2005 CE Bus Program 2A: Full Power Brakes

Study Guide
BMT-040601

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CE Bus Program 2A: Full Power Brakes

Introduction

As we mentioned in Program One of this CE Bus Training Series, entitled Orientation, the CE Bus **Full Power Brake** system provides better pedal feel, shorter stopping distances, a powered PARKING brake system, Anti-Lock Brakes, and Traction Control. But the Full Power Brake system offers a lot more, like Electronic Brakeforce Distribution to compensate for axle loading imbalances. And it does all this with simplified, computer assisted maintenance.

"This system is unique because it doesn't use fluid pressure from the power steering pump..."

This system is unique because it doesn't use fluid pressure from the power steering pump, instead, electric pump motors pressurize nitrogen accumulators. In fact, the system works much like an air brake system except that accumulators replace the air tanks and a pump motor replaces the air compressor.

Along with this advanced brake technology and performance, comes a greater challenge with respect to servicing the system.

The following program covers complete CE Bus Full Power Brake service. It is designed to provide all the technical knowledge and skill necessary to diagnose and repair this highly advanced brake system.

This program is divided into three modules. First, Brake System Theory, Features, and Components are covered in detail. Then Brake System Modes of Operation are covered, with a focus on Anti-Lock Braking and Parking Brake operation.

Finally, Diagnostics and Repair Procedures are covered.

Once you have successfully completed this program, you will have all the information you need to properly service IC Bus Corporation's new Full Power Braking system.

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Module I THEORY & COMPONENTS

Section 1 Hydraulic Theory

Hydraulic theory is based on the principle that a liquid will not compress. If pressure is applied to a liquid in a closed system, the pressure is transmitted equally throughout the system.

Hydraulic brake systems operate with this theory.

For example, if 20 psi is applied through the master cylinder, 20 psi can be measured anywhere in the lines.

"...hydraulic principles dictate that the total amount of travel input into the system will also be transmitted equally throughout the system."

In a similar manner, hydraulic principles dictate that the total amount of travel input into the system will also be transmitted equally throughout the system.

In other words, if the master cylinder piston is moved a distance of 1 inch, all affected brake caliper pistons will move a total of 1 inch throughout the entire system–assuming all pistons are the same size as the master cylinder piston.

If the master cylinder piston is moved 1 inch, each of 4 affected brake pistons move 1/4 inch each for a total of 1 inch of wheel brake piston travel.

However, force is typically increased at the wheel by increasing the size of the brake piston.

So, doubling the size of the brake piston in comparison with the master cylinder doubles the force at the brake piston.

The trade off for twice the force in this example is that now, brake piston travel is cut in half.

In the same way, if the brake piston size is four times larger than the master cylinder piston, this translates to four times the pressure but only 1/4 the travel across the brake system pistons.

The Full Power Brake system utilizes **Bosch pin slide foundation brakes**. Although the foundation technology remains much the same, many other aspects of the Full Power Brake system are enhanced with new design features and technology.

"The Full Power Brake system utilizes Bosch pin slide foundation brakes."

Dual Circuit Design

"...primary and secondary brake systems remain separate throughout–from the master cylinder, to the rotors."

Another key principle of the Full Power Brake System is dual system design. The brake system is divided into two completely separate systems to protect against overall system failure. One master-cylinder piston and reservoir chamber is used to actuate the brakes on one axle and a separate piston and reservoir chamber actuates the brakes on the other axle. The primary system refers to the front brakes and powered parking brake while the secondary system refers to the rear brakes. Again, primary and secondary brake systems remain separate throughout–from the master cylinder, to the rotors.

Antilock Braking System (ABS)

Another basic feature of the Full Power Brake system is the **Anti-Lock Braking System** or ABS. Using microprocessor technology, the bus senses when the wheels are about to lock up during braking. Using sensors positioned at each wheel end, the brake system **Electronic Control Unit** or ECU determines which wheel has started to slow by comparing its rotational speed with the remaining wheels. To avoid an imminent lock-up condition, the ECU signals solenoid valves to reduce hydraulic pressure

at the wheel until the wheel can momentarily recover. Next the ECU signals the solenoid valves to increase hydraulic pressure at this wheel so that momentary full braking can be achieved. This entire process is repeated several times a second until there is no longer a need to modulate braking. The synchronization of this process creates a pumping or pulsing action that ultimately allows the driver to realize the optimum balance between minimum stopping distance and vehicle stability when forced into a hard and abrupt brake maneuver or when stopping on wet or slippery surfaces.

Generally, if ABS develops a malfunction, it automatically reverts to conventional hydraulic brakes. The driver is alerted that the anti-lock system is not functioning by the dash-mounted warning light. When the ABS is disengaged, wheel lockup can occur if the driver over brakes.

"Generally, if ABS develops a malfunction, it automatically reverts to conventional hydraulic brakes."

Automatic Traction Control (ATC)

Automatic Traction Control or ATC is another Full Power Brake related feature. While ABS prevents a wheel lock-up or skidding condition during deceleration of the vehicle, ATC prevents wheel slippage or traction loss during vehicle acceleration. It accomplishes this with the Full Power

"Automatic Traction Control or ATC is another Full Power Brake related feature."

Brake ECU, by monitoring wheel speed to determine if one of the rear wheels is starting to spin when compared to the non-drive wheels. When this condition is evident, the ECU signals the ATC solenoid valves to apply hydraulic pressure to the brake calipers of the spinning wheel until all the wheels are synchronized. By only applying the brakes at the slipping wheel, power is transferred from the slipping wheel to the opposite non-slipping wheel. The non-slipping wheel allows the vehicle to gain momentum and move with more traction. At the same time the ATC system flashes a dash indicator lamp to alert the driver that a wheel spin condition is occurring.

"At speeds above 31 mph, all ATC events are controlled with engine torque only–no differential braking is applied above 31 mph."

When both wheels on a powered axle start spinning at speeds below 31 mph, the ATC system works with the engine computer or ECM to reduce engine torque so that the slipping wheels can recover. At speeds above 31 mph, all ATC events are controlled with engine torque only–no differential braking is applied above 31 mph.

ATC is available with International® I-6 and VT 365 engines.

Electronic Brakeforce Distribution (EBD)

The next feature of the Full Power Brake system is **Electronic Brakeforce Distribution** or EBD. Using the ECUs microprocessing capabilities and solenoid valves already discussed with ABS, the system identifies front-to-rear wheel slip imbalances during braking due to axle loading. Then the ECU distributes braking forces in proportion to axle loading to render a balanced brake application on the vehicle.

Brake Operation Memory

Next is operational memory. Memory within the ECU circuitry maintains a record of brake system operations, such as the number of brake applications and the number of "hard to extreme" braking occurrences. These records may be used to schedule preventive maintenance more effectively and efficiently.

"Memory within the ECU circuitry maintains a record of brake system operations, such as the number of brake applications and the number of 'hard to extreme' braking occurrences."

Powered Parking Brake System

Finally, the Full Power Brake system features The **Spring Applied/ Hydraulic Release** or SAHR parking brake. It uses hydraulic pressure to release the parking brake, a mechanical spring for brake application, and

electronic control for maximum functionality and security.

Since the unit is electronically controlled, the software in the ECU can be used to provide various parking brake interlock features. An example of interlocking is **auto apply**. With this option the park brake applies automatically when PB is selected with the transmission gear selector.

"All interlock functions are covered later in this program..."

All interlock functions are covered later in this program under Full Power Parking Brake modes of operation.

With these principles and features in mind, including the laws of hydraulics, pin slide brake technology, dual system design, ABS, ATC, and EBD, let's take a look at each component in the overall Full Power Brake system.

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Section 2 Full Power Brake System Components

Brake Pedal

The driver applies mechanical pressure to the brake pedal which is transmitted through the push rod to the master cylinder.

Dual Piston Master Cylinder and Fluid Reservoir/Stop Lamp Switch and Fluid Level Sensor

"The master cylinder and brake fluid reservoir unit is mounted to the engine side of the cowl panel in front of the driver."

The **master cylinder** and **brake fluid reservoir unit** is mounted to the engine side of the cowl panel in front of the driver.

It consists of a **dual channel piston assembly**, providing separate circuits for the front and rear brakes. It also contains the **spring pack** that returns the brake pedal to the up position. The reservoir includes internal baffles to provide a protected volume of brake fluid for the master cylinder in the event of a leak in the rest of the system. An external sensor mounted to the bottom of the reservoir detects when the brake fluid level is low. The travel switch that detects brake actuation is also mounted to the master cylinder. Both the sensor and the travel switch are replaceable without draining any brake fluid.

The purpose of the master cylinder is to translate the pedal force applied by the driver into the hydraulic pilot signals that are routed to the relay valve at the underside of the **Hydraulic Compact Unit** or HCU.

Unlike earlier systems, the pressure from the master cylinder only acts as a pilot pressure signal to the HCU and is not directly plumbed to the calipers.

Hydraulic Compact Unit (HCU)

The HCU acts as the heart of the system–it is located on the inside left frame rail, behind the driver's position.

"The HCU acts as the heart of the system–it is located on the inside left frame rail, behind the driver's position."

Like the master cylinder, the HCU is divided into front and rear hydraulic fluid routing passages for the primary and secondary brake circuits. It also has separate passages for the park brake circuits. The components located to the front of the HCU service the rear axle while the components to the rear service the front axle. However, the tubes feeding the front axle circuits are connected to the front and the rear axle circuits are fed by the tubes connected to the rear. For safety, two pressure relief valves are included to protect against overpressure.

Although there are two circuits, the electronically controlled ABS valves of

the HCU allow independent control of braking force at each of the four wheels.

Relay Valve

First, a dual circuit **relay valve** assembly is located at the bottom of the HCU. This valve receives signals from the primary and secondary hydraulic lines coming from the master cylinder. Then, proportionately it routes brake fluid from pressurized accumulator circuits to the wheel ends. It also connects the wheel ends to the reservoir when not braking.

"The relay valve is also actuated by the ATC valves during an ATC event."

The relay valve is also actuated by the ATC valves during an ATC event.

HCU Reservoir

The HCU also includes its own brake fluid reservoir. It is connected to the master cylinder reservoir through a low pressure gravity feed hose allowing both reservoirs to be filled from the master cylinder location. This reservoir assures that the pump motors and accumulators have a ready supply of brake fluid.

Again, it is divided into two channels with a baffle. The front half of the reservoir supplies the rear axle through one port while the rear half of the HCU reservoir supplies the front axle through another port.

Dual Accumulators

Both the front and rear brake circuits have their own accumulator with a pressure transducer. The accumulators are energy storage devices, with a lifetime charge of nitrogen on one side of a rubber membrane and brake fluid on the other side. The accumulator pre-charge enables a high number of reserve stops.

The factory nitrogen pre-charge is 1087 psi.

"The factory nitrogen pre-charge is 1087 psi."

The brake fluid under pressure in the accumulators is the force used to stop the vehicle, much in the same manner that compressed air in the air tanks is the force used in air brake systems.

Dual Electric Motors

The system also includes two independent electric pump motors, one for the front brakes and one for the rear brakes. Each pump motor is fused by a battery-powered 30A maxi-fuse located on the outside of the cowl panel.

"These motors drive pumps that charge the accumulators with brake fluid to maintain pressures between 1770 and 2320 psi during normal operation."

These motors drive pumps that charge the accumulators with brake fluid to maintain pressures between 1770 and 2320 psi during normal operation. The motors are controlled by the ECU based on readings from fluid pressure switches in the HCU.

Electronic Control Unit (ECU)

Next, is the ECU. It's the brain of the Full Power Brake system.

It contains the electronic hardware necessary to control the system. It provides all of the electronic control required for normal braking, ABS operation, ATC operation, EBD, and park brake operation. It also contains memory to store braking operational records and diagnostic trouble codes.

Also, the ECU interfaces with the other brake system components, as well as the vehicle electrical system through waterproof connectors. The 2-pin and 31-pin connectors are part of the ECU housing. The ECU also supplies electric power to the two pump motors.

The ECU is bolted to the non-frame-rail-side of the HCU.

Electronic System Controller (ESC)

The ECU receives certain information from the vehicle **Electronic System Controller** or ESC, which is mounted to the inside of the cowl, behind the instrument panel. Also, to turn on warning and status indicators, the ECU must communicate with the gauge cluster through the ESC.

"The ECU receives certain information from the vehicle Electronic System Controller or ESC, which is mounted to the inside of the cowl, behind the instrument panel."

Ten ABS/ATC Solenoid Control Valves

The ECU is mounted directly over ten solenoid valves and two pressure-sensing switches. Of these ten valves, eight are used to control the brakes in an ABS event. One ABS inlet valve and one ABS outlet valve per wheel.

Two ATC solenoid valves work in conjunction with the ABS valves to control the brake fluid pressure to each wheel during an ATC event.

In addition to the solenoid control valves, two pressure sensing switches monitor the pressures in the front and rear brake systems and will, when necessary, turn the pump motors on or off.

Brake Lines

Next, steel brake lines and flexible high pressure rubber hoses connect the HCU to the calipers.

"Calipers, brake pads, and rotors, provide the friction forces needed to bring the vehicle to a stop."

Calipers, Pads, Rotors, and ABS Sensors

Calipers, brake pads, and rotors, provide the friction forces needed to bring the vehicle to a stop. Again, the CE Bus features Bosch pin slide foundation brakes.

The ABS magnetic coil/pickup sensors provide wheel speed and position information to the ECU for ABS, EBD and ATC events. Keep in mind that broken or missing tone wheel teeth or corrosion between the teeth can cause inaccurate wheel speed signals.

Calipers, brake pads, rotors, and sensors are covered in detail in the International® Diamondlife™ Disc Brake training series.

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SAHR Powered Parking Brake System

Section 3

Overview

The Spring Applied/Hydraulic Release parking brake uses hydraulic pressure from the HCU to release the brake. It is a combination of mechanical, hydraulic, and electronic assemblies.

"The Spring Applied/Hydraulic Release parking brake uses hydraulic pressure from the HCU to release the brake."

The SAHR parking brake system is made up of the following components:

The **Pressure Supply Valve** or PSV, the SAHR Canister, brake cable, brake drum assembly, and brake switch.

Pressure Supply Valve (PSV)

The pressure supply valve is an electrically activated valve that allows pressurized brake fluid to enter or exit the SAHR canister as controlled by the ECU. The PSV is located on the HCU assembly.

Parking Brake Switch

The **parking brake switch** controls the pressure supply valve and is mounted near the center of the dash. A unique feature of the switch it that it has a neutral position. The vehicle operator must let go of the yellow

knob immediately upon application or release of the parking brake. The knob automatically returns to its middle or neutral position. If the switch is held in or out for more than 16 seconds, a fault code is generated.

Parking Brake Cable

The **parking brake cable** is a two-piece cable that connects the SAHR canister on the inside of the left frame rail, just ahead of the rear axle and the parking brake drum assembly, where the driveshaft connects to the rear axle. The cable adjustment point is at the rear of the SAHR canister.

"If the event of a failure that causes the parking brake to default to the ON position, the parking brake cable must be disconnected before the vehicle can be towed."

If the event of a failure that causes the parking brake to default to the ON position, the parking brake cable must be disconnected before the vehicle can be towed. Related to this, the SAHR canister must be bled if the parking brake cable is disconnected for any reason.

SAHR Canister

The **SAHR canister** is the main component of the powered parking brake system. It includes a cutoff valve that works with the PSV. Together, these valves control the release or application of the parking brake.

When the dash mounted parking brake switch is pressed, the SAHR canister becomes pressurized with brake fluid. This pressurized fluid causes the piston and shaft to move rearward and compress the two internal springs behind the piston, releasing the parking brake.

When the driver pulls the parking brake switch to apply the parking brake, the SAHR Canister is depressurized and the brake fluid is dumped back into the HCU reservoir. The two springs decompress and apply the parking brake.

"When the driver pulls the parking brake switch to apply the parking brake, the SAHR Canister is depressurized and the brake fluid is dumped back into the HCU reservoir."

The system has a safety function to ensure the parking brake is available if the coil or valve fails. Since this cut off valve is normally open, any problem causes the valve to default to its open position. Consequently, the PSV now acts as a back-up valve for controlling the SAHR canister, until the cut off valve problem is corrected. The driver is notified of this fault by a continuous

Service Park Brake Warning Light in the gauge cluster.

If both the cut off valve and the PSV fail, the SAHR canister defaults to the applied mode and remains applied until the problem is corrected.

"It is important to note that prior to towing the vehicle, the parking brake cable must be disconnected from the SAHR assembly."

It is important to note that prior to towing the vehicle, the parking brake cable must be disconnected from the SAHR assembly. If this is not possible, an alternative is to pull both the axle shafts before towing the bus.

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Electronic Gauge Cluster Warning Lights

Section 4

Overview

Six instrument cluster warning lights provide feedback to the driver concerning the operation and condition of both the brake and the ATC systems based on continuous ECU monitoring. Five of the indicators identify conditions that may require service. If a lit indicator is the result of a malfunction, diagnostic codes identifying the source will be stored in the ECU. Retrieval of the diagnostic codes is explained later in this program.

The warning lights that make up the system include, brake pressure, master cylinder fluid level, ABS, parking brake, service parking brake, and ATC.

"The warning lights that make up the system include, brake pressure, master cylinder fluid level, ABS, parking brake, service parking brake, and ATC."

Keep in mind that these lights are all tested during initial key on. Also, all of these indicators, except parking brake position, illuminate when a fault is detected by the ECU. They are programmed through the ESC and operate based on inputs from the ECU.

Brake Pressure

"The red brake pressure warning light indicates a low pressure condition if one of the two brake circuits is failing."

The **red brake pressure warning light** indicates a low pressure condition if one of the two brake circuits is failing. A continuous brake pressure warning light, referred to as a level 1 warning, is followed by a warning buzzer.

A flashing brake pressure warning light, referred to as a level 2 warning, means that both the primary and secondary circuits are experiencing this fault. The warning buzzer also sounds. The driver should pull the vehicle to the side of the road as soon as safely possible. Once the vehicle speed drops below 25 mph, engine limiting will limit the vehicle speed to 25 mph. Once the bus is stopped during this warning, the powered parking brake will automatically engage.

In addition, if the fault is detected in the front brake circuit or there is a fault in both circuits the driver will not be able to release the parking brake with the dash mounted switch until the low pressure problem is repaired and the ignition is cycled. And, as already stated in this program, before the bus can be towed under this warning, the SAHR canister must be disconnected or the axle shafts must be pulled.

Fluid Level

The **fluid level sensor and switch assembly** is located in the bottom of the master cylinder reservoir and signals the ECU when the brake fluid is below the Minimum mark at the front of the reservoir. The ECU then commands the red Fluid Level Warning light to illuminate continuously until fluid is added to the appropriate level.

"FULL POWER BRAKE FACT: A fault is detected by the ECU when pressure falls below 1550 psi. The normal operating range is 1770-2300 psi for both the primary and secondary brake circuits."

ABS Warning

The amber **ABS warning light** indicates a fault or an ABS event when it is continuously lit. Some fault conditions include:

- The Full Power Brake system ECU is not receiving power.
- The wheel speed sensors are too far away from the tone ring, the sensors are non-approved, or, the sensors are sending no signal at all.
- The ABS solenoid valves aren'tfunctioning properly.
- The ECU has determined that the voltage and current draw across the solenoid valves are out of range.
- Or, there is a loss of communication between the ECU and ESC.

Park Brake

The **red parking brake dash light** illuminates continuously when the brake is applied. Again, this is the only instrument cluster light related to the brake system that doesn't indicate a fault.

Service Park Brake

"The red service park brake light illuminates continuously when the ECU identifies a problem within the powered parking brake system."

The **red service park brake light** illuminates continuously when the ECU identifies a problem within the powered parking brake system.

For example, this light comes on when the parking brake cable has under-traveled, over-traveled, or when it has failed to travel at all. Cable travel is determined by the travel switch mounted on the SAHR canister. These under-travel or over-travel conditions can be caused by a worn or mis-adjusted parking brake drum assembly. They can also be caused by a broken, worn, or stretched brake cable.

The service park brake light also illuminates if the ECU detects a voltage or current problem with either the travel switch or the cut-off coil, mounted to the SAHR Canister, and the pressure supply coil, mounted to the HCU.

Coil problems have fault code assignments. It is best to replace the coil if a fault code is generated, indicating that it is either open, shorted, or has abnormal voltage.

"Coil problems have fault code assignments. It is best to replace the coil if a fault code is generated, indicating that it is either open, shorted, or has abnormal voltage."

Automatic Traction Control Indicator Light

The **Automatic Traction Control dash light** illuminates when there is a fault with the ATC circuits or when the bus is experiencing an ATC event.

When the ATC switch is set to the MUD/SNOW position, normal traction control is disabled and replaced with the mud and snow mode. With the switch in this position it is illuminated and the ATC dash light flashes. The mud and snow mode is also known as a reduced sensitivity mode, allowing for more wheel slippage before an ATC event.

In terms of faults, the traction control warning light illuminates when the ECU detects a problem with:

- The two rear wheel speed sensors.
- The two ATC solenoids.
- The two ABS solenoids that serve. the rear brakes.
- The ATC lamp function.
- The ATC switch.
- Or, the power circuits to the solenoids.

Fault retrieval will be covered later in this program.

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Module II MODES OF OPERATION

"Before performing diagnostics, it's a good idea to understand the different brake system modes of operation..."

Before performing diagnostics, it's a good idea to understand the different brake system modes of operation: normal braking, ABS braking, and Automatic Traction Control. Also, the Electronic Brakeforce Distribution mode may occur. In addition, there are a variety of Full Power Parking Brake operational conditions and Interlocks. In general, the ECU monitors the wheel speed sensors and other system parameters to determine which operational mode is necessary. It is important to note that the relay valves are hydraulically controlled while all other valves are electronically controlled solenoid valves. This portion of the program elaborates on each normal, ABS, ATC, and parking brake mode.

Section 1 Brakes Not Applied

First, let's discuss the normal modes.

"...the brake system is divided into two circuits: the primary circuit controls the front axle and the secondary circuit controls the rear axle."

To review, the brake system is divided into two circuits: the primary circuit controls the front axle and the secondary circuit controls the rear axle. The motor driven pumps maintain pressure in the accumulators where it is stored to provide braking energy. The pressure is maintained between 1770 psi and 2320 psi.

Without the brakes applied all of the solenoid valves are in their non-energized state. The only pressurized brake fluid is between the pump outlets and the relay valves. The state of the relay valves blocks the pressurized brake fluid from the rest of the system.

Since the ABS solenoid valves still remain in their normal positions, un-pressurized brake fluid flows back from the brake calipers past these ABS and relay valves until it dumps into two return ports of the HCU reservoir.

Normal Braking Mode

The second normal mode is when the brakes are applied. When the brake pedal is pressed, two "pilot signals" are sent from the master cylinder through the primary and secondary lines to the HCU relay valve. As already mentioned, these two hydraulic lines are dead-headed at the HCU relay valve. The fluid in these lines applies pressure to the relay valves, but doesn't flow into the HCU.

In response to these pilot signals, the relay valves route pressurized brake fluid from the accumulators through the "normally open" ABS inlet valve at each wheel end and is contained by the normally closed ABS outlet valve.

Section 2

"When the brake pedal is pressed, two 'pilot signals' are sent from the master cylinder through the primary and secondary lines to the HCU relay valve."

The relay valves are designed to apply braking pressure to the wheel end calipers in proportion to the strength of the pilot signals generated by the master cylinder.

When the brake pedal is released, the relay valve moves to block the flow of pressurized brake fluid from the accumulators.

Then, the pressurized brake fluid in the calipers is allowed to return to the HCU reservoir through the open ABS inlet valve and a portion of the relay valve.

Section 3 Antilock (ABS) Braking Mode

The ABS braking mode may begin during normal braking mode when the ECU determines that a wheel is about to lock up.

"During braking, in addition to monitoring the master cylinder travel switch, the ECU monitors the wheel speed sensors located at each of the four wheel ends."

During braking, in addition to monitoring the master cylinder travel switch, the ECU monitors the wheel speed sensors located at each of the four wheel ends. An ABS event occurs when the brake pedal is pressed and the ECU determines, from the sensor signals, that a wheel is about to lock up.

During an ABS event the ECU controls ABS operation by energizing

and de-energizing the solenoid controlled valves that route the brake fluid to the wheel end calipers. The valve coils are contained in the ECU assembly, while the valve cores are part of the HCU assembly. The wheels can enter the ABS mode independently. If only one wheel is starting to lock up, it will operate in the ABS mode while the other 3 wheels continue to operate in the normal braking mode.

While in the ABS mode, the ECU adjusts the brakeforce by electronically cycling through 3 ABS states several times per second. This prevents any wheel from locking, and, at the same time, maximizes brakeforce by modulating brake pressure.

The 3 ABS states are: Decrease Pressure, Hold, and Increase Pressure.

"The 3 ABS states are: Decrease Pressure, Hold, and Increase Pressure."

Once in the ABS mode, the system remains in ABS mode until either the brake pedal is released, as indicated by the master cylinder travel switch or when the wheel speed sensors no longer indicate a probable lock up.

In the first state of an ABS event, the ECU enters **Decrease Pressure**. In this state the ECU closes the ABS inlet valve and opens the ABS outlet valve for the affected wheel.

This action decreases the brake fluid pressure applied to the wheel caliper, allowing the wheel to recover and continue rotating.

The closed ABS inlet valve isolates the caliper from the pressurized brake fluid in the accumulator. The open outlet valve allows the pressurized brake fluid in the caliper to return to the HCU reservoir.

Once the skidding wheel approaches recovery, the ECU initiates either the ABS Hold state or the ABS Increase pressure state, or a combination depending on the dynamics of the ABS event.

"In the ABS Hold state the ECU keeps the "normally open" ABS inlet valve closed for the affected wheel and allows the ABS outlet valve to return to it's normally closed state."

In the ABS **Hold** state the ECU keeps the "normally open" ABS inlet valve closed for the affected wheel and allows the ABS outlet valve to return to it's normally closed state.

The ABS Hold state is initiated during an ABS event when the ECU determines that the brake pressure is optimum in terms of delivering the ideal balance between braking force and available stopping traction.

With both the ABS inlet and outlet valves closed, brake fluid pressure remains constant during the length of the hold state.

The ABS **Increase Pressure** state places both the inlet and outlet ABS valves in their normal states–the inlet is open and the outlet is closed.

The ABS Increase Pressure state is initiated during an ABS event when the ECU determines that brake force is not optimized in comparison with available stopping traction.

With the inlet valve open and the outlet valve closed, the brake fluid pressure applied to the wheel caliper increases according to the pressure placed on the brake pedal. Brakeforce is allowed to increase since lock up has been prevented and traction has been restored with either a previous Decrease Pressure state or a Hold state or both.

"Brakeforce is allowed to increase since lock up has been prevented and traction has been restored with either a previous Decrease Pressure state or a Hold state or both."

Again, these states: Decrease pressure, Hold, and Increase pressure are cycled many times a second by the ECU and continue until the vehicle has come to a complete stop or the brake pedal has returned to its up position. At this point, the Full Power Brake system returns to its normal braking mode.

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Section 4 ATC Modes

Now let's move to ATC Modes. The ATC system includes an ATC inlet valve and an ATC outlet valve. More specifically, the ATC inlet valve provides a second hydraulic input to the relay valves.

These two valves are situated in the HCU and work with the two rear ABS inlet valves and the two rear ABS outlet valves to restore traction.

"When the system is in the ATC inactive mode, the brake pedal is in the up position, which is the same as the normal: brakes not applied mode."

When the system is in the ATC **inactive mode**, the brake pedal is in the up position, which is the same as the "normal: brakes not applied" mode.

With the brake pedal still in the up position, the system enters into the ATC **active mode** when the ECU determines a rear wheel is starting to spin or lose traction and the traction control switch is in the TRAC CTRL position.

For illustration purposes, let's assume that the right wheel is in a no traction mode below 31 mph.

As the right rear wheel begins to lose traction, the signal generated by its wheel sensor indicates the slippage to the ECU. When the ATC event is

sensed by the ECU, it switches the states of the ATC valves and the ABS inlet and outlet valves to correct the traction problem.

With the ATC inlet valve now in the open state, and the ATC outlet valve in the closed state, the pressurized brake fluid is routed from the primary accumulator to the relay valves. The relay valves respond by applying pressurized brake fluid from the accumulator to the ABS inlet valves for the wheels. With only the right rear wheel slipping, the ABS inlet valve for the left rear wheel and both front wheels are closed by the ECU. Meanwhile the ABS inlet and outlet valves for the right rear wheel modulate to provide brake pressure.

"With the ATC inlet valve now in the open state, and the ATC outlet valve in the closed state, the pressurized brake fluid is routed from the primary accumulator to the relay valves."

In this condition, pressurized brake fluid is routed only to the right rear wheel where it applies braking force to the slipping wheel. Since the differential tends to drive the wheel that presents the least resistance, more of the driving forces are shifted to the left rear wheel. When the ECU no longer senses any wheel slippage, the ATC and ABS valves are returned to their normal positions.

At the same time, the ATC light flashes in the instrument cluster and the TRAC CTRL illuminates to alert the driver that a wheel spin condition is occurring.

"If both rear axle wheels are spinning the engine control module intervenes by reducing the engine torque."

If both rear axle wheels are spinning, the engine control module intervenes by reducing the engine torque. Over 31 mph, no differential braking occurs–ATC events are controlled with engine torque only.

The position of the dash mounted ATC switch is evaluated by the brake system ECU to control the sensitivity of ATC operation. Again, the ATC system is in the normal mode when the switch is moved to the TRAC CTRL position.

When the ATC switch is set to the MUD/SNOW position, the normal traction control feature is disabled and replaced with a mud and snow mode. This mud and snow mode is also know as a "reduced sensitivity" mode allowing a greater amount of wheel slippage in poor traction situations. As described earlier, when in the mud and snow mode, the indicator on the switch will be lit and the TRAC CTRL indicator in the gauge cluster will be flashing.

If at any time, the brake travel switch is actuated, then ATC is terminated.

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Powered Parking Brake Interlocks

The Full Power Brake system in conjunction with the vehicle ESC can provide additional safety features. These features are referred to as **interlocks**.

One example is key switch interlock. The parking brake applies automatically when the key is turned off and cannot be released until the key is turned on. If the key is turned off while driving, the park brake is prevented from applying until vehicle speed is less than 2 mph.

The second interlock feature is dynamic park brake apply protection. When the parking brake switch is pulled with the vehicle in motion, the HCU is used to apply the rear service brakes. The vehicle stops quickly and under control, without sudden brake application. After the vehicle has slowed to less than 2 mph, the driveline park brake is applied. Since the service brakes are applied initially in lieu of the driveline brake, the stop is under ABS control, preventing rear wheel lock-up.

This feature helps reduce premature wear and damage to the driveline brake caused by applying the parking brake before the vehicle is completely stopped.

Section 5

"The Full Power Brake system in conjunction with the vehicle ESC can provide additional safety features. These features are referred to as interlocks."

Another interlock is engine control. Engine intervention is used to prevent the operator from driving against parking brake application. Engine torque is reduced when the parking brake is applied, again to reduce premature wear to the driveline brake.

Next is **travel switch interlock**. The travel switch on the SAHR canister and circuitry in the ECU identify actuation of the parking brake and malfunctions in the parking brake circuit. Problems such as a broken parking brake cable cause the brake to remain applied.

"The final example of interlocking is the optional auto-apply feature."

The final example of interlocking is the optional **auto-apply** feature. It is available with automatic transmissions and automatically activates the parking brake when PB is selected with the shifter. It eliminates the need for a parking pawl in the transmission.

Auto apply interlocks also occur in the event of certain system faults:

- A loss of pressure in the primary brake circuit.
- A complete loss of system electrical power, with no power from either the battery or the alternator.
- An erroneous electrical signal, such as a false brake signal.

- And a park brake hydraulic circuit failure, such as something in the fluid circuit that prevents pressurization of the SAHR canister.

To release the parking brake:

- The key must be in the On position.
- The brake pedal must be depressed.
- If equipped, the wheelchair lift must be properly stowed.
- And, the transmission selector must be out of the PB mode.

Faults that will cause the parking brake to stay applied are:

- A parking brake switch electrical circuit fault.
- A loss of pressure in the primary circuit.
- A broken parking brake cable.
- A defective pressure supply valve (PSV).
- Or, the presence of active faults.

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Module III DIAGNOSTICS & REPAIR PROCEDURES

Section 1 Using Wabco Toolbox™ Software

This system, unlike other computer driven vehicle and engine systems, doesn't display fault codes on the instrument cluster.

"The Wabco Toolbox™ software is a PC-based diagnostic program that is used to retrieve faults that have been logged by the ECU in the Full Power Brake system."

The Wabco Toolbox™ software is a PC-based diagnostic program that is used to retrieve faults that have been logged by the ECU in the Full Power Brake system.

The software also provides repair instructions to fix any faults on the same computer screen.

The Toolbox also reports specific operating condition information, performs tests on individual components, and programs the ECU during a replacement procedure.

Viewing this data along with the fault code information provides a distinct advantage during Full Power Brake diagnostics.

It also allows the vehicle maintainer to schedule service intervals based

upon the number of cycles for the various components, such as the number of times the powered parking brake has been applied or the number of times the ignition switch has been cycled.

None of these functions can be accessed via the vehicle odometer display. Therefore, the Meritor® Wabco Toolbox™ software is required to do any service work on the CE Bus brake system.

The Meritor® Wabco Toolbox™ software user's manual is available on line at www.meritorwabco.com. Click on the link for Toolbox software, then the user's manual link.

"The Meritor® Wabco Toolbox™ software user's manual is available on line at www.meritorwabco.com."

Connect the EZ Tech® to the vehicle data port using EZ Tech® Link or a J1708 diagnostic cable.

Navigate to the Wabco Toolbox™ software.

Click the HABS icon on the toolbar.

Turn the ignition to the On position. The information from the ECU of the Full Power Brake system should appear in the corresponding boxes of this screen. The menu bar and toolbar, at the top of the screen, gives you access to all Toolbox functions.

These functions allow you to gather information regarding repair, operational conditions, and programming of the Full Power Brake system.

"If you aren't sure of the purpose of each icon, slide your pointer over them and a message appears explaining their functions."

If you aren't sure of the purpose of each icon, slide your pointer over them and a message appears explaining their functions.

Click the ABS icon on the toolbar to retrieve any faults that have been logged by the ECU.

The **Fault Information** window appears. This window provides a description of each fault, whether thy are active or inactive, and related repair instructions appear at the bottom of the screen.

In addition, you can clear, save, and update information within this screen.

Next, click the **Display** option on the menu to find information about the driving or vocational conditions of the vehicle. A menu bar drops down allowing you to click on the **Counters** option.

The **HPB Counters** screen appears.

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Shop Safety

Before beginning work on the Full Power Brake system, keep in mind that this is a sophisticated and complex, computer driven brake system that uses state-of-the-art components. Be sure that the procedures shown in this training program are followed precisely.

Also keep in mind that safety and environmental concerns are critical.

With regard to safety, be sure to follow each warning, caution, and note as they are presented throughout this training series.

Warnings indicate procedures and safety measures that must be followed precisely to avoid personal injury to yourself or other shop personnel and to avoid damage to the vehicle, equipment, or components.

Cautions indicate a procedure that you must follow exactly to avoid equipment or component damage.

Notes indicate operations, procedures, or instructions that are important for proper and efficient brake service.

Section 2

"With regard to safety, be sure to follow each warning, caution, and note as they are presented throughout this training series."

Handle HCUs and spare parts with care and attention.

Don't use compressed air to blow out hydraulic ports before installation on the vehicle.

"Don't allow brake fluid to come into contact with your eyes or skin."

Don't allow brake fluid to come into contact with your eyes or skin.

Before working on the brake system, thoroughly clean all bleeder screws and the master cylinder cap. Only used new DOT 3 or DOT 4 specified brake fluid from a sealed container to refill the system and to lubricate parts. Refer to ISIS® for the proper fluid specification.

⚠ WARNING:

Don't allow brake fluid to contaminate brake pads. Brake fluid contamination on brake pads could result in reduced braking which could result in property damage, personal injury or death.

Use extreme caution when handling brake fluid. Brake fluid is corrosive and damaging to painted surfaces.

During bleeding procedures, the brake fluid level must not fall below the "MIN" mark on the master cylinder reservoir.

After completing all desired brake service, test the brakes for function and inspect the system thoroughly for leaks.

Perform service inside a well ventilated dry shop. Make sure the vehicle is parked on a flat surface, with the parking brake set and the wheels blocked.

The ATC system CANNOT be disabled by placing the dash mounted switch in the “MUD/SNOW” position. The ATC system can be TEMPORARILY disabled using Toolbox software. Use extreme caution. When the ATC system is disabled using Toolbox software, it will remain disabled only until the next ignition cycle. The Toolbox screen indicates when the ATC function is disabled.

Failure to follow this warning could result in property damage, personal injury or death.

When working on the brake system, keep the work area and tools as clean as possible. Also, clean all connections or fittings before disconnecting or removing components. Use a suitable pan to catch any fluid when disconnecting components.

All openings should be immediately plugged during removal and remain so until re-installation to prevent the entry of dirt, and other foreign material and to prevent unnecessary loss of fluid.

Wear safety glasses when performing work of any kind. Also wear nitril gloves when working with fluids.

“Failure to follow this warning could result in property damage, personal injury or death.”

WARNING:

While servicing an ATC equipped vehicle, the ATC system MUST BE DISABLED before operating the vehicle with only one drive wheel lifted off the ground. Performing this operation on a vehicle with an active ATC system may result in the vehicle moving and falling from the jack stand as power will be transferred to the wheel that is still on the ground.

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Section 3 Required Tools

CE Bus service requires basic hand tools as well as the following special tools and supplies:

- The EZ-Tech®
- The EZ Tech® Link or interface cable
- One Master Cylinder cap adapter
- Calibrated torque wrenches
- One clean graduated glass or plastic bottle or receptacle
- One transparent rubber or plastic bleed hose
- A suitable crow's foot adapter to torque bleeder screws and break lines
- Sufficient supply of new DOT 3 or DOT 4 brake fluid from a sealedcontainer
- And, a steel band clamp wrench

In addition, pressurized fill and bleed equipment is required. Any of the following three types may be used:

"...pressurized fill and bleed equipment is required..."

1. **Fluid over fluid**. This type provides brake fluid under pressure from an external tank to the master cylinder reservoir. Shop air is used to pressurize the bleeder tank.

   Keep in mind that the following procedure must always be followed when using a fluid over fluid pressure bleeder.

   Check that the pressure bleeder has an adequate supply of brake fluid.

   "Check that the pressure bleeder has an adequate supply of brake fluid."

   Pressurize the unit to 14-22 psi and bleed any air from the unit.

   Connect the cap adaptor to the master cylinder reservoir.

2. **Air over fluid**. This type pressurizes the master cylinder reservoir with clean, dry, regulated shop air

   This pressurization method uses the reservoir cap adaptor, an inline, automotive, disposable, spray gun filter, and an in-line air regulator.

"Keep in mind that the following procedure must always be followed when using this dry nitrogen over fluid method."

Keep in mind that the following procedure must always be followed when using this air over fluid method.

Connect the disposable spray gun filter to the reservoir cap adaptor.

Connect the cap adaptor to the master cylinder reservoir.

Connect the inline air regulator to the disposable spray gun filter, and adjust the pressure to 14-22 psi.

3. **Dry nitrogen over fluid**. This type pressurizes the master cylinder reservoir with regulated dry nitrogen.

   Keep in mind that the following procedure must always be followed when using this dry nitrogen over fluid method.

   Connect the cap adaptor to the master cylinder reservoir.

   Connect the dry nitrogen hose to the reservoir cap adaptor, and adjust the pressure to 14-22 psi.

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Section 4 Common Service Repair Procedures

⚠ WARNING:

Opening brake system circuits for service means the brake system must be fully depressurized. Also, many parking brake service procedures require that the parking brake must be fully disengaged. For this reason, always perform brake service on a level surface with the wheels blocked using wheel chocks.

⚠ WARNING:

The Full Power Brake system is a pressurized system that reaches more than 2300 psi. This pressure is not reduced when the ignition is turned to the off position. Fully depressurize the system before servicing the brakes. Failure to depressurize the system may result in serious personal injury or death.

Any time a Full Power Brake system circuit must be opened for service, it must be fully depressurized first. Then, a bleeding process must be performed to complete the repair. Since these procedures are a vital part of almost every Full Power Brake repair, they are covered first. Then, as each repair process is outlined, we refer back to these essential procedures.

Also, any time accumulators are replaced as a part of brake service, a special depressurization and disposal procedure must be performed. Because of the importance of this procedure, it is also covered first.

System Depressurization

Start by removing the two brake system pump motor 30 amp fuses in the fuse panel located on the engine side of the cowl.

Connect the EZ-Tech® and open the Toolbox program.

Turn the key to the On position.

Depressurize the system by depressing the brake pedal a minimum

of 30 times. Use Toolbox to verify that the pressure at both accumulators is at O psi.

Disconnect the battery and ECM negative cable.

The system is now ready for servicing.

Pressure Bleeding Procedure

The following pressure-bleed procedure is required anytime the master cylinder circuit, the HCU-to-caliper-and-SAHR circuit, or the SAHR circuit alone is opened. Brake pedal bleeding is an unacceptable technique with the CE Bus Full Power Brake system.

If the master cylinder or master cylinder reservoir is replaced, then both circuits of the master cylinder must be bled by opening the bleeder screws at the HCU relay valve.

If the HCU or the HCU reservoir is replaced, then the entire system must be bled.

In this case, you must bleed the master cylinder circuit first. Then, you must bleed the calipers starting with the longest circuit from the HCU assembly and finishing with the shortest circuit.

NOTE:

If the SAHR parking brake circuit is to be bled as part of service, the parking brake cable must be disconnected. This ensures that the SAHR piston achieves a full stroke and forces most of the fluid volume out of the SAHR canister to move any trapped air into the bleeder screw area. If the SAHR canister is operable, this should be done before depressurizing the system.

WARNING:

Failure to properly bleed the system whenever any hydraulic system fitting is loosened or disconnected will allow air to remain in the system. Air in hydraulic lines will greatly reduce the pressure available for braking. This can increase vehicle stopping distance which could result in property damage, personal injury or death.

⚠ CAUTION:

Prior to working on the braking system, all bleeder screws and the master cylinder cap must be cleaned thoroughly. Cleanliness of fluid and areas around the service points has to be maintained. Don't use mineral oil-based fluid for cleaning. Mineral oil-based fluid can contaminate brake fluid and could damage the interior of the components and cause a system malfunction.

NOTE:

Cover all electrical connectors near the bleeder screws to make absolutely certain no brake fluid enters the terminals or plugs.

Then you must bleed the SAHR circuit. If only the SAHR or the PSV is replaced, then the SAHR circuit must be bled at the SAHR bleeder screw.

Any time the HCU or the HCU reservoir is replaced or the SAHR circuit is to be bled you must follow the cable disconnect procedure.

With the wheels blocked, place the transmission in PB or Neutral and turn the key to OFF.

Then, using a 15 mm wrench to hold the SAHR canister shaft, loosen the jam nut on the threaded rod with a 16 mm wrench.

While using the 15 mm wrench to hold the canister shaft, unscrew the threaded rod using an 8 mm wrench. The rod must be loosened approximately 2.5 inches before the cable disconnects. The cable will exhibit some resistance while being loosened because it is under tension.

Next, pressurize the unit. For demonstration purposes, we will use the fluid over fluid method. As a reminder, the air over fluid and nitrogen over fluid options are also appropriate methods.

Connect the reservoir cap adaptor to the master cylinder reservoir.

Maintain a pressure in the bleeder of 14-22 psi. Fit a hose onto the bleeder screw and submerge the free end of the hose into the bleed bottle.

"Maintain a pressure in the bleeder of 14-22 psi."

Open the bleeder screw until the fluid begins to flow. After draining a minimum of 8.5 ounces of fluid, check the stream for air bubbles. When no further air bubbles are observed, close the screw.

Remove the bleeder hose and torque the bleeder screw. Refer to ISIS® for the appropriate torque specification.

Release the pressure from the brake bleeder unit.

Remove the bleeder equipment from the master cylinder reservoir.

Check to make sure that the fluid in the reservoir is between the "MIN" and the "MAX" mark.

Reinstall the master cylinder reservoir cap.

Reconnect the batteries.

Reinstall the two pump motor fuses.

Turn the ignition On. The HCU pump motors will start running for about 45 seconds. This will fill the accumulators and pressurize the system.

"If the HCU pump motors fail to deliver a sufficient amount of fluid, the ECU will control the HCU pump motors in a self priming procedure."

If the HCU pump motors fail to deliver a sufficient amount of fluid, the ECU will control the HCU pump motors in a self priming procedure. In this case, the HCU pump motors should stop within 3 minutes, with the brake warning light and buzzer OFF.

If this is not the case, repeat the system bleeding procedure.

When the pump motors stop running, pump the brakes rapidly 4 times to activate both pump motors. After both motors stop running, turn the key off. Verify that the brake fluid level in the master cylinder reservoir is between the "MIN" and "MAX" mark.

Once again remove the two brake pump motor 30 amp fuses.

Depressurize the system by depressing the brake pedal a minimum of 30 times.

Reinstall the two brake pump motor 30 amp fuses.

Turn the ignition On. The pump motors will start running for about 45 seconds. This will fill the accumulators and pressurize the system.

This process ensures that all the air is completely removed from the accumulator circuit.

Recheck the fluid level in the master cylinder reservoir. Adjust as needed to the “MAX” mark.

Check the system for leaks.

If the parking brake cable was disconnected, reconnect the cable.

Use the EZ-Tech® to clear any codes.

Test the operation of the brake system.

Accumulator Disposal Procedure

If the accumulator is defective, before it can be discarded safely, it will need to be depressurized.

Secure the accumulator in a drill press using a vise to clamp the accumulator. The drilling point will be on the opposite side of the welded seam from the threaded port.

Center-punch the accumulator at the location to be drilled.

Using a 1/8 inch drill bit, slowly and carefully drill through the accumulator.

After the internal pressure is released, the accumulator may be scrapped.

“Recheck the fluid level in the master cylinder reservoir. Adjust as needed to the ‘MAX’ mark.”

⚠ WARNING:

If a leakage is noted in the system, before any repairs are attempted, the system MUST be depressurized BEFORE making any repairs.

⚠ WARNING:

The accumulator must be positioned correctly and securely in a drill press vise to prevent it from moving. Failure to follow the proper safety measures may result in personal injury or death.

⚠ CAUTION:

Any liquid spilled or drained from the accumulator should be treated as waste brake fluid and must be disposed of properly.

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Section 5 Service Repair Procedures

Accumulator Replacement

FULL POWER BRAKE FACT: If the accumulator has failed, it will be indicated by Toolbox diagnostics. It is recommended that when one accumulator fails, the remaining one should be replaced as well.

Depressurize the system according to the procedures demonstrated at the beginning of this module.

Use clamping pliers to pinch off the low pressure hose to the reservoir, being careful not to damage the reservoir inlet.

Carefully clean the area around the HCU, including the outside of the HCU itself.

Position a container to collect the fluid drained when performing the next step.

Using a strap wrench, remove both accumulators from the HCU.

NOTE:

Accumulators have a limited shelf life. Do not use components that have expired.

Plug the counter bores to ensure that no contaminates will enter the HCU.

Next, complete the **Accumulator Disposal Procedure** demonstrated earlier in this module.

Remove a plug from one of the counter bore areas of the HCU and one of the plugs from an accumulator.

Make sure the O-ring is installed on the accumulator and has been lubricated with clean brake fluid.

"Make sure the O-ring is installed on the accumulator and has been lubricated with clean brake fluid."

Reinstall one of the accumulators and tighten it by hand until it's snug. Next, tighten the accumulator using a torque wrench with a strap wrench attachment. This wrench should be an 18 to 24 inch long torque wrench. Torque to the specifications found on ISIS®.

Reinstall the second accumulator by repeating the previous steps.

Remove the clamp pliers from the low pressure hose.

Check to make sure that the fluid in the reservoir is between the "MIN" and the "MAX" mark.

Reconnect the batteries.

Reinstall the two pump motor fuses.

Turn the ignition On. The HCU pump motors will start running for about 45 seconds. This will fill the accumulators and pressurize the system.

"When the pump motors stop running, pump the brakes rapidly 4 times to activate both pump motors."

When the pump motors stop running, pump the brakes rapidly 4 times to activate both pump motors. After both motors stop running, turn the key off.

Verify that the brake fluid level in the master cylinder reservoir is between the "MIN" and "MAX" mark.

Once again remove the two brake pump motor 30 amp fuses.

Depressurize the system by depressing the brake pedal a minimum of 30 times.

⚠ WARNING:

If a leakage is noted in the system, before any repairs are attempted, the system MUST be depressurized BEFORE making any repairs.

Reinstall the two brake pump motor 30 amp fuses.

Turn the ignition On. The pump motors will start running for about 45 seconds. This will fill the accumulators and pressurize the system.

This process ensures that all the air is completely removed from the accumulator circuit.

"Recheck the fluid level in the master cylinder reservoir. Adjust as needed to the 'MAX' mark."

Recheck the fluid level in the master cylinder reservoir. Adjust as needed to the "MAX" mark.

Check the system for leaks.

Connect the EZ-Tech® and clear any codes.

Test the operation of the brake system.

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ECU Replacement

The Toolbox software detects a failed ECU. Like the accumulator the ECU has a limited shelf life. Be sure that the replacement part has not expired.

Also, be aware that the ECU has various programmable parameters that can vary according to the vehicle wheelbase and configuration. The default parameter settings are programmed at the factory. To ensure that a replacement ECU has the correct settings, use only the correct replacement number. Then refer to ISIS® to properly complete the programming of the replacement ECU.

Disconnect the battery.

Carefully clean the outside of the HCU.

Unlatch and disconnect both electrical connectors from the back of the ECU.

Remove the four screws that secure the ECU to the HCU.

Remove the ECU.

Carefully wipe the area surrounding the solenoid valve which was covered by the ECU. Don't touch the pressure sensor.

⚠ CAUTION:

To prevent damage to the ECU due to electrostatic discharge, always disconnect the battery before servicing the ECU.

⚠ CAUTION:

During this procedure, don't touch the two connectors serving the pressure sensing switches. They are very sensitive and can be damaged from a static electricity discharge. Also, these two pressure sensing switches and the ten solenoid valves (two ATC and eight ABS) are not serviceable components. Any damage to these items requires that a new HCU be installed. In addition, carefully pull the ECU straight away from the HCU to prevent damage to the ABS and ATC solenoid valves that protrude from the HCU.

NOTE:

The ECU has a limited shelf life. Do not use components that have expired.

Remove and discard the two orange seals from the two pressure sensing switches.

A new ECU service kit consists of an ECU module, two orange seals for the pressure sensing switches, and four new mounting screws.

Assemble the new orange pressure sensor seals into the new ECU module.

"Ensure that the pump motor connectors achieve full depth into the HCU before inserting the screws."

Carefully position the ECU module on the HCU valves and seat it by pressing simultaneously on all sides. Ensure that the pump motor connectors achieve full depth into the HCU before inserting the screws.

⚠ WARNING:

During this procedure, ensure that the ECU connectors are properly installed and latched to prevent them from becoming disconnected. Failure to securely connect and latch the ECU connectors could result in loss of braking functions during vehicle operation.

The gap between the HCU body and ECU module housing should be about eight thousandths of an inch. If this gap cannot be achieved, remove the ECU module, check for obstructions, verify that the seals are correctly installed, and reinstall the ECU.

Install the four mounting screws. Tighten in a crossing pattern to the specified torque found on ISIS®. Verify that the metal sleeves of the ECU module housing rest flat on the HCU body.

Connect and secure the ECU module connectors by engaging the latches.

Route and secure the wiring harness in the factory location.

Reconnect the battery.

Using the EZ Tech® and Toolbox, program the replacement ECU to match the VIN number.

Finally, test the brake system.

Wheel Speed Sensors Replacement

Cut the tie straps that hold the sensor cable to other components.

Disconnect the sensor cable from the chassis harness.

Clean the area surrounding the sensor to prevent contamination.

Remove the sensor from the spring clip by twisting and pulling on the sensor. Don't pull on the sensor by the cable.

"Don't pull on the sensor by the cable."

Remove the sensor and cable assembly.

Remove and inspect the spring clip and replace it if it is damaged.

Clean the area where the wheel sensor will be installed.

If a new spring clip is being installed, lubricate it with an approved lubricant. Refer to ISIS® for the specification.

Push the spring clip into the wheel end bracket until it stops.

Lubricate the sensor.

Push the sensor completely into the spring clip until it contacts the tooth wheel.

Reconnect the sensor cable to the chassis harness.

Reconnect the sensor harness with new tie straps.

Clear fault codes from the ECU.

Finally, test the brake system.

Master Cylinder Reservoir Replacement

⚠ CAUTION:

Before performing the following steps you will need a suitable container that can hold at least a gallon of fluid.

Depressurize the system according to the procedures demonstrated at the beginning of this module.

Disconnect the travel switch wiring on the master cylinder and the fluid level switch on the master cylinder reservoir.

Carefully clean the outside of the master cylinder reservoir.

Use clamp pliers to pinch the low pressure hose near the outlet of the master cylinder reservoir, being careful not to damage the reservoir outlet.

Remove the cap on the master cylinder reservoir.

Disconnect the low pressure hose from the master cylinder reservoir. Allow the fluid to drain. Plug the low pressure hose to prevent contamination.

Because of the master cylinder reservoir design, not all of the brake fluid will be able to be drained. Keep this in mind as you are handling the reservoir.

Remove the nut securing the reservoir to the master cylinder bracket.

Remove the 2 roll pins securing the reservoir to the master cylinder.

Lift the reservoir off of the master cylinder. Some resistance will be felt because of the rubber seals between the master cylinder and the reservoir.

Verify that the 2 rubber seals were removed from the master cylinder with the reservoir.

Plug the master cylinder ports to ensure that no contamination will enter.

⚠ CAUTION:

During the following procedure, do not depress the brake pedal unless instructed to do so.

"Because of the master cylinder reservoir design, not all of the brake fluid will be able to be drained."

⚠ CAUTION:

Care must be taken to protect the reservoir mounting tabs from excessive deflection when removing the roll pins. One method is to back up the mounting tab with a socket or similar object that allows the pins to be driven through the tab without deflecting the tab.

Carefully clean the top of the master cylinder.

Install 2 new black rubber seals into the ports on the top of the master cylinder.

"Lubricate the reservoir seals with new brake fluid."

Lubricate the reservoir seals with new brake fluid.

Install the new reservoir by placing it on the mounting bracket stud and carefully pivoting it downward to seat it fully onto the master cylinder seals.

⚠ CAUTION:

Care must be taken to protect the reservoir mounting tabs from excessive deflection when installing the roll pins. One method is to back up the mounting tab with a socket or similar object that allows the pins to be driven through the tab without deflecting the tab. It is important to line up the pin with the holes in the tabs.

Install the 2 roll pins that attach the reservoir to the master cylinder.

Install the nut to attach the reservoir to the bracket.

Secure the low pressure hose to the master cylinder reservoir outlet.

Release the pliers from the low pressure hose.

Connect the travel switch and the fluid level switch wiring on the master cylinder.

Fill the reservoir to between the "MIN" and "MAX" mark with new brake fluid.

Then, bleed the master cylinder circuit according to the procedures demonstrated at the beginning of this module.

Master Cylinder Replacement

Depressurize the system according to the procedures demonstrated at the beginning of this module.

NOTE:

The master cylinder has a limited shelf life. Do not use components that have expired.

Disconnect the travel switch wiring on the master cylinder and the fluid level switch on the master cylinder reservoir.

Use clamp pliers to pinch the low pressure hose near the outlet of the master cylinder reservoir, being careful not to damage the reservoir outlet.

⚠ CAUTION:

Before performing the following steps you will need a suitable container that can hold at least a gallon of fluid.

Remove the cap on the master cylinder reservoir.

Disconnect the low pressure hose from the master cylinder reservoir. Allow the fluid to drain. Plug the low pressure hose to prevent contamination.

⚠ CAUTION:

During the following procedure, do not depress the brake pedal unless instructed to do so.

Because of the master cylinder reservoir design, not all of the brake fluid will be able to be drained. Keep this in mind as you are handling the reservoir.

Disconnect the two brake tubes from the master cylinder. Plug the brake line tubes and the master cylinder ports.

Disconnect the master cylinder push rod clevis from the brake pedal by removing the clevis pin and spring retainer. Unbolt the master cylinder reservoir from the mounting bracket.

Unbolt the master cylinder from the mounting bracket.

Remove the master cylinder and reservoir from the bracket.

Replace the master cylinder reservoir as described in the previous section.

"Install the master cylinder reservoir assembly so that the stud on the bracket is inserted into the hole of the reservoir mounting tab."

Install the master cylinder reservoir assembly so that the stud on the bracket is inserted into the hole of the reservoir mounting tab.

The master cylinder base slips over the 2 mounting studs on the bracket and the master cylinder clevis passes through the hole in the cowl.

Reinstall the mounting nuts, securing the master cylinder base and the reservoir to the bracket.

Connect the master cylinder push rod clevis to the pedal assembly using the clevis pin and the spring retainer.

Lock the spring retainer.

Connect the primary and secondary brake tubes to the master cylinder. Torque to the specifications on ISIS®.

Connect the low pressure hose to the master cylinder reservoir using the existing hose clamp. Remove the clamp pliers from the hose.

Connect the travel switch and the fluid level switch on the master cylinder.

Fill the reservoir to between the "MIN" and "MAX" mark with new brake fluid.

Then, bleed the master cylinder circuit according to the procedures demonstrated at the beginning of this module.

WARNING:

In the following step the travel switch must be connected on the master cylinder to ensure that the brake system ABS functions operate correctly.

"Fill the reservoir to between the 'MIN' and 'MAX' mark with new brake fluid."

Master Cylinder Travel Switch Replacement

The travel switch on the master cylinder can be removed without opening the brake fluid system. Therefore, the switch can be replaced without depressurizing the brake system.

Disconnect the master cylinder brake pedal travel switch wiring.

Remove the 2 screws securing the switch to the master cylinder and pull the switch straight down.

"Position the replacement switch and seal so the mounting holes align with the holes on the master cylinder body."

Position the replacement switch and seal so the mounting holes align with the holes on the master cylinder body. Secure the switch with 2 mounting screws.

Connect the wiring to the master cylinder travel switch.

Fluid Level Switch Replacement

The fluid level switch is located on the bottom of the master cylinder reservoir. The switch can be removed without opening the brake fluid system. Therefore, it can be replaced without depressurizing the system.

Disconnect the fluid level switch wiring.

On the opposite end of the switch body from the electrical connector, squeeze the lock tabs and push the switch out of its holder tube.

Push the replacement switch into the holder tube until the locking tabs expand to hold the switch in place.

Connect the wiring to the switch.

Verify that the switch operates by checking the dash warning light condition against the level in the master cylinder.

HCU Replacement

The HCU must be replaced if any of the following components are faulty:

- The electric motor pump assemblies
- The relay valve assembly
- The pressure sensing switches
- Or, the ABS or ATC solenoid valves

In addition to these components, the HCU also includes a new reservoir and a new ECU. As an alternative, a Reservoir Kit and ECU Kit can be purchased separately.

"As an alternative, a Reservoir Kit and ECU Kit can be purchased separately."

The HCU DOES NOT include:

- An Accumulator Kit,
- A Pressure Supply Valve,
- And the HCU Assembly Mounting Brackets.

Keep in mind that the HCU assembly must be removed when servicing the HCU reservoir to prevent contamination of the system.

⚠ CAUTION:

Any form of contamination entering the system could prevent the system from operating correctly. Thoroughly clean the area around the fittings before disconnecting them. Always plug open ports and lines as quickly as possible.

It is also required due to limited clearance between the top of the HCU reservoir and the bottom of the bus body.

Depressurize the system according to the procedures demonstrated at the beginning of this module.

Carefully clean the area around the HCU, including the outside of the HCU itself.

Unlatch and disconnect the wiring to the ECU. Also disconnect the pressure supply valve.

NOTE:

This component has a limited shelf life. Do not use components that have an expired expiration date.

Using clamping pliers, pinch off the low pressure hose to the reservoir.

Position a container to collect the fluid drained when performing the next step.

Using a strap wrench, remove both accumulators from the HCU. By doing this you will gain easier access to the brake lines and reduce the weight of the HCU assembly.

Plug these counter bores to ensure that no contaminates will enter the HCU. Also, plug the ports on the accumulators and retain them for re-installation.

Using a backup wrench, secure each port fitting that is threaded into the HCU while you use a second wrench to disconnect the six brake line fittings.

"Using a backup wrench, secure each port fitting that is threaded into the HCU while you use a second wrench to disconnect the six brake line fittings."

Be sure to protect the tubes, and also the port fittings on the HCU by covering them with a properly sized plug until re-installation.

Disconnect the low pressure hose from the HCU reservoir.

Plug the low pressure hose and the reservoir inlet to prevent contamination and fluid loss during removal of the HCU.

To allow easier removal of the HCU, LOOSEN the two bolts securing the HCU mounting bracket to the frame rail. The bolts should be left in place, but must be loose enough to allow movement of the mounting bracket.

Remove the four mounting brackets bolts.

Remove the HCU by sliding it downward.

Retain the mounting hardware including 4 bolts and 4 bushings for use with the replacement HCU.

Move the HCU assembly to a clean workbench.

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HCU Reservoir Replacement (Only): Bench Top Procedures

Remove the 4 screws securing the reservoir to the main body of the HCU. Carefully lift the reservoir away from the HCU, being sure you don't introduce any dirt into the HCU ports.

Some resistance will be felt during this procedure due to the 4 rubber grommet seals between these two components.

Verify that all 4 grommet seals have been removed from the HCU ports and then discard them along with the failed reservoir.

Use an "HCU Reservoir Kit" to replace the reservoir or a "Rubber Grommets Kit" if the reservoir is determined to be OK and only the grommets have failed.

Remove the protective plugs and then install the new grommet seals into the top of the HCU ports, being sure to lubricate these seals with new brake fluid prior to installation.

Install the reservoir by pressing it carefully and fully into the grommet seals, making sure the reservoir's inlet is oriented toward the front side of the bus.

⚠ CAUTION:

Since you will be reusing the HCU, it is critical that the HCU is thoroughly cleaned, including all areas between the HCU main body and the HCU reservoir. Failure to properly clean the HCU will introduce contamination and may lead to overall failure of the Full Power Brake system once the HCU is reinstalled.

"...install the new grommet seals into the top of the HCU ports, being sure to lubricate these seals with new brake fluid prior to installation."

"Install the 4 mounting screws and torque to the specifications on ISIS®."

Install the 4 mounting screws and torque to the specifications on ISIS®.

Fill the reservoir with about two quarts of new brake fluid and then cap the reservoir.

HCU Installation

⚠ CAUTION:

Don't remove any of the protective caps of the HCU until the HCU is ready to be connected.

Place the 4 bushings into the HCU holes in both HCU mounting brackets, 2 per bracket. The stepped bushings are pushed into the holes from the inside surface of the bracket.

Position the HCU between the mounting brackets and secure it using 2 bolts per bracket. Verify that the mounting bushings remain in place.

Tighten the two bolts that secure the HCU mounting bracket to the frame rail that were loosened previously.

Connect the low pressure hose to the HCU reservoir and secure it with a hose clamp.

"Connect the brake lines to the HCU and torque to the specifications found on ISIS®."

Connect the brake lines to the HCU and torque to the specifications found on ISIS®.

Remove a plug from one of the counter bore areas of the HCU and one of the plugs from an accumulator.

Make sure the O-ring is installed on the accumulator and has been lubricated with clean brake fluid.

Re-install one of the accumulators and tighten it by hand until it's snug. Next, tighten the accumulator using a torque wrench with a strap wrench attachment. This wrench should be an 18 to 24 inch long torque wrench.

Torque to the specifications found on ISIS®.

Re-install the second accumulator by repeating the previous steps.

Remove the clamp pliers from the low pressure hose.

Secure the 2 electrical connectors to the ECU by engaging the latches.

Fill the reservoir to between the "MIN" and "MAX" marks with new brake fluid.

Bleed the master cylinder circuit, all wheel ends, and the SAHR circuit using the procedures demonstrated at the beginning of this module.

⚠ WARNING:

In the following step, ensure that the ECU connectors are properly installed and latched to prevent them from becoming disconnected. Failure to securely connect and latch the ECU connectors could result in loss of braking functions during vehicle operation.

Parking Brake Inspection and Drum Removal

"Replace the linings if there is uneven or excessive wear, cracks, warping, or the linings have been worn to less then 1/32 of an inch above the shoes."

Remove the drive shaft and support it with a jack stand.

Remove the park brake drum.

Inspect the brake shoes. Replace the linings if there is uneven or excessive wear, cracks, warping, or the linings have been worn to less then 1/32 of an inch above the shoes.

Replace the brake shoes if they are contaminated with grease, fluids, or other foreign substances.

⚠ CAUTION:

Keep grease and other foreign materials away from the brake shoe linings and drum surfaces. Contamination of shoe linings or the drum may result in damage to the brake linings.

Inspect the brake lever, cam, springs, hold down pins, adjuster nut, and the star wheel for cracks, excessive wear, or bends.

Inspect the adjuster cable assembly, adjuster nut and screw for damage or wear. Replace any worn or damaged parts.

Inspect the brake drum, replace the drum if it has uneven wear, deep grooves, excessive run-out or the measurement is not within specifications.

Brake Shoe Adjustment – Drum Installed

Raise the rear axle.

Insert a brake adjusting tool or a flat head screw driver into the parking brake adjusting hole and move the star wheel teeth down to expand the brake shoes. Continue adjusting until the drum cannot be turned.

Move the star wheel teeth up to retract the shoes until the drum just begins to run freely without any drag from the linings.

"Move the star wheel teeth up to retract the shoes until the drum just begins to run freely without any drag from the linings."

Lower the vehicle.

Test the operation of the parking brake.

This concludes the repair module and this CE Bus Full Power Brake Service program.

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