

Flyin' Miata

1.6 to 1.8 swap hints

People have been installing 1.8 engines in Miatas that originally came with 1.6es since the 1.8 engine was available. It's a pretty straightforward swap, but there are a few important things to know. Be sure to read this entire document before purchasing parts or starting the swap. No, really, read it all. While we're capable of reading this document back to you, that's not a good use of anyone's time. We also recommend you check with your local officials on the legality of engine swaps in your area as not all methods covered in these instructions will be legal everywhere and we can't answer questions specific to emissions regulations where you live.

Preliminary information

As with any unknown car / engine, we strongly suggest doing some preventative maintenance. Unless we have maintenance records (that we trust), we always do a full timing belt kit and a water pump. We also change all of the fluids. You guessed it - we do sell all of those parts. Also, unless you have a standalone ECU or are a gifted fabricator with lots of time, you'd be well-served to pick up our conversion kit. It turns the job into a pretty straightforward bolt-in affair, as opposed to something requiring a fair amount of fabrication. If you need some of our parts but not all, no problem - we sell everything individually, as well as in kit form.

Bear in mind that while we're familiar with US market cars, we have less familiarity with other markets. We do know some things, though: e.g., Euro 1.6 NBs don't have a provision for a CAS, and not all 1.8 JDM motors have EGR.

Several times throughout this document we will refer to standalone ECUs. Per EPA regulations, standalones are not emissions legal and thus are not legal to be operated on any U.S. public roads!

Electronics

The general rule is that if it's a mechanical part, it follows the engine (i.e., 1.8), and if it's an electronic part, it follows the chassis (i.e., 1.6). This means that you'll use a 1.8 engine (duh!), 1.8 intake and exhaust manifolds, and 1.8 fuel injectors (granted, that one could be considered electronic). You'll need to retain the 1.6 throttle body (because of the throttle position sensor) and the 1.6 ignition coils - hence the reason we sell a throttle body adapter and coil bracket as part of our conversion kit. But wait! You have a complete donor car, so you can just use the 1.8 ECU and wiring, right? Nope. Sure, it's possible, but it's going to make your life dramatically more complicated for little, if any, benefit. This is especially true with the NB (1999 - 2005) cars (01 - 05 cars have immobilizers which make it almost impossible), but it's still true with the 1.8 NA (1994 - 1997) cars. If you call us to ask if it's really that bad, we'll tell you it is. No, really. Unless you're bored, want a project, and have the skills, you really shouldn't use the donor car's electronics. All of this having been said, if you're using a standalone ECU, you can probably run whatever sensors you want - in other words, you can use your 1.6 wiring harness and the 1.8 TPS / coils / whatever, if you're willing to do some simple reprogramming and wiring. Most - but not all - of the electronics section won't apply to you.

Fan wiring

The sensor in the thermostat neck is what turns your primary engine fan on with the engine temperature. When you use the 1.8 thermostat neck, you lose the place to install the sensor. (Read the intake section to find out why you need to use the 1.8 thermostat neck.) This sensor is pretty basic - it grounds out when the temperature is high enough to warrant turning the fan on. You have a few different options for how to address this:

Option 1: Use our hose splice to mount the fan sensor in the upper radiator hose. This is by far the easiest method, unless you're using a standalone ECU. Search for 09-32065 on our website to find it or click [here](#). Note that this solution requires that the hose splice is grounded for the fan switch to work properly.

Option 2: If you have a standalone ECU (if you don't know what this is, you don't have one), you can use the wire at 1R (at the ECU) to turn the fan on - that would be your best option, if it's available. You may have already done this, in which case the sensor would be missing or unplugged.

Option 3: You can run the wire straight to ground by cutting it, putting on a ring terminal, and putting it under a bolt. This is good because it's easy, but it's bad because it means that the fan will be running whenever the ignition is on. This will shorten the fan's life (although they're pretty resilient) and could cause the engine to take a longer time to warm up. If you live in Alaska, this could be pretty bad, if you live in Arizona it's almost irrelevant.

Option 4: You can run the wire through a switch, then run it to ground. This is good because it will eliminate the problems above, but it's bad because your engine will overheat if you forget to turn the fan on. This makes us nervous, so we never recommend it.

Option 5: You can find a different way to mount the sensor:

Option 1: A dual-purpose (but more expensive) method is to purchase our coolant reroute kit. Search for 09-60010 or click [here](#).

Option 2: You can have a bung welded onto the thermostat housing or neck. Be sure that the sensor won't interfere with anything inside or outside of the housing / neck (such as the thermostat).

Coolant temp sensors

There are two coolant temp sensors in the back of the 1.6 head, one with a single spade connector, and one with two terminals in a plastic housing. The two-wire sensor feeds the ECU and the one-wire sensor feeds the temp gauge on the dash. On 94 - 97 engines, you'll need to swap over your two-wire sensor, but you can use the 1.6 or 1.8 one-wire sensor (after extending the wire). On 99 - 05 engines, you'll need to remove the single three-wire sensor, as it's not compatible with the 1.6 wiring. You can thread the 1.6 two-wire sensor into the three-wire sensor's hole, then remove an Allen-head plug on the left (exhaust) side of the coolant outlet on the back of the head to install the single-wire sensor

Alternator

1.6 cars use a V-belt for the alternator and water pump, whereas 1.8 cars use a four-rib belt. The easiest way to solve this is to get a 94-97 alternator for your 94-05 engine. The wiring between 1.6 and 94 - 97 alternators is a direct swap, except that you'll need to enlarge the ring terminal (to 8mm / 5/16"), as the stud on the 1.8 alternator is larger than that on the 1.6 alternator. It's critical that you **DO NOT USE A 99 - 05 ALTERNATOR**. The ECU controls the output of the alternator in the 99 - 05 cars, whereas the alternator itself controls its own output on 90 - 97 cars. In other words, a 99 - 05 alternator in your 1.6 chassis with stock wiring will output way too much voltage (when the engine is spinning fast enough) and will fry your electronics.

A second option, if your car came with a big-nose crank (mid-91 - 93, look for eight slots on the face of the crank pulley), is to bolt your 1.6 alternator (with its bracket), water pump pulley, and crank pulley onto your 1.8 engine. You'll need to either use a 1.6 water pump or cut the alternator mounting tab off of the 1.8 pump. If your car had a small-nose crank (90 - mid-91, look for four slots on the face of the crank pulley), you'll need to use the 1.8 crank pulley, water pump pulley, and 94 - 97 alternator.

Oil pressure sender

1.6 cars have true oil pressure senders, but all 1.8s - aside from 94s - have "idiot lights" turned into gauges. Hence, you'll want to install your original oil pressure sender in place of the 1.8's oil pressure sender. Your original sender is pretty big, whereas the sender on the new (post-94) engine is pretty small, but they both use the same spade connector and thread into the same place in the same way. Whatever you do, be sure that the oil pressure gauge and sender are matched.

AFM / airflow meter (stock ECU only)

If you want to be thorough, you can tweak the AFM. This is done by removing the freeze plug in the AFM and tweaking the bypass until your idle air/fuel ratio (with the car fully warmed up) is 14.7. **DO NOT DO THIS UNLESS YOU HAVE A WIDEBAND O2 SENSOR.** If in doubt, leave it as-is so you don't mess anything up.

Cam angle sensor (CAS) wiring

On 94 - 97 engines, you can use either the 1.6 CAS or the 1.8 CAS - the 1.6 CAS is technically different than the 1.8 CAS, but they're interchangeable and output the same signal. 99 - 05 engines use a totally different setup, but you can install your CAS in the new head and ignore the sensors that came on the engine. There will be one at the crank (that's present on the 96 - 97 engines as well) and one on the intake cam - either on the front of the valve cover (99 - 00) or the top rear of the valve cover (01 - 05). With a standalone ECU (and some rewiring and reprogramming), you can most likely use the original sensors if you'd like - with the stock trigger wheel or our high-resolution 36-2 trigger wheel. If you have a stock ECU, you'll need to use a CAS (either the original 1.6 or the 1.8, if you got one). Since the CAS will be farther away (the CAS is on the intake side with a 1.6 and the exhaust side with a 1.8), you'll need to extend its wiring - our conversion kit includes butt connectors and color-coded wires for that purpose. If your donor engine came with a crank sensor and you're using the 1.6 ECU, you won't use the crank sensor at all. You can remove it, but you'll need to seal the hole the bolt came out of. If you're using the 99 - 05 sensors and a standalone ECU, you can skip the CAS altogether.

Throttle body

The 1.8 throttle position sensor (TPS) won't talk to the 1.6 ECU, so you must retain the 1.6 TPS (if you retain the stock ECU). The 1.6 TPS won't bolt up to the 1.8 throttle body, so you'll need to reuse the complete 1.6 throttle body (and the idle air control valve (IAC) that's bolted to the bottom of the throttle body). The 1.6 throttle body uses a different bolt pattern than the 1.8, so you'll need an adapter - hence the reason we include it in the kit. Installation does require some drilling and tapping of the intake manifold. Instructions specific to the kit can be found [here](#) or search for 05-40000 on our site. The fact that you won't have the 1.6 air valve (the goiter on the 1.6 intake manifold) is irrelevant. Plumb the small coolant lines as they were on the 1.8 - from the outlet on the back of the head to the oil cooler, to the IAC, to the thermostat neck, to the water pump inlet.

Ignition coils

You must reuse your 1.6 coils, as the 1.8 coils aren't compatible with the 1.6 electronics (again, assuming you're using the stock ECU). The easiest method is to simply bolt your 1.6 coils into our coil bracket (04-70020 or [here](#)), which will allow you to bolt them to the 1.8 valve cover. Most plug wires won't fit with the coils in their original orientation, though - from left to right (as viewed from the front of the car), the 1.6 plug wire order is 2-3-4-1 and the 1.8 order is 1-4-2-3 (1 being the front spark plug). By swapping the signal wire between the two coils, you'll match your 1.6 coils to the 1.8 plug wire order and your plug wires will work (all 90 - 00 plug wires are the same). There are two wires (underneath a plastic cover) on the bottom of each coil. The power wire is red, and you can easily tell that it goes to both coils. The other wire is the signal wire. Swap those signal wires and use the correct (1.8) plug wire order.

Additional coil info: NA and NB Miatas fire their spark plugs in pairs, so each coil fires both plugs connected to it at the same time. In other words, as long as the wire pairs are connected to the correct coils, it'll work. Put yet another way, on a 1.8 (or a corrected 1.6), the wire order at the coils (viewed from the front of the car) can be 1-4-2-3 or 4-1-3-2. Or 1-4-3-2 or 4-1-2-3 - as long as 4 and 1 are on the passenger-side coil and 2 and 3 are on the driver's side coil, it'll work.

Intake

The 1.8 engine is physically longer than the 1.6, and with how the engine is mounted, that length is all on the front - this means that it's tough to fit the 1.6 intake in with the new engine. The throttle body adapter that's necessary for most installations just exacerbates this. If you have a non-stock intake (such as one of our turbo kits), these notes probably won't apply to you.

Using the stock 1.6 crossover pipe (the plastic pipe that runs from the airbox / air filter / AFM to the throttle body) will allow you to retain the 1.6 thermostat neck and the sensor that threads into it. However, it no longer physically fits. You can trim the fan shroud and remove the resonator box (big plastic box attached to the crossover pipe, just in front of the throttle body), but you'll still have a hard time fitting it. We don't recommend this option.

Aside from one of our turbo kits (just think of all the horsepower!), the 94 - 97 crossover pipe is the best option. This will match up to the 1.6 throttle body (on your shiny new 1.8 engine) and the 1.6 AFM / airbox. It will also fit much better than the 1.6 crossover pipe. However, this will require that you use the 1.8 thermostat neck, as was mentioned in the electronics section. **Changing the thermostat neck requires that you remove the timing belt**, so plan ahead. The 99 - 05 crossover pipes will fit as well, but they don't have a provision for an inlet for the IAC valve (the small valve underneath the throttle body that has a hose running to the crossover pipe). This is a solvable problem, but it's far easier to use a 94 - 97 crossover pipe.

With other intakes, you may or may not have interferences to figure out. For example, with our turbo kit, it'll be close, but you'll probably have to play with the intake to get it to best fit.

The 1.6 throttle cable is the wrong length for the 1.8 engine, so you'll need to either swap in the 1.8 cable or use our throttle cable bracket. The latter is far easier, so it's included in our conversion kit.

Exhaust

As mentioned previously, you must use a 1.8 header / exhaust manifold. You have a few options on the specifics, though.

Easy but expensive: purchase a 94 - 97 aftermarket header and a 94 - 97 catalytic converter. The aftermarket header will most likely be a single piece, whereas the stock setup consists of a header and a downpipe. The 94 - 97 cat will bolt up to your existing post-cat exhaust, assuming it was originally connected to a stock 90 - 93 cat.

Cheap but more effort: Use a 94 - 97 stock header, and connect it to your 90 - 93 downpipe. This setup leaves you without a bung for your oxygen sensor, so you'll need to get one welded in. 99 - 05 headers (stock or aftermarket) won't work without replacing or fabricating more pieces than is logical. Stick with 94 - 97 exhaust parts.

In the middle: Use a 94 - 97 stock header, 94 - 97 downpipe, and 94 - 97 catalytic converter. No fabrication is necessary, and the 94 - 97 cat will bolt up to your stock 90 - 93 post-cat exhaust.

EGR: The 90-93 1.6 doesn't use EGR (exhaust gas recirculation), but all (US) 1.8s have EGR. In nearly all cases, leaving all of the EGR parts on the donor engine is the easiest solution. The ability to use all of the factory EGR parts will vary somewhat depending on the year of the engine and other solutions implemented. On 94-97 donor engines, leave all of the EGR parts installed. On any engine using an FM turbo kit, you need to use one of the two EGR pipe options we offer (22-60200 for NA engines & 06-96000 for NB engines). On NB engines with naturally aspirated exhausts, this can be a little less straightforward. If you can find an exhaust solution that keeps the original exhaust manifold to the donor engine, you can use the original EGR pipe from the engine. Otherwise, you will need to modify/fabricate an EGR pipe to work with your setup.

Fuel

The 94 - 97 engines use the same fuel setup (one line from the tank, another line returning to the tank, i.e. "return") as the 1.6, although you will need to use the 94 - 97 fuel rail. The 99 - 05 uses a "return-less" system (only one line from the tank to the rail). With a stock ECU and a 99 - 05 engine, you'll need a 99 - 00 fuel rail (even for 01 - 05 engines). Bolt your 1.6 fuel pressure regulator (FPR, looks like a miniature top hat with a barb for a fuel line and a barb for a vacuum line) to the 99 - 00 fuel rail in place of the 99 - 00 damper (looks generally the same, but with no barbs). Point the return up, tweak the output slightly, and it should fit well. With a standalone ECU, you can change to a return-less system if you'd like. Contact us for more details. You can attach the 99-00 fuel rail to the 90-93 metal fuel lines on the chassis with a quick-disconnect fitting available at most parts stores. NAPA's part number is 730-6757.

94 - 97 engines have a PRC solenoid in the vacuum line that runs to the FPR. The solenoid is small and black, with two vacuum lines (an in and an out) and a two-wire connector. You won't use this, so remove it and run a vacuum line straight from the intake manifold to the FPR. 99 - 05 engines don't have a PRC solenoid.

One of the most common no-start issues with this swap is when the feed and return fuel lines have been reversed. The feed line, which connects to the fuel rail, is the rear-most hard fuel line on the chassis, next to the frame rail. The return line, off of the FPR, connects to the forward / top line. It's typically best to label these prior to disassembly, just to be sure.

Motor mounts

You'll need to use the 1.8 motor mount brackets (stamped or cast steel), which usually come with the salvage motor. Your 1.6 motor mount brackets won't work. All of the motor mounts (the blocks of rubber with studs in opposite sides) are the same between all 90 - 05 Miatas, but they're almost always ripped - hence the reason we suggest replacing them. You can replace them with OEM mounts (less noise, vibration, harshness, shorter life) or Mazda Comp mounts (more NVH but typically not to an objectionable level, longer life). If you want the smoothest Miata possible, get the OEM mounts. If you drive aggressively, track or autocross the car, or aren't bothered by NVH and want the longest life possible, get the Comp mounts.

Donor-engine specific information

1994 - 97: This is the easiest and cheapest generation to swap in. They're very good motors (all Miata engines are), but they're older and not especially fancy. You must use a 94 - 97 intake manifold, the 99 - 05 manifolds won't work without modification. You don't need to know anything, aside from what's above, to swap in these engines. 9.0:1 compression ratio (the 1.6 is 9.5:1).

1999 - 05: These engines have more upright intake ports (which give more power), more aggressive cams, and solid lifters - all good things. The original cam sensor setup is different on these engines, but you can simply bolt in the cam angle sensor (CAS) from your 1.6. With a standalone ECU, you can most likely retain the original sensors, it just takes a little wiring and programming. There are differences, though:

1999 - 00: This is the most sought after engine, and it shows in their prices. This engine has a variable-volume intake manifold (VICS) that will improve the low end power. You must use a 99 - 05 (preferably a 99 - 00) intake manifold. You need an rpm switch (look for MSD part #8950) to control the solenoid for the manifold; be sure to use the 5400 rpm "pill" (MSD part #8745). Follow the included instructions - power, ground, and rpm can all be found in the "Diagnosis" box on the left fender. The gray MSD wire should be connected to the ground wire on the VICS solenoid, the other wire on the VICS solenoid should be hooked up to switched power (white with a red stripe). Or use a standalone ECU, any decent one can control the VICS and much more. The throttle body sits a little higher with this engine, as a result of the intake manifold, but that doesn't create any tough / unsolvable problems. This engine is still a very easy swap, unlike the next one. 9.5:1 compression ratio.

2001 - 05: This engine has higher compression and a main bearing support plate, so it should make slightly more power and is a stronger engine (not that the earlier engines are weak). However, it also adds the complexity of VVT (variable valve timing). Your 1.6 ECU cannot operate the VVT, so your powerband will be flat (all of it in a naturally aspirated car, just the bottom end in a forced induction car), and you won't realize most of the benefits of the 1.8 swap. Operating this way won't hurt anything, and is acceptable in the short-term, but it's not a good long-term solution. If you have a way to control the VVT, such as a standalone ECU, a small amount of wiring and programming can eliminate that issue. If you have questions about solutions, it's best to call the people that sell those solutions - we don't know what we don't sell. 10:1 compression ratio (except for the MSM).

The oil line for the VVT means that you won't be able to mount the coils to the back of the valve cover as normal. You will have to come up with your own solution to either relocate the coils or substitute the factory hardline with a flexible AN style line.

The intake manifold has Mazda's VTCS system, which consists of four butterflies, one in each intake runner, right where the manifold meets the head. This is for cold-start emissions, and won't work in a 1.6 chassis (without a standalone ECU). This is okay as they default to open, but they will cost you a couple of horsepower, so you can remove them if you feel so inclined. Be sure that you seal any holes to the atmosphere (outside of the manifold) if you remove the butterflies and their rod.

2004 - 05 Mazdaspeed Miata (MSM): This is the best engine for turbo applications, but it's priced accordingly. It has lower compression but it still has the main bearing support plate. It also has the VTCS manifold of all 01 - 05 engines. It's possible to use the MSM turbo kit with a non-MSM chassis, but the pipe that runs from the turbo to the intercooler will be impossible to use and you'll have to fabricate some custom exhaust parts. If you can make new pipe, you'll just need to add a Voodoo box or standalone ECU and fabricate an exhaust. 9.5:1 compression ratio.

Hypothetical plans

Cost-no-object naturally aspirated build: Choose an 01 - 05 engine, a 99-00 intake manifold, a standalone ECU, a 94 - 97 Racing Beat header, and a 94 - 97 catalytic converter.

Cost-no-object forced induction build: Choose an MSM engine, a 99 - 00 intake manifold, our conversion kit and add a Stage 1 turbo kit. There will be some small (no-cost) changes necessary to the turbo kit, contact us for specifics.

Most economical build: Choose a 94 - 97 engine with a 94 - 97 stock header, weld a bung in, and purchase our conversion kit.

That's about it for most swaps. Please bear in mind that it's impossible for us to cover every possible issue you may encounter, so a swap like this will still need to be performed by someone with problem-solving abilities. Also, we can't support someone else's products and we'd really prefer to not read this information back to you. We're happy to help if you've purchased parts from us. However, in the interest of continuing to be a leading innovator in the Miata world (i.e., having the time to do so), we can't support you (without a fee) if you haven't purchased parts from us. If you're absolutely stuck, feel free to give us a call, and we can try to help out. Do be aware that if you're not a customer, you'll need to purchase our tech support.

To summarize:

What do I need?

- 94-05 engine with intake manifold
- 94-97 exhaust manifold or header
- 94-97 catalytic converter (possibly)
- 94-97 downpipe (possibly)
- 94-05 injectors (ideally with your new engine)
- Motor mount brackets to match your new engine
- 94-97 alternator (possibly)

[FM 1.8 conversion kit](#)

- 94-05 thermostat housing
- 94-97 crossover pipe

Also recommended: new rubber motor mounts, timing belt kit, new seals.

What do I reuse?

- 1.6 ECU and wiring harness
- 1.6 coils
- 1.6 throttle body, IAC, and TPS

Bear in mind that this list can and will vary based on your plans. Don't skip reading the document and use this list, as it might not be right for your purposes. Read the entire document, then add and subtract to / from these lists to suit your particular build.