

Boss Frog Installation Instructions

LSx Subframe and Axle Kits for Mazda Miata

(includes engine, transmission, differential and axle mounting kits 1 –4)



Introduction

Congratulations! You have purchased one of the highest quality engine swap subframe kits available today. Installing your new drivetrain involves many steps, but is really not that difficult if you take your time and understand what you are trying to accomplish. These instructions will clearly illustrate the methods we have found to work the best. If something does not fit properly, we would like to know about it, so that we can improve our products. Contact us at bossfrog@bossfrog.biz or see our website at www.bossfrog.biz.

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Safety

The most important factor when swapping an engine is your personal safety.

- Always use safety glasses.
- Use care when operating power tools, and always follow manufacturer's recommendations.
- Lift and support the car using the recommendations of the vehicle manufacturer.
- Beware of sharp metal edges and corners.

Boss Frog Warranty

A. Standard Boss Frog Warranty

Boss Frog Inc. (Boss Frog) warrants, in accordance with the provisions below, to the original purchaser for the period of 30 days from the date of delivery of a Boss Frog product, that the product is free from defects in material or workmanship. Boss Frog's obligation under this warranty is to repair or replace, at Boss Frog's election, without charge and at Boss Frog's place of business, any part or parts of the product which, in the judgment of Boss Frog, prove to be defective.

THIS WARRANTY AND BOSS FROG'S OBLIGATION HEREUNDER IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED OR IMPLIED, INCLUDING, WITHOUT LIMITATION, THE IMPLIED WARRANTY OF MERCHANTABILITY OR IMPLIED WARRANTY OF FITNESS FOR PARTICULAR PURPOSE, and all other obligations or liabilities of Boss Frog for incidental and consequential damages resulting from the design, manufacture, sale or use of the equipment. No person is authorized to make any warranty or assume for Boss Frog any liability not strictly in accordance with this warranty.

B. Purchased Product Warranty

This warranty does not apply to component parts not manufactured by Boss Frog, except to the extent of their individual manufacturer's guarantees.

C. Warranty Limitations and Exclusions

This warranty shall not apply to any product which, in the judgment of Boss Frog, has been altered or tampered with in any way, or has been subjected to misuse, neglect or accident. This warranty applies only to the original purchaser and may not be assigned without the express written consent of Boss Frog, Inc.

D. Product Changes and Improvement

Boss Frog is continually striving to improve its products, and therefore reserves the right to make improvements or changes when it becomes practical and possible to do so, without incurring any obligations to make changes or additions to the products sold previously.

Kit Contents –

1. Engine Subframe
 - Engine Subframe
 - Engine mounts & block adapters (2 ea)
 - Extended Steering Joint
 - Sway Bar mounts (4)
 - Hardware
2. Transmission Subframe
 - Transmission Crossmember
 - Transmission mount
 - Frame Reinforcement Channels (2)
 - Hardware
3. Differential Subframe
 - Lower Plate
 - Rear Plate
 - Front bushings (2)
 - Rear bushings (2)
 - Differential brace bars & backers (2 ea)
 - Differential mount tabs (4 -NA only)
 - Hardware
4. Axle Kit
 - Complete axle assembly, custom (2)
 - Spacer washer (2 or 4)
 - Wheel bearings (2)
 - Wheel hubs, custom (2)

Other things you will need to source (see below for descriptions):

- LSx Engine
- Bellhousing for LSx to T56 Transmission
- T56 Transmission
- Ford 8.8 IRS Differential (center section)

Guide to the installation and instructions:

An engine swap is a big project that will involve a great deal of work and patience. We have tried to outline the major steps to make your install go smoothly, but there be hundreds of minor details and questions during the install.

While we will help to answer these questions, you should also try using some of the online resources available to you. If you have not already done so, register with both LS1TECH.COM and MIATA.NET and start getting involved in the engine swap forums. These folks can answer your questions better and more completely that we can, because there is simply more combined knowledge out there.

It is probably easier to find the various drivetrain pieces separately from junkyards or on e-bay, but a few words of wisdom: try to purchase the engine/bellhousing/transmission all together, or find a wrecked Camaro or Firebird with the engine/transmission combination you want, and buy the whole thing. When you buy the engine and transmission separately, you will probably end up having to buy various parts and fasteners, which will take a lot of time and cost a lot of money.

Some kit vendors will tell you that this swap can be done in a “long weekend” if you have all the parts – this is simply a load of horse pucky. Take a deep breath – this will be marathon, not a sprint. Take one issue at a time, and don't be too concerned that you don't know all the answers upfront.

Components and Systems – General Information: Engine

1. Our engine of choice is the GM LSx series, which have aluminum blocks, and weigh only slightly more than a stock 1.6/1.8 liter engine. Other kits use a Ford 5.0 liter engine, which is also a good choice, but smaller displacement and heavier. To us, as long as you are going to all the work of a swap, why not get the biggest displacement and horsepower available while retaining the original balance of the Miata? The 3rd generation LS1 is a 5.7 liter engine that was used on '98-'02 Camaros and Firebirds, '04 GTO's and '97-'04 Corvettes, and is available for reasonable prices. The LS2 is a 6.0 liter engine used on 2005+ cars, so it is a little more pricey.
2. Water Pump - we use a '99 Corvette water pump because it is thinner, saving valuable space in front of the engine. A matching 'vette balancer will also help keep it short. The Camaro/Firebird components can also be used, but you may have more trouble fitting the radiator and hoses in.
3. Power Steering – can be hooked up to the engine if desired, but many people abandon it. Parallel parking will require a little more finesse, but the road feel is fantastic and most people that try manual steering won't switch back to power. The fit of the steering rack to the oilpan is tight, and the stock hardlines will not fit without modification. Boss Frog has a plumbing kit to make the rack fit, and either the Mazda or GM power steering pumps can then be used to power it. Additional information on de-powering the rack and hooking up PS systems is available on the Miata.net.
4. Air Conditioning – we usually recommend abandoning the air conditioning system too because of the limited radiator space. However, if AC is desired it can be hooked up using either stock or aftermarket coolers. See the forums for more information.
5. ECM – If you have an ECM (computer) with your LSX engine, it will need to be reprogrammed before you are done. If you don't have one, you can buy one off e-bay or a variety of vendors.

Transmission

1. We use a T56 transmission for our swaps. You can buy these used, or get a rebuilt one from several vendors. One word of caution – if you buy a rebuilt transmission without supplying a core, you will not receive any of the various plug-in parts. There is a reverse lockout, skip shift, backup light, and a few other plugs and solenoids that you will need to buy separately, as they will not come with the transmission.

Differential

1. Center Section - There are several different types of IRS (Independent Rear Suspension) differentials that are commonly used in Miata V8 swaps. We looked seriously at the Getrag differential used in Cadillac CTS and CTS-V vehicles. The bottom line is that these transmissions were designed for 3.6 liter engines, and they have had a lot of problems with seals, pre-load, and wheel hop which has resulted in recalls and thousands of angry customers – no thanks. There are also Jaguar and Toyota IRS units that would probably work, but are more difficult to find. Ford makes both 7.5" and an 8.8" IRS centers that have been used for decades. The larger 8.8 is heavier built, more common, and has tons of gear and traction options, so is the differential we recommend. The easiest way to find an IRS center section is from a 1986-97 Cougar, Lincoln Mark series and/or Thunderbird. There are several different rear covers available, but we use the one with a small vertical tab with two horizontal holes on the back. The nose of the differential should have two vertical holes, one on each side of the input.

2. Gears – there is a great debate on which rear end gears to use. Our opinion is that for a Miata V8, you will have more power that you will be able to easily transfer to the street. We consider highway cruising speed as a determining factor in picking the rear end gears. In a T56 6-speed, the top two gears are both overdrives, and 6th gear is a .5:1 ratio. There are lots of gear ratio calculators available on the internet. If you input a common Miata tire diameter and the various rear end gears, this is what you get in 6th gear:
 - 3.42 gear = 1788 RPM @ 70 MPH
 - 3.73 gear = 1955 RPM @ 70 MPH
 - 4.10 gear = 2143 RPM @ 70 MPHThe gear choice depends on how you plan to use the car. If it is a weekend racer, you may want the 4.10 gears. If you will drive a lot on the highway, a 3.73 gear might be a better choice. If you want better fuel economy, you shouldn't be doing this swap. For drag racing, our mule car (Zelda) has 3.73 gears and can do 110MPH in 5th gear (12.4 quarter mile with street tires).
3. Traction Control – there are several different manufacturers and styles of traction locks and limited slip, which can be debated to infinity. For a straight-line car, a Detroit Locker is hard to beat, but it is noisy and grabby for street driving. We prefer the Detroit True-Trac posi because it is a helical gear limited slip setup without any clutches. Be sure to order the one for a 28 tooth spline - #912A562 (not the 31 spline for straight axles).

Axles

1. Halfshafts – there is also a great debate over the best setup for the CV axles. Some vendors use the stock Miata outer CV and either a Ford or Cadillac inner CV. There is no doubt that the Miata outer CV was never intended to transmit the 300+ horsepower that your V8 will supply, so we have elected not to use it in our kits. Instead, we offer several axle choices.
 - All Boss Frog axles kits include a pair of custom length axle assemblies with CV's remanufactured to factory specs, new wheel bearings, new OE rear wheel hubs broached for the larger Ford outer CV's, and hub spacer washers.
 - The Stage 1 kit includes custom-made 4340 half axles (7.5 series), with Ford 7.5 inner and outer CV's.
 - The Stage 2 kit includes custom-made 4340 half axles (8.8 series), with Ford 8.8 inner and outer CV's
 - The Stage 3 kit includes same as Stage 2 except with a 4340 outer CV housing and hub spline.

Brakes

1. Of all the systems, the brakes stay pretty much stock. Of course, we recommend that you change to a big brake kit (Goodwin racing, others) but it is not a requirement. The brake lines run right next to the tunnel, so you may choose to re-route them after the engine and trans is installed. Remember that you will need to reroute a vacuum line from the back of the LSx to the Miata's brake booster.

Clutch

1. The clutch selection is a raging issue on the forums, so the choice is yours. Will a stock clutch hold up? Maybe, it depends how you treat it. Our feeling is that as long as you have it apart, just put a new one in. Read the forums and decide for yourself on the brand and size you need. We used an LS7 clutch in Zelda.

Clutch Hydraulics

1. Master Cylinder - the Miata clutch master cylinder is not big enough to handle the T56 transmission clutch. We recommend purchasing a new .75" bore cylinder such as a Wilwood ¾" Universal. Neither the pushrod or mounting base will directly fit up to the Miata system, so it must either be modified, or you can purchase a modified cylinder and mounting adapter from us.
2. A slave cylinder is mounted behind the clutch and inside the bell housing. GM in its infinite wisdom created a cross-pin fitting and quick disconnect adapter to couple the clutch hydraulics to the slave, but there is no parts available for the quick disconnect. The best option is to abandon the quick disconnect and purchase an adapter to get from the cross-pin to a -3AN or -4AN fitting.

Fuel

1. Pump - The Miata fuel system is not big enough to handle the LSX engine, so everything changes. The fuel pump we use is a Walbro 255 which is specified for the NA but also works on the NB. The first thing to do is remove the existing fuel pump from the tank. You can see that the new pump is very close to the same size, but you may need to cut a little off the hard line to make it fit. The instructions that come with the new pump are pretty complete – just follow their instructions.
2. Filter/Regulator – also needs to be changed because the LSX runs at a higher pressure. Buy a fuel filter/regulator from a '99 corvette, and mount it generally in the same place as the stock filter. There is a 3/8" male inlet and a slightly smaller male return line on one end, and a 3/8" female outlet on the other end.
3. Plumbing – some people run 3/8" hose barbs with flexible hose the full length of the car. We prefer a combination of 3/8" hard (brake) lines and flexible lines. We run two 3/8" SS braided hoses from the fuel pump to the inlet side of the filter – the center fuel pump line goes to the larger inlet line. You can use either Russell type fittings or hose barbs with clamps. The filter outlet requires a special fitting if you want to adapt to a hard line. We used 3/8" brake line to go toward the front of the car along the frame rail. Then we adapted back to flexible lines at the engine, using EFI fittings to attach to the fuel rail.

Steering

1. In order for the steering cylinder to clear the oil pan and still have adequate ground clearance, it is necessary to extend the steering shaft slightly. We do this extension at the lower steering knuckle. In our opinion, the small change in the steering cylinder location will not effect steering or handling, and is well worth not having to remove the dashboard and hack up the tunnel.
2. If you want power steering (we recommend de-powering it), the stock hard lines will not fit around the oilpan. You can either modify the existing hardlines, make new hardlines, or use metric adapters and flexible lines. Boss Frog offers all the adapters and stainless hoses in a single kit to make the steering rack fit.

Exhaust

1. There is not much room for headers and exhaust in this tiny engine bay, especially near the steering shaft and starter, so the headers need to be customized. We have custom headers to fit the available space, and these can either be purchased from us or you can make them yourself. The space where the exhaust passes through the differential mount is also tight. Depending on the size and type of exhaust tubing, you may need to flatten the tubing somewhat to fit under the rear axles. The exhaust system is usually best done at a custom exhaust shop.

Cooling

1. The stock radiator will not be adequate for the new engine. A bigger (35 - 37mm) radiator made for the Miata will have the lower hose outlet on the driver's side, where the LSX hooks both ends on the passenger side. We re-mount the larger radiator forward of the stock location, and route the lower inlet back to the passenger side with hard or flexible hose.

Driveshaft

1. You will need to get a driveline modified or made to connect the transmission and the differential. The donor cars mostly used 1310 series drivelines, which can easily be shortened by a driveline shop. We recommend upgrading to a larger 1330 series, and can supply these in our driveline kits.

Wiring

1. Harness – you will need to find or buy a harness. They can be purchased on e-bay used, or there are many vendors who make new harnesses.
2. Wiring – the LS1 harness is fairly self-contained. Basically you will need to hook the orange wires to constant 12V power, and the pink wires to switched ignition power. There are another dozen wires that need to be hooked up to instruments, fans, etc, but with the help of various LS1 forums it can be done.

Preparation for the Project

1. Prepare an area that you will be able to use for the duration of the project.
2. If you don't have a good set of tall jackstands, go borrow or buy some.
3. Gather up some pans, buckets, and oil dry – there is going to be some fluid loss.
4. Buy a couple boxes of plastic freezer bags and some markers.
5. Grab a table to set parts on as you remove them from the car.

Disassemble the Car

1. Before starting, crack the wheel bolts and both rear wheel nuts loose.
2. Jack up the car and get it on jackstands.
3. Our preference is to remove the front fenders and bumper, to avoid possible damage. You will probably want to install some Frog Arms before you close it up anyway.
4. Start disconnecting and removing parts, starting at the front and working toward the rear. Group fasteners and fittings and bag them together.
5. The engine and transmission can be removed together as a unit from the top (or bottom) – it will make it easier to resell as a complete pullout.
6. The exhaust can also be removed.
7. Label all wires and hoses as you disconnect them – it will make it much easier.
8. You will likely re-use the radiator fans but not the radiator. The AC and PS components should be saved if you plan to reinstall these systems.
9. Drop the front axle and K member as a single unit.
10. For NA cars, you will need to weld some tabs on the underside of the subframe.



- This can either be done in position underneath the car, or you can remove the entire subframe and work on a bench. To remove the subframe, remove the exhaust, driveshaft at the differential, power plant frame (PPF) from the transmission, and disconnect the brake line running to the front of the car and the e-brake cables. Remove the 6 nuts holding the subframe in place and lower to the ground. Once the subframe is out, disconnect the PPF from the differential, and remove the differential, axles, and uprights as described below. Refer to separate instructions for installing the new differential mounting tabs.
11. For NB cars, the subframe can remain in the car. To remove the rear axle from the upright, first remove the wheel nut and the brake calipers. Remove the brake rotor by placing a heavy hammer on one side of the raised section and hitting the opposite side with another hammer. This will usually flex the rotor enough to break it loose. With the wheel nut flush with the end of the axle, place a wood block over the nut and drive the axle just until it breaks free. Then remove the top bolt in the upright to allow it to tip

outward. From behind the hub, pull the outboard end of the half-axle out of the hub assembly.

12. Remove the inboard end of the axles from the center section by sliding two pry bars between the differential and one inner CV, one bar on each side of the joint, and “pop” the CV joint out of the differential. Remove each axle.
13. The differential can now be removed by disassembling the two rubber bushings in the top of the rear subframe. Do not tip the differential too much as it is full of oil.
14. Remove the uprights by taking out the lower pivot bolts. These can be tough to get out sometimes.

Body Modifications

1. We recommend removing the interior for the swap, including the carpet. You will need to cut the carpet underneath the console to get it out – try to cut it as far underneath as possible so it doesn't show.
2. Some vendors require substantial modifications to the tunnel including removal of the dashboard, but the Boss Frog kit does not. The only body work required is that the sheet metal gussets at the rear of the engine bay need to be removed to make room for the engine exhaust and bellhousing. The NA and NB gussets are slightly different from each other, but the concept is the same. A reciprocating saw works well for this job.
3. There are two tabs on the bell housing that will come very close to where the tunnel meets the firewall. It works best to dent this area in a bit to gain a little clearance, using a persuasion tool (hammer). The area that needs to be dented is at the lower edge of where the gusset was removed, at the intersection of the firewall and tunnel. See the photo for the exact locations.
4. Your choice of how much body work you want to do to cosmetically fix these areas.



Installing the Engine/Transmission

1. Position the urethane 3-bolt motor mounts on the block adapter plates. The top front hole of the motor mount should be common with the top front hole of the block adapters for each side. Attach the urethane engine mounts to the adapter plates using the short 3/8" bolts, washers, and lock washers. Make sure that the 3/8" bolts are flush on the back side of the adapters (use extra washers if needed), and use plenty of loctite. Bolt the block adapter plates to the engine using the provided M10 hardware. Be sure to use loctite here.
2. The easiest way to install the drivetrain is to have the engine/bellhousing/transmission all together first. We slide the complete assembly under the car and raise the engine with a lift. It will help to have a transmission jack at the tailshaft.
3. With the engine in the engine bay and raised up roughly into position, slide the engine subframe underneath, lift it up and bolt it into place using the original bolts and nuts. The rear tabs may be required to be spread slightly – this is an unavoidable circumstance of the welding process and will not affect the fit or strength of your subframe.
4. With the transmission at roughly the correct height, lower the engine to align the urethane engine mounts with the subframe mounts and start the 7/16" x 4" bolts into the engine mounts. It may be necessary to raise/lower or re-position the transmission slightly to get the engine mount bolts to align properly.

5. If you have purchased headers, make sure that you can get them in/out before locking in the engine. Also check the firewall area to be sure that the bellhousing and transmission has adequate clearance. Install and tighten the locknuts after everything is in position.
6. You will need to prepare your steering rack prior to re-installing it in the car. One option is to make it manual by removing the o-ring on the cylinder (instructions on Miata.net). The various plumbing can then be removed and plugged, or simply cut and crimp the lines. The other option is to retain the PS system, but some of the stock lines may interfere with the new subframe. It may be possible to gently bend the hydraulic lines for adequate clearance, or Boss Frog is in the process of developing plumbing kits to be able to use the PS system.
7. After removing the stock (lower) steering joint, install the extended steering joint (included in the kit) onto the end of the steering shaft and insert the retaining bolt and nut (Boss Frog will purchase this stock joint from you). Position the steering rack (P/S lines removed or modified) on top of the subframe mounts, and start the splined shaft into the extended steering joint. Note that the steering shaft has an adjustable length, and can be extended or retracted to better fit the lower steering joint. When the steering joint fits properly, insert the retaining bolt and nut into the steering joint. Using the large stock washers from the steering cylinder, insert the ½" x 2-1/2" bolts down through the cylinder into the drivers side subframe. Using the stock rubber mount and retaining loop, install the passenger end of the steering cylinder using the ½" x 1" bolts. Tighten all bolts with locktite.
8. Check to be sure that the steering joint does not contact the headers or exhaust system.

Install the Transmission Mount & Frame Channels

1. The frame reinforcement channels are quite easy to install, provided your existing frame rails are in good condition. Position the channels with the cutout corners toward the inside front, and use a floor jack to hold in place. Using the pre-drilled holes, drill through the floor and fasten with the ½" bolt heads on top.
2. After the engine is mounted to the subframe, attach the 2-bolt urethane transmission mount to the transmission nose using the supplied M10 bolts.
3. Position the transmission cross-member under the transmission mount, sliding the cross-member on top of the frame rail tabs from the rear (humps up). The twin holes in the middle of the cross-member should be towards the passenger side. Bolt the urethane transmission mount to the cross-member using the supplied 7/16" bolts.
4. Center the cross-member between the rails and mark the hole locations in the cross-member using the frame rail tab holes as guides.
5. Drill and bolt the cross-member to the frame rail tabs using the supplied 3/8" bolts. Make sure that your wiring harness, brake and fuel lines are in place before bolting in the transmission crossmember. Tighten all bolts using locktite.



Install the Differential

1. The rear differential kit has two mounting plates, a lower plate and a rear plate. The lower plate utilizes four existing holes (NB) in the rear axle framework, and should bolt right into place using the existing bolts. The NA chassis requires welding of these four tabs to the rear axle subframe, but this can be done outside the car (see separate instructions).
2. Place the lower plate on a transmission jack, set the 8.8 differential over the lower plate as shown, and bolt the front of the differential into place using the supplied urethane bushings and bolts.
3. The rear of the differential is mounted to the rear plate with the two flat urethane bushings and supplied bolts. This can alternately be done after the differential is in place.
4. The differential should now be raised into position using the transmission or hydraulic jack. Start the two rear bolts of the lower plate into the rear subframe using the stock fasteners.
5. Align the front holes of the lower plate with the rear subframe. Match the single hole of each subframe brace with the front holes of the lower plate and start the bolts.
6. Position the 2-hole ends of the subframe braces as desired under the floor, allowing room for the exhaust, and drill $\frac{1}{2}$ " holes. Bolt into place using the backer plates and $\frac{1}{2}$ " hardware.
7. Use the $\frac{3}{8}$ " x 1" bolts and hardware to secure the rear plate through the 4 existing holes in the rear subframe. There are two additional holes in the rear plate that should be drilled through both sides of the rear subframe, and use the $\frac{3}{8}$ " x 3-1/2" bolts and hardware to secure. Also drill through the supplied holes in the lower plate up through the rear plate and attach the two plates together with two more $\frac{3}{8}$ " x 1" bolts.



Install the New Bearings & Hubs

1. The old hub must first be removed from the upright and bearing by pressing or driving it out from the backside. We built a simple fixture to hold the upright while driving the hub with a piece of tubing or socket.
2. After the old hub is out, remove the internal snap ring from the outboard side of the wheel bearing. Using another piece of tubing, drive or press the old wheel bearings out.



3. Clean the inside surface of the upright, and press the new bearings back in, being careful to only push on the **outside edge** of the bearing. Remember to replace the snap ring after the bearing is installed.
4. Carefully push the new hub into place, while supporting the **inner edge** of your new wheel bearing.
5. Repeat for the other side.
6. Note – sometimes the hub will be stuck to the bearing, and will break either the old bearing or the snap ring, or both during removal. Use sockets of the correct diameter to push or drive on the desired surfaces during assembly and disassembly.

Install the Axles

1. Installing axles is fairly easy, and can be done a number of different ways. Detach the top bolt holding the rear wheel uprights and tilt the hub assembly outward. The brake line or lower upright bolt may also need to be removed.
2. Position one of the axle assemblies through the rear control arm. From underneath the car, start the inner CV spline into the differential. Push in all the way, making sure that the retainer ring on the end of the CV engages the center section to hold it in place.
3. For the (Stage 1) 7.5 axles, slide one spacer washer on to the outer CV spline shaft with the tapered ID toward the axle. The washer should fit up to the radius at the back of the spline shaft, flat against the CV housing. For the (Stage 2 or 3) 8.8 axles, use the tapered spacer washer as described above, plus add a second spacer washer. **Don't forget this step!**
4. Guide the outer CV spline shaft through the hub from the backside. Swing the upright back into place and insert the top bolt. Start the wheel nut, and tighten until the spacer washer is tight. There should be a slight gap between the back of the upright and the front face of the outer CV.
5. Torque all fasteners to the factory specs. Make sure that the outer CV boot clears your shock/spring combination without rubbing. If necessary, adjust the boot or shock height to gain enough clearance.
6. Repeat for the other side.
7. **Important** - check to be sure that both of the inner CV's lock firmly into place. If one inner CV knocks the opposite side loose during installation, grind the end of the inner CV housing spline shafts slightly and try it again.



You now have the “heavy” work done, and can proceed with the other systems. Boss Frog can supply many of these special components, or you can source them yourself. See our website at www.bossfrog.biz for more information, and thanks again for buying a Boss Frog.