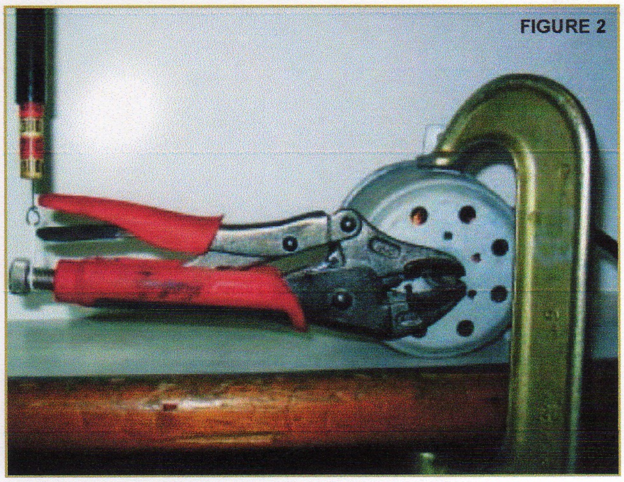
FIGURE 2

- Repeat the procedure above, but supporting one end of the vise grip by a scale or spring dynamometer (with the vise grip in the horizontal position; see **Figure 2**). Then, measure the difference between the weights with the motor stalled and with it turned off, and multiply this value by the lever arm of the vise grip to obtain the maximum torque of the motor, τ_{stall}. For instance, if the scale reads 0.1 kg with the motor turned off (because of the vise grip weight) and 0.8 kg when it is stalled, and the lever arm (distance between the axis of the motor shaft and the point in the vise grip attached to the scale) is 150 mm, then $\tau_{stall} = (0.8kg - 0.1kg) \times 9.81m/s^2 \times 0.150m = 1.03N \times m$.
- Because $\tau_{stall} = K_t \times (I_{stall} - I_{no\_load})$, you can obtain the motor torque constant by calculating $K_t = \tau_{stall} / (I_{stall} - I_{no\_load})$.
- Alternatively, if you were able to measure ω_{no_load} with a tachometer or spool, then you can calculate the motor speed constant using $K_v = \omega_{no\_load} / (V_{input} - R_{system} \times I_{no\_load})$. Check if the product $K_t \times K_v$ is indeed equal to 1, representing K_t in N×m/A and K_v in (rad/s)/V. This is a redundancy check that reduces the measurement errors. If you weren't able to measure ω_{no_load}, there is no problem. Simply calculate $K_v = 1 / K_t$, taking care with the physical units.
- Finally, once you have the values of V_{input}, K_t (and/or K_v), R_{system}, and I_{no_load}, you can obtain all other parameters associated with your motor + battery system using the previously presented equations (don't forget to later add the resistance of the electronics, as well). SV

Affordable 2.4 GHz

● by Pete Smith

The principal radio frequency for many years in USA combat robotics was 75 MHz PCM. This worked well enough, but the transmitters (TX) and receivers (RX) for PCM were both expensive, and the receivers were both bulky and not particularly reliable under combat conditions. The main problem, however, was the limited number of channels available and controlling the use of those channels in a major event.

The arrival of the Spektrum DX6 changed all that. It uses 2.4 GHz and each radio "binds" to and can control only one RX at a time without any possibility that it can interfere with (or be interfered by) another transmitter. This removed — in a stroke — many of the radio concerns at events. Organizers no longer had to worry about competitors interfering with each other or with other RC sets being used nearby, affecting safe control of the robots.

Competitors also no longer had to be concerned about being on the same channel as their opponent and perhaps being forced to make last minute receiver crystal changes. They also don't have to worry about getting the appropriate frequency clip to be able to test their bot.

As an added bonus, the 2.4 GHz receivers were smaller, cheaper, and more reliable. Radio reception in the bot was also vastly improved and less susceptible to interference from the rest of the bot's electronics.

Events now commonly specify that 2.4 GHz must be used, so many competitors face the expenditure of about $200 to get a new transmitter and receiver. However, a new range of very cheap 2.4 GHz equipment is now available and these bring the new technology within almost anyone's reach.

The radios are sold under a number of brands and with varying complexity, but the one I will be describing is probably one of the cheapest to buy that has all the functions that one would normally use in combat.

The HobbyKing HK-T6A (**www.hobbyking.com**) is a six channel, PC programmable set (**Figure 1**) and is usually sold for around $25 plus shipping. The incredibly low price does come with a couple of drawbacks. The first is that it does not have a rechargeable battery or charger, so you'll need to buy eight AA alkaline batteries for it. The second problem is that the only way to program the radio is using your PC via a special USB cable (an extra $3). Finally, the radio comes without a manual so you need to go to the Internet to download this and a driver and setup program. These are all available for download from the Team Rolling Thunder website at **www.teamrollingthunder.com**.

The receiver comes in two sections; the second smaller part is a second antenna. I have found reception to be fine without this second antenna and so I remove it by unplugging it from the main receiver body.

Binding the RX

The first task after adding the eight AA cells to the radio is to bind the receiver to the transmitter. This means that this receiver will only work with this transmitter until such time as it is rebound to another transmitter. (You can, however, bind multiple receivers to any one transmitter.)
The procedure is as follows:

1. First, make sure the TX is switched off.
2. Insert the provided binding plug and link into the "BAT" pins and an RX battery (or power from your bot's BEC) to the "CH1" pins on the RX (**Figure 2**). Two LEDS should start flashing on the RX indicating it is ready to bind.
3. Press and hold the "bind range test" button on the bottom left corner of the TX, then switch on the TX (on/off switch is on the lower right).
4. The LEDs on the RX should stop flashing after about 10 seconds indicating it has bound to the TX.
5. Release the "bind range test" button on the TX.
6. Remove the binding lead from the RX.
7. You can now test the TX by plugging in some spare servos to the RX and seeing if they respond to the TX stick movements. Be aware that channel allocations and responses may not be what you expect so do NOT connect the RX to your bot's weapon or drive motors at this time.

Loading the Device Driver

The second task is to load the device driver required for the USB cable. The required installation program can be found on my website at **www.teamrollingthunder.com** or from **www.silabs.com/products/mcu/Pages/USBtoUARTBridgeVCPDrivers.aspx**. The drivers installed without issue on my computer (running Windows XP).

T6config Programming Software

The T6config program is used to


FIGURE 1


FIGURE 2

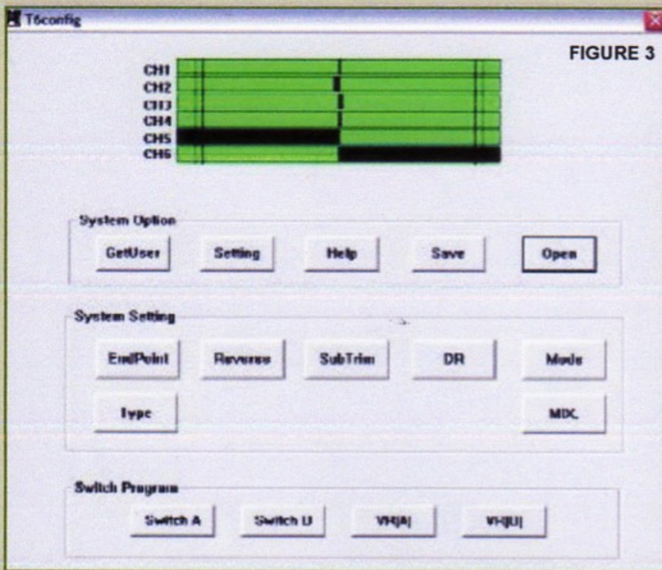

FIGURE 3

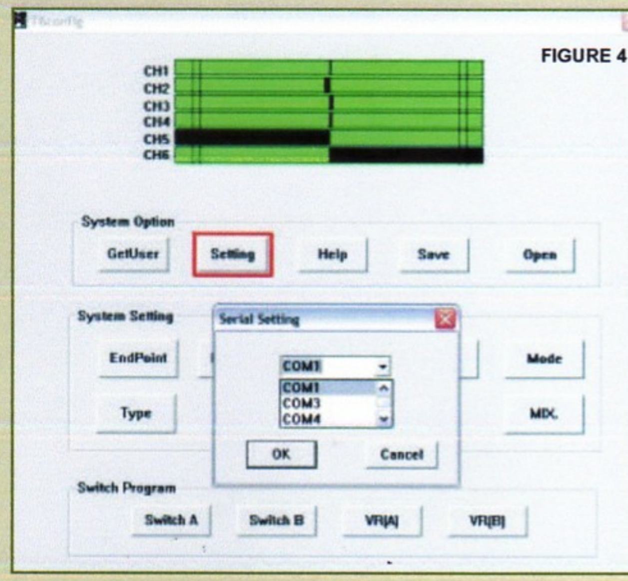

FIGURE 4

change the various settings on the TX. First, you must install the program t6config.exe. (Again, you can download that from my website.)

The install program must use a Chinese character set my computer doesn't have since it displays some unintelligable icons, but the program installs without needing user intervention at that point, so this doesn't present a problem. A T6config icon is added to your desktop.

Linking Your TX to Your PC

1. Power-up your computer.
2. Switch on your TX.
3. Plug in the round plug on the USB cable into the socket on the back of the TX.
4. Plug the other end of the USB cable into a spare USB port on your computer.
5. Launch the T6Config program on your computer. You should get a screen similar to that in **Figure 3**.
6. Click on the button marked "Setting" and a small window will pop up as shown in **Figure 4**.
7. Choose a COM port and click "OK."
8. If it is the right port when you move the sticks on the TX, the green bars will move in response. If they don't, then repeat step 7 and choose another COM port until they do.

This is where I ran into a problem. No matter what COM port I tried, the bars would not move. I tried a different TX (I had purchased four) and a different USB cable (I had a couple), and finally tried it out on two other computers to no avail.

I researched online but could not find anyone who had the same problem. Finally, in desperation, I tried plugging it into the powered USB hub I used on one of the computers and it worked immediately! I suspect that the power available from some USB ports is insufficient to correctly power the cable link, and the powered USB hub had a higher voltage or current capacity and allowed correct operation. The USB hub I used is shown in **Figure 5**. It came with a USB connection cable and a small transformer to power it. You can get hubs that are not separately powered but I doubt they would work.

FIGURE 5

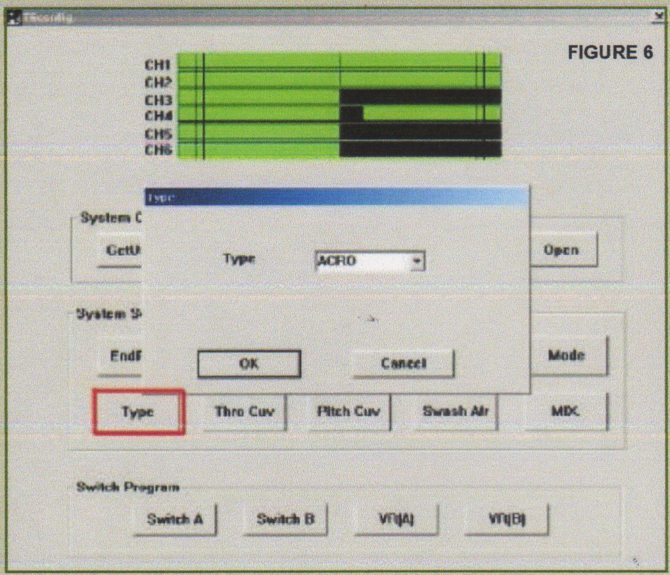

FIGURE 6

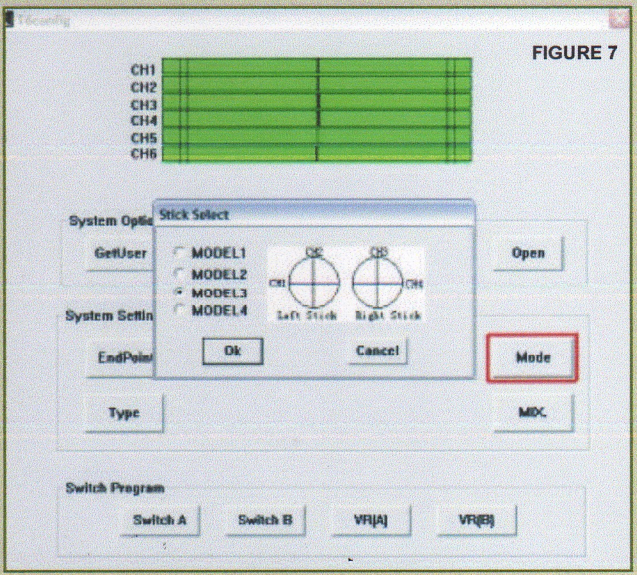

FIGURE 7

Programming Your TX

1. Click on the "GetUser" button in T6config. This uploads the default settings from the TX. Now, click on the "save" button to save the default settings onto your PC. Save the file somewhere that you will be able to find it again.
2. Click on the "Type" Button as in **Figure 6** and make sure "ACRO" is selected rather than one of the Helicopter settings.
3. In order to get the right hand stick on the usual channels (three and four), you click on the "Mode" button as in **Figure 7** and choose "Model 3" from the pop-up menu. This still leaves Throttle on Channel 2 and rudder on Channel 1, but it's closer to the usual setup on a Spektrum or Futuba TX.
4. You can reverse any of the channels by selecting "reverse" (**Figure 8**) and selecting or deselecting as required.
5. Dual rating is a little more complex. First, you must select what channels you want to dual rate by clicking on the DR button (**Figure 9**) and changing the values for DR ON and DR OFF; 100 and 18 worked well on Channel 4 in my bot hockey robots to calm down the steering response. Set all other channels (those that do not require dual rating) to 100 and 100. Now, you have to select which switch is used to operate this function. Click on the "Switch A" button (**Figure 10**) and select DR. This will set the switch at the top right of the TX to switch between the rates.
6. Mixing for Tank steer (if this is not done by the Drive ESC) can set up through use of the "Mix" button (**Figure 11**). The values shown worked well for my bots.
7. Similarly, the servo end points and sub trims can be set using the buttons as marked.

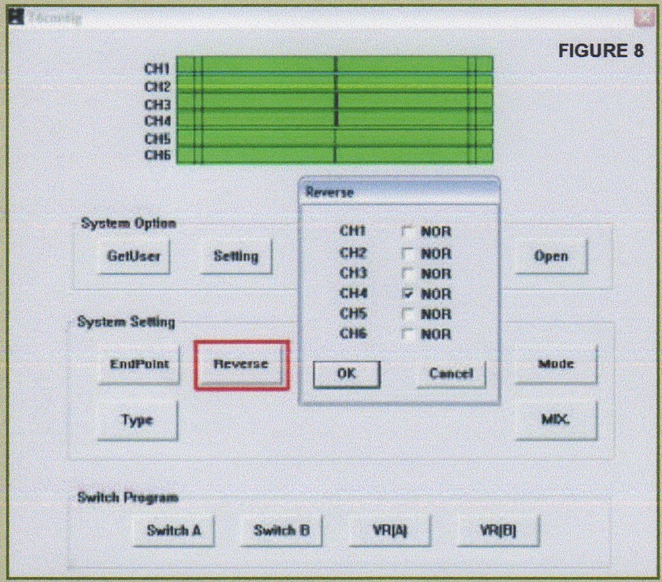

FIGURE 8

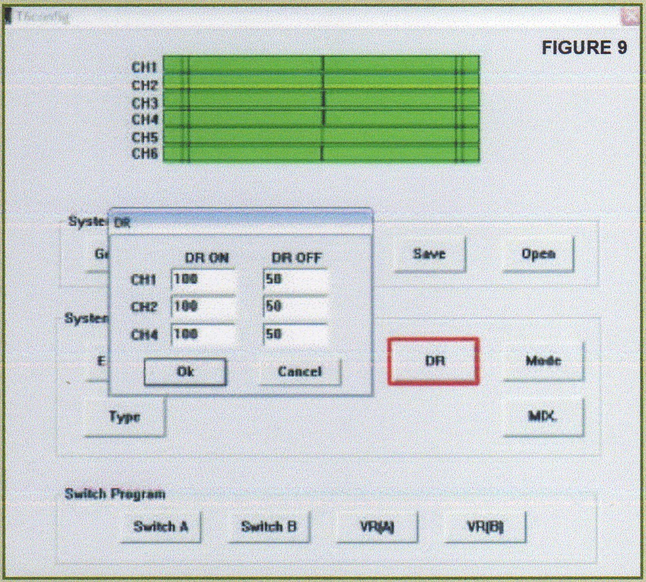

FIGURE 9

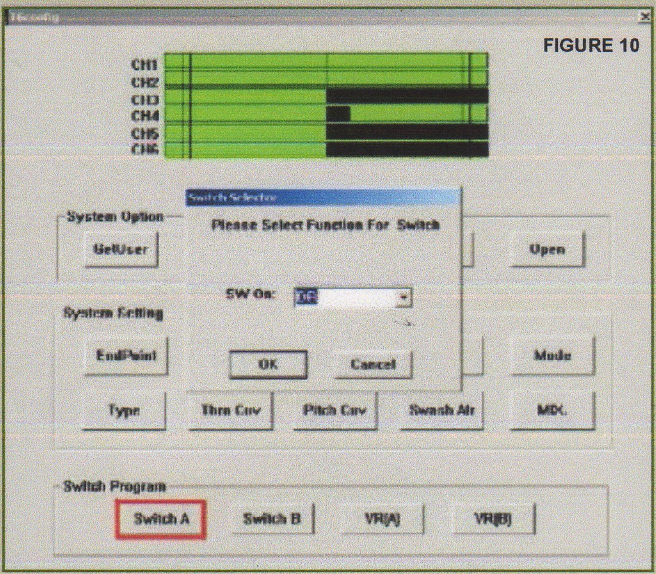

FIGURE 10

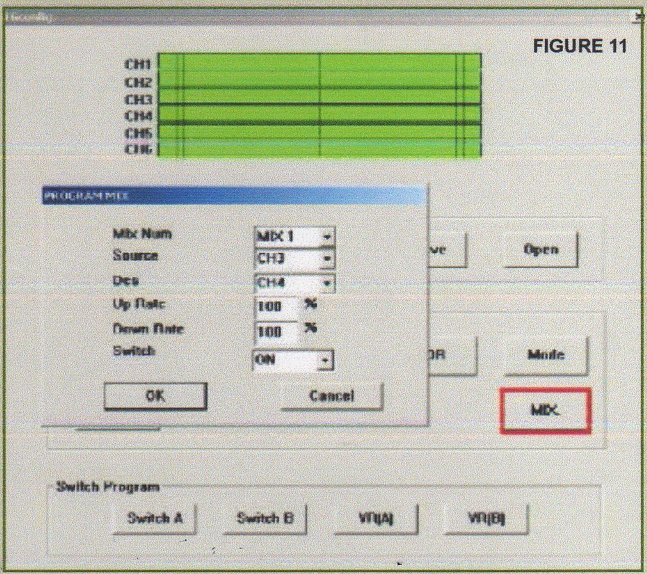

FIGURE 11

Save this file under a new file name in the same place as you saved the default settings. Click on "GetUser" and check that it has saved to the TX, as well. If it has not, then open the saved file using the "Open" button. The settings should now be downloaded to the TX. A file — Servomix — is available on my website that has the settings I use with two Banebots ESCs in my hockey bots. You can download this and then open it using TConfig to give you a start in setting up your own bot.

Switch off the TX and unplug the USB cable. You can now plug the drive motor ESCs into RX Channels 3 and 4 (ensure your weapon blade or drive belt is removed for initial testing). Power-up your bot and see how the bot responds to the controls. You may have to swap the ESCs around and swap the drive motor leads to get everything to run in the correct direction. If necessary, reattach the TX to the computer as before and change your configuration as required (reverse servos, tune dual rate settings, etc.) until you get the bot running just how you want it to.

Remember also that unless you have a laptop, you cannot change the TX settings at a competition, so make sure it's right before you go! Also, all your bots must use the same settings.

If you plan to use the TX a lot, then it's probably worthwhile to get a rechargeable TX pack. However, I could not find a battery/charger combo designed for this radio.

While setting up these cheaper 2.4 GHz radios is a little more complex than a standard computer radio like the Spektrum DX6i, they do work well and the price makes them a lot more affordable. SV

The Safe Use of Lithium Polymer or Lithium-Ion Batteries in a Combat Robot

● by Steven Kirk Nelson

I recently got back from COMBOTS 5 where I was the arena wrangler. Basically, my job was to provide safety and also train several new wranglers in the procedures used in running an event. A wrangler's job is not an easy one. You have to control the loading and unloading of the robots into the arena, control the power-up and power-down sequence of the robots, plus — when needed — enter the arena and