ROBOT BATTLES™

What this is…

… is a thrown together set of rules of thumb, suggestions, hints and general officiousness, with the intent of assisting in the construction of a CHEAP 12 pound robot from more or less easily found bits & pieces.

This was created as a take away document to supplement informal robot construction seminars conducted after a robot fight. The idea goes like this; have a robot fight and while watching folks are drunk on mechanical destruction & carnage, show them how easy it is to build their first bot. Right there, right then (recognize the economic model? First taste is free kiddo!). Give the folk a hand-out to take home for reference. They come to the next fight with their creations and a new group of ravenous mechanical destroyers is born (BWAH_HAH_HAH_HA!... Sorry). Repeat.

Who this is for

This is targeted at folks who have never built a combat robot before. It is not a technical document. Folks who have built a combat robot before will be bored silly by this. This will not help folk who have access to mills, lathes, CNC machines and degrees in electronics (you don't need my help—go build something cool).

Why listen to me?

If you are asking yourself the above question, the answer is that you probably shouldn't. I am not a heavy-weight in the robot combat world (or any other world). What I am is an intermediate level builder who really enjoys a hobby and would like to get others involved. I don't have lathes, mills, or CNC machines (OK, there is a degree in electronics but that isn't going to come into play here— promise).

What is a combat robot?

For the purposes of this exercise, a combat robot is an R/C car in a very bad mood with the desire to find other R/C cars and kick them into scrap. Purists will tell you that to qualify as a robot, a machine must be autonomous. Fine. Good. Go read something else.

WARNING

This is one if the few times in this little article that I am not in any way kidding. Combat robots are inherently dangerous. You do this at your own risk— I accept NO liability for ANYTHING. This hobby, in both its construction and execution, has the potential for fire, explosion, trauma and other injury as well as death. Be smart, be safe. Read manuals. Read warning labels. Ask questions. THINK.

The Basic Parts

To get a combat robot to do anything (other than be an vaguely amusing sculpture) you need six fundamental elements (this is the order we'll be discussing things):

1. **Speed Controller**—accepts the commands from your receiver, and translates those commands between the batteries and motors.
2. **Transmitter**—issues your commands to your robot.
3. **Receiver**—receives the commands at your robot.
4. **Motors**—makes the robot go (and hopefully kill the other robot).
5. **Battery/ Charger**—provide the power for your robot.
6. **Chassis**—holds everything but the Transmitter in one snug package.

The transmitter, receiver and the speed controller are the items that most folks just can't do for themselves. (If you are one of the folks that can build your own electronics hooray for you! Now go bask in your own superiority—QUIETLY, while the rest of us get on with our pitiful ignorant lives.) The bad news is that these items are relatively expensive and absolutely indispensable. The good news is that in recent years these items have become essentially commodities. You are encouraged to spend your money here, buying for the future. Investing in good quality radio equipment and high quality speed controllers is not only less frustration in the long haul, but much cheaper. With care, these items will fight on in multiple different chassis.

For this project, we're taking a short-cut— the selection of our source of motors, specifically the cheap & nasty battery operated drill. This is the source of the motors, the batteries & the charger. Outside of this project, how to try and save money on your robot is the subject of a fair bit of debate. My personal spending priority is:

1. Speed Controller
2. Transmitter/ Receiver (a.k.a. Radio system or R/C)
3. Battery/ Charger
4. Motors
5. Chassis

Especially the battery vs. motor priority portion can be the subject of disputes no less vicious than Mac vs. Wintel or any of the innumerable schisms that make religious studies such a side splitting (or slitting, these folk get SERIOUS) hoot. Well, I'm the one writing this, those are my priorities, and the rest of you can go schism among yourselves (again QUIETLY).

Speed Controller

The Speed Controller (ESC) is really the beating heart of a combat robot. It will probably be the most expensive item on your shopping list. Do not skimp here. Many of the items that can blow up or be damaged during a fight can be often be borrowed from other competitors in the pits (No really, one of the strange things about a robot fight is that your opponents are almost as interested in your bot being able to fight as you are. Otherwise, how else can they beat you to scrap? Oh yeah, ***the pits*** are where to find the bot builders who aren't fighting at the moment. Look for tables off to one side that look like a hardware store mated with an electronics shop & then exploded.). There are frequently enough spares floating around the pits to replace most of the items that die during a fight—but the ESC is expensive & consequently rare. Make protection of the ESC a basic criterion of your design.

The basic buy, don't buy elements for selection of an ESC are:

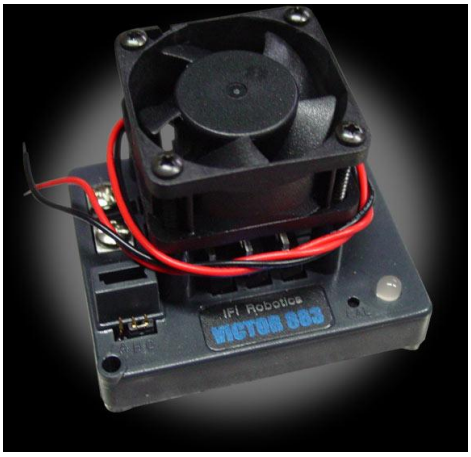
- **Type of Motor**—there are two basic motor types out there to be controlled; Brushed & Brushless. Most ESCs will only work with one type or the other. Make your system match. For the cheap 12 lb bot, get a brushed.
- **Voltage Capacity**—all ESCs will specify the maximum voltage that they can be supplied with. This specification is not a suggestion. It is an absolute maximum. Don't exceed the voltage; you will not be pleased with the results.
- **Current Capacity**—all ESCs will specify the maximum continuous current that they may supply to a motor. This specification is not a suggestion. It is an absolute maximum. For the cheap 12 lb bot, anything over 15 amps should be fine. But, like I said before- try to buy for the future.
- **Reversibility**—many of the ESCs designed for R/C cars will not reverse. In combat robots, this is bad. Unless you are blessed with supernatural driving ability (you are not), if you cannot backup, you will lose.
- **Braking**—there are quite a few ESCs out there, mostly for R/C boats & cars, which do not have electronic braking. This is a bit of jiggery-pokery in the circuit that stops the motor when your transmitter stick is in the middle (neutral) position. This can be the difference between stopping before you hit a spinning saw of death and coasting obliviously into it. There are some drivers out there (disgusting youngsters with the reflexes of a coked up snake, you know who you are) to whom this feature is a matter of indifference. For the rest of us, this should be a buy/ don't buy decision point.
- **BEC**— Battery Eliminator Circuit is a great feature to look for on an ESC. This will supply the power for a Receiver from the ESC, eliminating the requirement to make alternative arrangements. Keep in mind that if you have multiple speed controllers in a bot (say a dual channel brushed for drive motors & a single channel brushed for a weapon), that you should only use the BEC from one of them.

An important consideration in the ESC of your dreams could be number of channels. There are many ESCs available that will control 2 motors (Left & Right Channels) from the single board. This can simplify your layout considerably. Some ESCs allow for control of 3 channels, Left Right & Aux. This is very handy if you are interested (now or in the future) in having an active weapon on your robot.

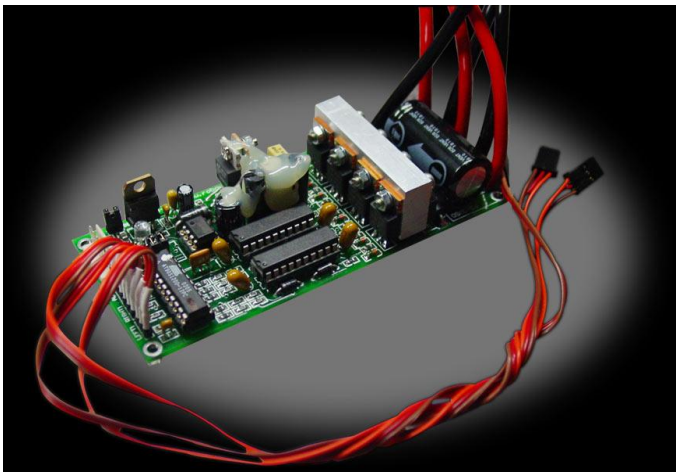
Mixing is a feature found on many ESCs. There are two steering techniques available to the combat robot; Tank & Mixed. In Tank steering, the left hand stick controls the left side motor(s), and the right hand stick controls the right side motor(s). Both sticks forward= forward, move one stick back and the other forward= a very fast turn. In Mixed steering, the ESC places Forward/Reverse on one stick axis(Y axis, up & down) & R/L on the X axis of the same stick. This results in a one handed drive, leaving the other hand and stick available for weapon control (BWAH_HAH_HAH_HA!... sorry).

Once you have an ESC- READ THE DOCUMENTATION! Keep it around. Download a copy & store it in your hard drive (you know you'll lose it one day).

Some examples of different ESCs



IFI Victor 883- 6-30v, 60a CC, single channel, REV, BRAKE $139.00 (http://www.robotmarketplace.com/products/IFI-V883.html)



IBC Dual Speed Controller—4-36v 2x 50A CC Motor Channels (REV, BRAKE, MIX, BEC) & Aux Relay Out $299 (http://www.robotmarketplace.com/products/0-IBC1.html)

Mini Tazer Brushless ESC—7-12v, 25a CC (REV, BRAKE, BEC) $65.99 (http://www.robotmarketplace.com/products/0-DYN4930.html)

Radio Systems (R/C)

You need a Transmitter (TX) & a Receiver (RX) that match each other. A handy guide to concepts in R/C basics can be found here: http://www.easyrc.com/radiosystems/index.html. A guide to R/C terminology is here: http://www.easyrc.com/radiosystems/radiosystems6.html.

Radio System Types

(The R/C systems shown below are examples of types, not recommendations)

- **Best- 2.4 GHz Spread Spectrum**: This tech will be the most glitch free and avoids Channel conflicts.
    - TX: Spektrum DX6i 6-channel 2.4Ghz - $129.99 (http://www.robotmarketplace.com/products/0-SPM6600.html)
    - RX: Spektrum BR6000 6 Channel Bot Receiver - $49.99 (http://www.robotmarketplace.com/products/RC-SPM6000BR.html)
- **Better- FM 75 MHz (channels 61-90)**: Good range & resistance to glitches.
    - TX: GWS GWT-4A - $57.99 (http://www.robotmarketplace.com/products/0-GWS-GWT4A.html)
    - RX: GWS 75Mhz 4-Channel Pico Receiver - Horizontal Pins - Futaba-Style - $20.99 (http://www.robotmarketplace.com/products/0-GWR4PII75HF.html)
- **Allowed- AM 75 MHz (channels 61-90):** Cheap
    - TX: Futaba 2PH 2-Channel AM/2- $52.99 (http://www3.towerhobbies.com/cgi-bin/wti0001p?&I=LXASX3**&P=TS)
    - RX: Included in above package
- **Avoid- 27 MHz**: Not allowed in most rule sets.

A note on channels

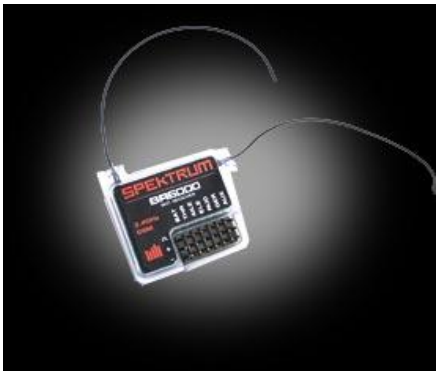
If you decide on an FM or AM system, you will have to also purchase channel crystals (XTAL). Crystals cost anywhere from $7-15 each. You need matching XTALs for both TX & RX (example: a channel 65 for your TX AND a channel 65 for your RX). Plan on having at least 3 channels (more is better) that work with your system to go to a fight. The reason for this is that you want to control only your bot—not other folks'. Of course the reverse of this is true—you REALLY don't want somebody else to have control of your bot! Having multiple channels to select from is frequently a requirement of the rule sets. Be prepared for this; it is really disappointing to not be allowed to fight because of channel conflicts. It is also a very good idea to test each channel pair in your completed bot BEFORE you show up at the fight. Like anything else, XTALs break.

To completely avoid channel conflicts, consider a 2.4 GHz spread spectrum system. While the initial investment is higher, these radios will bond with their receivers, creating a unique pair that that does not conflict with other systems. The result is fewer giblets to cart around and less scrambling in the pits to resolve radio issues.

Another consideration is the NUMBER of channels a TX/RX pair can control. For example, the GWS system cited for a FM system will control 4 separate things; say Left Motor, Right Motor, and a Weapon motor, with a channel left over. The example cited for an AM Radio only has 2 Channels of control which will be generally used up by Left Motor/ Right Motor. Try to not only consider what you build today, but what you may wish to build tomorrow.

If the ESC you select does not have BEC, you will need to provide a 5v source to the Receiver.

Spectrum DX6i—2.4 GHz



Spektrum BR6000 6 Ch Bot RX

GWS GWT4- 4 Ch FM m

GWS 75 Mhz 4-Channel Pico RX - Horizontal Pins

Futaba 2PH 2-Channel AM/2

Futaba R152JE 2Ch AM

Motors

You need at least two motors for your bot, one for Left side drive & one for Right side. The motors by themselves are not particularly useful; they spin too fast and with little real power. Some sort of transmission is also called for. For your first combat bot, allow me to recommend the quick "one-stop shopping" technique of the battery operated drill. This is a great inexpensive way to get both motor & transmission in a single fell swoop (there is an additional benefit to this that we'll discuss in the next section—multitasking baby!). The motors in the drill are the brushed type.

Keep an eye open at the hardware or "home improvement" store for sales. Perhaps the easiest way to get hold of very inexpensive motors is to purchase on-line from a site like Harbor Freight (http://www.harborfreight.com/). After I wrote that sentence, I found an 18v drill motor for $27 and a 4.8v for $15. An 18v drill motor would be delightfully adequate for a 12 lb to 30lb fighting robot (4.8v might be a bit anemic for a 12lb). Anything in the 9v and up range is a nice place to start. These drills cost less than most of the "specialty" motors alone.

Once you have the drill, there is a bit of surgery required (we call it hacking). I am lazy, so this will not be covered in this document. Instead, I refer you to a nice web article (http://www.wa4dsy.net/robot/drill-motor-hack) by a builder of almost mythic stature in the Robot Battles family of fighter/ builders, Dale Heatherington (spend some time on this site; there is LOTS of good stuff for the geek here. There are lots of other drill motor hacks out there, as usual, Google is your friend). Pay careful attention to the **July 2006 Update**, those set screws are vital.

What you have after the hack (and say $60, including shipping) is a pair of motors (transmission included) with a shaft already attached (the threads on that shaft are 3/8" 24, you can mount wheels directly to this), batteries to run them, and chargers for the batteries. This combo of materials, purchased separately, can easily cost (No kidding) Hundreds of dollars.

Battery/Charger

You need something to power your bot. Many fights don't allow Internal Combustion Engines (a.k.a. IC or ICE) because they have an unreasoning fear of fire (silly, yes, but the times we live in require tolerance of many strange opinions). We won't be talking about IC. For most of us, this leaves the electric option; for the vast majority of this group it means a battery (you mad scientists out there can work out your own alternatives, again QUIETLY).

So where is your battery & charger for this project? You already have it- it came with the drill guns you acquired and hacked for their motors. The batteries are low-end NiCads. You need a (possibly) new tool for this next bit—the Multi-meter (a.k.a. DMM or just meter). This will allow you to test the battery and all kinds of electrical thingummies in a number of ways. You don't need anything fancy (Though they are nice). Radio Shack, Home Depot, any hardware store is a good place to look for this item. Talk to the nice person at the store & tell them what you are doing (you're gonna blow their mind!). There are instructions in the box with your new toy (and best diagnostic friend). Additional instructions on the use of the DMM are here: http://www.wikihow.com/Use-a-Multimeter .

A Mile-high over view of the battery harvesting process goes like this:

1. Check how the battery fits into its charger before doing any surgery. This will ensure that the correct terminals touch the charger (+ goes to +; - goes to -. This is called polarity- Use that meter!).
2. Make notes as you go, marking polarity on both the batteries and the charger (Use that METER).

3. Carefully remove the cells from their plastic housing.
4. You may be able to solder wire (length is up to your requirements, at least 6") right onto the connector that was on the plastic housing (at least to the wires that connect to them). Alternatively, you can solder right onto the ends of the battery itself (especially if you were not careful in the above step). It is a good idea to use Red wire on the positive & Black for the negative (at the very least try to use different colors for this. Use that METER!).
5. Once you have the battery exposed & soldered, make sure to wrap it up nice & snug in electric tape.
6. Repeat this process for the battery from the other drill.
7. Use test jumpers to (wire with a clip on each side—make your own or go to Radio Shack) connect your battery to the charger. Be VERY careful to use correct polarity (USE THAT METER!).

(Soldering tips may be found here- http://www.mediacollege.com/misc/solder/)

Battery Guidelines

Here are some basic guidelines to the care & feeding of your battery and charger. Please note that items that include words in all capital letters (like NEVER & READ) are not suggestions; these have the potential of explosions, fire, injury and (I kid you not) death.

1. Only combine identical cells into batteries.
2. Only combine identical Batteries.
3. NEVER short circuit your batteries or cells (a short circuit is when you connect a battery's (or a cell's) own + to its own -).
4. REALLY NEVER short circuit Li type batteries or cells
5. MATCH your charger to your battery type (NiCad chargers will not work with Li)
6. MATCH your charger setting to your battery specifications
7. DO NOT over charge your battery
8. READ the manuals & documentation for your batteries & and your chargers (take them to your first couple of fights so you can refer to them if needed).
9. USE THE FLIPPING METER!

Chassis

This is where you get to use as much imagination as you may possess. I have built robots that, aside from the electronics, were constructed entirely out of materials acquired from (multiple trips) Home Depot. There are bots made from R/C Cars. There are bots made from wood. There are bots made from closed cell foam. There are bots made from exotic materials like Carbon Fiber & Titanium. The choice (and the skills & tools to implement that choice) is yours.

Fair warning—odds are good that your first robot will… and there is no nice way to say this… suck (this is true for almost all of us. If you aren't one of US, then you are one of THEM. And you should know what happens to one of THEM that get mouthy. Remember, QUIETLY). Don't sweat it. Your next one will be better, and so on. Some guidelines to ease you into the process:

1. Start simple.
2. Figure out how much you are willing to spend.
3. Target a first event (might I recommend Robot Battles @ DragonCon in Atlanta GA?). Read the event rules CAREFULLY. Keep these rules firmly in mind while designing &

building. It is really disappointing to be disqualified from fighting because your ignored a rule. (PS—the safety rules are NOT dumb).

4. Spend some time looking at other robots (Google is your friend)
5. Use what you know (example—if you can't weld, don't count on welding your frame together).
6. Draw it first. You don't need to be Leonardo, a sketch is fine. Chances are good that if you can't draw it, you won't be successful building it. Put the drawing away for a bit and look at it later, critically. Revise in the cold light of day. (see 1 & 2)
7. Make a materials list based on your drawing. I find it helps to order everything at once (I live on the outside of the galaxy and therefore order most everything on-line).
8. Take the components you have collected and lay them out in the approximate way you have drawn. Does it all fit? Revise & repeat. (see 1 & 2)
9. Budget your time as well as your money. Finish construction BEFORE you show up to the event.
10. Practice your driving BEFORE you arrive at the event.
11. Don't be afraid to change things.

That's all I have for you.

Good Luck, fight well. — B Davis

Sample List—12lb robot

(I'm picking inexpensive value here; make up your own mind. These are OPINIONS):

1) Transmitter- GWS GWT-4A 75MHz 4-channel Radio System (~$60)
2) Receiver—GWS Pico 4channel 75 MHz 4 Channel (~$21)
3) ESC— IBC Dual Speed Controller (~$299)
4) Motors, battery, charger—2 x Harbor Freight 12- 18v Cordless Drills (~$60)
5) Chassis—Use materials you are familiar with (~$???)

Useful Links

Where to fight:

http://www.robotbattles.com/
http://botleague.net/

Drill motor Hack:

http://www.wa4dsy.net/robot/drill-motor-hack

Pieces & Parts:

http://www.robotmarketplace.com/store.html
http://www.mcmaster.com/
https://sdp-si.com/eStore/
http://www.harborfreight.com/
http://www.towerhobbies.com/
http://www.robotpower.com/
http://www.battlepack.com/
http://www.solarbotics.com/

Places to help you think:

http://www.wa4dsy.net/robot/
http://forums.delphiforums.com/THERFL/messages/?start=Start+Reading
http://tech.groups.yahoo.com/group/Atlanta_robot_battles/
http://members.toast.net/joerger/AskAaron.html
http://www.societyofrobots.com/

Hard Data:

http://www.powerstream.com/Wire_Size.htm
http://www.tfcbooks.com/referenc/decimal.htm
http://www.matweb.com/search/PropertySearch.aspx
http://www.efunda.com/designstandards/screws/tapdrill.cfm