

ARE YOU READY FOR TOYOTA SMART KEY SYSTEMS?

Understanding
the 2004-2009 Prius
and 2007-2009
Camry HV Smart
Key Systems



Image courtesy Toyota
Motor Corporation
[www.toyota.com]

by: Paul Cortes

The Toyota Smart Key system was first introduced on the Prius five years ago in 2004. Many cars with Smart Key systems are now out of warranty, and many Smart Key service opportunities will not be covered by warranty anyway. It's a great time to increase your Smart Key system knowledge.

Learning about this system will pay off. Smart Key systems are not going to go away any time soon. In fact, they are likely to appear on more and more models, and their level of complexity is likely to increase as vehicle-customization features are added. Smart Key systems currently provide passive entry and starting. Future systems may passively customize the car to match each driver's preferences. Imagine a car that adjusts the seats, mirrors, climate control,

audio, suspension, shift timing, and throttle response for each driver, before they even get in the car!

That's enough future fantasy, back to the here and now....

This article will increase your Smart Key knowledge in two parts.

Part 1 will introduce you to the Smart Key components and their functions. A solid understanding of how the system works will aid in effectively using the service information available on TIS.

Part 2 will offer some useful real world diagnostic strategies you'll be able to use tomorrow.

Part 1: Components and Functions

Smart Key / Key Fob

The Smart Key looks like an alarm remote, a small black rectangle with a lock and unlock buttons. Unlike an alarm remote, it's passive. A person with a registered Smart Key in his pocket and will be able to enter, steer, and start the car without touching the key.

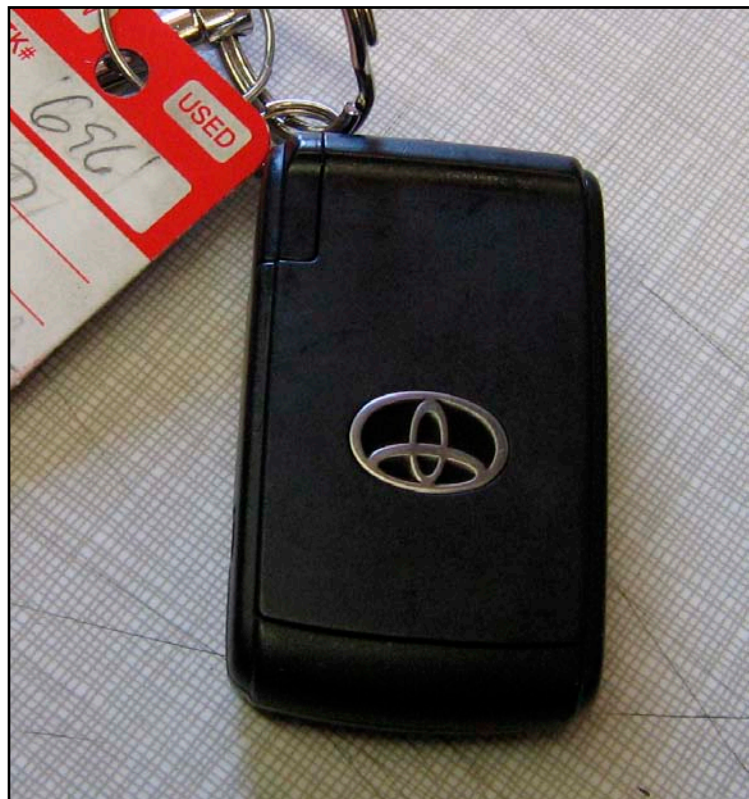
A few Prius came without the Smart Key option. These keys can be easily identified because the Toyota emblem is not chrome colored. The cars can be easily identified because they do not have a Smart Key cancel switch.

The Smart Key broadcasts wireless data at 315 MHz, at the very low end of the UHF band. "What data does the Smart Key broadcast?" you may ask. Well, one of the things a Smart Key broadcasts its unique Key ID code, which is burned into its memory at the factory. The other is the Vehicle ID code, which is obtained from the car and burned to the Smart Key during the registration process. Just as a key blank is cut to work with a particular vehicle, the key registration process also alters the Smart Key to "fit" the "lock".

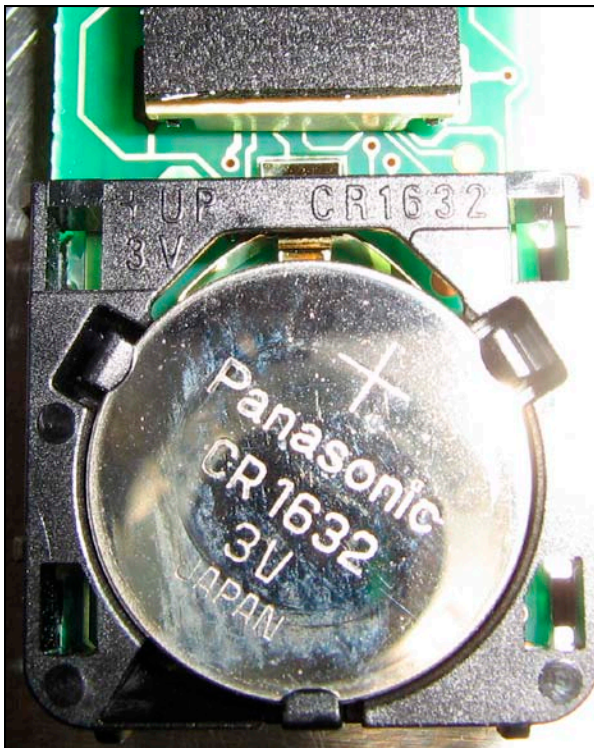
The Smart Key broadcasts using its own 3V battery power supply. In order to save battery power, the Smart Key will only speak when spoken to (by the oscillators). If a Smart Key 3V battery does go dead, the car can still be opened using the key insert in the driver's door, and started by inserting the Smart Key into the Smart key slot. However, wireless Smart Key functions will not work with a dead 3V battery. Replacement batteries (Camry PT# CR1632, Prius PT#CR2032) can be purchased from Walgreens and other stores.



A silver Camry Smart Key lying on a stainless steel counter.



A black Prius Smart Key with a chrome colored emblem.



A close up of a Smart Key battery.

Certification ECU (AKA: Smart Key ECU)

Depending on what you're reading, it may be called the Certification ECU, or it may be called the Smart Key ECU. Regardless of what it's called, the Certification ECU performs two functions --

Function 1

The Certification ECU holds codes, which are like electronic keys. The Certification ECU holds a copy of the Vehicle ID codes and a copy of the Key ID codes for verification with registered Smart Keys. It also holds a copy of the S-code for verification with the ID Code Box (more on the ID Code Box later).

Function 2

The Certification ECU is like a middle manager. Its "department" consists of the oscillators, the receivers/tuners, the Power Source Control ECU, the ID Code Box, and the Steering Lock ECU. When the Certification ECU wants information, it wakes the appropriate control unit up and demands a report. These individual control units have only a narrow view of the system; they only know the limited information they are designed to know. The Certification ECU has a broader view, and gathers and reports information from its "department" to the Power Source Control ECU and/or the Body Control Unit.

Exterior Oscillators

There are three exterior oscillators on both the Prius and the Camry: one in each front door and one in the rear bumper near the trunk/hatch. Oscillators broadcast 134.2 kHz wireless data at



A door oscillator.

regular intervals, in the hope a Smart Key will hear the broadcast and respond. The Exterior Oscillators are controlled by the Certification ECU. It's important to note that oscillators only talk; they don't listen. Oscillators are all mouth.

So what do oscillators say? They say, "Hey, wake up!" "What's your Vehicle ID code?" The longer the car sits, the less frequently the oscillator will talk. Eventually the Certification ECU will stop pulsing the Exterior Oscillators to save battery power. When this happens, the driver may need to use the unlock button on the remote to get the oscillators talking again.

If the Certification ECU receives a report that a matching Vehicle ID code has been received, it will command the Exterior Oscillators to ask another question, "What's your Key ID code?"

Touch Sensors / Rear handle switch

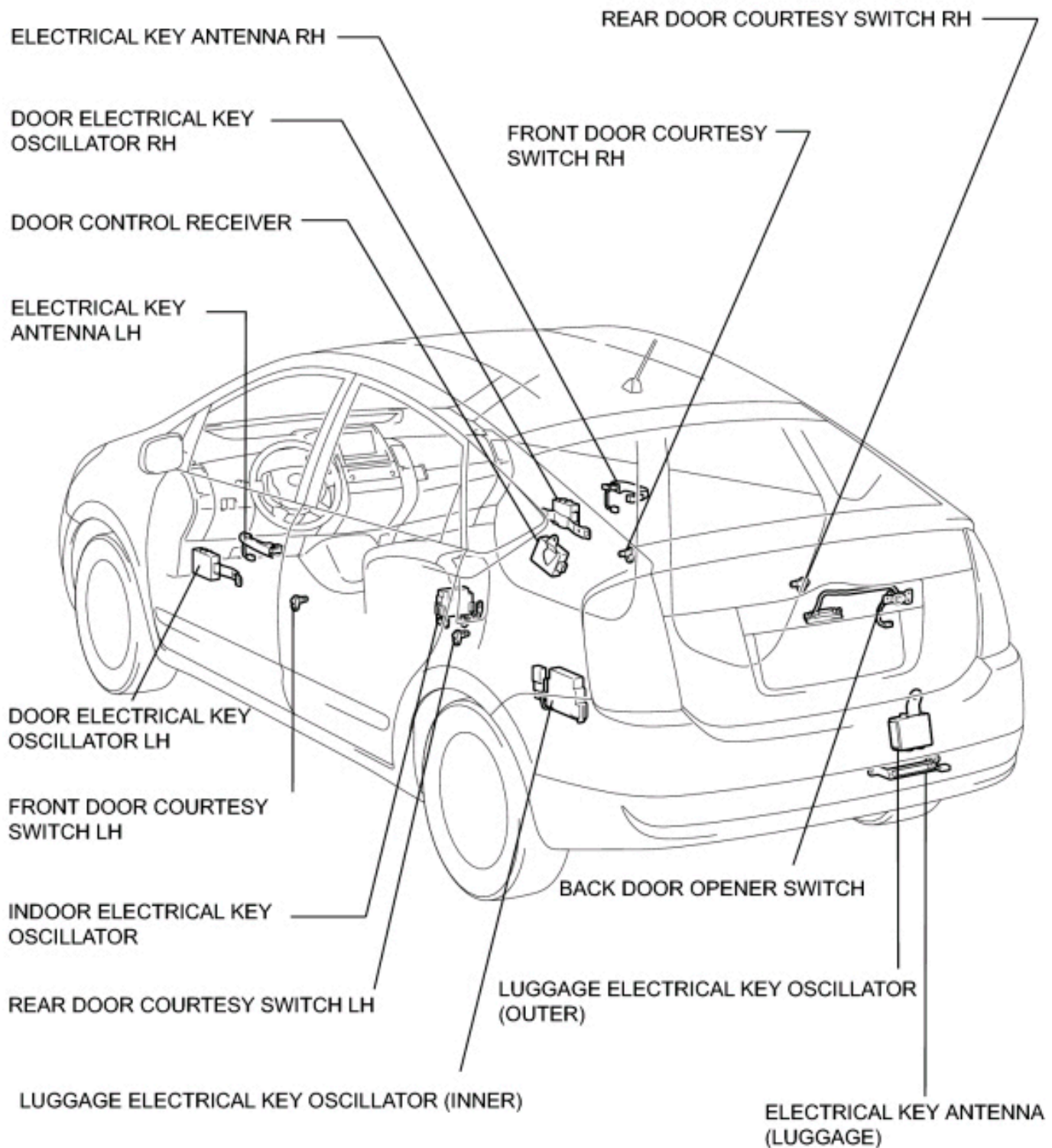
The car won't unlock the door(s) just because there is a registered Smart Key within range. First, the Certification ECU wants to know that the owner wants to get in the car, and isn't just walking by or standing near the car. The touch sensors on the inside of the door handles let the Certification ECU know that the driver wants in, and it obliges by telling the Body Control ECU to unlock the door or doors, depending on how the car has been configured.

The rear handle does not have a touch sensor, even though the rubber coating feels similar to touch sensors. The owner must press the hatch/trunk release before the Certification ECU pulse the oscillator, verify the codes, and



The touch sensor on the inside of the driver's door handle

TOYOTA SMART KEY PT1



Location diagram from TIS. (Courtesy of Toyota Motor Corporation.)

command the Body ECU to open the hatch. This is why there is a longer delay when waiting for the trunk to unlock than there is when waiting for the doors to unlock.

Interior Oscillators / Room Oscillator

There are two interior oscillators: one Front Room Oscillator, located in the center console, and on Rear Room Oscillator, located in the rear seat on the Camry, and in left quarter panel on the Prius. Like the exterior oscillators, they also broadcast at 134.2 kHz when the Certification ECU requests it.

Door switch / Courtesy light switch

The Certification ECU pulses the Interior Oscillators when the door is opened (it senses the open door via the courtesy switch and the Body Control ECU). If the driver doesn't try to start the car for a while, the Interior Oscillator will stop pulsing to conserve power. When the driver presses the Ready button, the oscillators will start to pulse again.



A door switch.



Power off = LED off



ACC = LED green



ON = LED amber

Door Control Receiver / Tuner

Unlike the Oscillators, the Door Control Receiver is “all ears”. It listens for the Smart Key to “talk” on the 315 MHz band. The Door Control Receiver is not terribly smart. If it hears something, it passes it along to the Certification ECU.

Power Switch

The power button is both an input, and an output. It houses two switches (redundant for self diagnosis), and a two color LED. The switches are inputs for the Power Source Control ECU, which will be explained a few paragraphs down. The LED is an output for the Power Source Control ECU and can indicate the current power mode as well all switch faults.

Power off = LED off

ACC = LED green

ON = LED amber

READY = LED off

Switch fault = LED flashing amber

Brake Switch

The brake switch is an important input. The car will not Ready without it. Like the Power Switch, the brake switch contains two separate switches for error checking. The brake switch for the Smart Key system is the same as the brake switch for the brake lights, so if the brake lights work, the brake switch signal is being recognized. On the Camry HV, the Power Button LED will illuminate when the brake pedal is pressed, allowing for a in-car brake switch check.

Smart Key Cancel Switch

This is the most common and easiest to diagnose “failure” of the Smart Key system. If this switch (located on the lower driver’s side dash) is accidentally pressed, the Smart Key will not be passive anymore. The driver will need to press the Smart Key unlock button to get into the car, and will need to insert the key into the Smart Key slot to start the car. Always check this first before signing the car in. It will make you a hero and save you from wasting time on an un-billable “repair”.

Same function, different name

Before continuing with the component description, let’s discuss out a couple of differences between the Camry HV and the Prius.

First, the Prius has a separate control unit called the Power Source ECU, which will be explained below. The Camry HV has the functionality of the Power Source ECU built into the Main Body ECU, so there is not a separate unit hidden under the dash. The Main Body ECU performs all of the Power Source ECU functions.

Second, the ID Code Box on the Camry is the same as the Transponder Key ECU on the Prius. In the parts catalog it may be called the Immobiliser ECU. On the Techstream, it’s called “Immobiliser”.

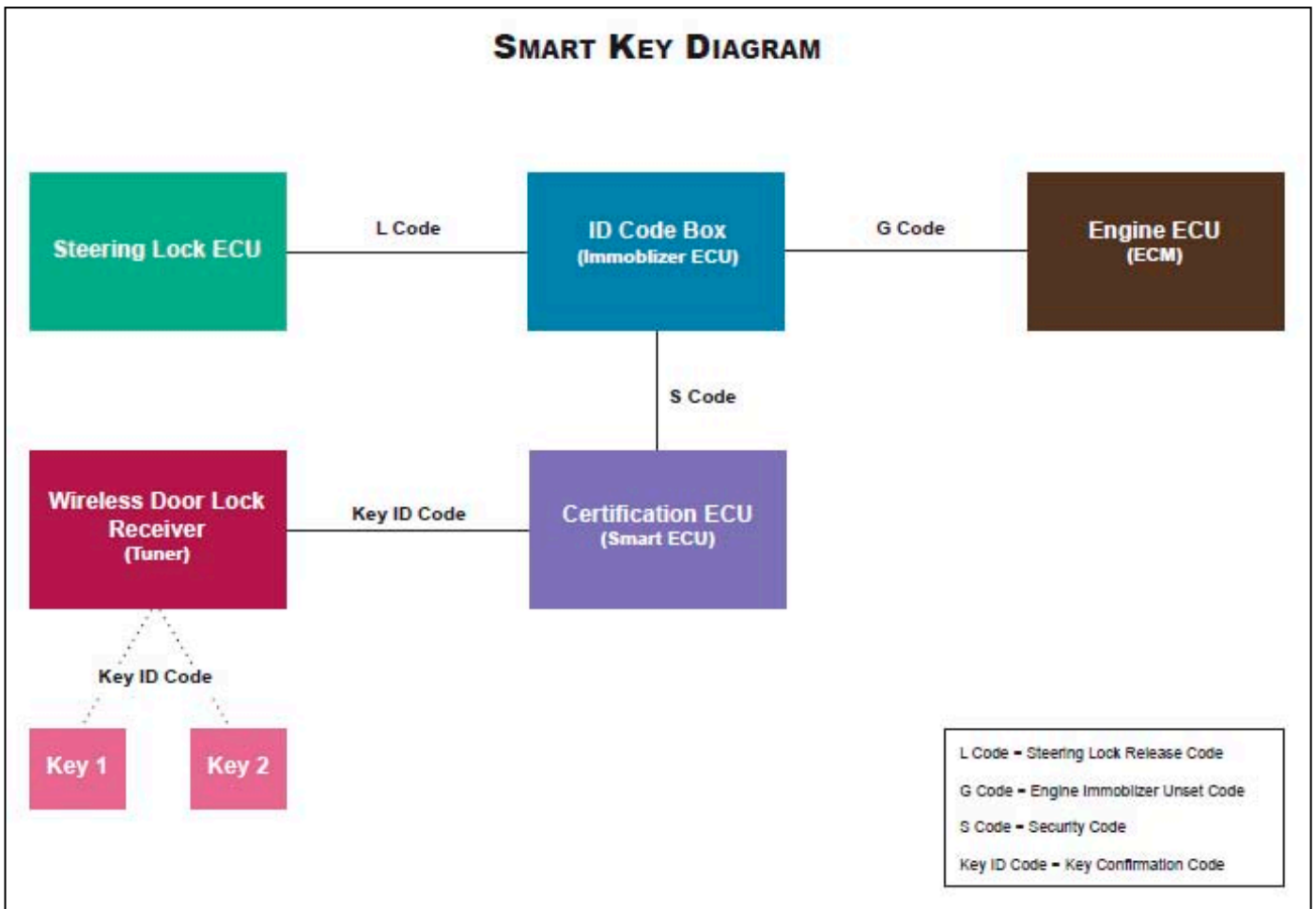
- It’s a bit confusing, but just remember that –
- Power Source ECU on Prius = Main Body ECU on Camry
 - Transponder ECU on Prius = ID Code Box on Camry = Immobiliser ECU on both

After the 2009 model year, the names (and perhaps functions) may change again. Even so, time spent learning this system will provide the building blocks for learning the next generation, even if they are not the same.

Power Source Control ECU (Prius) / Main Body ECU (Camry)

The Power Source Control ECU is described as the main output of the Smart Key system in the manual. What is it? It's like an electronically controlled ignition switch.

Instead of using a lock cylinder to control ignition switch access, the Certification ECU controls Power Source ECU access. The Certification ECU verifies the Smart Key's Vehicle ID and Key ID, and then the Certification ECU and Transponder ECU compare S codes. If they match, the Transponder ECU tells the Power Source Control ECU to allow ACC, ON, or START positions. It's important to know that even if the Power Source ECU is "hot wired", the car still cannot be started. The Immobiliser still must be satisfied in order for the car to Ready.



System diagram. (Courtesy TMC.)

ID Code Box (Camry HV) / Transponder Key ECU (Prius) / Immobiliser ECU

Think of the ID Code Box as “lock box” holding keys. Just as a traditional key is cut with a specific pattern of peaks and valleys to match a specific pattern of wafer placement in a lock cylinder, the bits of the electronic keys held in the ID Code Box must exactly match the pattern of the bits of the electronic keys held in other ECUs on the same car.

If the ID Code Box is a box containing the keys to start the car, we wouldn't want just anyone to be able to open it right? That's where the S code comes in (S is for Security). The S code is the “key” for the ID code box. If the Certification ECU has a matching S code, the ID Code box will “unlock” the other ECUs. If not, it won't and the car will remain immobile.

So lets imagine the Certification ECU has just communicated a valid S code to the ID Code box. The ID Code Box is now willing to allow its keys to unlock other ECUs. What will be unlocked?

If the car is a Camry, the steering unlocked first, then the HV ECU will be unlocked. If the car is a Prius, the HV ECU will be unlocked.

Steering Lock ECU (Camry HV only)


The Steering Lock ECU locks the steering column, thus aiding in the prevention of theft by eliminating the ability to steer the car. Here's how it works –

An L-code is stored in both the ID Code Box and the Steering Lock ECU. (L is for lock, as in steering lock). During the start-up sequence, the ID Code Box and the Steering Lock ECU compare codes and report to the Certification ECU. If the codes match, the Certification ECU tells the Main Body ECU to supply voltage to the Steering Lock ECU motor, and the lock pawl is pulled from the column. The retraction of the pawl is sensed by the Steering Lock ECU, and reported to the Certification ECU. If the steering lock retraction is not reported, the car will not “Ready” (start).

HV ECU (a component with only one name, hooray!)

The HV ECU is the primary power plant ECU. It tells the engine (ICE) when to run, when to stop, and how much power to produce. It tells the ABS ECU how to brake. It directs the charge and discharge of the HV battery after consulting with the HV Battery ECU. Perhaps most importantly, it drives the MGs (Motor/Generators) by controlling the inverter.

Without the aid of the HV ECU the car is not driving, so if you want to cripple a Prius, disabling the HV ECU is a good way to accomplish the goal.

A G-code (“go code”) is stored in both the ID Code Box (Immobilizer ECU) and the HV ECU. Once the steering lock has released (if applicable), the ID Code Box asks the HV ECU for its G-code. If it matches, the ID Code Box gives the HV ECU a start authorization and the car will Ready. 

Part 2 will offer some useful real world diagnostic strategies you'll be able to use tomorrow.